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THE

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No. I.—JANUARY, 1901.

ORIGINAL ARTICLES.

I.—Note on the Structure of Sarsens.

By Professor J. W. Judd, C.B., LL.D., F.R.S., V.P.G.S., etc.

[*Introductory Note.*—After the publication of my paper on the Sarsens, or Sarsen Stones, in the Wiltshire Archæological and Natural History Society's Magazine, vol. xxiii (1886), pp. 122–154, many friendly communications gave me further information on the subject, and additional references to published facts and opinions. From this correspondence, and my own notes made in the country, I propose to utilize much that seems to be of interest. The most important of these additions to our knowledge of the Sarsens is the following memoir on their constitution and structure by my friend Prof. Dr. J. W. Judd, C.B., F.R.S., etc., of the Royal College of Science, who most obligingly examined with care the microscopical structure of many specimens from authenticated localities. With his kind permission this valuable communication (dated March 9th, 1888) is here printed.—T. Rupert Jones.]

THE microscopic examination of a series of thin sections, cut from the Sarsens, shows that their minute structure varies as strikingly as does the appearance of their fractured surfaces. Microscopically, the Sarsens are seen to be made up of two kinds of materials, clastic fragments of crystalline minerals and a cement (base or matrix) of a microcrystalline or cryptocrystalline character. The relative proportion of these two constituents varies very widely in different cases.

The Sarsens with saccharoid fracture stand at one end of the series. An admirable example from Camberley, North Surrey, is seen to be almost wholly made up of sand grains, with very little in the way of cement visible. Much of the cementing material in this rock is ferruginous, and the rock is more incoherent than is the case with most Sarsens.

At the other end of the series stand the Sarsens exhibiting a fracture resembling that of some cherts. Under the microscope the greater part of their mass is seen to be made up of excessively minute and imperfectly developed quartz microlites, and these occasionally exhibit a tendency to the spherulitic arrangement. A beautiful example of this kind of Sarsen is one from Poxwell Ring, near Dorchester. In this case the original sand grains seem to have almost wholly disappeared, and an aggregate of grains of secondary quartz has been formed, which crystallize out freely on the sides of cavities. In parts, the section shows admirable spherulitic structure, and the iron-oxides have separated into small globular masses. The appearances exhibited are strikingly like those of some flints with highly crystalline structure.

All the other sections examined show the detrital crystalline particles enveloped in more or less of the fine-grained secondary matrix. The detrital grains consist mainly of quartz. By far the greater part of these quartz grains exhibit the bands of liquid cavities so characteristic of the quartz of granites and gneisses; corroded quartz grains with glass or stone cavities, evidently derived from quartz-felsites, occur, but are much less rare, as are also the polysynthetic grains, some of which may have been derived from schistose rocks. With the quartz grains are a few unmistakable particles of flint, but these are never numerous. Felspars and other minerals are usually rare. Sometimes the grains appear to be well rounded, and at other times they seem perfectly angular; but it is probable that in all cases a considerable amount of corrosion of the surfaces of the grains has taken place. Only in one or two doubtful cases have I seen what could be taken as a deposition of secondary silica upon, and in optical continuity with, the detrital quartz.

In a specimen from the valley of the Kennet (Enborne Lodge gravel-pit) we have perfectly angular quartz grains embedded in a nearly compact cement—one which can be resolved only under very high microscopic power.

A very remarkable variety of Sarsen is one from Staple-Fitzpaine, about 10 miles west of Taunton. In this rock the grains are much larger than in any other Sarsen that I have examined; they are markedly angular, and though quartz grains form a majority of the whole, yet felspars and other minerals occur much more usually than in the other specimens examined. If this should be found to be the rule with Sarsens from the most westerly localities, it would indicate that the granitic and metamorphic rocks which yielded the materials of which they are composed lay to the west of the London Basin.

[In a subsequent letter (February 27th, 1889) Professor Judd states that this "specimen from Staple-Fitzpaine has a fragment of whitened flint in it. The microscopic characters of which are unmistakably those of a silicified Chalk-mud full of fragments of Globigerina."]

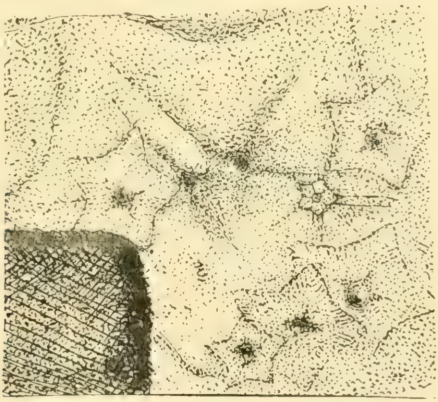
The cement of the flint-conglomerate of Hertfordshire consists of quartz grains, with a few grains of flint, embedded in a crypto-crystalline siliceous groundmass. There is no very striking resemblance between the cement of this conglomerate and that of any of the Sarsens which I have examined.

II.—NOTE ON CERTAIN IMPRESSIONS OF ECHINODERMS OBSERVED ON THE SANDSTONE SLABS IN WHICH THE SKELETONS OF *HYPERODAPEDON GORDONI* AND *RHYNCHOSAURUS* ARE PRESERVED.

By Prof. RUDOLF BURCKHARDT, Ph.D., of the University of Basel, Switzerland.

WHEN searching for traces of the dermal structure preserved in the specimen of *Hyperodapedon* in the British Museum (Natural History) in London,[1] my attention was drawn to certain spots where the matrix showed projections and pits of a polygonal shape, which I detected when I took the photographs of this Triassic reptile. Primarily occupying myself with the matrix of the principal slab, in which the skeleton is enclosed, I quite thought I had only to deal with dermal structures similar to those discovered in *Rhynchosaurus.*

One of these spots, lying between the ninth and tenth ribs of the left side, particularly attracted my attention. This I was at first inclined to regard as a dermal ossification, the pentagonal character of which was unquestionable. On closer inspection I found, however, the whole of the matrix *densely covered with similar structures*, a circumstance which became still more perplexing in proportion as I discovered their immense numbers, which were equally abundant at a considerable distance from the body, and also in the matrix of the counterpart which had not been touched by the chisel. The matrix of the Rhynchosaurian fossils from Warwickshire also showed the same character; indeed, I found some on these slabs in even better condition of preservation.



Prints of Echinoderms in the Triassic Sandstones of Warwickshire and Elgin. From a specimen in the British Museum (Natural History). × 3.

Actual petrefactions they were not, but simply the hollow impressions leaving a film behind, between the coarse grains of the sand. In size they vary between 3 mm. and 3 cm. in diameter. The matrix is crowded with these bodies, which are deposited over each other, all of them lying in the same plane as the skeleton of

[1] See "On *Hyperodapedon Gordoni*": GEOL. MAG., 1900, Nov. and Dec.

Hyperodapedon. Those facing the observer with their upper sides have left teat-like projections in the stone; others appear as funnel-shaped depressions made by a massive body.

In shape they are star-like pentagons, of about the same form as the bodies of Euryalidæ.

In diagonal opposition to the main portion of the star-shaped bed lies a small pentagonal plate consisting of five parts, which radiate from a central piece. I believe I have also detected some radiating striæ on the outer pentagon in a few exceptionally well-preserved examples, as well as some finer striæ, skirting the margin of the extreme pentagonal radially, where they arrange themselves in regular order. Besides these pentagons I noticed some series of smaller segments of about $\frac{1}{2}$ mm., which to the number of six unite with each other, though rarely more, in which latter case they are very difficult of detection.

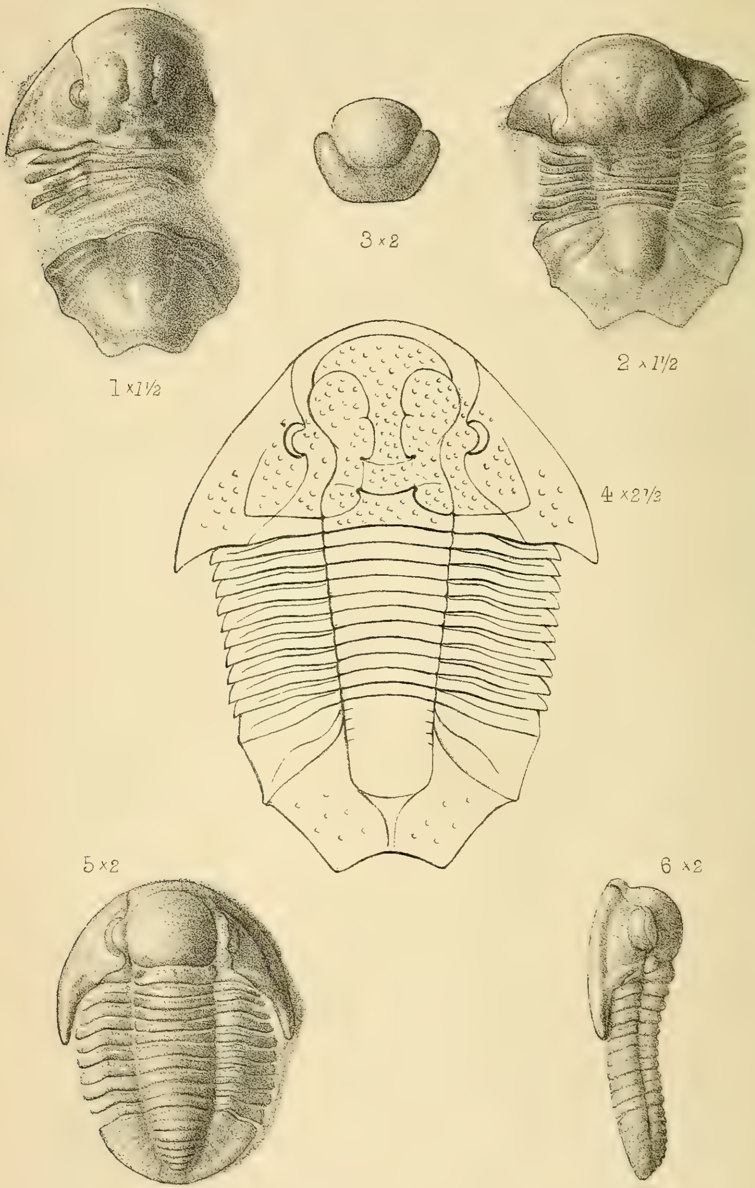
The conclusions I have arrived at as to these structures, and to which I give expression quite reservedly to specialists engaged in this branch of geology, are as follows:—

These pentagonal forms are empty caverns left by Echinoderms of a Eurylaid shape, having peripheral arms, either simple or forked. To whatever group of Echinoderms they may belong will be a matter of investigation by specialists. Under no circumstances are they parts of *Hyperodapedon.* The two pentagonal sets of which they are composed, together with their projecting limbs, are forms which do not resemble any other type of the classes of invertebrates. In favour also of this inference is their enormous quantity and the great diversity in their sizes. The extreme delicacy of these impressions is probably the reason why my examination of the slabs did not yield a better result, as might have been the case if the stones had been more recently quarried or specially prepared for this purpose.

That no remains of their external skeletons are preserved, is in no way detrimental to this hypothesis, as a corollary to this is found in the case of those hollows left by Elgin reptiles, which E. T. Newton so admirably described from casts taken from their natural moulds. No other fossils having been found in these localities except reptiles, is also an argument in favour of such an interpretation as the above.

From a like presence of these casts in both localities, the Elgin sandstones, which Smith Woodward quotes as "supposed Trias," should be of the *same age* as the sandstones belonging to the Upper Triassic of Warwickshire and Shropshire.

Interesting as may be the task of pursuing this highly attractive geological question, it is a matter of real regret that I am compelled to deny myself the pleasure of conducting the investigation of this subject further. I must confine myself here to the statement only, that I have good reason for believing that I have observed similar petrefactions of organic origin in some rather imperfect fragments from the Maleri deposits in India.



G. M. Woodward del. et lith.

West, Newman imp.

Wenlock Limestone Trilobites.

III.—Woodwardian Museum Notes: Salter's Undescribed Species. II.

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

(PLATE I.)

Lichas scutalis, Salter. (Pl. I, Figs. 1–4.)

1873. *Lichas scutalis*, Salter MSS.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 130 (*a* 954).
1877. *Lichas verrucosus*, Woodward: Cat. Brit. Foss. Crust., p. 43.
1878. *Lichas scutalis*, Edgell MSS.: Cat. Camb. Sil. Foss. Mus. Pract. Geol., p. 84.
1891. *Lichas verrucosus*, Woods: Cat. Type Foss. Woodw. Mus., p. 147.

There are three specimens of this species in the Woodwardian Museum, viz.: (1) Salter's fine original specimen (*a* 954) from the Wenlock Shale of Malvern, belonging to the first part of the Fletcher Collection, acquired prior to 1873; (2) a poor specimen probably from the same collection and horizon, locality unknown; and (3) an almost perfect specimen, also from the Wenlock Shale of Malvern, belonging to that part of the Fletcher Collection recently presented by Mrs. Fletcher. This specimen will be designated the Fletcher specimen in distinction to Salter's original specimen. Both these specimens show almost the whole trilobite preserved in excellent condition, and from them the following description has been drawn up.

Diagnosis.—*Head-shield* broadly parabolic, nearly twice as broad as long, and slightly produced backwards at genal angles; strongly convex from back to front and from side to side, slightly flattened between the eyes across the middle portion of the posterior half; anterior half of head-shield bent down very steeply to margin, almost at a right angle to posterior half; sides bent down as steeply in front, but less steeply towards genal angles, where they flatten out.

Glabella wide, occupying nearly whole middle third of head-shield; forms most elevated portion of head-shield, but is not swollen nor raised with independent convexity above fixed cheeks. Median lobe much expanded in front, its narrow laterally-projecting tongues overlapping anterior lateral lobes; constricted strongly at level of anterior lateral furrow, behind which it gradually decreases in width with nearly straight sides to the base of anterior lateral lobes, where it again expands a little. Behind this point the median lobe is only weakly marked off from the two pairs of posterior lateral lobes, but is traceable in the Fletcher specimen to the straight occipital furrow, where it has nearly double the width it possessed between the anterior lateral lobes.

Anterior lateral lobes large, of broadly oval shape, rather wider in front than behind, where the furrow which defines them is very faint. They extend about two-thirds the whole length of the glabella with their longer axes obliquely directed inwards, and with a gentle convexity of their own, bending down strongly in front with the median lobe and at the sides with the general curvature of the head-shield. In front they are separated from the marginal furrow of the head-shield by the lateral projections of the median lobe.

Middle lateral lobes subquadrate in shape, small and indistinctly defined, being marked off in front from the anterior lobes by a very faint depression sweeping round the hinder end of the latter lobes and representing the middle lateral furrows. They are still more indistinctly marked off posteriorly from the basal lobes by weak grooves, while their outer sides are defined by the faint axal furrows and their inner sides by the continuation of the anterior lateral furrows to the occipital segment.

Basal lobes likewise weakly marked off from the rest of the glabella and fixed cheeks, but relatively large, being nearly the size of the middle lobes ; subrhomboidal rather than triangular in shape, owing to the basal (posterior lateral) furrow starting, not from the level of the occipital furrow but a little way in advance of it. The posterior side of the basal lobes is marked off from the occipital segment by the strong deep occipital furrow.

Occipital ring flattened and very broad in the middle behind the straight portion of the occipital furrow at the base of the median lobe of the glabella, but with its lateral portions only about half the width, and bent backwards behind the basal lobes.

Axal furrows strongly marked only along the outer side of the anterior end of the anterior lateral lobes, being posteriorly very weak, as above mentioned. Behind the point where they pass into the marginal furrow which bounds the glabella in front they arch outwards, curving round inwards posteriorly as they define the anterior lateral lobes, to the base of which they nearly extend with a deeply impressed course. Here the middle lateral furrows pass imperceptibly into them. Behind this point the axal furrows become very weak, and curve outwards along the outer side of the middle and basal lobes to end in the occipital furrow.

Anterior lateral furrows arise far forwards, curving round the broad anterior end of the anterior lateral lobes, and then run with nearly a straight course backwards along the inner side of these lobes, slightly converging. At the posterior end of the latter each furrow bends a little outwards to end in a small pit from which the middle furrow starts. About half-way along the inner side of these anterior lobes there is a slight outward kink in these anterior furrows, from which a faint groove runs outwards a little distance across the lobe, such as has been noticed in *Lichas ornatus* (Angelin),[1] *Lichas anglicus* (Beyr.), and other species. Behind the pits at the base of the anterior lobes the anterior lateral furrows are traceable as faint slightly divergent grooves (especially clear in the Fletcher specimen), which finally meet the occipital furrow at the inner posterior angle of the basal lobes.

Middle lateral furrows weak and short, starting from the pit on the anterior furrows and curving round the base of the anterior lobes to merge imperceptibly into the stronger axal furrows.

[1] Schmidt: Rev. Ostbalt. Silur. Trilob., Abth. ii (1885), p. 109, t. vi, fig. 18*a*.

Basal furrows extremely faint. As mentioned above, they are not straight lateral prolongations of the median portion of the occipital furrow, as is the case in many species, but they arise a short distance in front of it on the backward continuation of the anterior lateral furrow, and curve slightly forwards to join the axal furrow nearly at right angles.

In Salter's original specimen there is in addition to the above furrows a shallow transverse depression arched backwards, extending across the neck of the median lobe at the base of the anterior lateral lobes and between the pits on the anterior furrows. A similar transverse groove is seen in *Lichas palmatus* (Barr.), *L. scaber* (Beyr.),[1] and *L. anglicus* (Beyr.).

Occipital furrow composed of a central straight portion, not deeply impressed, and of lateral portions curving strongly backwards and strongly marked behind the basal lobes.

Fixed cheeks small, with an anterior wing forming a very narrow strip between the axal furrow and the facial suture. At the base of the anterior lateral lobes of the glabella, where the axal furrow bends in, the cheeks increase in width, expanding behind the eye and entering into the general convexity of the head-shield.

Eye-lobes of moderate size, prominent, horizontally-extended outwards on a level with the general convexity of the glabella, and situated just in front of the base of the anterior lateral lobes. A short furrow separates them from the fixed cheeks. In front of the glabella is a flattened horizontally-extended border of moderate width, widening a little laterally as it passes into that of the free cheeks, and marked off by a shallow marginal furrow.

Free cheeks triangular in shape, with an inner strongly convex portion abruptly elevated above the flattened broad border, and marked off behind by the occipital furrow and scarcely in front by the very weakly-defined marginal furrow which circumscribes its base and joins the occipital furrow at nearly a right angle. This inner convex portion of the free cheek bears the eye at its summit, but nearer the front than the anterior border.

Eye semicircular and prominent, rising up vertically with a high visual surface beneath the overhanging eye-lobe.

Border of free cheek flattened, rapidly increasing in width from the front to the genal angle, owing to the inward course of the marginal furrow. Genal angles slightly produced into blunt points.

Ornamentation.—The glabella, occipital ring, fixed cheeks, and the convex portion of the free cheeks are ornamented with tubercles of moderate size, rather sparingly distributed. On the flattened border of the free cheeks, particularly near the genal angles, there are also a few similar tubercles.

Thorax.—The thorax in the Fletcher specimen is nearly perfect and shows nine narrow segments, but in Salter's original specimen it is not so well preserved and only seven segments can be distinguished. In each case the specimen has its head and tail strongly bent upwards, and this has caused the body to break across at the

[1] Barrande: Syst. Silur. Bohem., vol. i (1851), pl. xxix, figs. 7 and 24.

junction of the head and thorax, forcing back the head over the first few segments of the body and concealing them. In the Fletcher specimen there are indications of one segment being thus covered, making the actual number of thoracic rings to be ten.

Axis of thorax gently convex, broad, tapering gradually to the pygidium, each ring consisting of a simple narrow band, apparently devoid of ornamentation. The anterior rings of the axis appear to be wider than the corresponding pleuræ, but the posterior ones to be narrower. Axal furrows weak.

Pleuræ semicylindrical, horizontally extended as far as the fulcrum, but then bent downwards, flattening again towards their extremities, which are separate and free. The fulcrum is distant from the axal furrow about one-third of the length of the pleura, and is obtusely rounded. Each pleura curves gently forwards to the fulcrum, then bends more strongly backwards, and again bends forward slightly towards its extremity. The surface of each pleura is marked along its inner portion by a nearly median furrow, which runs straight outwards to the fulcrum and then curves backwards over the outer portion to the point, dividing this outer portion into a flattened anterior and an elevated posterior part, but near the end the whole breadth of the pleura is flattened. The extremity is bluntly pointed. There are a few obscure traces of tubercles on the pleuræ.

Pygidium.—Broad and roughly pentagonal, gently convex from side to side, having its lateral lobes bent down, but flattened along its margin. Its component segments are closely fused together, and only the two anterior pleuræ on each side are marked out.

The pygidium is arched forwards in front; posteriorly it is forked, and each side is angulated by the projection of the extremities of the second pair of pleuræ.

The posterior margin lying in the fork is rather less than half the anterior width of the pygidium. The re-entrant angle is about 135°, and the sides meet the lateral borders at an angle of a little over 90° at the obtusely rounded divergent points of the fork. (In the Fletcher specimen these points are rather more acute.)

Axis cylindrical, convex, and prominent, being strongly raised above the lateral lobes. Its posterior end is pointed and prolonged to reach the posterior margin of the pygidium at the re-entrant angle, sloping down rapidly to the level of the flattened border. The cylindrical portion of the axis measures only about two-thirds the total length of the pygidium.

First axial ring only distinct, and marked off behind by a strong continuous furrow. Very obscure traces of four or five rings behind it. Axal furrows well marked on each side of the cylindrical portion, but very faint behind it and scarcely traceable to the margin.

Lateral lobes of pygidium, bent down on each side of the axis and consisting of a convex inner portion and a flattened marginal portion. Each lateral lobe measures anteriorly about $1\frac{1}{2}$ times the width of the axis.

First pair of pleuræ distinct, each pleura expanding outwardly to double its axial width, and with a squarely truncated extremity, not projecting beyond the margin. A straight diagonal furrow marks the surface, but does not reach the extremity, and the outer anterior angle of the truncated end is flattened as in the pleuræ of the thorax, as if for rolling-up. The groove separating the first from the second pleura runs obliquely backwards and outwards at an angle of about 30° to the front margin of the pygidium, curving gently forwards at its outer end.

Second pair of pleuræ distinct, each pleura increasing rapidly to double the width possessed by the first pleura on the margin; end broad, truncated, and with posterior angle projecting beyond the margin as a distinct tooth; posteriorly marked off by weak furrow making an angle of about 45° with front margin of the pygidium. A median, slightly oblique furrow traverses the surface of the pleura, but stops short of the margin.

The position of the projecting ends of this second pair of pleuræ is about half-way along the lateral margins of the pygidium. Behind them the margin takes a slight curve inwards to the points of the posterior fork.

The lateral lobes behind the second pair of pleuræ show no segmentation or furrows, but probably are composed of two pairs of pleuræ, one ending at the lateral pointed extremities of the posterior margin and the other at the axal furrows in the re-entrant angle.

A few scattered tubercles are visible on the flattened marginal portion of the lateral lobes, especially near the posterior angles.

Measurements.

	I.	II.
	mm.	mm.
Length of head-shield	13·0	11·5
Width of head-shield	26·0	21·0
Length of glabella	11·0	8·5
Width of glabella at front end	10·5	10·0
Width of glabella at level of eyes	8·25	7·5
Width of glabella at neck-furrow	9·0	9·0
Width of thorax	about 22·0	19·0
Width of axis of thorax	uncertain	8·0
Length of pygidium	11·5	10·0
Width of pygidium at front end	18·0	18·0
Width of pygidium between posterior angles	9·0	8·0
Width of axis of pygidium	6·0	6·0

I = Salter's specimen. II = Fletcher's specimen.

N.B.—In the Fletcher specimen the hypostome is also seen in its proper position on the lower surface of the upturned head. It is subpentagonal in shape; its length is less than its breadth, which is greatest across the middle. The central portion, which is also of greater breadth than length, is marked off by a continuous furrow from the border, is gently convex, and occupies about two-thirds of the whole length of the hypostome; its anterior end is strongly arched forwards, and its sides and posterior edge are nearly straight and parallel respectively to the lateral and posterior margins of the hypostome. A pair of faint short furrows run obliquely inwards from the lateral angles. The border is broad and flattened, extending down the sides of the central portion from the lateral angles and round the posterior margin, where it is broadest and slightly excavated. The posterior angles are obtusely rounded.

Measurements.

	mm.
Length of hypostome	7·0
Width of hypostome across middle	9·5
Length of central portion	5·0
Width of central portion	7·0
Width of posterior border	2·0

Remarks.—To none of the other British species of *Lichas* from the Wenlock Series does *L. scutalis* show any close resemblance. *L. verrucosus* (Eichw.),[1] with which it has been confounded, belongs to a lower stratigraphical horizon, and differs in the following particulars,—the shape of the median lobe of the glabella, the form and size of the basal lobes, the course of the axal furrows, the position of the basal furrows, the course of the occipital furrow, the absence of a transverse groove across the median lobe of the glabella, the position of the eye and eye-lobes, the shape of the pygidium and the furrows on its lateral lobes, the shape of its axis, etc., etc. In fact, *L. verrucosus* is so utterly different from *L. scutalis* that it is surprising that they were ever considered identical or even closely allied. It is needless to enter into a minute comparison of the two species, as their specific separation is obvious.

Schmidt (loc. cit.) remarks that *L. scutalis* is quite distinct from *L. verrucosus* (Eichw.).

The species which shows most points of resemblance is Barrande's *L. ambiguus*[2] from Étage Ee2, which is more or less equivalent to our Wenlock. This species has a glabella with anterior lateral furrows continued down to the neck-furrow, with weak middle and basal furrows, and with axal furrows having the same general course and development as *L. scutalis,* though less curved inwards in the middle. The anterior lateral lobes are closely similar, even to the indentation on the inner side, but they are less oblique; the middle lobes are rather less distinct, and the basal lobes are only separable from them by their more swollen character. There is also a somewhat similar shallow depression across the neck of the median lobe. The smaller convexity of the head-shield and the greater parallelism of the sides of the glabella are points of difference. The occipital segment is also narrower, and the occipital furrow has a different course. The thorax of *L. ambiguus* is unknown. It is in the pygidium that we find the most striking points of resemblance: the shape of the axis and its continuation to the posterior margin, the presence of only two pairs of pleuræ on the lateral lobes with their furrows, the projection of the extremities of the second pair beyond the margin, the smooth unfurrowed posterior portion of the lateral lobes, the flattened margin, the

[1] Eichwald: Beitr. z. Kenntn. Russl., Bd. viii (1843), p. 63, t. iii, fig. 23. Schmidt: Rev. Ostbalt. Silur. Trilob., Abth. ii (1885), p. 62, t. ii, figs. 1–11.

[2] Barrande: Syst. Silur. Bohem., vol. i (1851), p. 606, pl. xxviii, figs. 16–21.

posterior fork. The pygidium differs in being relatively narrower, in possessing a shorter axis with more rings, in the extremities of the first pleuræ projecting beyond the margin, and in the posterior margin being less deeply excavated.

PROETUS FLETCHERI, Salter. (Pl. I, Figs. 5 and 6.)

1873. *Proetus Fletcheri,* Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 134 (*a* 825, *a* 828).
1877. *Proetus Fletcheri,* Salter: Woodward, Cat. Brit. Foss. Crust., p. 56.
1891. *Proetus Fletcheri,* Salter: Woods, Cat. Type Foss. Woodw. Mus., p. 151.

This species, which is recorded by Salter (loc. cit.) from the Wenlock Limestone of Dudley, is mentioned by him after *Pr. latifrons* (McCoy) as "a broader species in all parts, more like *Pr. Ryckholti* (Barr.) than *Pr. latifrons* (McCoy)."

There are three specimens of *Pr. Fletcheri* in the Woodwardian Museum, which were labelled by Salter *a* 825 (2) and *a* 828, and are thus entered in his "Catalogue." But mounted on the same tablet are seven other unlabelled specimens of *Proetus,* of which only one belongs to this species, all the others showing points of difference. There are four other specimens of the true *Pr. Fletcheri* in the Woodwardian Museum, three of which are from the Fletcher Collection and the other from the Leckenby.

The specimens from which the following description is drawn up are those three labelled by Salter *a* 825 (2) and *a* 828.

DIAGNOSIS.—General shape longitudinally oval, more than twice as long as broad.

Head-shield broadly parabolic, about twice as wide as long, gently concave posteriorly, moderately convex from side to side, bent down in front. Genal angles produced into spines.

Glabella very broadly oval, as broad as long, more than one-third the width of the head-shield at base, narrowing slightly towards the obtusely rounded anterior end, which reaches the anterior border of the head-shield; gently convex from side to side, bent down steeply in front of eyes.[1] Surface marked by two pairs of furrows, but anterior pair generally obsolete. Basal pair of furrows short, weak, shallow; curve slightly backwards; situated at level of middle of eye and at more than one-third the length of glabella from neck-furrow. Anterior pair of furrows when present very weak, directed obliquely backwards from level of anterior end of eye.

In Salter's specimen *a* 825 (here figured Pl. I, Fig. 5) there is an additional pair of small pit-like impressions on the glabella, situated behind the basal furrows and close to the occipital furrow, and about half-way between the axal furrows and the median line of the glabella. I have not noticed them preserved in the other specimens, but they may be compared with somewhat similarly placed basal pits on the glabella of some specimens of *Pr. bohemicus* (Corda).[2]

[1] Owing to this strong downward bend of the front end of the glabella, the shape seems to be subcircular in Fig. 5.

[2] Barrande: Syst. Silur. Bohem., vol. i (1852), p. 452, pl. xvi, figs. 6, 7.

Axal furrows weak in front of the eye, and passing into the marginal furrow at the front end of the glabella. Between the eye-lobe and glabella, and posterior to the eye, they are deep and strong.

Occipital furrow stronger than axal furrows, and arched forward in the middle and at each side in front of the lateral occipital nodule.

Occipital ring rounded, considerably wider than a thoracic axial ring, and furnished with a small median tubercle and a pair of lateral nodules, which are sharply circumscribed, of oval shape, swollen, prominent, and occupying nearly the whole width of the occipital ring at the base of the axal furrows.

In front of the glabella is a raised and rounded border, well defined by a strong marginal furrow.

Fixed cheeks with narrow anterior wing and large, semicircular, horizontally-flattened eye-lobe, strongly elevated to nearly the height of glabella. Eye-lobes reach from anterior lateral furrows of glabella to behind basal pair, but do not project enough laterally to cover whole upper surface of convex eye. Posterior wing of fixed cheek small and triangular, owing to course of facial suture. Occipital segment of cheek rounded, raised, and narrower than occipital ring behind glabella.

Facial sutures cut anterior border of head-shield at a distance apart equal to basal width of glabella. From these points of section they curve backwards and slightly inwards to front of eye, then bend out and circumscribe eye-lobe, and behind it curve sharply outwards to cut neck-ring obliquely at an angle of 20°–30°, reaching the posterior margin close to the base of the genal spine.

Free cheeks triangular, furnished with broad, rounded, and striated border, continued backwards at the genal angle into the genal spine, which is broad at the base, tapers rather rapidly to its pointed extremity, and is less than half the length of the head-shield. It is ornamented with longitudinal striations. The marginal and occipital furrows meet each other at the genal angle at an angle of nearly 60°. The inner portion of the free cheeks is strongly elevated and convex, with steep anterior but gentler lateral and posterior slopes. On the summit it bears the large prominent eye which extends for nearly two-thirds the length of the glabella. A shallow groove encircles base of eye, and runs round it from the level of the occipital furrow to the anterior lateral furrow of the glabella.

Thorax about equal in length to head-shield, consisting of ten segments, with a broad, gradually tapering, cylindrical axis, nearly half as wide again as the pleural portions. Rings of axis simple, regular, and devoid of ornamentation. Axal furrows distinct, but not deeply impressed.

Pleuræ semicylindrical; each consisting of an inner, straight, horizontally-extended portion and an outer, longer, extra-fulcral portion, which is bent gently downwards and backwards at an angle of 45°. Inner portion crossed by diagonal furrow, making an angle of about 20° with the straight anterior edge. This furrow divides the inner portion into two unequal parts, of which the posterior is much the larger. On the extra-fulcral portion the furrow is obsolete, and the anterior part of the pleura is flattened into an articulating surface which passes underneath the preceding pleura. Fulcrum well-marked and angular, at the junction of the inner and outer portions of the pleura. Extremities of pleuræ truncated and rounded.

Pygidium semicircular, about two-thirds the length of the thorax; with simple entire margin, and distinct raised border. The anterior edge of pygidium resembles that of a pleural ring, the inner part being short and straight and the outer part oblique with an articulating surface. Lateral and posterior margins incurved and concentrically striated below.

Axis conical, strongly elevated above the flattened lateral lobes, and tapering more rapidly than axis of thorax to an obtusely pointed extremity, reaching the marginal furrow inside the raised border. Seven to eight rings recognizable on axis, of which only the three first are clearly separated by strong intersegmental furrows, the posterior ones being more or less indistinct. Lateral lobes gently bent down on each side, and marked with three or four pleuræ with inner horizontal portion generally distinguishable, but devoid of fulcrum. A weak longitudinal furrow runs down the centre of each pleura.

Border of pygidium distinct and raised slightly above level of lateral lobes, narrower at anterior lateral angles and behind axis than in middle of sides. It is marked off by a shallow marginal groove, and in one specimen (*a* 825 of Salter's Catalogue) the pleuræ and their furrows are faintly traceable across it, but in some individuals it is very indistinct.

Ornamentation.—The whole surface of the head and pygidium is finely granulated.

MEASUREMENTS.—Salter's specimen *a* 825 :—

	mm.
Length of whole trilobite	22·0
Length of head-shield	8·0
Length of thorax	8·0
Length of pygidium	6·0
Width of head-shield at base	15·5
Width of pygidium	10·5
Width of glabella at base	6·0

REMARKS.—This species resembles *Pr. bohemicus*, Corda,[1] in the following particulars: (1) shape, relative size, and proportions of glabella; (2) presence of lateral nodules and median tubercle on occipital ring; (3) relative proportions of thoracic axis and pleuræ; (4) characters of pleuræ; (5) shape of pygidium, pygidial axis, and border; (6) granulated test.

Pr. bohemicus differs, however, in having a semicircular rather than parabolic head-shield, in possessing very short genal spines, smaller eyes and eye-lobes, and a relatively narrower border to the head-shield; in the presence of three pairs of lateral furrows on the glabella; in the greater length of the thorax; and in the smaller size

[1] Corda: Prodr. Böhm. Trilob. (1847), p. 73, pl. iv, fig. 43. Barrande: Syst. Silur. Bohem., vol. i (1852), p. 452, pl. xvi, figs. 1–15.

of the pygidial pleuræ. On the other hand, *Pr. Ryckholti* (Barr.),[1] to which Salter saw a resemblance, agrees in the shape of its head-shield, in the faintness of the lateral furrows of the glabella, in the size of the genal spines; in the median tubercle on the occipital ring; in the relative size of the eyes; and in the general aspect of the pygidium. But it differs in the shape and proportions of the glabella and of the thorax; in the absence of lateral occipital nodules; in the shape of the pleuræ; in the more rapidly tapering axis of the pygidium; and in the smooth test. *Pr. Fletcheri* shows, therefore, a much closer resemblance to *Pr. bohemicus* than to *Pr. Ryckholti.*

EXPLANATION OF PLATE I.

FIG. 1.—*Lichas scutalis.* Salter's original specimen, *a* 954; Wenlock Limestone, Malvern. × 1½.

FIG. 2.—*Lichas scutalis.* Fletcher Collection specimen; Wenlock Limestone, Malvern. × 1½.

FIG. 3.—*Lichas scutalis.* Hypostome of Fletcher Collection specimen. × 2.

FIG. 4.—*Lichas scutalis.* Outline restoration. × 2½.

FIG. 5.—*Proetus Fletcheri.* Salter's specimen, *a* 825; Wenlock Limestone, Dudley. × 2.

FIG. 6.—*Proetus Fletcheri.* Side view of same specimen.

NOTE.—The two figured specimens of *Lichas scutalis* are bent up at the head and tail, causing some foreshortening of these parts in the figures, and the ends of the pleuræ to be widely separated.

IV.—NOTE ON THE PREPARATION OF SPHERULITES.

By HENRY BASSETT, Jun.

LAST February, while working in the Chemical Laboratory of University College, London, I had occasion to make some sulphanilic acid. This was done in the usual way by heating a mixture of 100 grammes of concentrated sulphuric acid and 30 grammes of aniline to 180°–190° C. in an oil bath for four hours. The flask containing the mixture was left in the oil bath to cool, and on examining it the next day I was surprised to find that the solid mass inside had developed a beautiful spherulitic structure. As I believe this has never been observed before, it may be worth a description.

In colour the material is a bluish (or sometimes greenish) grey, and it is practically a mass of spherulites, some of which are an inch in diameter. They are mostly well developed, and are slightly lighter in tint than any intervening portions of the mass in which a spherulitic structure is only faintly visible. They consist of concentric layers, alternately nearly white and pale blue in colour, with rather ragged edges, as may be seen in the figure. Adjacent spherulites, or sometimes even what are apparently simple ones, often exhibit sharp divisional planes like joints, from the one having grown up against another as they were developing from independent centres. Though these centres cannot in all cases be seen, there is sufficient evidence in others to justify applying this explanation to all. The mass, judging from the position of the spherulites, seems to have started crystallizing from a number of independent points, both on the surface of the glass and on the surface of the molten mixture.

[1] Barrande: Syst. Silur. Bohem., vol. i (1852), p. 439, pl. xv, figs. 15–19.

As pure sulphanilic acid is colourless the bluish-grey colour must be due to the production in the course of the reaction of a small quantity of impurity, which is of the nature of an aniline dye.

When we come to study the spherulites more closely we find that, not only do they exhibit an alternation of colour in concentric shells, but also that near the upper surface of the mass, as incomplete spherulites developed downwards these were prolonged as a kind of film on the surface of the glass above the solid mass, this film no doubt being originally caused by the adherence to the glass of a small quantity of liquid when the vessel was shaken. An examination of this thin section (as it were) of a spherulite shows that the pale bands in the solid mass are continued on the surface of the glass as bands of closely packed crystals, while the dark bands coincide with the bands on the glass where there are very

Photograph of the bottom of a flask containing the spherulitic structure.

few crystals. It is thus quite obvious that the alternate dark and light rings of the spherulites have been caused by a zoning out of the sulphanilic acid, the interstices having been filled up by the blue, very viscous magma (for only about 40 per cent. of the mass is sulphanilic acid, the rest being chiefly sulphuric acid). On this supposition the rings would be formed as follows:—A ring of radiating crystals would first be formed round some nucleus, but as the surrounding magma would thus be deprived of most of the sulphanilic acid it contained in solution, this ring would be succeeded by a ring where there were very few crystals, then another ring with a great many crystals would follow, and so on. The formation of these spherulites would thus be very analogous to the formation of 'Napoleonite' and spheroidal granites, to take extreme cases, while even spherulites in glassy igneous rocks often show similar colour-banding. This zoning out of the sulphanilic acid accounts for the ragged edges of the rings, while the existence of a hollow at the top of the mass where the spherical surface of the spherulites can be seen also points to the liquid magma having thus been soaked up.

I have since several times repeated the experiment, and find that the spherulitic structure is developed every time, provided that the liquid is allowed to cool slowly, although even when cooled quickly one or two may be formed. The size of the spherulites obtained varies greatly; on one occasion I prepared one which was two inches in diameter, but, as is so often the case in nature, the moderate-sized ones are generally the prettiest. Sometimes, after having left the flask to cool, I found next day that the material had not all solidified, but that there was a floating crust with spherulites growing downwards and also a solid layer at the bottom with spherulites growing upwards, thus confirming the opinion as to independent development from the two surfaces which I had formed from the examination of the first batch obtained. I should add, however, that the spherulitic structure is not always developed on the free surface of the mass, nor have I been able to prepare again the spherulitic films (if I may so call them) on the sides of the flask. The time taken for the mass to crystallize completely varies from one to three days, depending, I imagine, on the amount of impurity present. When the crystallization takes place very slowly it is very beautiful to watch the small spherulites gradually growing in a dark, almost black, magma, until finally it is completely transformed into spherulites. In this intermediate state the specimen looks very much like spherulitic obsidian.

When the spherulites are formed very slowly the zones, which are so noticeable in specimens which have formed more quickly, are not nearly so frequent or well-marked. This perhaps is due to the fact that, as the crystallization is so slow, diffusion is able to prevent the magma round the centres of crystallization becoming exhausted.

I may add that the sulphuric acid present renders the mass very deliquescent, so that in order to preserve it the flask containing it should be sealed off in the blowpipe flame.

After about two months' keeping the mass begins to recrystallize, and, in course of time, the original structure is entirely obliterated and replaced by an immense number of small spherulites about 1 mm. in diameter. This molecular change is curious, but the fact that not even the external form of the original spherulites is preserved, is probably due to the presence of fluid, which, when recrystallization took place, was able to escape and collect at the bottom of the flask.

My thanks are due to Mr. Coomára-Swámy for having very kindly photographed the structure for me. This figure, however, does not represent the best specimen, for the shape of the vessel in which that had been formed was unfortunately unsuitable for photographing.

V.—The Sources and Distribution of the Far-Travelled Boulders of East Yorkshire.

By J. W. Stather, F.G.S.

About ten years ago, when studying the drifts of East Yorkshire, Mr. G. W. Lamplugh counted and roughly classified the larger boulders of Flamborough Head and other selected localities on the coast. This work has been continued by members of the Hull Geological Society, who have up to the present time recorded nearly four thousand boulders, of twelve inches and upwards in diameter. To avoid possible error, arising from the moving beach and other causes, only the boulders actually in place in the clay were noted, or such as had obviously recently fallen from the cliffs. The whole of the coastline from Spurn to Flamborough has been surveyed in this way, and also portions of the coast north of Flamborough as far as Saltburn. The lists thus prepared have been published from time to time by the Hull Geological Society and by the Erratic Blocks Committee of the British Association.

These lists bring to light several interesting and previously unnoticed facts with regard to the distribution of the far-travelled boulders, especially when the lists obtained at Dimlington and Redcliff in South Yorkshire are compared with the lists from Upgang and Saltburn in the north. Before, however, discussing the statistics of the boulders, it will be advisable to give a brief description of the localities where the lists were compiled.

(i) Dimlington is situated on the sea-coast near the southern extremity of Holderness. The cliffs average about eighty feet in height for upwards of two miles, and are entirely composed of glacial material, chiefly boulder-clay. Here were noted 334 boulders of twelve inches and upwards in diameter.[1]

(ii) Redcliff is on the north shore of the Humber, near North Ferriby, and is twenty-four miles west-north-west of Dimlington. The cliff continues along the Humber side for two-thirds of a mile with an average height of eighteen feet, and together with the adjacent beach is composed of boulder-clay. The boulders recorded here were 373 in number.[2]

(iii) Upgang is one and a half miles north of Whitby; the cliff sections are one hundred feet or more in height, and consist largely of boulder-clay. In this neighbourhood Mr. Lamplugh counted and classified two hundred boulders of twelve inches and upwards in diameter, the majority of which were of local origin; the percentages given in the table below are based on his list.[3]

(iv) The cliffs between Saltburn and Redcar present the most northern exposure of boulder-clay on the Yorkshire coast. These sections yielded 133 boulders of twelve inches and upwards in diameter.[4]

1 Trans. Hull Geol. Soc., vol. iii, p. 6.
2 Proc. Yorkshire Geol. and Polytech. Soc., vol. xiii, pt. 2, p. 211.
3 Ibid., vol. xi, pt. 3, p. 403.
4 Trans. Hull Geol. Soc., vol. iii, p. 7.

After eliminating all the *local* boulders from the lists, at the above-mentioned localities, the relative proportion between the several groups of *far-travelled* boulders is as follows :—

Groups.	I. Dimlington.	II. Redcliff.	III. Upgang.	IV. Saltburn.
	per cent.	per cent.	per cent.	per cent.
1. Carboniferous limestones and sandstones	55	59	70	73
2. Basalt (Whin Sill)	32	30	24	20
3. Magnesian limestone ...	0	0	5	7
4. Granite, gneiss, etc.... ...	13	11	1	0 [1]
	100	100	100	100

It will be seen from the above table that among the far-travelled boulders of the East Yorkshire drift deposits, Carboniferous rocks (group 1) take numerically the leading position ; and the Carboniferous area west and north of the Tees is generally regarded as their place of origin. Group 2 consists of boulders of black basalt, very plentiful in East Yorkshire and very easy to distinguish. The source of these basalts is undoubtedly the Whin Sill. It is clear, then, that groups 1 and 2 have travelled into our district from practically the same area; nevertheless, it will be seen, on referring to the above table, that the relative proportions of the boulders from the two groups vary considerably from point to point. Thus, while both groups probably decrease *numerically* southwards, the percentages show that the basaltic group increases *relatively* from Saltburn southwards. The obvious explanation seems to be that large boulders of basalt bear transport better than similar masses from the Carboniferous sedimentary rocks.

The Magnesian limestone (group 3) occurring in the East Yorkshire boulder-clays is matched by the rock found *in sitû* at Roker, near Sunderland. This limestone is rarely found except as pebbles in South Holderness, but these grow perceptibly in numbers and size northwards. Large boulders begin to appear north of Scarborough, and at Whitby and Saltburn they form from 5 to 7 per cent. of the foreign boulders present in the clays.

Besides the above-mentioned rocks, the East Yorkshire drifts, especially in the southern parts of Holderness, are rich in boulders of igneous rocks of widely diverse types, and these are included in group 4. Phillips long ago pointed out that in the drifts of the Yorkshire coast there were rocks from the English Lake District; and it is now certain also that the Cheviots and Scandinavia are well represented; but the source of by far the greater number of the rocks included in this group is not yet known. The table shows that the boulders of group 4 diminish both numerically and

[1] This group was not represented by any boulders of the requisite size in the cliff sections when this table was compiled, but several large boulders of Shap granite were seen in the gardens and about the town, which had probably been derived from the neighbouring drifts.

proportionately northwards, the figures being 13 per cent. at Dimlington and 1 per cent. at Whitby. This northward decrease of the group as a whole is all the more noteworthy when we remember that the Shap granites and the Cheviot porphyrites, both included in group 4, increase rapidly in the same direction. This seeming anomaly arises, I think, from the influence of the boulders from Scandinavia. Among the boulders of South Holderness occur very commonly rocks which agree with certain well-known types of Scandinavia; of these the best known are the augite-syenite (laurvikite) and the rhomb-porphyry. These types, although not by any means unknown in the drifts of North Yorkshire, are much rarer there than in the south. For instance, at Dimlington one hundred specimens of the Scandinavian rocks above named would be found to one of Shap granite, while, on the other hand, at Robin Hood's Bay or Runswick Bay (both near Whitby) the Shaps outnumber the Norsemen by at least twenty to one. Seeing, then, that the known Scandinavian rocks in group 4 are much more common in the south of the county than in the north, and that the distribution of the unidentified rock types included in the same group agrees in this respect with the Scandinavian rocks, I think it may be fairly inferred, that these unidentified rocks are probably largely from Scandinavia also.

Mr. Harker arrived at a similar conclusion when examining Mr. Lamplugh's Flamborough specimens.[1] He regarded the bulk of the granitic and gneissic specimens as having been derived either from Scandinavia or from the Scottish Highlands, and remarks: "Among these are some undoubted Norwegian rocks, while none can be pointed out as certainly brought from Scotland. It may be, then, that the whole of the doubtful rocks are also of Norwegian origin."

It is worthy of note with regard to the smaller boulders and pebbles of the boulder-clay and gravels of East Yorkshire that among these the percentage of the far-travelled rocks is much higher than among the larger boulders. There are certain types also among the smaller specimens which seldom appear as large boulders. Among these is a fairly definite group of rocks, which are known among East Yorkshire collectors as *porphyrites*, and are referred with some confidence to the Cheviot Hills. The evidence in support of this conclusion may be briefly stated as follows:—(1) The erratics seem to match the descriptions of the Cheviot rocks published by Mr. J. J. H. Teall and others. (2) Pebbles of these rocks increase, both in numbers and in size, as we approach the Cheviot district. (3) During a recent excursion (July, 1900) to the Cheviot Hills, arranged by the Yorkshire Geological and Polytechnic Society, many rocks similar to these East Yorkshire erratics were seen in place.

There is still another note to be made with regard to the Cheviot boulders, and that refers to their vertical distribution. I think it will be found, that the Cheviot rocks are more plentiful in the

[1] Proc. Yorkshire Geol. and Polytech. Soc., vol. xi, pt. 3, p. 409.

upper clays along our coast than in the lower beds. But however this may be, it is quite certain that the somewhat scanty drift that reaches farthest up the valleys on our coast, and climbs the eastern flank of the Yorkshire wolds, and the Oolitic moorlands, is, as far as the foreign boulders are concerned, composed almost entirely of rocks from the Cheviot area. The Scarborough district supplies a good example of this rule. The comparatively low ground adjacent to the sea is covered with thick drift full of boulders of the usual types. On the other hand, Seamer Moor, which is a mile and a half west of the town and six hundred feet in height, is capped by drift, the foreign pebbles of which are largely porphyrites. It must not be understood from this, however, that other types are entirely absent at high levels. Occasional specimens from probably all the groups are found wherever the drifts extend. But the rule is, that at high levels and along the western margin of the drift generally, the porphyrites prevail. And if we follow that very ill-defined line which separates the drift areas from the driftless, it will be generally found that the outermost fringe of straggling pebbles on the fields is largely composed of porphyrites.

All the facts respecting the distribution of the boulders of East Yorkshire, as far as I have seen, appear to agree with the supposition put forward by Mr. Lamplugh in his paper on the drifts of Flamborough Head,[1] viz., that the North Sea ice-sheet attained its maximum development and reached farthest inland before the ice flowing from the north-west had reached this part of the coast, and that the North Sea ice dwindled away as the flow from the Pennine Chain and the Cheviots gained strength.

VI.—On the Formation of Reef Knolls.[2]

By R. H. Tiddeman, M.A., F.G.S.

(Communicated by permission of the Director-General of the Geological Survey.)

At the meeting of the British Association at Newcastle in 1889 I brought out my interpretation of the probable origin of the limestone knolls of Yorkshire.[3]

It was shown that the Lower Carboniferous Rocks in the North of England had two distinct types—that the Yoredale or Northern type extended from the Craven Faults to the Tyne, and that the Southern or Bowland type occupied the country from the Craven Faults to near the Western Seaside plain and extended south as far as Derbyshire. Without now recalling the two tables of the succession there given, I mentioned specially the curious construction of certain mounds of limestone which I called reef-knolls, gave my reasons for supposing that they had been gradually built up on a slowly sinking sea bottom by the gradual accretion of animal remains somewhat in a similar manner to coral reefs. I also showed that from the enormously disproportionate thickness of rocks in the

[1] Q.J.G.S., vol. xlvii, p. 428.
[2] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.
[3] Report Brit. Assoc., 1889.

area of the downthrow side and from other considerations there was every reason to suppose that the Craven Faults were actually taking place during the formation of those rocks.

My friend Mr. J. E. Marr, F.R.S., has in a most courteous way, whilst taking my geological mapping as for the most part correct, found reasons for dissenting from all the groundwork on which it was founded.[1] In combating Mr. Marr's views I offer no opinion on knolls of other localities or other ages which he brings forward in support of his views. I speak only of the Carboniferous knolls of which I have written, and with which I am well acquainted. Speaking generally, I think the differences between us may be thus summarized:—

1. Mr. Marr disagrees with my reading of the succession and thickness of the rocks on the south side of the Craven Faults, and, whilst I consider that we have two distinct successions of different thickness caused by a difference in the rate of submergence in the two districts, and by shallower and deeper seas, he regards the rocks on both sides as having been one series of like thickness in orderly sequence to the north, but, so to speak, shuffled by earth-movements on the south of those faults and repeated several times by overthrusts.

1*a*. In illustration let us take a pack of cards, say arranged in suits as representing the regular country on the north side, and several packs similarly arranged to represent the greater thickness on the south side. Shuffle these last to represent the supposed disturbance and overthrusting. Shall we always find after shuffling the same general succession? Yet over a tract reaching from Draughton to Chipping and from Settle to Derbyshire, we do get such a general succession, and that does not at all resemble the succession on the north side of the faults. The overthrusting to do this effectually must cover the whole of this wide area comprised in three or four counties, and not confine its operations to a narrow disturbed belt near the Craven Faults. Is Mr. Marr prepared to make his orogenic movements extend over so large an area, and thereby arrange the whole country, which they break up, into so orderly a disposition?

2. Mr. Marr regards the great difference between the black and white limestone, the form and constitution of the reef-knolls, the abundance in them of perfect fossil forms in a well-preserved state, the conglomerates and breccias which accompany them, as all being the result of what he calls orogenic movements; in other words, of the folding repetition and overthrusting of the rocks, with here and there *relief of pressure*. More especially is the last called in as being the reason for the abundant and well-preserved fossils and the change of the limestones.

It is extremely difficult for me to accept these views. If we could believe that a black, well and thinly bedded limestone can by any physical change be converted into a white crystalline mass with

[1] Quart. Journ. Geol. Soc., vol. lv, pp. 327–361.

little visible bedding, but with abundant fossils in a perfect state, we have still to learn what has become of the shales which are almost always present with the black limestone. If squeezed out, as might be suggested, they would at least leave partings behind, and the rock would be more bedded than it is.

Mr. Marr contemplates the likelihood of several different limestones being shifted together to make one reef-knoll, but if so, are we not as likely to get the thin sandstones of the Pendleside Grit sandwiched into them as well? Yet sandstones and shale-beds are unknown in the reef-knolls.

Mr. Marr makes a number of statements about what he calls the Vs of the Middle Craven Fault. His opinion is that this is a great thrust-plane dipping gently north, and that the Coal-measures are forced beneath the limestone, and so on along its course. A bed of coal in the limestone at Ingleton is regarded by him as having been forced up from underlying Coal-measures by pressure, and not as originally interbedded. Unfortunately for these views, there are no proper Vs or dipping planes of faulting indicated in the map. The sinuous track of the Craven Fault is not so drawn to accommodate any theory, but is merely put where the exposures of rock show it to run. Its wanderings are either dictated by or stand in relation to the two principal lines of jointing in the limestone, which range W.N.W. and N.N.W. Sometimes one direction, sometimes the other, has the mastery. At Clapham the line is absolutely straight, and does not curve up-stream as suggested by Mr. Marr. The coal-seam mentioned is well known to me. On searching it I found several *Producti*, fairly perfect, embedded in it and filled with it, and the conclusion I came to was that it was either a coal-seam which had grown on a reef and been submerged, or a deposit of seaweed. These *Producti* seem to disagree with the injection theory. Such coal-seams are found occasionally in the limestone. One near Kirkby Lonsdale has been worked for coal.

Mr. Marr has mentioned two places where knolls of grit occur. I do not admit that a knoll of grit can have anything in common with the reef-knolls of Craven unless it be the external form; but if such structures were made by earth thrusts and abounded, it would no doubt be a strong point in favour of his views. One of these grit knolls is said to be in the canal at the back of Shipton Castle. I think this must be an error. I know of no sandstone in that locality, though I know it well. I have consulted others who are, as geologists, conversant with Shipton, competent to form an opinion, and they agree with me that nothing but limestone and shales occur in that canal at that point. The beds there are certainly contorted, but they are not sandstone, and contortions do not necessarily imply reef-knolls.

I feel unable to regard Mr. Marr's 'model knoll' as in any respect resembling what I have called reef-knolls. That is, according to his views, a broken plication of a thin hard bed of limestone in a mass of softer shale, the shale surrounding its broken fragments. The knolls to which I allude are almost solid limestone from top to base.

They have no alternations of hard and soft beds, and, so far as I have seen, no repetition of beds by folding. The evidences of movement on their flanks, if any, are not more than one would expect from the vertical pressure of a more or less plastic shale upon what is at least a less plastic limestone.

I admit fully that there are abundant evidences in the district of faulting, of great pressure, and quite likely of overthrusts; but to say that these have given to these rocks a change of character, or are responsible for the order of their succession, appears to me to be invoking an unnecessarily powerful but yet inadequate force. Such thrust-planes as are implied would meet the geologist in the field at every turn, and force themselves into recognition. They would admit of easy mapping, and no statement of their existence would be complete without some such systematic recognition.

NOTICES OF MEMOIRS.

I.—On some Recent Geological Discoveries in the Nile Valley and Libyan Desert.[1] By Hugh J. L. Beadnell, F.G.S., F.R.G.S.

IN this paper the author draws attention to some interesting discoveries made by him during the last three or four years while attached to the Geological Survey of Egypt. When the latter Survey was established in 1896 the publications and maps, both geological and geographical, of the Rohlfs Expedition of 1873–74 still remained the only source of information on the greater part of Egypt.

In his geological reports Zittel, the geologist of the Rohlfs Expedition, calls special attention to the absence of any unconformity between the Cretaceous and Eocene deposits, in fact mentioning this as one of the most important results obtained. More extended researches have, however, enabled the author "to bring forward incontestable evidence from at least two areas in the Libyan Desert, namely, Abu-Roash, near Cairo, and Baharia Oasis, that instead of this perfectly gradual petrographical and palæontological passage, undisturbed by any unconformity, from the uppermost marine Chalk into the oldest Tertiary beds, there is as a matter of fact a strongly marked unconformity, representing a long lapse of time in the process of sedimentation. During this period the Cretaceous was elevated into land, often with intense folding and faulting, and underwent considerable denudation before subsidence led to the entire or partial submergence of the area below the sea, and allowed the deposition of successive beds of Eocene in a markedly overlapping manner."

The accompanying table is compiled chiefly from the work of Professor Zittel and the Geological Survey of Egypt.

[1] Abstract of a paper read (with the permission of Captain H. G. Lyons, R.E., F.G.S., the Director-General of the Egyptian Geological Survey) before the International Geological Congress at Paris, 1900.

TABLE OF THE EOCENE AND CRETACEOUS SERIES IN THE LIBYAN DESERT AND NILE VALLEY.

EOCENE.	Bartonian.	UPPER EOCENE of Siwa Oasis, with *Nummulites Fichteli*, *N. intermedia*, *N. Rutimeyeri*, and *Orbitoides papyracea*.
	Parisian.	UPPER MOKATTAM. LOWER MOKATTAM, with *Nummulites Gizehensis* limestones.
	Londinian. Suessonian. Flandrian.	UPPER LIBYAN. *Callianassa* beds, *Alveolina* limestones, etc. LOWER LIBYAN. Limestones with *Operculina libyca*, *Lucina Thebaica*, *Nautilus Forbesii*, etc.; Esna Shales (of Qena, Farafra, Kharga, etc.).

		ABU-ROASH.	BAHARIA OASIS.	DAKHLA OASIS.	NILE VALLEY.
CRETACEOUS.	Danian.	White Chalk with corals, *Ostrea*, *Spondylus*, *Rudistes*, etc.	White Chalk with corals, *Gryphæa vesicularis*, *Exogyra Overwegi*, *Pecten Farafrensis*, *Corax pristodontus*, etc.	White Chalk with corals. *Ventriculites*, *Ananchytes ovata*, *Gryphæa vesicularis*, *Pecten Farafrensis*, etc. Greenish and ash-grey leafy clays.	White chalky limestones.
	Senonian. Campanian. Santonian.	Part of White Chalk? Marls and limestones with *Tissotia Tissoti*, *Ostrea Costei*, *O. dichotoma*, etc.; *Echinobrissus Waltheri*. Marls with *Plicatula Ferryi*. Flinty limestones.	Probably some of the intermediate beds are Senonian or Turonian.	Bone-beds. Nubian clays and sandstones.	Beds with *Trigonoarca multidentata*, *Ptychoceras*. Bone-beds. Nubian clays and sandstones.
	Turonian.	Limestones with *Nerinæa Requieniana*, *Acteonella* (*Trochacteon*) *Salamonis*, *Biradiolites cornu-pastoris*, *Millestroma Nicholsoni*.			
	Cenomanian.	Limestones with *Cyphosoma Abbatei*, *Hemiaster roachensis*, *Sphærulites*, *Radiolites*, etc. Clays and sandstones.	Limestones and variegated sandstones with *Hemiaster roachensis*, *Heterodiadema libycum*, *Neobolites Vibrayeanus*. Sandstones and clays with *N. Vybrayeanus*, *Exogyra flabellata*, *E. Mermeti*, and *E. olisoponensis*.		

The author then discusses separately several typical localities, which may be briefly alluded to.

Abu-Roash.—This peculiarly interesting Cretaceous complex, near Cairo, has been described by Walther and Schweinfurth as having been brought into position among the Eocene deposits by faults along its four sides. This view, however, is strongly opposed by the author, who maintains that the fault theory is absolutely untenable, "as a most casual examination of the boundary of the Cretaceous, at almost any point where its junction with the Eocene was visible, instead of suggesting the existence of faults, yielded indubitable evidence of their absence, and the presence instead of a well-marked unconformity." At some points "the upper surface of the white chalk of the Cretaceous shows a most irregularly eroded surface, which is covered by a bed of rolled pebbles, sometimes a metre thick, the latter being overlaid by a thick bed of Eocene shelly limestone, followed by a series full of characteristic Upper Mokattam fossils." The author further points out the existence in this area of Danian beds, the uppermost member (White Chalk) being apparently homotaxial with the White Chalk of Baharia and Farafra.

Baharia Oasis. — Of the remarkable sand belt which occurs between the Nile Valley and this oasis, the author says:—"This sand belt has a total breadth of five kilometres, and runs slightly west of north and east of south (parallel, in fact, to the normal direction of the wind). Its origin is much further north, probably in the neighbourhood of the oasis of Moghara, while to the south it runs, as far as known unbroken, into the depression of Kharga, whence, after a slight break, it continues southwards. Its length is thus certainly over 350 kilometres. The dunes are composed of light-yellow, siliceous, well-rounded sand-grains. The steepest sides are those facing west, which have an angle of 30°–31°. It is a remarkable sight, this narrow band of sand dunes extending across the open desert as far as the eye can reach, maintaining an almost exactly straight course, an even breadth, and with sides as well defined as if drawn with the edge of a ruler."

The author's work shows that, contrary to original ideas, there is in reality a remarkable development of Cretaceous rocks in the oasis of Baharia and the surrounding desert on the west and south sides.

The lowest beds, consisting of sandstones, clays, and marls, attain a thickness of 170 metres, and are of Cenomanian age. Above them come limestones and variegated sandstones (45 metres), followed by white chalk of Danian age, 40 metres thick. (See Table.)

As at Abu-Roash, the junction between the Cretaceous and Eocene is unconformable, the deposits of the latter overlapping successively the different beds of the former.

The author, in discussing the age and origin of the peculiar ferruginous quartzites which so constantly cap the numerous isolated hills within the depression, brings forward evidence which tends to show that these "were deposited in a lake which formed here when there existed only a slight depression in the Eocene and Cretaceous rocks, ages in fact before erosion had carved out the depression to its present form. The large amount of ferruginous material and general character of the beds point to freshwater lacustrine deposition and precipitation. Lithologically they are often exactly similar to the Oligocene beds of the Fayum and Jebel Ahmar, and to the deposits on the road between Feshn and the oasis, and it may be that they are of the same age."

The author states that the igneous rocks of Baharia are of Post-Cretaceous, probably Oligocene, age, contemporaneous with the basalt sheets of the Fayum, of Abu-Roash and the desert to the west, and of Abu-Zabel; and that the andesites of the Libyan desert at Bahnessa, Gara Soda, and Jebel Gebail were likewise erupted at the same time.

After describing the important folds which occur in Baharia the author continues:—"The Cretaceous beds as a whole evidently form a large anticline . . . . which has its axis more or less parallel to the syncline already described. It is continued into the north end of Farafra, where the dip is well marked . . . . Yet the Eocene beds forming the plateau are in general quite horizontal, even in close proximity to inclined Cretaceous beds . . . . it seems certain that the Cretaceous beds, after the deposition of the White Chalk of Danian age, underwent upheaval, denudation, and finally depression, before the deposition of the earliest Tertiary beds.

"In this part of Egypt it appears that the subsiding Cretaceous land had the form of a long, flat, irregular ridge of anticlinal structure, extending from Dakhla oasis through Farafra, Baharia, and Abu-Roash. The northern end of this ridge was the last to subside and receive Eocene deposits, which accounts for the fact that in Farafra the Cretaceous is overlaid, always unconformably, by the Esna Shales of the Lower Libyan, in Baharia by limestones of the Upper Libyan, and at Abu-Roash by still younger beds of Lower and Upper Mokattam age."

The author finds other evidence which "suggests the probability that there was another period of possibly even more important earth-movements in Post-Eocene times. In this case, it seems not unlikely that the folding was closely connected with the important series of earth-movements which took place in North-East Africa and South-West Asia in early Pliocene times, and which gave rise to the formation of the chief topographical features of the country, such as the Nile and Jordan valleys and their attendant series of lakes."

The author's theory as to the origin of these wonderful depressions in the Libyan desert is interesting, and may be quoted in full. He writes:—"Baharia is a self-contained depression without drainage outlet, so that the ordinary methods of removal of disintegrated material do not here apply. Next, we have a large, flat, anticlinal ridge of Cretaceous beds, with at least one subsidiary, sharp, parallel, synclinal fold, overlaid by more or less horizontal beds of Eocene limestone. Since the elevation of this part of North Africa into dry land in late Tertiary times, denudation must have gone on continuously over the whole surface of the country.

"The most important denuding agent at the present day in the Libyan desert is wind-borne sand, the erosive action of which is very powerful and at once apparent to every traveller in these regions; but in the past there may have been, and probably were, other eroding agencies as well at work on the surface of this part of North Africa. Imagine, then, the general planing down of the country little by little through a long interval of time, until the anticlinal ridge of Cretaceous beds was reached, with its attendant soft sandstones and clays. As soon as the latter were exposed the action of denudation would have rapidly quickened, chiefly by the breaking up of the constituents of these beds by changes of temperature, rains and frosts, and the removal of the resulting sand and dust by wind. In this way must these wonderful depressions have been formed.

"Generalizing, then, we may say that where there have been extensive deposits of soft beds, and these have become exposed by the action of denudation, there large depressions have been cut out. The existence of soft Cenomanian sandstones and clays is thus the primary cause of the existence of the depression of Baharia, the soft Esna shales have played a similar role in that of Farafra, while, again, Dakhla is cut out in a thick series of soft beds of Danian age. The other oases and depressions probably owe their existence largely to the same cause."

Farafra and Dakhla Oasis.—In Farafra the author's chief additions to our knowledge were rather geographical than geological, although some evidence is brought forward to show that the very fossiliferous clays on the road between Farafra and Dakhla are somewhat younger than the age assigned to them by Zittel.

In Dakhla oasis thick and extensive highly phosphatic bone-beds of considerable commercial value were discovered.

Fayum.—It was in this province that there existed, some 2,000 years before Herodotus, the celebrated Lake Moeris, the exact site of which has led to so much discussion. The author shows that the geological evidence, in the shape of clays with numerous freshwater shells and fish-remains, of the same species as those at present inhabiting the existing lake, proves that the ancient lake occupied the lowest part of the depression, i.e. that now occupied by the Birket el Qurun and a considerable area of the low surrounding country. His position, in fact, closely agrees with that assigned to the lake by Major Brown, who bases his conclusions chiefly on considerations of level.

An extensive series of fluvio-marine beds, with intercalated sheets of basalt near the top, is shown to overlie the Upper Mokattam formation throughout the north part of the Fayum. This series is provisionally regarded as Oligocene. At the top come the silicified, wood-bearing sandstones, which stretch northwards across the desert to beyond the latitude of Cairo.

Within the Fayum depression, high up on the slopes or summits of the surrounding ridges, are found extensive raised beaches, probably of marine Pliocene age, at which time the sea stretched far up the Nile Valley.

Nile Valley.—In conclusion, some highly interesting facts are brought forward with regard to the Nile Valley itself, which the author summarizes as follows:—"The general north and south direction of the Nile Valley in Egypt, the remarkable high, lofty, wall-like cliffs by which it is hemmed in, the absence of any true river deposits at any considerable height above the river, the almost entire absence of hills or outliers of the plateau within the valley, the proved existence of bounding faults throughout a long stretch of the valley, lead us to infer that the formation of this gorge was brought about by faulting, rifting, and folding, and not cut out in the usual way by river action."

Between Cairo and Assuan the Nile Valley floor is covered for the most part with deposits of comparatively recent geological age, which may be divided into (1) Marine, Pliocene; (2) Lacustrine, Pleistocene; and (3) Fluviatile, Recent.

The marine Pliocene deposits, discovered near Esna by Mr. Barron and the author in 1897, consist of a thick series of limestones and interbedded conglomerates. In the limestones numerous foraminifera were found, and have been described by Mr. F. Chapman.

The lacustrine series consist of fresh-water deposits of the most variable nature, including gravels, conglomerates, clays, marls, limestones, and tufas. They have been mapped and examined by the author throughout a large length of the Nile Valley from Qena to Cairo. Calcareous tufas, crowded with the most beautiful impressions of leaves and twigs, abound in places. At Isawia the limestones of the series are of considerable commercial importance, supplying the material for the construction of the great dam at Assiut. Finally, the fluviatile deposits include the Nile mud and other recent accumulations.

In conclusion, the author shows the probable date of the formation of the Nile Valley gorge to be Lower Pliocene, and refers it to the same great series of earth-movements which determined and formed the main physical feature of North-East Africa and part of Asia. After the deposition of the Pliocene beds a gradual elevation led to the final retreat of the sea, the valley then becoming the site of a series of fresh-water lakes in which were deposited large quantities of calcareous tufa, which enclosed the numerous leaves carried into the lakes from the surrounding forests.

Finally, "in later Pleistocene times drainage must have become well established down the Nile Valley, and a river, the youthful Father Nile, commenced its career by carving out a channel through the valley deposits, before, owing to changed conditions, it finally took to depositing layer upon layer of 'Nile mud,' thus forming the strip of cultivable and inhabitable country without which the Land of Egypt, as we know it, would be non-existent."

II.—British Association for the Advancement of Science. Bradford, 1900. Joint Discussion, Sections C and K. On the Conditions under which the Plants of the Coal Period grew.

1. Flora of the Coal-measures. By R. Kidston, F.R.S.E., F.G.S.

LEAVING out of consideration a few genera of which we possess little or no definite knowledge, the flora of the Coal-measures consists of Ferns, Calamites, Lycopods, Sphenophylleæ, Cordaites, and Coniferæ.

In genera and species the Ferns are probably more numerous than the whole of the other groups, and contain representatives of the Eusporangiate and Leptosporangiate members of the class. The Eusporangiate, or those ferns whose sporangia are unprovided with an annulus, were more numerous in the Carboniferous period than at present, though in the Coal-measures they do not appear to have been more numerous than the genera with annulate sporangia. Tree ferns, though not very common, are more frequent in the Upper than in the Lower Coal-measures, in the lowest beds of which they seem to be very rare.

The Calamites are largely represented throughout the whole of the Coal-measures, *Asterophyllites* (*Calamocladus*) and *Annularia* probably being their foliage.

Lycopods are also very numerous, and are represented by many important genera — *Lycopodites*, *Lepidodendron*, *Lepidophloios*, *Bothrodendron*, and *Sigillaria*, with their rhizomes *Stigmaria* and *Stigmariopsis*. These genera contributed largely to the formation of Coal.

The genus *Sphenophyllum* was also frequent during Coal-measure times, and forms a type of vegetation essentially distinct from any existing group.

The Gymnosperms are represented by Cordaites, Coniferæ, and Cycads.

The Cordaites had tree-like trunks and long yucca-like leaves. They are plentiful in the Coal-measures, and, like the arborescent lycopods, must have been a prominent feature in a Carboniferous forest scene.

The Coniferæ, so far as I have seen, are only represented by a single specimen of *Walchia* from the Upper Coal-measures; and though Cycads have been discovered in the Upper Coal-measures on the Continent, I am not aware of any British species which can be referred with certainty to this group.

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2. The Origin of Coal. By A. Strahan, M.A., F.G.S.

The deposition of the Coal-measures was due to the subsidence of large portions of the earth's crust to a depth often amounting to several thousand feet. The subsidence, being unequal, led to the formation of coal-basins, parts of the margins of which are still recognizable. That the intervening areas rose no less rapidly than the basins sank is proved by the vast denudation suffered by the earlier Palæozoic rocks during the Carboniferous period.

The subsidence was counterbalanced during Coal-measure times by sedimentation, for the occurrence of marine beds among deposits of a generally estuarine aspect proves that the surface was maintained at or near sea-level. The Carboniferous sediments consist, in the majority of coalfields, of marine limestones in the lower part, of marine grits and conglomerates in the middle part, and of estuaro-marine sandstones and shales in the upper part. The sequence is due, firstly, to the admission of the sea to the subsiding areas; and lastly, to the restoration of level brought about by sedimentation and denudation. But there is evidence also of the sedimentation having been more or less spasmodic. Thus the Limestone Series generally consists of repetitions of small groups of strata, each group being composed of sandstone, followed by shale, shale followed by limestone. Similarly the Coal-measures present repetitions of sandstone followed by shale, shale by coal. Limestone in the one case and coal in the other are therefore comparable in this respect, that each represents an episode when sedimentation had come to a pause. Early views as to the origin of coal, namely, that it was formed of vegetable matter drifted beyond the region to which the finest mineral sediment could reach, were in accordance with these facts.

More minute examination of the strata, however, revealed proofs of land-surfaces in the Coal-measures, and it was generally accepted that the coal-seams represent forests in the place of their growth. The evidence may be summarized as follows:—

(1) Rain-pittings, sun-cracks, and footprints prove that the surfaces of some of the beds were exposed to the air.

(2) Erect tree-trunks of large size, in some cases attached to large spreading roots, are not uncommon. Land-shells, millipedes, and the skeletons of air-breathing reptiles have occasionally been found within the hollow trunks.[1]

(3) The underclays of coal-seams are traversed in all directions by branching rootlets, unlike the drifted fragments in the bedding planes of the other strata. They were described as an invariable accompaniment of coals, and as being the soils in which the coal-forest was rooted.

(4) Coal-seams, with thin minute partings, persist over vast areas, and it was thought impossible that so wide and regular a distribution of vegetable matter could have been accomplished by drifting.

(5) The chemical composition of the coals was believed to prove that the vegetable matter underwent partial decomposition in the open air before being submerged or buried.

This evidence, however, though it proves the existence of land surfaces, is not conclusive of the coal-seams being forests in place of growth. The rain-pittings, sun-cracks, and footprints occur, not in the coals, but in the intervening strata. Of the erect tree-trunks a large proportion occur in sandstones devoid of coal, a few only having been found to stand upon an underclay, or to be associated

[1] C. Brongniart and others have shown that air-breathing insects of the orders Neuroptera, Orthoptera, Thysanura, and Homoptera, were *very numerous* in the Coal-period in Europe and America.—Edit. Geol. Mag.

with seams of coal. Vast areas of coal have been worked without any such trunks having been encountered. The majority of the trunks, moreover, are destitute of spreading roots, and are believed to have been floated to their present positions. The land-shells, insect and reptilian remains, are of extremely rare occurrence.

The underclays do not resemble soils, inasmuch as they are perfectly homogeneous, and lie with absolute parallelism to the other members of a stratified series. They are not always present beneath coal-seams, but, on the other hand, often occur in them or above them. Frequently they have no coal associated with them. The rootlets in them have no connection with the coal, which is a well-stratified deposit with a sharply defined base.

The persistence of the partings and characters of the coal over wide areas is in favour of their being subaqueous deposits, for on so large an expanse of land there must have been river-systems and variations in the vegetation. The stream-beds, known to miners as 'wash-outs,' are not proportioned in size to the supposed land-surfaces.

Subaërial decomposition of part of a mass of vegetable matter would take place whether it were floating or resting on dry land. Spores, which enter largely into the composition of many coals, would travel long distances either by wind or water.

Some coal-seams show clear proof of a drifted origin, as, for example, those which are made up of a mass of small water-worn chips of wood or bark. Other seams pass horizontally into bands of ironstone, and one case has been observed of a coal changing gradually into a dolomitic tufa, doubtless formed in a stagnant lagoon. Putting aside exceptional cases, the sequence of events which preceded the deposition of a normal coal-seam seems to have been—firstly, the outspreading of sand or gravel with drifted plant-remains, followed by shale as the currents lost velocity. The water was extremely shallow, and even retreated at times, so as to leave the surface open to the air. The last sediments were extremely fine, homogeneous, and almost wholly siliceous, and in them a mass of presumably aquatic vegetation rooted itself. This further impediment to movement in the water cut off all sediment, and the material brought into the area then consisted only of wind-borne vegetable dust or floating vegetable matter carrying an occasional boulder. Lastly, the formation of the coal-seam was brought to a close by a sudden invasion of the area by moving water. The mass of vegetable matter, often after suffering some little erosion, was buried by sandstone or shale rich in large drifted remains of plants or trees, and the whole process was recommenced.

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3. Botanical Evidence bearing on the Climatic and other Physical Conditions under which Coal was formed. By A. C. Seward, F.R.S.

Botanical investigations into the nature and composition of the vegetation which has left abundant traces in the sediments of the Coal-measures may be expected to throw some light on the natural conditions which prevailed during that period in the earth's history that was *par excellence* the age of coal production. The minute examination of petrified tissues has rendered possible a restoration of the internal framework of several extinct types of plant-life, and has carried us a step further towards the solution of evolutionary problems. It is possible, even with our present knowledge, to make a limited use of anatomical structure as an index of life-conditions, and to restore in some degree from structural records the physiological and physical conditions of plant-life characteristic of the close of the Carboniferous epoch.

(1) *Evidence furnished by the Coal-period Floras as to Climatic and other Physical Conditions.*

The uniformity in the character of the vegetation has no doubt been somewhat exaggerated; e.g., the *Glossopteris* flora of Australia, South Africa, and South America. The existence of botanical provinces in Upper Palæozoic times.

A comparison of the Coal-period vegetation with that of the present day as regards (i) the relative abundance of certain classes of plants, (ii) the geographical distribution of certain families of plants during the Carboniferous epoch and at the present day. The importance of bearing in mind the progress of plant-evolution as a factor affecting the consideration of such comparisons. The possible existence of a Palæozoic Mountain flora of which no records have been preserved.

(2) *The Form, Habit, and Manner of Occurrence of Individual Plants as Indices of Conditions of Growth.*

Comparison of Calamites and horse-tails. Fossil forests of Calamites. *Psaronius* stems *in sitû* and bearing roots at different levels, suggesting growth in a region of rapid sedimentation. Vertical stems either *in loco natali* or drifted. Climbing plants possibly represented by *Sphenophyllum*, some species of ferns and Medulloseæ. Function of the so-called *Aphlebia* leaves of ferns.

(3) *Anatomical Evidence.*

The value of evidence afforded by anatomical features. Risks of comparison between structural character of extinct and recent plants. Structure considered from the point of view of evolution, as the result of adaptation to external conditions, and to mechanical and physiological requirements.

(*a*) *Spores and leaves.*— Abundance of spores provided with filamentous or hooked appendages; adaptation of spores to floating or to wind-dispersal. The leaf structure of Calamites, ferns, etc.; presence of stomata, palissade tissue, and water-glands; the 'parichnos' or aërating tissue in the leaves of Lepidodendreæ and Sigillarieæ.

(β) *Stems and roots.*—Absence of annual rings of growth. The large size of water-conducting elements connected with rapid transport (e.g. *Sphenophyllum*) or with storage of water (e.g. *Megaloxylon*). The chambered pith of Cordaites, quoted as evidence of rapid elongation, of little or no physiological significance. Abundance of secretory tissue. Anatomical characteristics of a Lepidodendroid type of stem; great development of secondary tissue in the outer cortex, little or no true cork, lax inner cortex. Lacunar tissue in the roots of Calamites; hollow appendages of *Stigmaria*. Indications of xerophytic characters may be the result of growth in salt marshes.

(4) *Evidence as to the Manner of Formation of Coal.*

(*a*) The structure of *calcareous nodules* found in coal-seams; the preservation of delicate tissues, the occurrence of fungal hyphæ, and the petrification of Stigmarian appendages as evidence in favour of the subaqueous accumulation of the plant-débris found in the calcareous nodules.

(*b*) *Ordinary coal* microscopically examined. Spores, fragments of tissues, bacteria, and the ground substance of coal. Coal found in the cavities of cells in carbonized tissues. Suggested non-vegetable origin of the matrix of coal. 'Boulders' and coal-balls included in coal-seams.

(*c*) *Boghead, Cannel coal, and Oil-shales.* Recent investigations of Bertrand, Renault, and others. The structure and mode of origin of torbanite, kerosene, shale, etc. Suggested origin of Boghead from the minute bodies of algæ (*fleurs d'eau*), spores, etc., embedded in a brown ulmic substance found on the floor of a lake. Absence of clastic material. Cannel coal characterized by abundance of spores.

(*d*) *Paper-coal of Russia.*—The paper-coal of Culm age in the Moscow basin consists largely of the cuticles of a Lepidodendroid plant. Bacterial action as an agent in the destruction of plants and as a factor in the production of coal.

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4. By J. E. Marr, F.R.S.

(1) *What is coal?*—A non-scientific term introduced into scientific nomenclature for substances of divers character, and, therefore, probably of different modes of origin.

(2) *Was the Carboniferous period one where conditions suitable to formation of coal were unusually widespread?*

Coincidence at this period of dominant giant cryptogams, extensive plains of sedimentation, and suitable climatic conditions. Such coincidence never occurred before or after the Carboniferous period.

(3) *What work should be done in order to advance our knowledge of origin of coal?*

In the past light has been thrown on coal-formation by chemical, petrological, palæontological, and stratigraphical studies, and these should be continued.

(*a*) *Chemical.*—Importance of study of chemical composition of fire-clays and other accompaniments of coal in addition to coal itself.

(*b*) *Petrological.* — Dr. Sorby's work on origin of grains of mechanically formed rocks (sandstones, etc.) should be continued.

(*c*) *Palæontological.*—Studies of faunas and floras throwing light on physical and also on climatic conditions.

(*d*) *Stratigraphical.*—Much detailed work is required in many parts of the world to discover over what periods coal-formation occurred in exceptional amount. Tendency at outset to refer all Upper Palæozoic coal-formations to the Coal-measures.

III.—On the Construction and Uses of Strike-Maps.[1] By J. Lomas, A.R.C.S., F.G.S.

In studying the deformations which a series of rocks have undergone, we are apt to regard the vertical movements as all-important, and neglect the horizontal movements to which they have been subjected. This is largely owing to the difficulties experienced in picturing such horizontal movements and representing them on a plan. Lines dependent on surface inequalities confuse the worker when he seeks to use the ordinary geological maps for this purpose. It is easy to get rid of these lines by projecting the strikes of the beds on to a horizontal plane. We then have the appearance that would be produced if the country were planed down to a horizontal surface. The outcrops would coincide with the strikes, and any deviation from straight lines would indicate horizontal movements. Vertical movements would also be shown on such a plan by the closing up of outcrops of beds of equal thickness. All the data necessary to represent these features on a strike-map are given in the ordinary Geological Survey sheets. To construct such a map, first trace the dips given on the geological map and draw short lines at the points of the arrows, at right angles to the direction of dip. We thus have represented the strikes of the beds at a number of points. Now it is necessary to connect these up by lines to show the strike at intermediate places. It would not be safe to connect one line with another, as the strikes may refer to different beds. In order to overcome this difficulty, draw a series of lines parallel to the strike line on both sides of it. On doing this for all the positions it will be found that the lines either connect themselves in linear series, or we have represented a series of tangents to curves which become evident when the lines are prolonged in the direction of the strike. Care should be taken not to connect in the same line strikes with dips in contrary directions, and it is well to represent the dip side of the strike lines by a short mark ——┬——. When the amount of dip is known, as well as the direction, we can represent the steepness of the folds by suitable shading, either by hachures or closeness of strike lines. As an illustration I exhibit strike maps of the district about Clitheroe, including the well-known knolls at Worsa and Gerna. The anticlinal ridge just north of Chatburn is clearly shown, and the strata dipping with wavy folds towards the Ribble on the north and Clitheroe on the south. The Salt Hill quarries are excavated in this southern slope at a place where the fold becomes acute. The knolls at Worsa and Gerna appear like whirls or eddies, such as may be seen in a stream when the flow is obstructed by boulders in the stream bed.

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

IV.—The Concretionary Types in the Cellular Magnesian Limestone of Durham.[1] By G. Abbott, M.R.C.S.

Associated with the Cannon-ball bed near Sunderland is a cellular limestone which is much more extensive, and exhibits still more remarkable physical features. Although described by Professor Sedgwick more than sixty years ago with other magnesian beds in the North of England, it is still comparatively unknown. He divided the concretions in these strata into four classes, but I have been unable to find any classified collection except the one in the Newcastle Museum, and even in this series it is only partially done.

My own studies at Fulwell and Hendon lead me to suggest a new classification, with *five primary forms*, viz.: (1) rods, (2) bands, (3) rings, (4) balls and modified spheres, (5) eggs. *Combinations* of these forms constitute the major part of these massive beds, and frequently a bed of less than a foot thick shows examples of several different combinations. These I place in ten classes, though they may have to be added to. The chief types are (1) tubes, (2) 'cauliflowers,' (3) basaltiform, (4) irregular, (5 and 6) troughs and bands (two kinds), (7) 'floral,' (8 and 9) 'honeycomb' or coralloid (two kinds), (10) pseudo-organic.

I exhibit photographs on the screen showing both the primary forms and the combinations as seen (wherever possible) in the undisturbed rock sections.

My own conclusions are as follows:—

1. That the rod structure is *secondary* to the formation of the conspicuous bands which run across the beds at various angles. (These bands need to be distinguished from the bands mentioned among the 'primary forms.') The conspicuous bands act as planes of origin for the 'rods,' and do not cross through the long axes of the rods themselves. They appear never to cross the bedding planes, though occasionally they follow them and also the outline of the joints. The question therefore arises, whether this does not give us a clue to the age and sequence of the changes which have occurred in these beds, and whether the previous existence of joints does not mean that the beds were already above the sea-level when the changes commenced.

2. The rods invariably start from the last-mentioned bands, and may be seen at every possible angle. As they have grown upwards and obliquely as well as downwards the term 'stalactitic' is a very misleading one to use. As Mr. Garwood stated long ago, these beds "present many points which appear irreconcilable with the theory of their stalactitic origin."

3. The first step in the series of changes which have taken place was probably an orderly but unsymmetrical arrangement of amorphous molecules of calcium carbonate which separated themselves from those of the carbonate of magnesia.

4. The internal architecture is due to such arrangement of amorphous particles of lime which has since been coated with an

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

outer crystalline layer. In some cases, however, the entire mass has undergone a complete subsequent change into a crystalline structure.

5. Pearl-spar (crystals of the combined carbonates) is seldom met with. I failed to find any.

6. In the Fulwell beds there are very few fossils, and where met with, as at Marsden, concretionary action is seldom traceable near them.

7. The specimens at Fulwell which arouse the most interest are coralloid masses ('honeycomb' of the quarrymen). They are confined, so far as I could discover, to a stratum, about 1½ foot thick, above the marl bed, and lie in close juxtaposition to each other, which accounts for their peculiar external shape.

In conclusion I would point out the close resemblance which exists between the 'lines' and 'planes' in these concretionary beds, and the 'lines' which shoot across congealing water. In some respects the architecture of the magnesian beds compares with the ice decorations seen on our window-panes in frosty weather.

V.—The Jurassic Flora of East Yorkshire.[1] By A. C. Seward, F.R.S.

THE plant-beds exposed in the cliff sections of the Yorkshire coast have afforded unusually rich data towards a restoration of the characteristics and composition of a certain facies of Mesozoic vegetation. Rich collections of plants from Gristhorpe Bay and other well-known localities are found in the British Museum (Natural History), also in the Museums of Scarborough, Whitby, Cambridge, Oxford, Manchester, York, Newcastle, Leeds, and elsewhere. The Natural History Museum, Paris, contains several important Yorkshire plants, some of which have been described by Brongniart and Saporta. The following species have been recognized from the East Yorkshire area :—

Marchantites erectus (Leck., ex Bean MS.); *Equisetites columnaris*, Brongn.; *Equisetites Beani* (Bunb.); *Lycopodites falcatus*, L. & H.; *Cladophlebis denticulata* (Brongn.); *C. haiburnensis* (L. & H.); *C. lobifolia* (Phill.); *Coniopteris arguta* (L. & H.); *C. hymenophylloides* (Brongn.); *C. quinqueloba* (Phill.); *Dictyophyllum rugosum*, L. & H.; *Klukia exilis* (Phill.); *Laccopteris polypodioides* (Brongn.); *L. Woodwardi* (Leck.); *Matonidium Goepperti* (Ett.); *Pachypteris lanceolata*, Brongn.; *Ruffordia Goepperti* (Dunk.); *Sagenopteris Phillipsi* (Brongn.); *Sphenopteris Murrayana* (Brongn.); *S. Williamsoni*, Brongn.; *Tæniopteris major*, L. & H.; *T. vittata*, Brongn.; *Todites Williamsoni* (Brongn.); *Anomozamites Nilssoni* (Phill.); *Araucarites Phillipsi*, Carr; *Baiera gracilis*, Bunb.; *B. Lindleyana* (Schimp.); *B. Phillipsi*, Nath.; *Beania gracilis*, Carr; *Brachyphyllum mammillare*, Brongn.; *Cheirolepis setosus* (Phill.); *Cryptomerites divaricatus*, Bunb.; *Ctenis falcata*, L. & H.; *Czekanowskia Murrayana* (L. & H.); *Dioonites Nathorsti*, sp. nov.; *Ginkgo digitata* (Brongn.); *G. whitbiensis*, Nath.; *Nageiopsis anglica*, sp. nov.; *Nilssonia compta* (Phill.);

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

N. mediana (Leck., ex Bean MS.); *N. tenuinervis*, Nath.; *Otozamites acuminatus* (L. & H.); *O. Beani* (L. & H.); *O. Bunburyanus*, Zign.; *O. Feistmanteli*, Zign.; *O. graphicus* (Leck., ex Bean MS.); *O. obtusus* (L. & H.), var. *ooliticus*; *O. parallelus* (Phill.); *Pagiophyllum Williamsoni* (Brongn.); *Podozamites lanceolatus* (L. & H.); *Ptilozamites* (Leck., ex Bean MS.); *Taxites zamioides* (Leck.); *Williamsonia gigas* (L. & H.); *W. pecten* (Phill.).

The English flora is compared by the author with Rhætic, Jurassic, and Wealden floras of other regions; a comparison is made also between the fossil flora and the vegetation of the present day.

VI.—On the Fish Fauna of the Yorkshire Coalfields.[1] By Edgar D. Wellburn, F.G.S.

Only the Lower and Middle Coal-measures are present. The author described the Lower Measures, their extent and general characters, with their beds of marine and fresh-water origin. The Middle Measures and their general character: formed in a series of fresh-water lake basins. The author described the fish-remains, where found and in what state of preservation. Elasmobranchs, Teleosteans (and in some cases Dipnoans), commingled, i.e. marine and fresh-water types in the same beds; Elasmobranchs found in marine and fresh-water beds; Dipnoi only found under fresh-water conditions. Teleostean orders, Crossopterygii and Actinopterygii found in both fresh-water and marine beds. The conditions under which coal was deposited was shown to have a bearing on the occurrence and habits of the fishes. The swim-bladder of Cœlacanths, and its peculiar use to them under certain conditions. The Elasmobranchii were represented by eleven genera and twenty-three species; Ichthyodorulites by seven genera and eight species; Dipnoi by two genera and two species; and the Teleostomi by twelve genera and thirty-three species. A tabular list of fish-remains was given showing their stratigraphical distribution; several new fish-bearing coal shales were recorded, the distribution and vertical range of the Yorkshire coal-fishes being thus greatly extended; several genera and species new to Yorkshire, and others new to science, were referred to by the author.

REVIEWS.

I.—Catalogue of the Bateman Collection of Antiquities in the Sheffield Public Museum. Prepared by E. Howarth, F.R.A.S., F.Z.S., Curator of the Public Museum and Mappin Art Gallery. 8vo; pp. xxiv and 254, with 262 illustrations in the text. Published by order of the Committee. (London: Dulau & Co., 1899. Price 3*s.* 6*d.*)

The very valuable and interesting collection which forms the subject of this excellent Catalogue is not only entirely British, but is confined to Derbyshire, Staffordshire, and Yorkshire, and is the work of three generations of Batemans of Middleton Hall,

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

Derbyshire, from 1759 to 1847, assisted by Mr. Samuel Carrington in Staffordshire, Mr. James Ruddock in the North Riding of Yorkshire, Mr. Stephen Glover in Derbyshire, and Mr. Samuel Mitchell of Sheffield, an antiquary of wide erudition.

Following the Collection, the Catalogue is arranged as under, viz.:

Celtic Period: Stone and bronze weapons and utensils, Nos. 1–526, pp. 1–89; urns and other pottery, Nos. 757–896, pp. 91–156; miscellaneous objects, crania, querns, Nos. 897–985, pp. 157–174; tools, personal ornaments, Nos. 527–598, pp. 175–190.
Romano-British Period: Nos. 599–687 and 986–1117, pp. 191–218.
Anglo-Saxon Period: Nos. 688–756, pp. 219–231.
Miscellaneous Objects: Nos. 1118–1288, pp. 232–254.

In his excellent Introduction Mr. Howarth observes that: "Records of the dead are almost the only means whereby any reliable account can be constructed of the life and customs of the earliest inhabitants of Britain, with whom writing was unknown; pictorial art, if not quite beyond their skill, was of the simplest kind, and their dwellings were of such a temporary and unsubstantial character that all traces of them vanished before the historical period. The care of the dead forms their most lasting memorials, and it is these sepultural mounds that furnish the principal information respecting the early Britons. Derbyshire has contained many conspicuous examples of ancient barrows, tumuli, or grave-mounds, and, fortunately, amongst the Bateman family there were men of leisure, means, and knowledge, with the taste for exploring these sepulchral storehouses and carefully preserving them; and it was chiefly owing to the labours of Mr. Thomas Bateman that the collection which bore his family name was formed." (p. v.)

"Under the Celtic Period are grouped all those objects found in the burial-places, or in any way associated with the ancient Britons, whether belonging to the round-headed or long-headed races, two distinct types which may have sprung from two different groups afterwards associated together. Authorities agree in regarding the earliest race inhabiting these islands as Celts, and as the exact indications of time are few there is the freer scope for the imagination. Let us take it, then, that 1600 years before Christ, Britain was inhabited by a Celtic race of long-headed men of low mental development and small stature. The Phœnicians traded with Britain for tin, lead, and skins, 600 years before Christ; and about 500 B.C. Hecatus, a Greek writer, describes Britain as an island opposite the coast of Gaul about as large as Sicily.

"In or about the year 350 B.C. the Belgæ, a tribe descended from the Scythians, invaded the island. They were men of larger stature than the Celts, their heads were round rather than long, and they were inured to the dangers and hardships of war. The Belgæ conquered and occupied the southern and south-western counties, driving the Celts to the north and north-west. When the Romans invaded the island, first in 55 B.C. under Julius Cæsar, and about a century later in the reign of Claudius, the Belgæ were the tribes first encountered. The skulls found in the barrows mainly belong to the round-headed type, some of them being mesaticephalous, representing the characters of the two types." (p. vi.)

It is interesting to notice the "very great care and trouble expended over the construction of many of the grave-mounds, probably those in which were deposited chiefs of tribes or important individuals of the community, for it is impossible that these huge mounds, which sometimes contain only a single interment, and never very many, could have been constructed for all the people who died. It is these barrows or tumuli which furnish the evidence of the customs, habits, and rites of these ancient people.

"The chief characteristic of a Celtic place of burial is a large mound, sometimes circular, in other cases oval, and more rarely long-shaped, the latter being regarded as the most ancient. These mounds differ considerably in dimensions, from 20 to 200 feet in diameter and from 1 to 24 feet in height. They were usually placed in a conspicuous position on or near the summit of some natural elevation of the land. The mounds of earth and stone are called barrows, and are formed of materials from the immediate neighbourhood of the situation in which they were placed. In some cases a mound of stones or a cairn was erected over the dead." (p. vii.)

Burial by Cremation.—"Where the bodies were cremated the ashes were afterwards carefully collected together, tied up in some fabric, and placed on the ground; or they were covered by or put into an urn, and frequently placed in a cist or in a cavity hewn in the rock."

Ordinary Interment.—"*Inhumation* was the more common mode of burial, the body probably being wrapped in some skin or garment, for although these have long since perished, pins, buttons, and other articles found in barrows indicate that they were used as fastenings for sepulchral clothing of some kind. Some barrows contain burnt and unburnt bones, one body having been interred in the position in which it died, while the others were burnt; and it may be inferred from these occurrences that the sacrifice of human life at the death of a chief was practised amongst the ancient Britons, as is the custom in recent times with many uncivilized races. The wife, children, or slaves may thus have been immolated to keep the head of the family company in a future world." (p. viii.)

Objects found in Celtic Tumuli and Barrows.—"The contents of the graves lead strongly to the supposition that belief in a future state was held by these primitive people, provision evidently being made for them to carry on their work and amusements. Besides the cinerary urns, which were obviously intended to contain the cremated bones, other vessels of three distinct types have been found with interments, both of burnt and unburnt bodies. These are generally known as food-vessels, drinking-cups, and incense-cups, though it must not be inferred that they were strictly used for the purposes implied in those names." (p. viii.)

"Implements and weapons, both in stone and bronze, are frequently found in barrows, as also personal ornaments in the shape of necklaces, glass beads, buttons, bronze and bone pins. Numerous examples of these finds are recorded, amongst them being some pieces of red ochre, the rouge of that period, used for decorating the body. Although the use of iron was then unknown, pieces of rubbed and polished iron-ore have been found in barrows, as if they had some special significance as charms.

"Stone and bronze weapons are sometimes found in the same grave, the two materials evidently being used at the same period, probably this marking the time when bronze first came into use and before it had been generally adopted. A leaf-shaped dagger is the principal bronze weapon found in a grave, bronze implements being much less numerous than those of stone. The pins in bronze and bone and the buttons in Kimmeridge Coal show that some form of dress was worn which these were intended to fasten." (p. ix.)

Mr. Howarth draws the following conclusions:—"It would appear from the teachings of the tombs of the ancient Britons that they were in a semi-savage state, without any fixed religion, with the sagacity to make tools, vessels, weapons, and implements for daily use. That the use of stone only gradually gave place to the use of bronze from an acquired knowledge of the properties of the ores of copper, tin, zinc, and lead. While no special differentiation of purpose is shown in their manufactures, yet they indicated a separation of certain objects for distinct uses. Clothing was worn amongst them, consisting of skins and probably manufactured stuffs, such as jute and flax. They cultivated the soil to a certain extent, and had domestic animals for labour and sustenance. While believing in a future state, their ideas of religion were of a very vague character, and they still practised certain barbarous rites which belong only to savages. The period which is covered by the history of Celtic barrows probably extends over many hundreds of years, and they show the advance the people had made during that time, ranging through the later or neolithic stone-period to the opening of the age of bronze, the people of the Palæolithic period being much more ancient than the architects of these barrows, and of a much more primitive type." (p. xviii.)

Space does not permit us to give a fuller notice of this very excellent and well-illustrated Catalogue and Guide to one of the most valuable collections of its kind to be seen in any museum in this country. We venture to suggest to the author that the very beautiful necklaces, said to be of 'Kimmeridge Coal,' figured on p. 59 (J. 93, 431, G. 79), p. 61 (J. 93, 434, G. 113), and p. 63 (G. 158), were really originally made of jet from Whitby, which, owing to damp, etc., have lost their pristine lustre and become decomposed by age and long interment in the earth, until they resemble Kimmeridge Coal or 'Brown-coal' in aspect. We compliment Mr. Howarth upon the production of this excellent Catalogue of the Bateman Collection, and the Committee of the Sheffield Museum in authorizing the publication with such ample illustrations. The Collection itself is well worthy of a pilgrimage to Sheffield, nor is it the only one to be seen in this admirable Museum.

II.—The Geology of the Country between Atherstone and Charnwood Forest. By C. Fox-Strangways, F.G.S. With Notes on Charnwood Forest by Professor W. W. Watts, M.A., F.G.S. 8vo; pp. 102. (London: printed for H.M. Stationery Office, 1900. Price 2s.)

This Memoir, which has been written in explanation of the New Series map, Sheet 155, contains a good deal of detailed information of practical value respecting the northern part of the Warwickshire Coalfield and the southern part of the Leicestershire Coalfield. A number of records of borings and sinkings are given. Professor Watts contributes a summary of the interesting observations which he made while mapping in detail the old rocks of Charnwood Forest. These he groups in the 'Charnian System,' whose position in the great Pre-Cambrian sequence cannot at present be determined. Among the other rocks dealt with by Mr. Strangways are the Stockingford Shales (Cambrian), the Permian and Trias, the Glacial, and more recent deposits. With the aid of Mr. Whitaker he contributes a useful geological bibliography of Leicestershire.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—November 7, 1900.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "Additional Notes on the Drifts of the Baltic Coast of Germany." By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S., and the Rev. E. Hill, M.A., F.G.S.

The authors, prior to revisiting Rügen, examined sections of the Drift to the west of Warnemünde, with a view of comparing it with that of the Cromer coast. Where the cliffs reach their greatest elevation, two or three miles from that town, they are composed of a stony clay, which occasionally becomes sandy. At intervals, however, sand interbanded with clay occurs, filling what appear to be small valleys in the Drift. A layer of grit and stones, occasionally associated with a boulder, occurs once or twice between these sands and clays. The valleys are excavated in the great mass of stony clay which extends for four or five miles to the west of Warnemünde; and the synclinal slope of the layers and the contortion of the underlying bedded sands indicate that the mass filling them has been let down as a whole, either by solution of the Chalk beneath the Drift or by the melting of underlying ice. Of these two hypotheses the authors view the latter with the more favour, but it also has its difficulties.

In Rügen, Arkona was visited; here Chalk occurs, apparently as a sort of island in the Drift. At the well-known locality by the lighthouse it seems to overlie a drift, but on closer examination the latter appears more probably to have filled a cavity excavated in the Chalk, this apparent inlier of Drift probably being only a remnant of a much larger mass; therefore it is likely that this part of the coast nearly corresponds with a pre-Glacial chalk-cliff against which the Drift was deposited.

In the Jasmund district the authors lay special emphasis on three points: — (1) The 'inliers' of Drift appear to occupy valleys excavated in the Chalk; (2) these valleys can be traced for some distance inland; (3) the steep walls of Chalk towards which the Drift dips sharply, and against which it ends abruptly (usually on the southern side), often trend gradually inland, as if the present coastline had passed obliquely across an old valley. In one or two instances the Drift is slightly twisted up against this steep face of Chalk. The authors call attention to cases where the Drift clearly rests against old surfaces and cliffs of Chalk; and to one in particular, which was not visible in 1898, where (*a*) clay, (*b*) sand, and (*c*) clay occupy a shallow valley, and have assumed a synclinal form. The authors give reasons to show that neither solution of the Chalk, nor ice-thrust, nor folding, nor even faulting, can satisfactorily explain the peculiar relations of the Drift and Chalk in Rügen; and they can find no better explanation than that offered in their previous paper.

2. "On certain Altered Rocks from near Bastogne and their Relations to others in the District." By Catherine A. Raisin, D.Sc. (Communicated by Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.)

Professor Renard, from the petrographical study of specimens, and Professor Gosselet, after description of the district and its stratigraphy, have attributed the changes in these rocks to mechanical disturbances. Dumont had previously described many examples and inclined to the view of contact-alteration, which was favoured by Von Lasaulx's discovery of a granite in the Hohe Venn and M. Dupont's identification of chiastolite from Libramont.

The present paper treats especially of the garnetiferous and hornblendic rocks, giving the full petrographical and field details of a few examples. It points out that the effects of pressure are evident over the whole district, while mineral modifications resembling the results of slight contact-action are found in certain areas. In a few cases these modifications are more marked, and sometimes increase as we approach veins composed of quartz, felspar, and mica, such as might be connected with a concealed granite.

The peculiar garnetiferous and hornblendic rocks, although occurring within the zone of alteration, are extremely limited, often forming patches or bands a few feet across. They differ, as described in the paper, from ordinary contact-altered rocks. The evidence, in the authoress's opinion, is in favour of Prof. Bonney's suggestion that they are due to some form of hot-spring action.

II.—Nov. 21, 1900.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "A Monchiquite from Mount Girnar, Junagarh (Kathiawar)." By John William Evans, D.Sc., LL.B., F.G.S.

After a brief account of the rocks of the monchiquite type, in which ferromagnesian silicates are embedded in an isotropic matrix with the chemical constitution of analcime, the author describes an example from Mount Girnar, where it is associated with a nepheline-syenite intrusive in a mica-augite-diorite.

The most striking feature of this rock is the occurrence of colourless spheres of various sizes up to about 1 mm. in diameter. The rest of the rock is mainly composed of a hornblende of the barkevikite type; a pale-green augite is also present. Both the spherical spaces and the interstices between the ferromagnesian silicates are usually filled with an isotropic material which has the composition and most of the physical properties of analcime. This material does not, however, show the anomalous double-refraction which is characteristic of that mineral, nor has it any crystalline outlines, being simply an allotriomorphic glass-like groundmass. It contains a large number of acicular inclusions, most of which do not affect polarized light; they exhibit a parallel arrangement in one or more directions, and appear to indicate a high degree of symmetry. Cleavage-cracks with similar orientation may be occasionally observed. As it is clearly a crystalline body, its isotropic nature refers it to the cubic system, and its identity with analcime may be considered proved. It is evident that this mineral, growing outward from different centres, has formed the spherical spaces by pushing aside the previously crystallized minerals until they came into contact one with the other, and has afterwards crystallized in the interstices between them.

The presence of a groundmass of analcime (or one having the same composition) in all the members of the widely distributed monchiquite group of rocks implies the occurrence in different localities of a residuary magma of uniform composition, which remains liquid after the other constituents of the rock have crystallized out. Analcime must, therefore, represent an eutectic compound. If the cooling were sufficiently rapid the magma would consolidate as a glass, as may be the case with some monchiquites. On the other hand, where such a magma has separated and cooled slowly enough, a nepheline-syenite will be formed.

At some points the analcime in the spheres and in the interstices has become decomposed into alkali-felspars and nepheline, as in the pseudo-leucites of Dr. Hussak, so that in these places the rock might be described as a hornblende-tinguaite. In other parts much of the analcime has passed into cancrinite.

The presence of a mineral of the eudialyte-eucolite group is also noticed.

2. "The Geology of Mynydd-y-Garn (Anglesey)." By Charles A. Matley, Esq., B.Sc., F.G.S.

Mynydd-y-Garn, a hill of less than 600 feet elevation, stands above the village of Llanfair-y'nghornwy in North-West Anglesey. The mass of the hill is an inlier of sericitic and chloritic phyllites (Garn Phyllites), surmounted by a massive conglomerate (Garn

Conglomerate), and surrounded by black slates and shales of apparently Upper Llandeilo age. The general dip of all the rocks is northerly and north-easterly.

The Garn Phyllites are usually green altered shales and fine gritty rocks, and are intensely contorted near their southern boundary. Even where not contorted they show under the microscope evidence of powerful earth-movement. They are considered by the author to be part of the 'Green Series' of Northern Anglesey. They are cut off to the west and south by a curved fault, probably a thrust, which brings them against Llandeilo slates and breccias.

The Garn Conglomerate, Grit, and Breccia, a formation perhaps 400 feet thick, rests upon the Garn Phyllites and contains fragments derived from them, as well as pebbles of quartz, grit, gneissose and granitic rocks, etc. It passes up gradually into black slates, from which a few Upper Llandeilo fossils have been collected. In the black slates an oolitic ironstone or ferruginous mudstone has been found, which may perhaps be on the same horizon as the similar rock recorded by the author in Northern Anglesey.

On the eastern side of Mynydd-y-Garn is another group of rocks, the Llanfair-y'nghornwy Beds, which the author correlates with the basal part of his Llanbadrig Series. They consist of phyllites resembling those below the Garn Conglomerate, but they contain also beds and masses of quartzite, grit, and limestone. They are much broken, and partly in the condition of crush-conglomerates. They have been thrust over the Llandeilo black slates, and the thrust-plane has been traced to the coast at Porth yr Ebol. This thrust is continuous with that which forms the southern boundary of the 'Green Series' of Northern Anglesey.

The district around Mynydd-y-Garn has been affected since Llandeilo times by two powerful earth-movements, acting one from the north, the other from the north-east. The first-mentioned prevailed in the area west and north-west of the hill, where the pre-Llandeilo rocks are frequently shattered to crush-conglomerates. Around Mynydd-y-Garn itself and east of it the principal direction of movement has been from the north-east; south of the hill the structure is perhaps the result of the interference of these two movements.

3. "On some Altered Tufaceous Rhyolitic Rocks from Dufton Pike (Westmorland)." By Frank Rutley, Esq., F.G.S. With Analyses by Philip Holland, Esq., F.I.C., F.C.S.

The specimens described were collected by the late Prof. Green and Mr. G. J. Goodchild from the Borrowdale volcanic series which constitutes the central mass of Dufton Pike, and the chief interest attaching to them is their alteration, probably as the result of solfataric action. One of the rocks, which has the composition of a soda-rhyolite, contains felspar, augite, magnetite, and possibly spinel or garnet, scapolite, and ilmenite. The porphyritic crystals of felspar are much corroded, and are sometimes mere spongy masses in which mica and opal-silica have been developed, together with small quantities of carbonates. In a second example, felspar fragments appear as a meshwork of rods which extinguish simultaneously, and are embedded in an isotropic groundmass crowded with globulites and little rods. A faint streakiness, which cannot be fluxion-structure, passes through the matrix of the rock and the meshwork of the felspar fragments without deflection. Analyses of the rocks and diagrams constructed from their molecular ratios correspond closely with those of soda-rhyolite and potash-rhyolite respectively.

III.—Dec. 5, 1900.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Corallian Rocks of St. Ives (Hunts) and Elsworth." By C. B. Wedd, Esq., B.A., F.G.S. (Communicated by permission of the Director-General of the Geological Survey.)

Starting 2½ miles south-west of Elsworth, the author traces the Elsworth Rock at intervals through Croxton, Yelling, Papworth Everard, etc., to Elsworth, and thence towards Fen Drayton and near Swavesey. The Oxford Clay is found to the west of it, and the Ampthill Clay to the east. Frequent fossil lists are given, and the character of the rock is described at the different exposures. Again, from Haughton Hall, west of St. Ives, the 'St. Ives Rock' is traced through that town and towards Holywell. The actual connection with the Elsworth Rock cannot be seen owing to an area of fen. But that the two rocks are identical the author considers is proved by the consistency of the two rocks, the absence of any other rock-bed, the dip of the strata, and the presence of Ampthill Clay above. The Corallian strata of the area appear to have been deposited more slowly than the Oxfordian strata. Of the two zonal ammonites of the Corallian, the dominant form in the Elsworth Rock and in the stone-bands of the Ampthill Clay is of the *plicatilis* and not the *perarmatus* type.

2. "The Unconformity of the Upper (red) Coal-measures to the Middle (grey) Coal-measures of the Shropshire Coalfields, and its bearing upon the Extension of the latter under the Triassic Rocks." By William James Clarke, Esq. (Communicated by W. Shone, Esq., F.G.S.)

The Upper Red Measures have a much greater extension in the Shropshire Coalfields than the productive measures below. In the Shrewsbury field they are the only Carboniferous rocks present, and rest on pre-Carboniferous rocks.

When the sections of collieries at and near Madeley are plotted on the assumption that the base of the Upper Carboniferous rocks is horizontal, the Lower Measures are found to be bent into a syncline rising sharply to the north-north-west and more gently to the south-south-east. A second syncline, broader and deeper, extends from Stirchly towards Hadley, but the westerly rise is often hidden by the boundary-fault of the coalfield. This phenomenon is known locally as the 'Symon Fault'; and instead of taking Scott's view that it represents a hollow denuded in the Lower Coal-measures, the author considers it due to folding before late Carboniferous times.

A third little syncline occurs at the Inett and Caughley. Similar phenomena are exhibited in the Forest of Wyre Coalfield, where a series of unproductive measures come in between the Lower and Upper Coal-measures. The axis of the folds runs east-north-eastward, and their amplitude and length diminish in proceeding from north-west to south-east. Inter-Carboniferous folds also occur in the North Wales and North Staffordshire fields.

3. "Bajocian and Contiguous Deposits in the Northern Cotteswolds: the Main Hill Mass." By S. S. Buckman, Esq., F.G.S.

After giving comparative sections at Cleeve, Leckhampton Hill, and Birdlip, to show the disappearance of three horizons at the second locality and five more at the third, the author interprets the absence of the beds as due to 'pene-contemporaneous erosion,' brought about by the elevation of rocks, due to small earth-movements along a main south-west to north-east axis and subsidiary axes north-west to south-east. In the Northern Cotteswolds the beds which come in at Cleeve disappear, while there is a development of the Harford Sands, the Tilestone, and the Snowshill Clay above the Lower *Trigonia*-Grit. A series of detailed sections along the main hill-mass is given. On tracing the rocks from west to east across the Northern Cotteswolds, the whole of the Inferior Oolite disappears, except quite the upper portion, which rests directly on Upper Lias, and the Upper Lias itself undergoes denudation; eastward the latter thickens again, and basal beds of Inferior Oolite reappear. Thus the axis of an important anticline is along the Vale of Moreton. The general result of the observations does not confirm Professor Hull's view that these members of the Jurassic are thinning and disappearing eastward. The observed phenomena were really brought about by contemporaneous erosions; whereof the principal one occurred before the deposition of the Upper *Trigonia*-Grit. A revised map of Bajocian denudation is given, and it is shown that, owing to anticlinal axes along the Vales of Bourton and Moreton, pene-contemporaneous erosion must have had considerable influence in determining the position of these valleys. Such erosion is likely to have taken place along similar lines at different times, and therefore may be connected with folds in Palæozoic rocks and may have a bearing on the thickness of rocks overlying the Coal-measures. A table of the dates of the chief erosions in Jurassic times is appended to the paper.

OBITUARY.

CHARLES JOHN ADRIAN MEŸER.

Born May 23, 1832. Died July 16, 1900.

By the death of Mr. Charles Meÿer we have lost a geologist who has contributed largely to our knowledge of Cretaceous rocks and fossils. He belonged to a family in whom a love of natural history was inherent, and from the time of his leaving school until his appointment to the Civil Service he greatly assisted in the preparation of a new edition of H. L. Meÿer's "Illustrations of British

Birds." Always a careful and patient observer, he acquired a close acquaintance with the habits and song-notes of British birds, and never ceased to take an interest in them.

In July, 1857, he was appointed to a post in the Accountant General's Office of that time, in a division which was subsequently transferred to the Chancery Courts under the title of the Supreme Court Pay Office. At that time his family lived near Godalming, and his attention was attracted to the fossils to be found in an old quarry in the Lower Greensand near the house. These interested him so much that he began to study them and the rocks containing them, and this laid the foundation of that interest in geology which bore good fruit in after years. From that time he always devoted his short holidays to visiting places of geological interest, chiefly along the south coast, and almost always where rocks of Cretaceous age were to be seen.

He had a remarkably keen eye for fossils, and knew the value of recording the exact bed from which they came; hence his notebooks contain carefully measured sections, and his published papers show that he had always the correlation of beds in different places before his mind.

He gradually gathered together a fine collection of Cretaceous fossils, comprising many thousand specimens, obtained entirely by his own hands. It comprises fossils from the Lower Greensand, Gault, 'Upper Greensand,' and Blackdown Beds, from the Devonshire Cenomanian, and from the several stages of the Chalk, and it contains many unique specimens. This collection, by the generosity of his sister, Miss C. Meÿer, has been presented to the University of Cambridge, together with a smaller but fine collection of London Clay fossils collected by his brother, Mr. Christian H. Meÿer, C.E., during the dockyard extension works at Portsmouth.

The first paper published by Mr. C. J. A. Meÿer was a note on the age of the Blackdown Beds in 1863, and from that time to 1878 he contributed frequently to the pages of the Geological Magazine and of the Quarterly Journal of the Geological Society. A list of his papers is given below, but two of the most notable may be specially mentioned.

In his paper "On the Relations of the Wealden and Punfield Formation" he took a view which was opposed to that held by another well-known geologist, and maintained it with such success that it is now generally accepted as correct.

His paper on the Cretaceous Rocks of Beer Head is really a very condensed account of his exploration of the Devon cliffs from Sidmouth to Lyme Regis. He visited this coast again and again, collecting carefully from every bed in the succession; and as he was practically the first to explore this fine collecting ground, he obtained a large number of excellent specimens, especially from those beds which he numbered 10, 11, and 12, and which lie at the base of the Chalk. He continued to collect from these cliffs for many years after the publication of his paper, and the value of his researches was acknowledged by Messrs. Jukes-Browne and W. Hill in their paper on the "Delimitation of the Cenomanian" (1896), when he communicated to them a list of the many additional fossils he had obtained from these beds, with notes on some of the species.

Specimens from his collection have been figured by Messrs. Davidson, Lycett, and Woods in the volumes of the Palæontographical Society, and no doubt others will appear in the monograph Mr. Woods has undertaken.

Mr. Meÿer was distinguished for his quiet and courteous manner, his habit of patient enquiry and of accurate observation, and by his willingness to impart any information that he possessed. When we remember that his life was really spent in the routine of office work, and that all his scientific work was done in his evenings and in his short holidays, we may well wonder that he did so much, and regret that he was not able to give more time to a pursuit for which he was so well qualified.

We are indebted to Miss C. Meÿer for some of the information in the above notice.

LIST OF PAPERS.

MEŸER, C. J. A.

Age of the Blackdown Greensand. (Geologist, vol. vi, 1863, pp. 50–56.)

Three Days at Farringdon. Position of Sponge-gravel. (Geologist, vol. vii, 1864, pp. 5–11.)

A New Species of *Terebratella*, from the Bargate Stone (*T. trifida*). (Geologist, vol. vii, 1864, pp. 166–7.)

Notes on Brachiopoda from the Pebble-bed of the Lower Greensand of Surrey; with descriptions of the new species, and remarks on the correlation of the Greensand Beds of Kent, Surrey, and Berks, and of the Farringdon Sponge-gravel, and the Tourtia of Belgium. (GEOL. MAG., Vol. I, 1864, pp. 249–257.)

On the Discovery of *Ophiura Wetherelli* at Herne Bay. (GEOL. MAG., Vol. II, 1865, p. 572.)

Notes on the Correlation of the Cretaceous Rocks of the South-East and West of England. (GEOL. MAG., Vol. III, 1866, pp. 13–18, Pl. II.)

Notes on Cretaceous Brachiopoda, and on the Development of the Loop and Septum in *Terebratella*. (GEOL. MAG., Vol. V, 1868, pp. 268–272.)

On the Lower Greensand of Godalming. (Geol. Assoc.—separate paper, 20 pp. Read before the Association 4th Dec., 1868.)

Note on the Passage of the Red Chalk of Speeton into an underlying Clay-bed. (GEOL. MAG., Vol. VI, 1869, pp. 13–14.)

On Lower Tertiary Deposits recently exposed at Portsmouth. (Quart. Journ. Geol. Soc., vol. xxvii, 1871, pp. 74–89; Phil. Mag., vol. xli, 1871, p. 546.)

On the Wealden as a Fluvio-lacustrine Formation, and on the Relation of the so-called 'Punfield Formation' to the Wealden and Neocomian. (Quart. Journ. Geol. Soc., vol. xxviii, 1872, pp. 243–255.)

Further Notes on the Punfield Section. (Quart. Journ. Geol. Soc., vol. xxix, 1873, pp. 70–76.)

On the Cretaceous Rocks of Beer Head and the adjacent Cliff-sections, and on the relative Horizons therein of the Warminster and Blackdown Fossiliferous Deposits. (Quart. Journ. Geol. Soc., vol. xxx, 1874, pp. 369–393.)

Micrasters in the English Chalk.—Two or more species? (GEOL. MAG., Dec. II, Vol. V, 1878, pp. 115–117.)

Notes respecting Chloritic Marl and Upper Greensand. (GEOL. MAG., Dec. II, Vol. V, 1878, pp. 547–551.)

An Excursion to Guildford. (Report in Proc. Geol. Assoc., vol. v, 1878, pp. 161, 163.)

MEŸER, C. J. A., & JUKES-BROWNE, A. J.

Chloritic Marl and Warminster Greensand. (GEOL. MAG., Dec. IV, Vol. I, 1894, pp. 494–495.)

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VIII.

No. II.—FEBRUARY, 1901.

HER MOST GRACIOUS MAJESTY

QUEEN VICTORIA

PASSED AWAY 22 JANUARY, 1901,

BELOVED AND MOURNED BY ALL HER PEOPLE, AFTER A GLORIOUS REIGN OF 64 YEARS.

ORIGINAL ARTICLES.

I.—British Pleistocene Fishes.

By E. T. Newton, F.R.S., F.G.S., etc.

THE search for small vertebrates in deposits of Pleistocene age has, within the last few years, been prosecuted with much zeal by several workers, and has brought to light the remains of many species of mammals, as well as birds, reptiles, and amphibia; the bones in some instances occurring in great numbers. The remains of fishes, however, have but rarely been found with the bones of other vertebrata, and never in any abundance. Some interesting discoveries of fish-remains have nevertheless been made; but the records of them are scattered through various publications, and it seems very desirable to bring all this information together.

It is sixty years since Sir C. Lyell,[1] in a paper read before the Geological Society (January, 1840), first made known that remains of fresh-water fishes had been found, by himself and Mr. J. B. Wigham, in the fresh-water deposit which occurs in the cliffs at Mundesley, Norfolk. These remains had been examined by the Rev. Leonard Jennings and Mr. Yarrel, and were referred by them to Perch, Carp, Pike, and Trout.

In the following year (January, 1841) Sir C. Lyell[2] made a further communication to the same society, in which he stated that the fish-remains noted in the earlier paper, together with some additional specimens from the same locality, had been submitted to M. Agassiz, who thought the Perch, Pike, and Trout differed from the living species, and that the remains referred to Carp were really

[1] Proc. Geol. Soc., vol. iii (1843), p. 171. Lond. & Edinb. Phil. Mag., May, 1840.

[2] "On the Fresh-water Fossil Fishes of Mundesley as determined by M. Agassiz": Proc. Geol. Soc., vol. iii (1843), p. 362. Ann. Mag. Nat. Hist., vol. viii (1842), p. 61.

a species of *Leuciscus.* No statement was made as to the nature of the remains which had been found, nor what became of the specimens.

M. Agassiz seems to have been impressed with the idea that no fossil forms could be identical with living species, and this, apparently, led him to attach greater importance to the slight differences, which he saw between the Mundesley remains and the corresponding parts of living fishes, than would be allowed by naturalists of the present day. Certain fish-remains, more recently obtained from these fresh-water deposits at Mundesley, which in all probability represent the same forms as those found by Lyell, cannot, I think, be separated from living species.

In the year 1854 Professor J. Morris[1] recorded *Esox* sp., from the Pleistocene of Copford, Essex : the specimens were jaws and teeth in the collection of Mr. Brown, and they are now preserved in the British Museum, South Kensington (Nos. 36,658–60). Other remains of Pike from Copford were presented to the British Museum by the Rev. O. Fisher (No. 4,848).

Twenty years elapsed before Mr. William Davies[2] recognized, in 1874, the remains of Pike in the collection of Sir Antonio Brady, from the Brickearth of Ilford, specimens which are now in the British Museum, South Kensington (No. 45,810). These remains were doubtfully named *Esox lucius* ?, but were acknowledged to be inseparable from that species, and in 1890 were so named, without doubt, by Messrs. A. Smith Woodward and C. Davies Sherborn.[3] During Mr. Clement Reid's[4] Geological Survey of the "Country around Cromer," he obtained a number of specimens from the classical Mundesley river bed, and among them remains of Pike, *Esox lucius* (M.P.G.—C.R. 665–6). Since the Survey Memoir was published, Mr. Reid has collected from the same place scales and teeth referable to *Perca fluviatilis* (M.P.G.—C.R. 666) and a tooth of the genus *Leuciscus* (M.P.G.—C.R. 869). We are thus able to confirm the occurrence of three of the forms recorded by Sir C. Lyell; and there seems no sufficient grounds for referring them to other than recent species. Two or three different kinds of scales remain at present unidentified, but none of them can be definitely named *Salmo*, the fourth genus mentioned by Sir C. Lyell.

Mr. Reid's researches in the neighbourhood of Holderness,[5] Yorkshire, enabled him to record *Perca fluviatilis* from both Hornsea (M.P.G.—C.R. 1,119) and Withernsea (M.P.G.—C.R. 1,071).

In the year 1888 Mr. G. W. Lamplugh[6] gave an account of a deposit at Sewerby, near Bridlington Quay, which yielded bones of *Elephas*, *Rhinoceros*, *Hippopotamus*, etc., and is doubtless of Pleistocene age. With these mammalian bones were also found vertebræ of fishes, which almost certainly belong to Codfish. This record is the more interesting as it is the only known instance of

[1] Catalogue of British Fossils, 2nd ed. (1854), p. 326.
[2] Cat. Pleistocene Vert. Coll. Sir Ant. Brady, 1874, p. 61.
[3] Catalogue of British Fossil Vertebrata.
[4] Mem. Geol. Surv., 1882, p. 126.
[5] Mem. Geol. Surv., 1885, pp. 82 and 85.
[6] "An Ancient Sea Beach near Bridlington Quay": Brit. Assoc. Report for 1888.

marine fish-remains being found in a British Pleistocene deposit. The proximity of the sea would easily account for the presence of these fish bones, as well as for the marine molluscs which were found with them; but it also suggests the possibility of a more recent introduction. Mr. Lamplugh's careful work is, however, a guarantee that the fish bones were cotemporary with those of the Mammoth, and the condition of the specimens, which are now in the Jermyn Street Museum, is precisely the same.

Two teeth, probably of Pike, found by Mr. B. B. Woodward in the Crayford Brickearth in 1891, are now in the British Museum.

In the year 1891 Mr. F. C. J. Spurrell presented to the Museum of Practical Geology a number of specimens from the Brickearth of Erith, and among these were some teeth of *Esox lucius* (No. 5,646).

Mr. Clement Reid's most interesting work on the series of strata found at Hoxne,[1] in Norfolk, not only brought to light a large number of plants, but also of small bones of vertebrata, among which, from Bed E, were remains of *Perca fluviatilis* (M.P.G., 6,084) and *Leuciscus rutilus* (M.P.G., 6,083). In the following year, 1897, the results of Mr. Reid's similar researches at Hitchin[2] were published, and from beds on the same horizon as D and E at Hoxne he was able to record *Perca fluviatilis, Esox lucius, Tinca vulgaris, Leuciscus erythrophthalmus*, and *L. rutilus* (M.P.G., 6,301).

For some time past Mr. M. A. C. Hinton and Mr. A. S. Kennard have been searching the various Pleistocene beds at Grays Thurrock, and have obtained a good number of bones and teeth of small vertebrates, among which are many belonging to fresh-water fishes. Some account of these was read before the Essex Field Club[3] on October 27th, 1900. About a dozen otoliths, which agree most nearly with those of the Ruff, are provisionally referred to *Acerina vulgaris* ?; a number of teeth doubtless belong to the Pike, *Esox lucius*; several pharyngeal bones and numerous isolated teeth are referred partly to Roach, *Leuciscus rutilus*, and partly to Dace, *L. vulgaris*; one tooth has the characteristic curved and crenulated crown of the Rudd, *L. erythrophthalmus*; and there is a single vertebra, having the peculiar tubular neural arch found in the Eel, which is with much hesitation named *Anguilla* ? *vulgaris* ?

There is a series of small vertebrata from Grays Thurrock in the Brown Collection in the British Museum (No. 28,079), among which are remains of fishes referable to Pike, Rudd, and probably Dace.

Many otoliths of fishes have been collected by Mr. Clement Reid from Pleistocene beds on the foreshore at Selsea; they belong to about sixteen different forms, but none of them have been definitely recognized as of living species. It is almost certain that the greater number of these otoliths have been derived from the denudation of Eocene strata in the neighbourhood, and they cannot, therefore, be included among the British Pleistocene fishes.

The discoveries of Pleistocene fish-remains on the Continent have

[1] Brit. Assoc. Report for 1896.
[2] Proc. Roy. Soc., vol. lxi (1897), p. 45.
[3] Essex Naturalist (in the press, not yet published).

been even fewer than in England. Dr. Alf. Nehring,[1] in his "Uebersicht über 24 mitteleuropäische Quartär-Faunen," mentions the following:—From (1) "Westeregeln bei Magdeburg" (p. 474), *Esox lucius*; (2) "Die Räuberhöhle am Schelmengraben zwischen Nürnberg und Regensburg" (p. 488), *Silurus glanis, Esox lucius, Cyprinus carpio*; (3) "Der Hohlefels im Achthal bei Ulm" (p. 490), *Cyprinus carpio* (or *Perca fluviatilis*); (4) "Die Fuchslöcher am Rothen Berge bei Saalfeld" (p. 495), *Esox lucius*; (5) "Die Höhle von Balve in Westfalen" (p. 504), *Esox lucius*. The age of the specimens from the first two localities is doubtful.

Dr. A. Smith Woodward has kindly called my attention to Professor F. Bassani's[2] record of *Anguilla vulgaris, Cyprinus carpio,* and *Leuciscus aula* from beds at Pianico, Lombardy, which Dr. Forsyth-Major assures me are of early Pleistocene age.

British Pleistocene Fishes at present known,

With the Localities from which they were obtained and the Collections in which they are preserved.

B.M. = British Museum. M.P.G. = Museum of Practical Geology.
H. & K. = Collection of Messrs. Hinton and Kennard.

Perca fluviatilis, Linn. (Perch): Mundesley, Hornsea, Withernsea, Hitchin, Hoxne (M.P.G.).
Acerina vulgaris?, Cuv. & Val. (Ruff): Grays Thurrock (H. & K.).
Salmo sp. (? Trout): Mundesley (*fide* Lyell).
Esox lucius, Linn. (Pike): Erith, Hitchin (M.P.G.); Copford, Ilford (B.M.); Grays Thurrock (B.M. and H. & K.).
Leuciscus rutilus, Linn. (Roach): Mundesley ?, Hitchin, Hoxne (M.P.G.); Grays Thurrock (H. & K.).
Leuciscus vulgaris, Flem. (Dace): Grays Thurrock (B.M. and H. & K.).
Leuciscus erythrophthalmus, Linn. (Rudd): Hitchin (M.P.G.); Grays Thurrock (B.M. and H. & K.).
Tinca vulgaris, Cuv. (Tench): Hitchin (M.P.G.).
Anguilla ? *vulgaris* ?, Turton (Eel): Grays Thurrock (H. & K.).
Gadus morhua ?, Linn. (Codfish): Sewerby (M.P.G.).

II.—On *Belinurus kiltorkensis*, Baily.

By Professor Grenville A. J. Cole, M.R.I.A., F.G.S.

In 1899 Messrs. Rupert Jones and Henry Woodward[3] stated that *Belinurus* "has not at present been found in rocks of earlier age than the Coal-measures." *Belinurus grandævus*, described in the same paper, was referred, with probability, to the Lower Carboniferous. A writer ("R. W. E.") in the *Ottawa Naturalist*[4] for January, 1900, thereupon called attention to the record of *Belinurus* from the Kiltorcan Beds of Ireland. This record is founded on Mr. W. H.

[1] Zeitsch. d. Deutsch. geol. Gesell., 1880, p. 468, where reference will be found to the original records.
[2] Atti Soc. Ital. Sci. Nat. vol. xxix (1886), p. 344.
[3] "Contributions to Fossil Crustacea": Geol. Mag., 1899, p. 389.
[4] Quoted in Geol. Mag., 1900, p. 177.

Baily's discovery[1] of "a well-marked head (or carapace), to which is attached portions of two of the thoracic segments." Dr. Henry Woodward,[2] in 1878, accepted this determination, on the basis of sketches furnished to him by Mr. Baily, who had by this time discovered a second, though distorted, specimen. The Kiltorcan Beds, it may be remarked, are of Upper Old Red Sandstone age, and are part of the 'Yellow Sandstone Series,' which passes conformably up into the Lower Carboniferous Shale. They are not, therefore, of such high antiquity as the writer in the *Ottawa Naturalist* suggests.

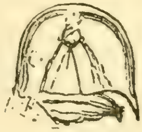
1   2

FIG. 1.—Sketch of the less imperfect specimen of *Belinurus kiltorkensis*, Baily, showing the principal features visible with a platyscopic lens. Natural size. The carapace is viewed from the under side.

FIG. 2.—Sketch of the distorted specimen, viewed from the upper side with the aid of a platyscopic lens. Natural size. The details of the central portion are best seen in this example, though the whole is greatly broadened.

The question having thus been raised, I obtained the permission of the Director-General of the Geological Survey to examine the specimens preserved in the collections in the Dublin Museum. Mr. Baily's specimens have, at some later time, been relabelled as 'Limuloides'; but the carapace is certainly not of the hemiaspid type. It presents the continuous unnotched margin shown in Mr. Baily's original drawing. The better specimen is, I feel confident, presented to us from the under side, and shows more detail than has hitherto been attributed to it. The flat border, 1 mm. wide, is followed by a smoothly curving region, from which the protuberances rise which correspond in part to the glabella in the trilobites. The form of these is best seen from the annexed sketches, which, like Mr. Baily's, have been made from the original specimens. The distorted example is seen both as an external cast and in relief, and the four elevated portions stand out distinctly on it. They seem to have been highest at their margins, a rim thus occurring about a depressed area on each. This feature is also seen in Mr. Griesbach's drawings of the better known species of *Belinurus*.[3]

The eyes indicated by Baily are based on a thickening that occurs on the edge of the 'glabella,' where it descends to meet the smoother lateral area. The evidence is slight, but agrees with what is already known of *Belinurus*.

There are indications of radial ribbings on either side of the

[1] "On Fossils obtained at Kiltorkan Quarry, Co. Kilkenny": Report Brit. Assoc. for 1869, p. 75.

[2] "British Fossil Crustacea" (Palæontographical Society), p. 238.

[3] "Brit. Foss. Crust." (Pal. Soc.), pl. xxxi.

'glabella,' like those that have been attributed to impressions of the limuloid limbs.

The 'pleuræ' (if we may use the nomenclature adopted in the case of trilobites, with which these forms provide so valuable a link) are furrowed, while in *Hemiaspis* (*Limuloides*) they are unfurrowed. Traces of three segments are preserved in the more perfect specimen. Even the somewhat abrupt posterior bend, so characteristic of the pleuræ of *Belinurus reginæ*, is noticeable in the first segment of *Belinurus kiltorkensis*, and was doubtless repeated in the others.

Protolimulus (*Prestwichia*) *eriensis*, described from the Devonian of Pennsylvania by H. S. Williams and A. S. Packard,[1] is only known by its under surface; but the cephalic shield does not resemble that of the Kiltorkan specimens.

I feel, then, that *Belinurus* may safely be regarded as occurring in the Upper Old Red Sandstone of Ireland, which some authors have proposed to include in the Lower Carboniferous Series. There seems no reason to depart from the determination made by Mr. Baily and Dr. Woodward thirty years ago, a determination that has become widely known through the works of Zittel and other palæontologists.

III.—History of the Sarsens.

By Professor T. Rupert Jones, F.R.S., F.G.S., etc.

Additional Notes.—These further references and fuller quotations are here given with the view of making the History of the Sarsens, or Sarsen Stones, more complete and more easily available, especially by indicating the chronological succession of observed facts and published opinions.

§ 1. Origin and Constitution of the Stones called 'Sarsens.'
§ 2. Fossils in Sarsens.
§ 3. Localities. I. In the Counties north of the Thames: (1) Northamptonshire, (2) Suffolk, (3) Essex, (4) Hertfordshire, (5) Buckinghamshire, (6) Oxfordshire, (7) Middlesex. II. In the Counties south of the Thames: (8) Kent, (9) Surrey, (10) Hampshire, (11) Berkshire, (12) Wiltshire, (13) Dorset, (14) Somerset, (15) Devon.
§ 4. Bibliographic List.

§ 1. Origin and Constitution of Sarsens.

(See also Part i in Wilts Mag., 1886, p. 126.)

1819. G. B. Greenough, in his "Critical Examination of the First Principles of Geology," p. 112, says that the Greyweather Stones ('Greywether sandstone,' etc., p. 293), scattered over the southern counties of England, have been evidently derived from the destruction of a rock which once lay over the Chalk.

1871. In the Transactions of the Newbury District Field Club, vol. i, p. 99, Sarsens are referred to as "indurated blocks of sandstones and conglomerates."

1882 and 1885. Sir Archibald Geikie, treating of siliceous cements in sandstones, writes, "where the component particles are

[1] Packard, "Carboniferous Xiphosurous Fauna of North America": Mem. Nat. Acad. Sci. Washington, vol. iii (1886), p. 150.

bound together by a flinty substance, as in the exposed blocks of Eocene sandstone known as 'Grey-weathers' in Wiltshire, and which occurs also [Landenian, sandstone] over the north of France towards the Ardennes" ("Textbook," 2nd ed., 1885, p. 162).

In a letter, Sir Archibald has obligingly stated that the first and best account on which the reference to the above was based is by Dr. C. Barrois, Ann. Soc. Géol. du Nord, vol. vi (1878–9), p. 366. See also his short paper in the Assoc. Française, 1879, p. 666. Gosselet quotes Barrois in his great work "L'Ardenne," 1888, p. 829. Further references are also given by these two authors.

1885. The Rev. A. Irving, taking it for granted that a large river in Eocene times flowed from a region of Palæozoic rocks in the west, in the direction of the Thames Valley to the east, said that the detritus would be quartzose and felspathic; the felspars would ultimately be decomposed by the agency of carbonic acid, and gelatinous hydrated silica would be produced. (Proc. Geol. Assoc., vol. viii, pp. 156, 157.)

1887. The Rev. A. Irving, in a letter dated March 6th, 1887, writes:—"You have overlooked one point which I have tried to bring out in some relief—the fact that the surface acquires a porcellanous texture, not due to cementation by iron (for from the superficial layer the iron is entirely leached out), but to an actual change of the material by a solution-process. I suggested (three or four years ago) CO_2 as the chief agent; but later work has shown me that the organic acids contained in *peaty* water have played a far more potent part in this sub-metamorphic change."

1888. In the GEOLOGICAL MAGAZINE, Dec. III, Vol. V, Dr. T. G. Bonney states that the Sarsens of the Tertiaries are of concretionary origin: "In the Sarsen Stones, and with matrix of the Hertfordshire Puddingstones, there is chalcedonic silica converting sandstone into quartzite" (pp. 298–300).

1888. J. Prestwich: "Geology," etc., vol. ix, p. 342. "These sands [of the Woolwich and Reading Series] also occasionally contain concreted blocks in irregular local beds of sandstone, sometimes with very hard siliceous cement." Footnote at p 342: "Mr. Whitaker and Prof. Rupert Jones think that in Berkshire and Wiltshire they [the Sarsens] are more frequently derived from the Bagshot Sands." The 'Puddingstone' of Bucks and Herts is here referred to the Reading Beds. Further on, at p. 364, it is stated that Sarsens occur in the Bagshot Sands of Frimley and Chobham.

N.B. — Concretionary action has produced in many Sarsens mammillations on a large scale, which show on some surfaces irregular, coalescent, smooth swellings, with shallow, valley-like slopes and depressions, like those on the so-called 'bowel-stones' of the Lower Greensand near Aylesbury. H. B. Woodward's "Geology of England and Wales," 2nd ed. (1887), p. 377. Such mammillated Sarsens occur in Suffolk, Wiltshire, and elsewhere.

N.B.—The convexity of the lower face of a Sarsen lying in its original sand-bed is due to the concretionary formation of the stone.

1901. J. W. Judd's "Note on the Structure of Sarsens" (GEOL. MAG., January, 1901, pp. 1, 2) gives definite descriptions of the intimate constitution of many Sarsens from authenticated localities.

N.B.—Besides the Tertiary sandstones, other and older white sandstones have yielded large and small blocks, now on the surface or in superficial deposits; for instance, Upper and Lower Greensand, Liassic sands, Millstone Grit, etc.

§ 2. Fossils.

(Refer also to pp. 142–147 of Part i in Wilts Mag., 1886.)

1871. Professor John Phillips, in his "Geology of Oxford," 1871, p. 447, states:—"I have never found shells in any of these stones lying in their native beds, and have some scruple in mentioning that they do occur in a layer in one of the blocks at Stonehenge. But, as I did not choose by chiselling that monumental stone to attract attention to it, probably it may for many years to come escape all injury except that which it must suffer from the strokes of time."

1878. In the churchyard of Sandhurst, a large Sarsen perforated with pipe-like holes lies at the foot of the old yew-tree there. (T. R. J., Trans. Newbury Distr. F. Club, vol. ii, p. 249.)

1887. C. C. King suggested that in the Avebury district the Sarsens were more particularly perforated by rootlets, and that, if so, the shoals or sandbanks formerly bearing the trees were better conditioned for the vegetation than other parts of the formation.

1888. J. Prestwich: "Geology," etc., vol. ii, p. 344. The indications in the Sarsens of the former presence of rootlets, possibly of Palms, are here mentioned.

1888. The same kind of fossil tubular marks in Sarsens may be seen in some blocks on the side of the Newbury-Hermitage road, or Long Lane, west of Coldash Common.

1897. Rootlet-holes, mostly vertical, occur in a Sarsen in a brickfield near Watford, Herts.—C. D. Sherborn.

N.B.—The perforations due to rootlets have been widened on the exposed surfaces of the stones by water-action and blown sand, so as to leave the surface variously pit-marked.—T. R. J.

N.B.—Analogous pipe-like remains of rootlets occur as long, small, vertical holes, in the Hastings sand-rock, East Cliff, Hastings (*Geologist*, vol. v, 1862, pp. 135, 136, fig. 9; and Geol. Mag., 1875, p. 589); in the Triassic (?) Sandstone of South Sweden; and in some of the estuarine, Jurassic shales of Yorkshire, near Whitby (A. C. Seward) and near Scarborough.—T. R. J.

§ 3. Localities.

I. (1) *Northamptonshire.*—1896. Mr. Edwin Sloper observed in a pit at the Northampton Brickworks at Blisworth a Sarsen that had evidently fallen from the base of the Drift overlying the Lias clay there. This Sarsen was to be cared for by being placed in the gardens of the Hotel at Blisworth. It consists of a white sandstone with siliceous cement, and with filamentous cavities, which are faintly stained with limonite.

(2) *Suffolk.*—1889. Sarsens are abundant in the neighbourhood of Nayland, at corners of cross-roads and elsewhere. Fine-grained

saccharoidal, and stained. Many with large and small tubular holes, some of which are split open and form furrows on the surfaces, often due to old natural splitting.

1889. Hartest Green, Suffolk. A large brownish Sarsen (5 ft. 8 ins. × 5 ft. 2 ins. × 3 ft. 6 ins.), much rounded (almost like a boulder), fine-grained and whitish inside, where wounded by blows of stones. Much pitted naturally on the outside. Flattened at the top, and worn smooth by boys' play. It was taken years ago out of a field now occupied by Mr. Griggs, and required eight horses to drag it. It is stated in a letter from a resident there that "it measures 12 feet round (probably touching the ground for 6 feet of its length), and about 4 feet across, weighing 5 or 6 tons." It is not alluded to as a boulder by the Committee on Boulders, etc. (British Association).

1889. At Newton Green there is a large Sarsen stone (4½ × 3 × 2 feet) by the side of the pond next to the "Saracen's Head" Inn, which shows on one side a 'bowelly' surface, and the other sides split flat.

1889. One stone (3 feet long) with bowelly surface, and with tubules, is at Frost Farm, Stoke, near Nayland. Near Nayland, at the corner of cross-road from Bures to Colchester, there is a Sarsen 7 ft. 6 in. long, roughly oval in outline. By the side of the high road near the Popsey bridge, a little east of the Anchor bridge, Nayland, a Sarsen standing on the bank (3 × 1½ feet) shows a natural surface with a large hole, also a boldly mammillated surface (bowelly). Its upper end and sides are split flat; lower end buried.

1889. In a letter dated Ipswich, September 12th, 1889, the late Dr. J. E. Taylor obligingly informed me, with regard to some Sarsen stones found at Ipswich, that "the Reading stone-bed specimen [not a Sarsen] is highly calcareous, but I have found no traces of Foraminifera in it. The mammillated stone is purely siliceous. . . . . The siliceous stones are abundant hereabouts; the others not so. I got them both [the stones referred to] during the excavation of the deep sewers in one of the streets of this town."

(3) *Essex.*—1896. T. V. Holmes: Proc. Geol. Assoc., vol. xiv, p. 190. A large Sarsen is here mentioned that has been removed from the Glacial Gravel at Writtle Wick, near Chelmsford. A note on the possible origin of the word Sarsen is also given.

1896. A. E. Salter: Proc. Geol. Assoc., vol. xiv, p. 394. In the Epping Forest gravel A. E. Salter noticed "Sandstones and Sarsens, both large, various, and plentiful. At Epping Forest I saw three, measuring 9 in. by 5 in., 12 in. by 6 in., and 20 in. by 5 in. respectively." In the high-level Glacial Gravel at Witherthorn, four miles east of Ongar, "large Sarsens (2 ft. by 1½ ft.)" (p. 395). At Woodton, in the Yare Valley, "a block of Hertfordshire Puddingstone was found" (p. 399).

(4) *Hertfordshire.*—1897 and 1899. The Rev. Alex. Irving describes both Sarsens and Herts Puddingstones as common in the Stort Valley (Herts and Essex). He refers both to the Bagshot Series, the latter particularly to the Pebble-beds; and he states that both rocks are agglutinated by the same kind of siliceous cement

(Proc. Geol. Assoc., vol. xv, pp. 196 and 236). He duly mentions that Mr. Whitaker regards the Hertfordshire Puddingstone of the neighbourhood under notice as having, in part at least, been consolidated pebble-beds of the Woolwich and Reading Series, like those at Addington, near Croydon. See also Mr. Whitaker's Address to the Herts Nat. Hist. Soc., Proc., vol. x, pt. 4 (September, 1899), p. 116.

(5) *Buckinghamshire.*—1890. A row of coarse, gravelly Sarsens lies along the side of the road up to the church at Badenham. They were placed there by the Rector, who said that such stone underlies the Rectory house and lawn close by; and some blocks of it were still lying about there. In the church tower, up along the re-entrant angles of the buttresses and tower, numerous ordinary fine-grained Sarsens are built in with the flint-work. Professor Prestwich said, June 21st, 1890, that the coarse-grained Sarsens at Bradenham came from the base of the Tertiaries.

In Buckinghamshire Sarsens are known as 'Wycombe stones,' and in the Bagshot district as 'Heath stones.'

(6) *Oxfordshire.*—1871. Professor J. Phillips regarded the Sarsen stones as concretionary portions of extensive sand-beds once overlying the district with its previously excavated Chalk valleys. The loose sands were carried away by denudation, and the solid portions suffered displacement. Some containing flint pebbles and fragments lie on the north side of the Wiltshire downs. Some large Sarsens are found in the Drift, for instance at Long Wittenham, near Abingdon. See his "Geology of Oxford and the Valley of the Thames," 1871, pp. 447 and 462.

(7) *Middlesex.*—1891. Horace B. Woodward, in the GEOL. MAG., Dec. III, Vol. VIII, pp. 119–121, succinctly described a very large Greywether, of irregularly quadrangular form, that was found lying in the London Clay, at the bottom of the Thames Valley Gravel, at Moscow Road, Bayswater, in enlarging the cellarage of the "King's Head." It was 9 ft. 6 ins. long, and at least 2 ft. 8 ins. thick. Mr. H. B. Woodward remarks that Sarsens have been found in many places at the same horizon in the base of the Thames Valley Gravel—at the Law Courts in the Strand, and near Kew Bridge; at Ealing in the Brent Valley; at Ilford, and at Grays; but not usually of large size nor common. He notes also that Sarsens and Hertfordshire Puddingstone occur in the Brickearth in Buckinghamshire, derived in Glacial times from the wreck of Woolwich Beds and Bagshot Sands. The Thames Valley got its gravel mainly from the Glacial Drift. The Bayswater Sarsen is six miles distant from nearest known Glacial Drift; and, he says, "it is quite possible that this particular block may have been derived directly from an outlier of Bagshot Sands, or it may have been left as a relic of Preglacial denudation near the spot where it has now been found."

1895. At the Grove, Stanmore (the residence of Mrs. Brightwen), large Sarsens have been collected from the neighbourhood and made into a grotto. One slab measures about 6 × 3 × 2 feet; another, about 6 × 6 × 2 feet. The surfaces of these two large slabs have been deeply scored by running water, and pierced in all directions by rootlet and other holes.—C. D. S.

1896. In the Proc. Geol. Assoc., vol. xiv, p. 158, Mr. Allen Brown states that "a large tabular water-worn Sarsen, and a portion of it broken off in Quaternary times," were found in the gravel at Hanwell; and that another Sarsen occurred at the base of the gravel at the back of Hanwell Station.

1900. In "The Pits," old gravel workings, an allotment, now wooded, belonging to William Sherborn, Esq., and formerly part of Bedford Common, Middlesex, there is a large Sarsen, measuring about 5 × 5 × 2 feet, from one end of which a block about a foot thick was removed.—C. D. S.

1900. In front of the roadside inn (the "Griffin") at Totteridge or Whetstone, near Highgate, stands a short thick Sarsen, about 25 inches high above ground, and 20 inches broad at top and 18 inches below. It is locally said to be as large again below the surface; and to have been used as a 'whetstone' for their weapons by the soldiers going to the Battle of Barnet (1471).—A. O. Brown.

1900. Horace B. Woodward describes a Greywether from the Gravel of South Kensington, in the Geol. Mag., December, 1900, p. 543 (with figure). It measures 3 ft. 10 ins. × 3 ft. 3 ins. × 2 ft., and is in many respects analogous to the specimen from Bayswater described above. A smaller one has just been found on the same spot (January 23, 1901).

(To be continued.)

IV.—Some Geological Notes on Central France.

By M. S. Johnston.

(PLATES II–IV.)

I THOUGHT, perhaps, some readers of the Geological Magazine might be interested in a few notes taken during the International Geological Congress excursion to the Massif of Central France and the region of the Causses, and on the chief rocks there, with the best places for finding examples.

By making Clermont Ferrand a starting-point, the Puy de Dôme may be visited first. The road winds its way up from the extensive plain of Limagne. This plain, of Tertiary age, extends all along the foot of the Monts Dômes from Brioude to the Loire. It is formed by an alluvial deposit left by an ancient lake of the age of the Paris Basin, whose waters at periods of high level probably flowed into Lac Limagne. The Monts Dômes rise abruptly from this plain, their basalt flows forming in places precipitous cliffs.

At Royat, the great basalt flow of Quaternary age is reached, at the foot of which abundant mineral springs gush out. On either side of the lava rise rounded hills of granite; the typical granite of these hills is grey and coarsely crystalline.

The Puy de Dôme is composed of trachyte. The typical rock contains large crystals of sanidine, and is very acid, having 62 per cent. of silica. M. Michel-Lévy is of opinion that the trachyte is a dyke which has been buried in the scoria, projected from the crater, of which every vestige has been obliterated. On the north side of the Puy de Dôme there is a curious sandy scoriaceous deposit, containing small rounded grains and specular iron. The grains are considered by M. Michel-Lévy to be lapilli from the volcano. Down the side of the Nid de Poule there is a large deposit of scoria and bombs of various forms.

The Puy de Pariou is a scoriaceous cone, with an immense lava stream of andesite flowing round the eastern side of the cone to the basaltic plateau of Prudelles, which imposed so great a barrier that the stream divided and flowed down to the Limagne plain on either side of the plateau. Between Puy de Pariou and Prudelles, at Le Cressigny, a cordierite gneiss may be found, while the Pliocene basalt of Prudelles contains zeolites.

Proceeding from Royat by train to La Bourboule, the confines of Mont Dore massif are entered upon. The line runs round the north of the Monts Dômes. At Volvic a fine andesitic stream is crossed; this stone is much quarried for building purposes, whose durable qualities are well seen in the cathedral of Clermont Ferrand.

On arriving at La Bourboule, the first section of interest is at a short distance from the station at Lusclade, where rhyolites, perlites, phonolites, and trachytes are found. One section of rhyolite, facing the road to Mont Dore and at a small gorge, shows remarkable stratification, the rhyolite being of two kinds, glassy and fibrous. Up the gorge the rhyolite becomes perlitic, and masses of ophitic basalt from the heights above have fallen into the bed of the stream. Phonolites without nepheline, with nosean and haüyne, are found a few yards further to the south.

The district of Mont Dore is formed by two principal centres of eruption—one at the Pic de Sancy, the other between the Banne d'Ordenche, Puy de la Croix Morand, and Puy de l'Angle, overlooking the gorge mentioned above. The Pic de Sancy is trachytic, and fine porphyroidal trachyte may be found on its northern slopes. In the ravines of the Grande Cascade and Egravat remarkable sections are seen, tuffs and conglomerates of trachyte or andesite alternating with compact flows of different rocks, as trachytes, andesites, basalts, and labradorites.[1] The greater part of the massif is formed of materials of every size from fine cinerites to conglomerates.

Cinerites containing vegetable remains are well exposed on the west side of the valley of the Dore, to the north-west of Mont Dore les bains. At the Ravin de la Grande Scierie is an interesting example of denudation and successive volcanic phenomena. The bottom of the ravine is of cinerite, which rises on either side and is capped by porphyritic trachyte. After the first erosion of the valley a stream of lava poured down it, partly filling it, and which was in its turn eroded and has left its mark in a bank of andesite on both sides of the ravine. A little further on is a basaltic dyke rising

[1] A labradorite of French geologists is a basic andesite of English geologists.

FIG. 1.—The Orgues de Bort, left bank of the Dordogne.

FIG. 2.—Promontory of Basalt, Carlat.

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as an isolated hill in the centre of a circular valley. This is the Roche Vendeix.

After traversing some woods the road opens on to a fine panorama, an immense circle bounded by the mountains of Mont Dore, the Cantal and Cézallier, and the hills of lesser heights, the Orgues de Bort and the Limousin. The village of Latour is built on a basaltic promontory. The columns of basalt are magnificent; their broad tops serve as excellent foundations to the houses, and are especially well seen in the small hill, on which once stood a castle.

Here the road descends into the valley, and the scenery is changed. Rounded and striated hills of granite betoken the presence of ancient glaciers, and between them stretch marshy fields of peat, whose undersoil is formed of scratched pebbles and erratic blocks of every size. The glaciers were of Pliocene age and when the volcanoes of Auvergne were at their highest. The glaciers have scooped out curiously shaped valleys, and the moraines lie along successive hills, whose contours are rounded and lowered as far as La Pradelle, when the materials spread themselves out over a flat tableland, which constitutes the plateau of Lanobre and extends to the Orgues de Bort, whose precipitous escarpment dominates the left bank of the Dordogne. It may be added that at Bagnols erratic blocks, forming immense heaps, repose on rounded, polished, or striated cordierite gneiss.

From Bort a short drive brings one up to the Orgues de Bort; these 'orgues' are of phonolite (Pl. II, Fig. 1). A cap of phonolite, rising in immense columns, overspreads a hill of augen gneiss. Many of the 'eyes' in this gneiss are very large and in regular and continuous layers.

The view from this hill is very fine. The massifs of Mont Dore and the Cantal are both seen; the Dordogne and the Rhue have cut narrow precipitous valleys on the north and east, but on the south, after the junction of the two streams, the valley widens and there are some small glacier-formed lakes, which are filling with peat.

On leaving Bort by train for Aurillac the line, a marvel of engineering skill, winds between the spurs of the Cantal, which the train crosses, ascends, and descends in constant succession. Before reaching the slopes of the Cantal a small Carboniferous deposit is crossed, in which mines are worked at Champagnac.

Aurillac is built on the banks of the Jordanne, and on crossing the railway to the south of the town the alluvial terraces of Quaternary age, with the rounded hills of mica-schist rising above them, are very noticeable. There is also in this valley other evidences of glacial action, and at Vezac a Quaternary moraine is prominent, forming waterfalls and rapids in the small stream.

The next interesting section on the road to Carlat is an andesitic conglomerate at Cabanes. This conglomerate is found in great blocks amongst tuffs and andesitic dust, and forming a high hill. The theory concerning this deposit is, that it may be the projection of what was the last effort of the volcano. From this hill is also seen a wonderful promontory of basalt. This promontory is formed of very regular columns and overlies a Pliocene river bed, situated some hundred feet above the valley of the Goul. The basalt is breached in places; the largest, as seen in Pl. II, Fig. 2, has caused the andesitic breccia below to be seen.

After leaving Carlat the road takes a sharp turn to the south, and a section of cinerite, with loose felspar crystals, is found near the top of a hill overlain by concretionary Miocene sand.

The road now continues around the southern spurs of the Cantal, which presents new vistas of beauty at every turn, and on reaching Curebourse a magnificent panorama of the valley of the Cére is obtained. At a short distance from Curebourse and above Vic-sur-Cére is the celebrated section of Mougudo of compact cinerite, containing fossil plants. About twenty-two species of plants have been found there, in the shape of leaves, twigs, trunks, and wood opal.

The road now follows the valley of the Cére, where there is an abundance of volcanic breccia, mostly capped by columns of basalt. At Thiezac, near St. Jacut, is a noticeable section across the valley and one which may be easily distinguished at sight. On the north-west side the highest rocks are of andesite, then a band of porphyritic basalt, beneath this a mass of breccia, with dykes of andesite and labradorite overlying the mica-schists. The formation of the small hill, on which stands a white statue of the Virgin, is a dyked breccia, while on the south-east side of the Cére rises a dome of trachyte and phonolite, tilting the breccia containing andesite and cinerite dykes, and capped by andesite and Oligocene basalt.

The two most striking features now in the landscape are the peak of the Puy Grion, a weathered phonolite dyke on the left, and the Plomb du Cantal, the highest summit in this region, and situated on the edge of the crater ring on the right. The lateral ravines and the flanks of the cirques are riddled with dykes, as are also the cliffs along the valley of the Allagnon, which is reached by the tunnel of Lioran, three-quarters of a mile long.

At a waterfall not far from Lioran a trachyte called the 'roche de deuil' is to be found, and at Laveissière, a short distance further on, the base of an ancient volcano may be seen resting on Oligocene limestone. The Rocher de Bonnevie rises in successive tiers of basaltic columns above the town of Murat, and there is also a fine example of columns, showing various directions of contact cooling in the hill below Brédon church. In the village of Brédon are cave dwellings, which were inhabited as late as fifteen years ago.

From Murat a good excursion can be made to the Puy Mary (Pl. III, Fig. 3). The road leads up the valley of the Chevade to the Col d'Entremont, where there is a large exposure of augitic andesite, with haüyne, which is used for tiles. Many of the specimens are good sounding clinkstones. At this point the road descends and crosses the valley of the Dienne, which has its origin at the foot of the Puy Mary, and is a good example of a glacially and aerially denuded valley.

FIG. 3.—Puy Mary and the Valley of the Dienne.

FIG. 4.—Phonolite Hills in the Megal, Velay.

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The peak of the Puy Mary is capped by an andesite, with porphyritic felspars and hornblende, overlying a band of porphyroidal basalt, which is situated on a mass of breccia; the whole three deposits being dyked by phonolite, basalt, and andesite. From the top of this Puy a fine view of the crater of the Cantal is obtained. The Cantal massif was formed by one crater, the remains of which may be traced from the Puy Mary; its ring is eight miles in diameter, the highest points being the Plomb de Cantal, the Puy Mary, and the Puy Chavaroche. In the centre of the crater are several cone-shaped hills of phonolite, the Puy Grion being the highest. These are weathered dykes, phonolite having the peculiarity of weathering into cones, as will be observed in Pl. III, Fig. 4 of the phonolite hills of the Megal district.

The order of deposition in the Cantal region is—Miocene basalt, trachyte, and phonolite; andesitic breccia; andesitic and phonolitic flows; and finally, the plateau basalt.

On leaving the Cantal district and proceeding by train to Le Puy, another volcanic area may be studied, that of Velay. The chief points to be noticed along the line are the union of Quaternary moraines from the valleys of the Allagnon and Allange at Neussargues, and at Merdogne a remarkable basaltic rock overspreading cinerites, containing Miocene flora; at this point also the valley casts off its glacial character, and narrows itself between walls of gneiss, often amphibolic. At Lempdes the plain of the Limagne is reached, but soon the line turns to the south, and after Arvant it passes over some part of the Oligocene plain and then on to the gneiss again. At Darsac is to be seen a characteristic view of the plains of basalt, with the scoriaceous cones of the axis of the Velay chain in the distance.

The plain in which Le Puy is situated bears striking evidence of the wearing away of volcanoes. In the centre are two isolated rocks of breccia, the Roches Corneille and Aguilhac, surrounded by Oligocene deposits. From the Roche Corneille is seen the plain, whose edges rise on all sides in terraces and hills, first of ravined Oligocene deposits, then of volcanic remains. Over the hills to the south and east are the Mezen and Megal peaks. On the north, in the middle distance, is a small volcano which has been cut in half; the crater pipe and outer slopes can still be clearly traced. The hills of Polignac and Denise are both of interest. At Denise the hill is composed of a pipe of scoria, often containing granite, and two varieties of breccia, one of Middle Pliocene age, the other of the age of *Elephas meridionalis*: in the latter was found the 'Man of Denise,' but how he got there is still a vexed question; his skeleton has been placed in the Le Puy Museum.

The Loire flows along to the east of Le Puy, but in early Quaternary times the principal river flowed away to the west on the south of the town.

The Megal and Mezen district is one of the most interesting round Le Puy. This region is the oldest volcanic area of the Velay, and is composed almost entirely of basalt and phonolite; indeed, the latter is so abundant that it is called 'le pays des phonolites,' and the rock gives a characteristic appearance to the landscape (Pl. III, Fig. 4). Some of the best sections for obtaining it are at Lardeyrol, specimens without nepheline; at Mont Pidgier, containing a vast quantity; at Boussoulet and Montvert, a phonolite rich in nepheline and ægyrine; near Estables the 'rocher d'Aiglet'; and the Mezen peak itself is mainly composed of this rock.

On the road from Le Puy to Blavozy are several excellent sections of arkose of Eocene age and Oligocene sandy clays and spotted marls, while at Blavozy itself there is a very large deposit of arkose, in which great crystals of orthoclase from the older granite appear. At Queyrières is found a good Miocene trachyte.

There are a few glacial lakes in this district, the chief one being that of St. Front, crater-form in shape and worn in the basalt.

Large crystals of orthoclase and hornblende can be picked up in the labradorite tuffs of Besseyre, many of the hornblende crystals being very nearly perfect in shape. Between Coubon and Le Puy may be noticed the lava streams from the Mont Jonet of Quaternary age, overspreading those of the Garde d'Ours, which was an active volcano in Pliocene times.

The geologist may now, if he chooses, pass from the land formed by the internal fires to that deposited in the waters, by driving from Le Puy to Mende, a distance of ninety-two kilometres. One first traverses igneous and metamorphic rocks as far as Mont Lozère, at which point the Liassic and Jurassic plateaux are reached, and where the road makes a rapid descent into the valley to Mende.

The rocks to be noted *en route* are first the bombs containing peridotite found in a cone at Tarreyre. Basaltic plateaux are crossed until one arrives at Langogne. The hills on the west side of the valley of the Allier are of porphyritic granite; here the felspathic crystals of orthoclase are very large.

From Chateauneuf de Randon one perceives the Causses, of Secondary age, rising against the crystalline mass of Mont Lozère. The Causses are immense undulating barren plateaux of limestone of Jurassic age. There are frequent depressions called 'sink-holes,' and the whole country from Mende to the Cevennes on the south is supposed to be riddled with caverns; some with underground streams, as at Bramabiau and Padirac, others, where there is an entire absence of running water and where they are slowly filling with stalactitic materials, as at Dargilan.

Pl. IV, Fig. 5 is a view taken from the pathway up to Dargilan, the entrance of the cave being at the top of the cliffs in Middle Jurassic dolomitic limestone; the rounded formation on the top of the precipitous cliff is of Kellaway age. The Causses are also cut up by cañons, that of the Gorge de Tarn being the largest. The river of this gorge is fed by underground springs, and its sides are weathered out into pinnacles and buttresses.

In the Dourbie gorge, not far from Milhau, is Montpellier-le-Vieux. The limestone on the top of the Causse Noir has been worn away either by weathering or, as some think, by underground

Fig. 5.—Below the Cave of Dargilan, Middle Jurassic Limestone.

Fig. 6.—Tindoul 'Puit,' leading to the underground river near Rodez.

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streams and afterwards aerial denudation. Here is the most wonderful representation of an old city, with its ramparts, castles, and halls; there are, of course, many fantastically sculptured rocks, but the Chateau Gailliard is a marvel, of which only the eye can form any idea.

At Eglazine, in the Tarn gorge, is a basalt flow which has half filled a denuded volcanic neck of breccia. In the basalt, which is Pliocene in age, are large crystals of augite and inclusions of olivine. The breccia also contains well-developed crystals of various minerals.

The Tindoul (near Rodez) and Padirac (near Rocamadour) caverns have very deep holes or 'puits' to the entrance of the underground galleries. The one at Padirac is 245 feet; the Tindoul is a little less (Pl. IV, Fig. 6).

The Bramabiau is situated near the east and west fault which brings up the crystalline rocks of the Cevennes above those of Jurassic age. This fault is very well marked by the configuration of the country, as to the north of it are the table-like causses, to the south rises the jagged outline of the Cevennes. The Cevennes are the watershed of the Mediterranean and the ocean rivers, and their south-east and north-west slopes present different aspects. From Mont Aigoual, on the south and east, are seen narrow and steep gorges in endless successions; the spurs of the mountains, running out in long rows, give the appearance of waves of the sea. On the north and west the valleys are broader and less steep, and the mountains have flatter tops.

Mont Aigoual is formed by a granite intruded into the Cambrian sandstone, which has been metamorphosed into gneiss and schists. The granite is porphyritic, containing large orthoclase crystals, sometimes four or five inches long.

An excursion to these parts may be ended at Rocamadour, a curious little village clinging to the precipitous side of a cañon and celebrated during many centuries for its pilgrimages.

V.—On an Insect from the Coal-measures of South Wales.

By H. A. Allen, F.G.S.

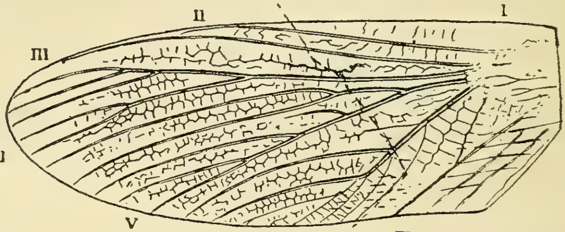
THE rarity of insect remains from the Carboniferous rocks of the British Isles is demonstrated by the small number of genera and species included in the lists published by such authorities as Dr. Henry Woodward[1] and Mr. S. H. Scudder.[2] A portion of a wing, with a neuration unlike that of any specimen yet described, having recently been exhumed, it may be deemed not unworthy of notice.

The specimen was obtained by Mr. G. Roblings from the top of the four-foot seam in the Lower Coal-measures of Llanbradach Colliery, Cardiff. A fragment of shale split into two pieces exposes nearly the whole of a wing lying almost flat; the distal portion of

[1] Quart. Journ. Geol. Soc., vol. xxxii (1876), p. 63. Geol. Mag., 1887, p. 49, Pl. II; ibid., p. 433, Pl. XII.

[2] Mem. Boston Soc. Nat. Hist., vol. iii (1883), pp. 213–224.

it, as far as the broken line in the figure, is seen on one half of the shale, and a little more of the basal part on the other. The base is wanting, and what remains of the basal portion has suffered much injury. The length of the fragment, measured from the apex, is 41 mm., and the greatest breadth of the wing, measured from the costal to the posterior margin, is 13 mm.



Wing of *Fouquea cambrensis*, n.sp., from the Coal-measures of South Wales. × 2.

The costal nervure (the *vena marginalis* of Heer), numbered I in the Figure, is marginal.

The subcostal (*v. mediastina*), II, is simple, and is situated about midway between the costal and the anterior branch of the radius. It curves gently towards the costal margin, and dies out at about 12 mm. from the apex of the wing.

The radius (*v. scapularis*), III, is bifurcated near the base; its anterior portion is simple, curves gently towards the costal margin, then turns rearward, and dies out near the apex of the wing. The posterior portion of the radius is situated slightly in advance of the long axis of the wing, and runs nearly in a straight line towards the apex. It gives off a bifurcated branch at 15 mm., a simple one at 10 mm., and a second simple branch at 8 mm. from the apex of the wing. All these branches of the posterior portion of the radius reach the posterior margin of the wing near the apex.

The median (*v. externo-media*), V, is forked at a short distance from the base; the anterior branch runs parallel with the radius for a distance of 6 mm., and then divides into two minor branches, which reach the posterior margin by a slight curve. The posterior branch of the median runs straight towards the margin, produces a few branchlets, and, 9 mm. from its point of bifurcation, sends an offshoot direct to the margin; 4 mm. further the branch bifurcates. All the branches of the median join the apical half of the posterior margin.

The cubitus (*v. interno-media*), VII, is directed towards the middle of the posterior margin until within a distance of 2 mm., where it turns sharply in the direction of the apex. A simple branch is given off at 5 mm. from the margin, and a few branchlets may be seen running out from the main branch.

Nearer the base faint indications of nervures occur which may form the anal system (*v. analis*), IX, but, on account of the injured condition of the wing, their origin cannot be traced.

Over the areas between the principal nervures there is a delicate reticulation. No transverse nervules are present, with the exception of a few faint traces in the costal area. The specimen assumes the colour of the shale in which it is embedded.

Of the few wings known from the British Carboniferous rocks, those of *Lithomantis carbonaria*, from the Coal-measures of Scotland, described by Dr. H. Woodward,[1] to a certain extent resemble our specimen, but differ in the shape of the area situated anteriorly to the subcostal nervure, i.e. the costal area, which in *L. carbonaria* is narrow near the base and increases in width towards the apex, whilst in our specimen the reverse obtains. The difference in the shape of the wing and in the neuration will not admit of the specimen above figured being referred to *L. carbonaria*, H. Woodw.

For corresponding reasons this new specimen cannot be placed with *Lithomantis Goldenbergi*, Ch. Brongn.,[2] notwithstanding the fact that the costal area is somewhat similar in shape. The posterior or branched limb of the radius is situated much further from the anterior margin than in either of the two species of *Lithomantis* mentioned, and bears fewer branches.

Gryllacris (*Corydalis*) *Brongniarti*, Mant., from Coalbrookdale, differs from the South Wales specimen in its neuration, especially in the radius, which bifurcates much nearer the apex of the wing, and also in the transverse nervules, which are strongly marked.

In the simplicity and general appearance of its neuration our wing much resembles *Dictyoneura sinuosa*, Kliver,[3] but in that species the important subcostal nervure is directed towards the apex and does not curve towards the costal margin. M. Kliver's specimen lacks both base and apex, and therefore the above-mentioned character may perhaps be deceptive.

The genus *Fouquea*, to which our specimen may be referred, is described by Ch. Brongniart,[4] who states that "it agrees with *Lithomantis* in its neuration, but differs greatly in the reticulation; the nervules which unite the nervures are so numerous that they anastomose and form a veritable network."

The shape of the wing, the position of the longitudinal nervures, and the reticulation in our specimen bear a general resemblance to *Fouquea Lacroixi*, from Commentry, but neither of the two species figured by C. Brongniart[5] exactly agree with it, since in both of them the branches running from the principal nervures to the posterior margin are more numerous. The cubitus also shows a considerable difference.

The specimen differs from any described form that has come under my notice, more especially in the cubitus. The injury to the base of the wing is most unfortunate, and it is consequently impossible

[1] Quart. Journ. Geol. Soc., vol. xxxii (1876), p. 60, pl. ix, fig. 1.
[2] Rech. Insects Fossiles, pl. xxxvii, figs. 1, 2.
[3] Palæontographica, Bd. xxix (1883), p. 260, t. ii, fig. 4.
[4] "Rech. Insectes fossiles des Temps prim.," p. 372; St. Etienne, 1893.
[5] Op. cit., pl. xxxv, figs. 10, 11.

to trace any of the principal nervures to their source, but the wing is otherwise in a good state of preservation.

It will be placed, provisionally, in the genus *Fouquea*, Ch. Brongn., and, in order to note the principality in which the wing was found, I propose the name *Fouquea cambrensis*.

The specimen has been presented to the Geological Survey Museum, London, by Mr. Roblings.

VI.—Recent Denudation in Nant Ffrancon, North Wales.

By Edward Greenly, F.G.S.

READERS of this Magazine may remember that early last August there were descriptions in many provincial and even in some London newspapers of an extensive 'landslip,' which had occurred on the side of the mountain called Carnedd Dafydd, on the eastern side of the valley of Nant Ffrancon, in North Wales. The impression conveyed was perhaps somewhat exaggerated, and yet the phenomenon was on a scale quite large enough to be of geological importance.

In a brief but vividly written article in the Geological Magazine for January, 1900, my friend Mr. J. R. Dakyns described a number of cases of denudation on an important scale that had come under his observation. It may be well, therefore, in the same way, and under a similar title, to preserve a record of this landslip. There was almost incessant rain from the 5th to the 10th of August, with streams all in heavy spate and floods in many districts, and on August 6th (I believe) at about 4 p.m. two torrents broke out on the side of Carnedd Dafydd, carrying with them a great deal of debris, and blocking the road in the valley for many yards. The spot is on the eastern side of the valley, nearly opposite the house called Pentre, shown on the Geological Survey and old Ordnance Maps.

The mountain side here is composed of the Bala volcanic series, alternations of various igneous rocks with hard grits, resting, with a south-easterly dip, upon a thick mass of softer and rather homogeneous black slates. The volcanic series form a great range of crags along the brow of the mountain some hundreds of feet in height, cut into huge buttresses and deep recesses, while the dark slates give rise to long uniform steep slopes extending from the foot of these crags to the bottom of the valley, and along them the road is carried at a height at this point of about 200 feet above the alluvial plain. These slopes are covered with great sheets of scree, resting upon loose glacial debris, which, though rising here and there into moraine-like mounds, have for the most part, and at the point where the landslip occurred, a pretty uniform slope.

As we pass up the valley from the north we see nothing but two streams of stones, grey and fresh-looking, near the road. They do not extend far up the slopes, and appear, indeed, rather insignificant; but this is due to the great depth of the valley, and when we arrive at the place where they cross the road they are much more imposing in appearance. From this point we see that they are fans of debris spread out at the ends of two long channels, which, light grey and evidently quite newly cut, are conspicuous features all down the slopes from the foot of the crags. The northern one can be traced by the eye a little way up into the crags themselves, but from below we cannot tell whether the two channels, which disappear behind a great rocky buttress, have or have not a common origin.

The northern stream of debris crossed the road, broke down the wall, and poured over on the other side a fan or cone of great stones all the way down to the alluvial plain, while the finer material was spread out upon the alluvium itself, and some even reached as far as the river Ogwen. This fan is about 58 yards wide at the road, and begins a considerable distance above it, the angle at its top being a moderate one.

Some of the debris is very coarse. I measured one block of felsite $12 \times 6 \times 4$ feet, standing on its narrow side, a little way above the road. How far this had been carried by the torrent, I do not know; it may have been embedded in the drift before, but from its position on the fan it must have travelled a good many yards.

The southern stream crosses the road about 175 yards further on, and is about 33 yards wide at that place. It is more conspicuous in the distance than the other, and the amount of material at the road is very great, but it does not go so far down into the valley, the debris stopping on the steep slopes and not reaching the alluvium.

Above these fans the work has been wholly erosive. At the head of the northern one the channel cut in the drift and scree seemed to me to be more than 20 feet deep, and I think that it was cut down to the solid slate here and there. On the steep rocky slopes at the crag's foot the gully had been swept very clean and white. Whether the erosive work affected solid rock as well as drift, I cannot tell. I saw no sign of a rock-fall in the crags, and to ascertain whether there was any it would be necessary to go some way up into the gully. The material of the fan, however, did not seem to me quite angular enough to suggest any great fall of solid rock, considering the short distance of transport.

Whether this be so or not, it is clear that torrential denudation, the work of only one afternoon, and probably of a very short time in that afternoon, has cut channels through 20 feet or more of drift and scree on the mountain side, moved blocks of felsite of as much as 288 cubic feet, and spread out fans of stones and debris a quarter of a mile in length.

The fans and channel would be well worth being photographed. In the *Windsor Magazine* of November last there is an account of a disaster near Driffield in the Chalk wolds of Yorkshire, said to have been caused by a 'waterspout.' The article is illustrated by photographs, not only of damage to buildings, but of channels and fans of debris very like these; and the point of origin is there quite clear. These views, indeed, are of considerable geological interest.

In view of the great importance of the subject of denudation, it really seems a pity that instead of occasional papers, there should not be some kind of regular organization for collecting and recording descriptions of what is actually going on at the present time.

VII.—Alleged Prints of Echinoderms in Triassic Reptiliferous Sandstones.

By F. A. Bather, M.A., D.Sc., F.G.S.

In the Geological Magazine for January, 1901 (n.s., Dec. IV, Vol. VIII, pp. 3, 4), Professor Burckhardt describes certain markings in the sandstone matrix of specimens of *Hyperodapedon* and *Rhynchosaurus* in the British Museum, from Elgin, Shropshire, and Warwickshire (the last, however, not being, as implied by the legend to the figure, represented in the Museum). He believes that these are hollow imprints "left by Echinoderms of a Euryalid shape, having peripheral arms, either simple or forked," but he appeals to specialists to decide to which group of Echinoderms they are due. Since these marks are said to be exceedingly numerous, and since Dr. Burckhardt uses them as evidence of contemporaneity, I thought it my duty, as the specialist nearest at hand, to examine these statements without delay.

Any student of Echinoderms would probably gather from Professor Burckhardt's description that the impressions were those of Pentacrinid columnals, with a pentagonal lumen, and with occasional cirri. The outlines drawn by Dr. Burckhardt do not really agree with that of the disc of a Euryalid ophiuran, nor does the paucity of alleged arm-structures confirm that suggestion. The asserted abundance of the pentagons also favours the idea that they are due to Crinoid columnals, for many sandstones filled with imprints of those structures are known from all parts of the world and all ages, including the Trias. The only difficulty that a reader would find in accepting this conclusion would be, that these immensely numerous and by no means minute appearances have escaped the notice of all the eminent geologists and palæontologists who have devoted to these sandstones the most anxious and pertinacious scrutiny.

Examination of the actual specimens, in which I received the kind help of Dr. A. Smith Woodward, has led to very different results. In common with those of my colleagues whom Professor Burckhardt endeavoured to convince, I am absolutely unable to distinguish the appearances described and drawn by him. Anyone that looks long enough at a rough sandstone surface can make out as many patterns as there are faces in the fire. But a scientific question is not to be decided by the vote of a majority, and the fact that we cannot see may only show that our senses are deficient. Fortunately there is other evidence.

Professor Burckhardt himself adduces the "hollows left by Elgin reptiles" in favour of his interpretation. But these hollows are all quite smooth and are iron-stained darker than the matrix, in these respects resembling the hollows left by Echinoderm fragments in many another sandstone. Moreover, the fractured rock surfaces of the British Museum specimens under discussion do show imprints in places, whether of dermal armour and scales, or abdominal ribs, or perhaps fragments of some other creatures; and all the markings clearly recognizable as of organic origin have a smooth surface. But wherever or whatever the markings perceived by Dr. Burckhardt may be, their whole surface is admittedly rough with "the coarse grains of the sand," and they show no distinctive colour.

"In size" these impressions are said by Professor Burckhardt to "vary between 3 mm. and 3 cm. in diameter." Now Echinoderm plates or tests of this area must have had an appreciable thickness, and this thickness would be manifest in their hollow casts, since the rock has undergone no extraordinary pressure. Therefore the spaces should be visible in section wherever the rock is broken at a sharp angle. But Dr. Burckhardt, who had a piece of the matrix specially chipped off for examination, will doubtless admit that such is not the case.

If the matrix did contain impressions or moulds of Echinoderm objects of the nature described by Professor Burckhardt, one would certainly expect to find them lying roughly parallel to the plane of stratification, and we are indeed told that these bodies are "all of them lying in the same plane as the skeleton of *Hyperodapedon*." But the skeleton in question is a large, irregular object, and the exposed surfaces along which the matrix has been fractured are not in any one plane, but lie at various angles. There is no trace of lamination, and if any objects ever did lie on the rough fracture-surfaces, they must have been deposited in most irregular fashion, and the sandy floor of the Triassic lagoon in which these reptile skeletons lay undisturbed must have been unlike any sea-bed before or since. But it is well known that the Elgin sandstones are quite objectionably like dozens of other sandstones, and one cannot doubt that were Professor Burckhardt to pursue the geological studies he finds so attractive, he would discover equally clear or equally obscure appearances, in many rocks besides those "fragments from the Maleri deposits in India."

We conclude, then, that the phenomena described by the learned professor are mainly subjective, such objective basis as they possess being furnished solely by the mechanical arrangement of sand-grains and the natural irregularity of a broken surface.

VIII.—On the Pectoral Fin of *Cœlacanthus*.

By Edgar D. Wellburn, L.R.C.P., F.G.S., F.R.I.P.H., etc.

Among the fossil fishes of the Talbragar Beds (Jurassic?) described by Dr. A. Smith Woodward in a memoir of the Geological Survey of New South Wales (1895), there is the ventral portion of the abdominal region of a Cœlacanth fish, having one of the pectoral fins well shown. The fin is shown in counterpart, and is thus described:—"It exhibits, as usual, the characteristic obtuse lobation and the large fringe of articulated attenuated dermal rays, and is unique in displaying some of the endoskeletal supporting bones. These elements seem to have been well ossified, though with persistent cartilage internally. At the base of the fin there occurs a broken fragment of bone [1] incapable of determination; but

[1] My specimen would point to the fact that this is a fragment of the clavicle.

in the lobe of the fin itself there is a series of four well-defined, hourglass-shaped supports. Of these bones the anterior three are much elongated, and nearly equally slender, while the fourth is much more robust and expanded at its distal end. The four elements radiate from the anterior half of the base of the fin; and it seems very probable that some smaller cartilage behind and near the distal border of the lobe have disappeared from lack of ossification. The fin-rays gradually increase in length from the anterior border to the middle of the lobe, whence they decrease again backwards, and finally become extremely delicate."

In my collection there is a specimen of *Cœlacanthus tingleyensis,* Davis, from the Cannel Coal, Middle Coal-measures, Tingley, Yorkshire, crushed vertically, which exhibits the pectoral fins, and one, the left, shows characters very similar to those given by Dr. Smith Woodward. The clavicle is well shown and springing from a point about its centre; and opposite to the process which is usually seen on these bones there are six basal supports, of which the anterior four are elongated and more or less uniform in thickness, the fifth is more nearly hourglass-shaped, and the sixth (fourth of Dr. Woodward?) is more robust and widely expanded distally. No supports are seen posteriorly to the sixth, but as the dermal rays extend some distance behind this point, and as the lobe of the fin has here suffered somewhat from crushing, it seems highly probable that there were two, if not three, supports posterior to the sixth, but that they have in the specimen been destroyed during fossilization. At their distal extremities each support is opposed to two or more of the dermal rays, which, as pointed out by Dr. Woodward, "increase in length from the anterior border to the middle of the lobe, whence they decrease backwards, and finally become extremely fine." All the rays are closely articulated distally.

From the above it will at once be seen, as pointed out by Dr. Woodward, that the pectoral fin of *Cœlacanthus* is a striking contrast to that of the existing Crossopterygian *Polypterus,* the basalia more closely approaching that of the Actinopterygii.

NOTICES OF MEMOIRS.

I.—The Movements of Underground Waters of Craven.[1]—First Report of the Committee, consisting of Professor W. W. Watts (Chairman), Mr. A. R. Dwerryhouse (Secretary), Professor A. Smithells, Rev. E. Jones, Mr. Walter Morrison, M.P., Mr. G. Bray, Rev. W. Lower Carter, Mr. W. Fairley, Mr. P. F. Kendall, and Mr. J. E. Marr. (Drawn up by the Secretary.)

The Committee is carrying out the investigation in conjunction with a Committee of the Yorkshire Geological and Polytechnic Society. The present is merely an interim report, as the work is still in progress.

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

It was decided that the first piece of work should consist of an investigation of the underground flow of water in Ingleborough. This hill forms with its neighbour, Simon's Fell, a detached massif, which is peculiarly suitable for investigations of this nature. The summit of the group is formed of Millstone Grit, then follow Yoredale Shales and Sandstones, the whole resting on a plateau of Carboniferous Limestone. Many streams rise on the upper slopes of the hills and flow over the Yoredales, but without exception their waters are swallowed directly they pass on to the Carboniferous Limestone, to reappear as springs in the valleys which trench the plateau.

The Committee first turned its attention to tracing the water which flows into Gaping Ghyll hole. It was generally believed that the water issued at a large spring immediately above the bridge at Clapham Beck Head and immediately below the entrance to Ingleborough Cavern. On April 28 specimens of the water from this spring were taken for analysis before the introduction of any test. Two cwt. of ammonium sulphate was then put into the water flowing into Gaping Ghyll, and at the same time the amount of the water was gauged and found to be equivalent to 251,856 gallons per diem. A few hours later a second quantity of 2 cwt. of the same substance was introduced. On the same day 1½ lb. of fluorescein in alkaline solution was put into a pot-hole known as Long Kin East, about 1,300 yards north-east of Gaping Ghyll.

In view of the important influence which the direction of the joints in the limestone had been found to exercise over the flow of underground water,[1] the direction of the joints in the limestone clints in the neighbourhood of Long Kin East was taken, and was found to be N.N.W. to S.S.E., and to run in such a direction as to lead to the probability that the water would reappear at the springs at the head of Austwick Beck, and these were consequently watched.

The ammonium sulphate put in at Gaping Ghyll reappeared at the large spring at Clapham Beck Head on the morning of May 3, and continued to flow until the evening of May 6, when the water again became normal. Thus the time occupied by the ammonium sulphate in travelling from Gaping Ghyll to Clapham Beck Head, a distance of one mile, was about five days. No ammonium sulphate was found in any of the other springs in Clapdale. This result proved beyond doubt that Gaping Ghyll was connected with Clapham Beck Head.

The fluorescein put in at Long Kin East showed itself at Austwick Beck Head, but not at any of the neighbouring springs, on May 11, having taken over thirteen days to travel, the delay being probably due to the small amount of water flowing at the time of the experiments.

These results are of considerable importance, as they definitely reveal two lines of divergent movement of these underground waters, and indicate a subterranean watershed of much interest.

[1] See previous investigations of the Yorks. Geol. and Polyt. Soc. Committee.

The influence of the master-joints of the Carboniferous Limestone in determining the direction of flow of these underground waters was also, as at Malham, clearly shown.

The next set of experiments was carried out by the joint Committee on June 8 and following days.

In order to confirm the results in connection with the Gaping Ghyll to Clapham Beck Head flow, and further to ascertain more definitely if there existed any connection between Gaping Ghyll and the smaller springs in Clapdale, 10 cwt. of common salt was put into the waters of Gaping Ghyll on June 4, and a further 10 cwt. on June 5, samples of the water from each of the springs being taken several times a day until June 25.

One pound of fluorescein in alkaline solution was introduced into the stream flowing through Ingleborough Cave on June 8 at 10 p.m., at the point where the water plunges down a hole in the floor of the cave, and marked 'Abyss' in the 6-inch Ordnance map. Five cwt. of ammonium sulphate was introduced into a sink on the allotment, about 500 yards north-east of Long Kin East, on June 9, at 3 p.m.; and at 3·15 p.m. on the same day 1 lb. of fluorescein in alkaline solution was poured into the stream which flows past the shooting-box on the allotment and sinks near the Bench Mark 1320·1.

The fluorescein introduced into the abyss came out of Clapham Beck Head, and possibly at Moses Well and other springs in Clapdale, but this point requires further investigation, the evidence being as yet somewhat unsatisfactory. The salt from Gaping Ghyll appeared at Clapham Beck Head on June 15, 16, 17, 18, 19, 20, and 21, being at its maximum on June 18, but not at any of the other springs.

The ammonium sulphate put into the sink on the allotment appeared at Austwick Beck Head on June 22, the other springs in the neighbourhood being unaffected on that day; but on the 24th and 25th there were slight increases in the amount of ammonia in two small springs in Clapdale, viz., the small spring below Clapdale Farm and Cat Hole Sike. As one of these streams is close to the farmyard, and the other was at the time nearly dry and flowing through pasture land, no importance is attached to these slight increases. Of the fluorescein put in below the shooting-box no trace has since been found, and the same is the case with ½ lb. of methylene blue introduced into Grey Wife Sike, above Newby Cote.

Several most interesting problems still await solution in this area, one of them being the relations of the Silurian floor which underlies the Carboniferous Limestone of the plateau to the flow of underground water. The two sinks Gaping Ghyll and Long Kin East are only about 1,300 yards apart, and yet the waters of the one take a direction quite distinct from those of the other, and eventually emerge in a separate valley, the distance between the springs being 1½ miles apart, the great mass of Carboniferous Limestone known as Norber, a hill upwards of 1,300 feet in height, lying between the two valleys. In Crummack Dale it is seen that the Silurian rocks form a ridge running in an approximately north-west and south-east direction, and unconformably overlain by the Carboniferous Limestone. If this line be continued it separates the Gaping Ghyll to Clapham Beck Head flow from that of Long Kin East to Austwick Beck Head. Thus it appears that this ridge of Silurian rocks forms an underground water-parting, which the Committee hopes to be able to trace for a considerable distance across the area.

The magnitude of this undertaking will be to some extent realized when it is stated that upwards of 400 samples of water have been tested for common salt, ammonium, and fluorescein, making in all upwards of 1,200 tests. The whole of the grant of £40 has been spent upon the investigation, and a small sum in addition. The experiments which have been carried out have indicated which are the most suitable reagents for use in different cases, and it is consequently hoped that future investigations will be carried out at rather less cost than has been the case up to the present. The Committee ask to be reappointed, with a grant of £50.

II.—THE UNDERGROUND WATERS OF NORTH-WEST YORKSHIRE.[1] By Rev. W. LOWER CARTER, M.A., F.G.S., Hon. Sec. Underground Waters Committee, Yorkshire Geological and Polytechnic Society.

Part I. The Sources of the Aire.

THE Silurian and Carboniferous rocks between Malham Tarn and Malham are traversed by two branches of the Craven Fault with the downthrow to the south. Malham Tarn lies on Silurian, and its overflow sinks in the limestone directly the northern fault is crossed. The drainage of the area to the west of the Tarn disappears at the Smelt Mill Sink. The drainage of the area east of the Tarn is carried off by Gordale Beck, along the course of which some water sinks into the jointed limestone. To these three sinks correspond three principal outlets, the stream at Malham Cove, Aire Head Springs, and the springs at the bottom of Gordale.

The history of previous investigations is then given. From the centre of Malham Cove a dry limestone gorge runs in a northerly direction to the Tarn. Up to the beginning of this century flood-waters were known to traverse this valley and discharge over the Cove. There are several sinks along the line of this dry valley. Now all the overflow is taken by three sinks south of the Tarn.

Various efforts have been made to trace the connection between the sinks and outlets. Flushes of water from the Tarn have been shown to affect Aire Head before Malham Cove. Experiments by introducing chaff, bran, magenta, and uranin into the sinks failed to show any traces at the outlets.

The present investigation was carried out during 1899, by a Committee of Engineers, Chemists, and Geologists, appointed by the Yorkshire Geological and Polytechnic Society. Flushes of water were sent down from the Tarn to the Tarn Water Sinks.

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

Aire Head Springs responded in two hours. With large flushes a rise in Malham Beck was also observed.

The chemical investigations were as follows:—

Ammonium sulphate was put in below the Malham Tarn Sluice on June 22, and appeared at Aire Head from July 4 to 11. Distinct traces were also found at Malham Cove on the same dates.

Common salt and fluorescein, put in at the Smelt Mill Sink between June 22 and 28, appeared at Malham Cove from July 4 to 11.

Fluorescein, put in at Tranlands Beck on June 22, appeared at Scalegill Mill on June 23.

Ammonium sulphate, put into upper Gordale Beck on August 26, appeared at the springs below Gordale Scar on September 7.

Common salt, put into Cawden 'Burst' on September 18, appeared at Mire's Barn from September 23 to 27.

Fluorescein put into the bottom of Grey Gill Cave was not traced.

A geological investigation of the area showed that the limestone is traversed by two sets of prominent joints, of which the master-joints, which run in a north-west to south-east direction, are very well developed. These master-joints are found to largely determine the flow of the underground waters. The direction of these master-joints unites the Smelt Mill Sinks and Malham Cove directly, and that may be taken as the direction of flow. A parallel line from Malham Tarn Sinks would bring the water from them to Grey Gill, a dry valley in the escarpment to the east of Malham Cove. No evidences of moving water were found there.

To the south of the Mid-Craven Fault the jointing of the limestone is found to be variable; but prominent joints were found bearing in a north-east and south-west direction. If the Tarn water followed these joints on crossing the fault it would traverse a direction almost at right angles to its previous course, and following the limestone in its bend underneath a synclinal of Yoredale shale, would be likely to reappear at Aire Head Springs, which is the nearest point for re-emergence on the southern side of the anticlinal.

The master-joints north of the Mid-Craven Fault would similarly carry the water which sinks into the bed of Gordale Beck south-eastward into the limestone, and if, as it nears the fault, it followed a set of joints running at right angles to the previous set, it would come out at the springs at the foot of Gordale Scar, which was found to be the case by the chemical tests. Gordale itself turns in this direction from some cause.

The conclusions of the Committee are:—

1. That Malham Cove Spring discharges the water from Smelt Mill Sink and the limestone area west of the dry valley; and under certain conditions some of the Tarn water.

2. That Aire Head Springs discharge the main portion of the water disappearing down Malham Tarn Water Sinks.

3. That Gordale Beck Springs discharge the water sinking in Upper Gordale.

4. That chemicals put into Cawden 'Burst' appeared at Mire's Barn.

5. That Tranlands Beck Sinks discharge at Scalegill Mill.
6. The investigations show that within the area the main direction of underground flow is along the master-joints of the limestone.

III. — The Caves and Pot-holes of Ingleborough and the District.[1] By S. W. Cuttriss.

THE portion of Yorkshire to which this paper refers is contained in Sheets 49, 50, and 60 (New Series) of the 1-inch Ordnance Survey. The great Craven Faults which traverse it in a north-west to south-east direction have produced a difference of level of the strata of several thousands of feet; the limestones on the south side of the Faults being far below the surface.

The Silurian slates and grits form the basement beds, and are exposed in several of the valleys. On these rests the Carboniferous Limestone, which has a thickness of about 500 feet from the base to the present exposed surface on Ingleborough. The name Carboniferous Limestone is here applied only to distinguish a particular bed of rock in the district. Above this are a series of thinner limestones, shales, and sandstones (the Yoredales of Professor Phillips), capped by Millstone Grit.

Towards the west the Carboniferous Limestone has been cut off by the Dent Fault, while the Craven Faults determine its extension towards the south. The main line of fault passes through Ingleton, Clapham, and Austwick to Settle, then eastwards by Malham. North of this is another fault, near the first at Austwick, but about $1\frac{1}{2}$ miles apart at Malham. Further north the most interesting caves and pot-holes are found in an area comprising the Leck Fells, Kingsdale, Chapel-le-Dale, Ribblesdale, and around Ingleborough.

The whole area may be divided into three sections:—

1. The Yoredales, comprising the rocks of that name. These limestones being comparatively thin, and intercalated with beds of shale and sandstone, the caves are small and obstructed with earth, through which the water percolates. They are at an elevation of from 1,300 to 1,600 feet, and do not materially affect the drainage of the ground.

2. The Southern Carboniferous, including the Carboniferous Limestone between the two Craven Faults. Although part of the same formation as the Carboniferous Limestone north of the Fault, yet the caves in the two sections differ entirely in their characteristics. Here they are distinguished by an absence of running water, the walls are covered with a considerable thickness of calcareous deposit, and their entrances are blocked with clay and rock débris. The well-known Victoria and Attermire Caves are included in this section. A further characteristic is the entire absence of pot-holes—vertical chasms in the ground caused by falling water enlarging the rock fissures.

3. The Main Carboniferous, which includes the remainder of the Carboniferous Limestone within the area defined. Here there are no

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

dry caves, all being active drainage channels. Pot-holes also are very abundant. In the Leck Fell and Kingsdale districts the caves are almost without exception those of engulfment, while in Chapel-le-Dale and Ribblesdale they are chiefly caves of débouchure. The first-named are usually low at the entrance. The passages then increase in height to 20 feet or more, but rarely exceed 6 feet in width, usually much narrower. Some may be traversed a quarter of a mile or more, such as Lost John's Cave, which terminates in a subterranean pot-hole over 100 feet deep. The caves of débouchure are much more numerous. The mouth is generally wide and shallow, with a flat roof. A cascade or waterfall is usually found some little distance in, beyond which the passage is a simple water-worn channel, gradually shallowing and broadening until too low to permit of further progress.

The pot-holes occur at or near the top of the limestone, at between 1,100 and 1,300 feet elevation, and always where there are surface streams, which fall into the chasms. Over thirty have been named, nearly all of which have been descended by the writer and friends, members of the Yorkshire Ramblers Club, many of them for the first time. Half the number are over 100 feet deep. Gaping Ghyll, on Ingleborough, attains a depth of 350 feet, and was first descended by Monsieur E. A. Martel, in 1895. Rowten Pot, in Kingsdale, was conquered in 1897, and found to be 365 feet deep, thus being the deepest known pot-hole in the country.

No evidence of the presence of the Silurian rocks has been found, the lowest observable rock being either light or black limestone. The average Summer temperature in both caves and pot-holes is 48° Fahr.

The writer has prepared a special map of the district on which are shown all the known caves and pot-holes, with the surface streams. Such a map illustrates in a forcible manner the interesting fact that the entire surface drainage of Ingleborough is swallowed up by the limestone. Not a single stream from the higher levels continues an uninterrupted course into the valley below.

IV.—The Outcrop of the Corallian Limestones of Elsworth and St. Ives.[1] By C. B. Wedd, B.A., F.G.S.

(Communicated by permission of the Director-General of the Geological Survey.)

THE ferruginous and oolitic limestones known as the Elsworth and St. Ives Rocks are now generally believed to be one and the same, an opinion supported by my own work in that district recently. The limestone in question has long been known to occur at St. Ives in brick-pits, being well exposed to the west of the town. It was known also to occur throughout the village of Elsworth. Mr. Cameron noticed a fossiliferous rock outcropping near Hilton, between Elsworth and St. Ives. No other surface exposures were known, but a similar rock was found in the railway cutting at Bluntisham, north-east of St. Ives, at Swavesey, east of the same

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

place, and Bourn, south of Elsworth, and a few other localities, and like rock was found in Wells.

The outcrop can be traced almost continuously from a mile west of the brickyard at St. Ives, striking eastwards along the northern flank of the Ouse valley, and passing north of St. Ives to Needingworth; here it bends abruptly southwards to Holywell and forms a gentle rise. The southern part of the village of Holywell stands on a gravel-capped escarpment of the rock; a collection of fossils in the Woodwardian Museum, Cambridge, agreeing closely with those of the Elsworth and St. Ives Rocks, was believed to have come from Holywell. East of Holywell the outcrop must cross the Ouse valley; I found traces of the rock in a drain some distance west of Swavesey. From here, south-westwards, it is not seen again till it appears at the surface between Hilton and Conington, where a rock was noted by Mr. Cameron. Southwards from here the outcrop crosses a valley to the rising ground west of Elsworth, through which village a narrow tongue of the rock runs still further south. The main outcrop, however, flanks the northern slope of the drift-capped high ground to the west, and can be traced along the slope through Papworth Everard, westwards to Yelling, following the contour of the ground. At both of these localities there are good and highly fossiliferous exposures in streams. Thence the outcrop disappears southwards under drift, but the rock may be seen again to the south, less than two miles south of Croxton, in a ditch in the valley of the Abbotsley Brook.

To the north, east, and south-east of the line of outcrop of this limestone, the ground is occupied by Ampthill Clay, to the west by Oxford Clay. It will thus be seen that the Elsworth and St. Ives Rocks, besides agreeing closely in their fauna, outcrop along the same line of strike, with Ampthill Clay above and Oxford Clay below. The dip is always small, and the rock at Bluntisham, if it reaches the surface at all, does so probably as an inlier, though it may be directly connected at the surface with the outcrop east of St. Ives.

V.—On Rapid Changes in the Thickness and Character of the Coal-measures of North Staffordshire.[1] By W. Gibson, F.G.S.

(Communicated by permission of the Director-General of the Geological Survey.)

VARIABILITY in thickness and character of the strata is universal throughout the Carboniferous period, but is nowhere more marked in the Midlands than in the coalfield of the North Staffordshire Potteries.

This important coalfield consists of two portions. On the east the productive measures lie in a well-marked syncline, while on the west the strata rise in a sharp anticline extending from Silverdale to Talke. The two productive areas are separated by a strip of ground two and a half miles broad, composed of barren upper measures.

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

A notable difference in the thickness of the strata and nature of the coal-seams characterizes these structurally distinct areas. In the centre of the syncline, near Shelton, the vertical distance between the highest ironstone, or summit of the productive measures, to the Bullhurst coal, or lowest workable seam, is about 1,300 yards. On the anticline at Apedale only 800 yards of strata separate the same horizons. This makes a remarkable decrease in thickness of 500 yards of strata in a distance of under three miles. The reduction in thickness westward of the productive measures is continued, though in a less degree, in the upper barren series, but owing to the absence of shaft sections the amount cannot be definitely stated. It is known, however, that the red marls forming the lower portion of the upper barren series are more than 1,000 feet thick near Etruria station on the Shelton property, and about 850 feet thick near Silverdale, on the south-eastern limb of the anticline. With the decrease in thickness a change has taken place in the lower coals of the productive series. The seams which are house or steam coals on the east change into gas and coking coals on the west.

This great variability seems to show that separate areas of deposit were being marked out by local movements of elevation and depression, and thus fulfilling in North Staffordshire the conditions characteristic of the Carboniferous of the Midlands generally, as pointed out by Professor Lapworth.[1]

In North Staffordshire it happens that the areas of maximum and minimum deposit correspond with a syncline and anticline. If this be true generally, and not merely a local coincidence, we may expect the coals in the unexplored coalfield which lies at the surface to the west of the anticline, and which represents the eastern margin of the great synclinal of Coal-measures beneath the Cheshire plain, to be of a different quality from those in the anticline, while the thickness of the measures will be increased.

VI.—On some Fossil Fish from the Millstone Grit Rocks.[2]

By Edgar D. Wellburn, F.G.S.

The Millstone Grits are naturally grouped into three divisions, viz.: (1) Rough Rock; (2) Middle Grits; (3) Kinder Grits at base. The Middle Grits, consisting of grits, sand, shales, are subdivided into A, B, C, and D beds, A being uppermost. The Pennine Anticline is mostly composed of these rocks, and on the Lancashire side at the head of Calder Valley, on the south side in a quarry at the summit, there is a good exposure of the D shales; in these the majority of fish remains were found; a few occurred at the same horizon at Wadsworth Moor, Sowerby, Kilne House Wood, and Eccup, Yorkshire. The majority are in nodular masses, few in shales, and are associated with a marine fauna. The fish-bearing beds were formed under marine estuarine conditions. They are of great geological and zoological interest, as largely increasing

[1] "A Sketch of the Geology of the Birmingham District": Geol. Assoc., 1898, p. 364.

[2] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

our knowledge of the fish fauna in rocks whose yield of fish remains has hitherto been extremely limited; and zoologically inasmuch as (1) one genus and several species are new; (2) one Lower Old Red Sandstone fish is present; (3) the occurrence of the Lower Carboniferous types, *Orodus, Psephodus, Pristodus.* The author made some remarks on the fish remains, and exhibited a table of their stratigraphical distribution.

REVIEWS.

I.—The Geology of Central and Western Fife and Kinross. (Memoirs of the Geological Survey of Scotland.) By Sir Archibald Geikie, F.R.S., D.C.L., etc., Director-General. With Appendix of Fossils by B. N. Peach, F.R.S. 8vo, cloth; pp. x, 284. (Glasgow: printed for H.M. Stationery Office, 1900. Price 5*s.* 6*d.*)

THIS well-printed memoir is in the main a description of the geological formations which are represented in Sheet 40 of the Geological Survey map of Scotland, which was published in 1867. The ground was surveyed in part by the author, and in part by Mr. H. H. Howell, Prof. John Young, Prof. J. Geikie, and Mr. B. N. Peach, when Murchison was Director-General. It is not surprising, therefore, that the nomenclature, especially of the igneous rocks, has undergone considerable changes, noticeable when we compare the tablets on the map with the table on p. 13 of the memoir. Much additional information on the coalfields has, however, in recent years been obtained by Mr. J. S. Grant-Wilson, and the Director-General has himself revisited the area from time to time. Consequently every effort has been made to bring the information up to date by personal observation, and with the help of other workers whose publications are listed in the Appendix. It is needless to add that in point of style the memoir bears the most favourable comparison with any previously published by the Geological Survey.

The country described is a highly important one, extending from the Firth of Tay west of Tay bridge to the Firth of Forth at Queensferry. It is composed chiefly of Carboniferous rocks and Old Red Sandstone, with numerous interstratified and intrusive igneous rocks. In the northern part is the Ochil chain, formed mainly of hard lavas of Lower Old Red Sandstone age; the central part, in which lies Loch Leven, is hollowed out of comparatively soft red sandstones forming the plains of Kinross and the Howe of Fife; and in the southern part there is again a belt of hilly ground, more varied and broken than that in the north, and composed mainly of Carboniferous rocks with hard eruptive sheets, which form the Lomond Hills and other prominent heights.

While perusing the very interesting Introductory chapter it would have been useful to the reader to have had a small map depicting the main outlines of the geology and topography, with the names of the chief hill ranges, rivers, and lakes. In succeeding chapters the author gives a full account of the strata, entering into many particulars concerning the eruptive rocks, and recording detailed sections of the coal-bearing strata in the Carboniferous Limestone series and Coal-measures. In this great series the highest division is the "Upper or Barren Red Sandstone Group," composed of red, purple, grey, yellow, white, and variegated sandstones, shales, clays, and marls, with some thin limestones and poor coals. Many fossils have been obtained in this group by Mr. J. W. Kirkby, including fishes (*Diplodus*, *Megalichthys*, etc.), crustacea (*Bellinurus*, *Eurypterus*, *Prestwichia*, etc.), as well as molluscs such as *Anthracomya* and the annelide *Spirorbis pusillus*. Full lists of them and of fossils from the other formations are given by Mr. Peach in the Appendix; special mention being made of the long and enthusiastic labours of Mr. Kirkby.

Sir A. Geikie remarks that "The topography of the whole region has been profoundly modified by the geological events of the Ice Age. So thick was the mass of ice which then descended from the Highlands, that it passed over the lofty ridge of the Ochils and the other hills to the south, and turned eastwards into what is now the Firth of Forth and the North Sea." Of the glacial deposits, and also of Recent deposits and the latest changes, many interesting descriptions are given; and there is a final chapter on the Economic Minerals. Some detailed notes on the petrography of the Igneous rocks are contributed by Mr. Herbert Kynaston, in an appendix.

II.—Memoirs of the Geological Survey of the United Kingdom. The Cretaceous Rocks of Britain. Vol. I. The Gault and Upper Greensand of England. By A. J. Jukes-Browne, B.A., F.G.S.; with contributions by William Hill, F.G.S. Royal 8vo; pp. xiv, 499, with 85 figures and 5 plates. (London: Wyman & Sons, 1900. Price 9*s*.)

In the preface Sir Archibald Geikie, the Director-General of the Geological Survey, states that the present volume is the first of two in which the Upper Cretaceous Rocks of England will be described by Mr. Jukes-Browne, who has been collecting the materials for the subject since 1884. Owing, however, to his unfortunate ill-health, he has been unable to complete the necessary field-work, but this obstacle has been overcome by the assistance of his friend and coadjutor Mr. William Hill, who has examined the outcrops of the formations in the South and East of England, and in addition has carried out a series of important researches on the mineral and organic constituents of the deposits by means of microscopic sections and the examination of residues after treatment with acid.

The strata described in this volume have, since early days, attracted the attention of many of our British geologists, amongst whom may be reckoned William Smith, Thomas Webster, William Phillips, Dr. Mantell, Dr. Fitton, Sir R. Murchison, and R. A. C. Godwin-Austen. At a more recent period, Mr. C. J. A. Meyer, Mr. F. G. H.

Price, Dr. Charles Barrois, and others have studied their stratigraphy and fossils in more detail. They have also been described in some of the previously published memoirs of the Geological Survey, as in those on the Isle of Wight by A. Strahan, on the Isle of Purbeck by A. Strahan, those on West Suffolk and West Norfolk by W. Whitaker and A. J. Jukes-Browne, and that in the neighbourhood of Cambridge by W. H. Penning and A. J. Jukes-Browne. Chemical analyses of the rocks, besides those already published, have been made by Professor J. B. Harrison, Mr. Berry, and Dr. W. Pollard. Mr. F. Chapman has determined the foraminifera of the Gault, whilst the author and Mr. E. T. Newton, assisted by Mr. H. A. Allen and Dr. Kitchin, have revised the synonymy of the rest of the fauna. The author has made use of the knowledge to be obtained from the above and other writers on the geology of these rocks to add to his own observations, and thus render the monograph as complete as possible.

The first chapter contains the introduction to the Upper Cretaceous Series, which is regarded as consisting of the following four stages or groups of strata :—

4. Upper Chalk.
3. Middle Chalk.
2. Lower Chalk.
1. Gault and Upper Greensand (Selbornian).

The combined thickness of these stages where the series is most fully developed, as in the Isle of Wight, is about 1,900 feet. The Upper Series, on the whole, succeeds conformably the Lower Cretaceous Series, but there is evidence of a very general subsidence of the region at an early period of the Upper Series, which produced an overlap of the Lower Greensand by the Gault. In deep borings in the East of England, the Gault is known to rest directly on Palæozoic rocks, whilst in a westerly direction it is deposited successively on Wealden, Jurassic, and Rhætic beds, and in the Haldon Hills Greensand rests on the lower part of the New Red Series. The general dip of the Upper Cretaceous is easterly, but this is interrupted by several anticlinal flexures with an east and west direction, which produce local dips to the north and south. The most important of these are (1) that traversing South Dorset and the Isle of Wight, which is believed to be continuous with the anticlinal axis of the Pays de Bray; (2) a series of local and parallel flexures in a tract extending from the Vales of Wardour and Warminster through Central Hants and the southern part of Sussex; and (3) the anticlinal axis which runs through the Vales of Pewsey and Kingsclere.

Chapter ii, giving an historical account of the Chalk, Upper Greensand, and Gault, mainly deals with the origin of the term 'Upper Greensand.' The name 'Greensand' was used by William Smith and T. Webster for the greensands, including also the Malm or Firestone, between the Chalk and the Gault. Subsequently, W. Phillips and Dr. Mantell mistook the sands below the Gault

(Lower Greensand) for the Greensand of William Smith, which gave rise to much confusion. The true succession of the beds was pointed out by Dr. Fitton in 1824, who suggested the name of *Merstham Beds* for the firestone and greensand above the Gault and *Shanklin Sands* for the sands below. The proposition of Webster that the beds should be respectively called 'Upper Greensand' and 'Lower Greensand' finally prevailed, and these terms were adopted by the Geological Survey in 1839 and have since continued in general use.

It was not until a later date that the accepted character of the Gault and Upper Greensand as definite and distinct formations of the Cretaceous System was called in question. Mr. Godwin-Austen stated in 1850 that the Upper Greensand was a purely conventional name, and that the differences between the fauna of the Devizes and Blackdown Beds (Upper Greensand) and that of the Upper Gault of Folkestone are only such as might be expected between arenaceous and argillaceous portions of the same zone. He further added that the Gault was not an independent formation, but merely the accumulation of a given condition of deep-sea, synchronous as a whole with that portion of the Cretaceous deposits which we call Upper Greensand. Godwin-Austen's views were supported and confirmed by the investigations of Meyer, Price, Dr. Barrois, and more especially by the author of this memoir, who maintained that the Gault and Upper Greensand were merely different lithological facies of one group of deposits. For the new group the name 'Selbornian' is proposed by Jukes-Browne after the well-known Hampshire village made famous by Gilbert White the naturalist. The name is the more appropriate as the village is situated on the Malmstone, and the Gault clays are well developed near by. The author does not propose that 'Selbornian' should supersede the terms Gault and Greensand, but that it should be employed in a similar relation to them as the general term Wealden to the Weald Clay and Hastings Sands. It is strange that this new term, though constantly used throughout the memoir, should not have found a place on the title-page. In justification of its introduction the author states—

"As a matter of fact *gault clay* and *greensand* are only two of the different kinds of deposits that make up the group for which the name Selbornian is now proposed; it is only by a stretch of the imagination that malmstone can be called greensand, inasmuch as an ordinary malm contains but a small proportion of quartz sand and still less glauconite, so that it is not a sand nor is its colour green. There are large areas over which the formation is really a tripartite one, and could actually be mapped as consisting of *Gault, Malmstone*, and *Greensand*; there are also areas where it consists wholly of Gault, i.e. of grey clays and marls; others, again, where it consists entirely of sand and sandstone; and finally, there is a large area where it is neither the one nor the other, but is represented by red chalky limestone and red marl."

Chapter iii, on the value of zones in the Cretaceous System, comes in here somewhat parenthetically, but, as hinted in the preface, it may be regarded as in some measure introductory to the completed monograph on the Cretaceous System. In it the author places on record some of the conclusions drawn from a study of the zones in this system, "especially with respect to the proper conception of a zone, the use of an index species, and the limitations which must be placed to the zonal method." To give a succinct explanation of a zone is by no means easy; the author says that "perhaps it may be defined as a band of sedimentary material within which certain species are either restricted or are specially abundant, and during the formation of which certain species acquired their greatest exuberance and their greatest geographical extension. More than this, however, is implied by the modern idea of the term *zone*, for a zone is only one of several successive zones; it is not merely a specially fossiliferous band in a thick mass of sediment, but is a subdivision of such a mass or group of beds; such a group being generally divisible into two, three, or more zones, one succeeding another." The above definition seems to us open to much criticism, which, however, cannot be entered on here; we should prefer the shorter definition of Mr. J. E. Marr, here quoted: "Zones are belts of strata, each of which is characterized by an assemblage of organic remains, of which one abundant and characteristic form is chosen as an index."

A general account of the Gault and Upper Greensand (Selbornian) is given in Chapter iv, and it is claimed that the clays, marls, sands, and sandstones of this Selbornian stage fall naturally into three groups or sub-stages: (1) Lower Gault; (2) Upper Gault and Devizes Beds; (3) Warminster Beds.

Hitherto it has been usual in England to consider the clayey beds containing *Ammonites interruptus* as the base of the Gault, and the underlying sandy beds as belonging to the Lower Greensand. In the uppermost beds of these lower sands at Folkestone and in three other localities in the South of England *Ammonites mammillatus* has been met with, whilst in France the same species occurs in a zone of fossiliferous sandy beds in association with *Am. interruptus*, and by French geologists these beds are included in the Albian as part of the basement bed of the Gault. The author considers this will justify placing the sands with this fossil as the base of the Gault in this country, although it has never been found here associated with *Am. interruptus*.

The zone of clays with phosphatic nodules at its base, containing *Am. interruptus*, forming bed 1 of Mr. Price, is about 10 feet in thickness at Folkestone and from 20 to 50 feet in the Midland Counties. The upper part of the Lower Gault, which includes Price's beds 2–7, is placed in the zone of *Am. lautus*. It can be distinguished near Devizes, and is believed to form the larger part of the Lower Gault in Oxfordshire and the adjoining counties. The thickness of the Lower Gault in different parts of the country varies between 34 feet and 200 feet, but there is much difficulty in determining with certainty where a line can be drawn between the Lower Gault and the Upper in many areas.

The next division comprises the Upper Gault and Upper Greensand (in part)—the Merstham or Devizes Beds, which are placed in the zone of *Ammonites rostratus.* The lower portions of this zone consists of marly clays, and above these are the well-known beds of Malmstone or Firestone, siliceous rocks with a considerable amount of silica in the colloid state, which has been derived from the spicules of siliceous sponges. This Malmstone occupies a large area in the South of England estimated at nearly 4,000 square miles. It extends from near Westerham, Kent, on the east, and from its thickness along the western outcrop the author believes that it stretched originally far to the westward over the counties of Oxford, North Wilts, and Gloucestershire. This Malmstone passes into a fine-grained micaceous sandstone.

In the Isle of Wight and in the South-West of England, a large portion of this zone of *Am. rostratus* consists of fine soft sands with intermediate beds of hard calcareous sandstone; in some places the cemented materials take the form of oval or rounded doggers or burr-stones. Again, in the Blackdown Hills of Devonshire and near Stourton in Wiltshire, the sands of this zone contain siliceous nodular accretions, formerly worked for whetstones, the silica in which is derived from sponge remains.

The third division of the Selbornian comprises the highest portion of the Upper Greensand, and as this is most highly developed near Warminster it is known as the Warminster Beds, and included in the zone of *Pecten asper* and *Cardiaster fossarius.* The zone of *Pecten asper* near Warminster includes three sets of beds: (1) Greensand and sandstone; (2) fine grey sand with layers and nodules of chert; and (3) a light greensand with calcareous concretions, which forms the highest portion of the series and contains the well-known Warminster fauna. The author states that no Ammonite or other Cephalopod has yet been found in this zone which does not range into the Chalk above or into the beds below.

Pecten asper, the principal index fossil of this zone, has a wide distribution both in this country and in France. In England it has been found in the Malmstone of Hampshire, that is, in the zone of *Am. rostratus,* and occasionally it occurs in the same zone in France. In the zone distinguished by its name it is found near Warminster and other places in Wiltshire, also in Dorset, and the Isle of Wight. It passes up into the Chloritic Marl, and occurs in the nodule bed at the base of the Chalk near Chard, and in certain beds of Cenomanian age in Devonshire. In France also this species is common in the 'craie glauconieuse,' the equivalent of our Lower Chalk. Its mere occurrence, therefore, cannot be considered as proof that the bed containing it belongs to the Upper Greensand.

The Warminster or *Pecten asper* division of the Upper Greensand is confined to the south-western and south-central counties from the Isle of Wight to Buckinghamshire. Its maximum thickness is estimated at 60 feet, but where the chert beds are not present it is reduced to about 12 feet. The well-known chert beds of the Undercliff in the Isle of Wight are included in this division.

Chapters v–xxii give detailed descriptions of the varying features of the zones of the Selbornian as they are exposed in different counties, beginning with the easterly exposure on the coast at Folkestone to its most westerly extension on the Haldon Hills, near Exeter, from thence returning in a north-easterly direction through the counties of Wilts, Berks, Oxford, Buckingham, Cambridge, Norfolk, Lincoln, and York. The changes in the character of the beds in areas not far removed are somewhat striking: we can only briefly mention some of them.

Beginning at the well-known coast section at Folkestone, the Lower Gault (excluding the debateable 6 feet of sand of the *Am. mammillatus* zone) consists mainly of grey and dark fossiliferous clays, about 29 feet in thickness. The lower portion of the Upper Gault is likewise of marly clays, having a thickness of 50 feet, and these are overlaid by glauconitic sands and buff marls with but a few fossils, 27 feet in thickness. Thus the total thickness of the Selbornian at this spot is 106 feet, and the materials are mostly marly or clayey.

In Surrey the Lower Gault consists of clays somewhat similar to those in Kent, but fossils are comparatively scarce in them. No definite boundary between the Upper and Lower Gault is known: the upper beds are of a more sandy character, and they are succeeded by the Malm and Firestone (Merstham Beds), representing the Upper Gault and Upper Greensand, which are 60–80 feet in thickness in the west of the county. The author considers that the entire thickness of the Malmstone belongs to the zone of *Am. rostratus*, together with the 8–10 feet bed of greenish sand which comes in between the Malmstone and the base of the Chalk Marl, and that the zone of *Pecten asper* is not represented. We do not find any reference to the excellent section of the Merstham Beds exposed in the last two or three years in the new cutting of the London, Brighton, and South Coast Railway at Merstham.

The Selbornian is well shown in the coast sections of South Dorset and Devon from Golden Cap to Axmouth. The lowest beds are, at Golden Cap, pebbles, sands, and sandy clays, resting on the Lias, nearly 30 feet in thickness; they contain Gault fossils, and are referred to the upper part of the Lower Gault; above these is a series of greenish and yellowish glauconitic sands, about 100 feet in thickness, which may represent the zone of *Am. rostratus*, and over these are some thin chert beds. Further westward, at Black Ven, the sandy beds representing the Gault, containing some obscure fossils, reach a thickness of about 180 feet, and the overlying chert beds, belonging to the highest division of the Upper Greensand, are 10 feet in thickness.

At Whitecliff, South Devon, the sands below the chert beds, forming the lower division of the Upper Greensand, contain the same fossils as occur in the Blackdown Beds, and are included in the zone of *Am. rostratus*. They are less than 90 feet in thickness. At Hooken Cliff and Whitecliff, the chert beds of the highest division of the Upper Greensand reach a maximum thickness of 70–80 feet: they contain species of *Exogyra* and *Orbitolina concava*, but *Pecten* *asper* has not been found in them or in the topmost bed of calcareous sandstone.

In Oxfordshire and Buckinghamshire the Lower and Upper Gault clays have been proved by borings in various places to reach a thickness of 144–230 feet. Fossils occur in the Lower Gault which elsewhere in the South-East of England are only found in Upper Gault; for example, *Am. rostratus, Am. varicosus,* and *Am. cristatus* are associated with *Am. lautus, Am. splendens,* and *Am. tuberculatus.* The Upper Gault becomes marly, and passes into a micaceous marl and malmstone.

At Stoke Ferry in West Norfolk the Lower and Upper Gault is represented by a blue clay about 56 feet in thickness; more than half of it probably belongs to the zone of *Am. rostratus.* Northwards the clay is replaced by calcareous material and gradually thins out, so that at Hunstanton there is only about 3½ feet of red earthy limestone between the sands of the Lower Cretaceous and the Lower Chalk. The author and Mr. Hill maintain the view put forward by them in 1886 that the Red Chalk is the actual stratigraphical equivalent of the Gault. They also agree with Dr. Barrois that the zone of *Pecten asper* is wanting in Norfolk, and that there is a direct passage from the Red Chalk to the Chalk Marl.

The Red Chalk is shown again in Lincolnshire and in Yorkshire, where it gradually passes into a stiff red marl with calcareous nodules. Mr. F. Chapman has recorded 86 species of Foraminifera from this rock in Norfolk and Yorkshire, and 52 of these, or about 60 per cent., have been found in the Gault of Folkestone, whilst only 25 occur in bed 2 of the Chalk Marl of Eastwear Bay, thus indicating that the Red Chalk has a closer relation to the Upper Gault than to the Chalk Marl.

In Chapters xxiv and xxv Mr. W. Hill describes the microscopical structure and the mineral ingredients of the Gault, Red Chalk, Greensands, Malmstones, etc. The Gault marls and clays consist in part of very finely divided, apparently structureless material, without reaction in polarized light between crossed nicols; in part of fine detritus of quartz, mica, and glauconite, with entire and fragmentary tests of organisms. Thin microscopic sections of the Gault do not give good results, and its characters were best ascertained by washing and sifting different samples.

The coarser particles of quartz, mica, and felspar fragments form but a small proportion in typical Gault clays. Zircon, rutile, tourmaline, magnetite, ilmenite, garnet, and cyanite were also recognized by Mr. Teall. The glauconite occurs in irregular rounded and mammillated grains, seldom more than 0·5 mm. in diameter, also as minute cylindrical rods, apparently moulded in the canals of sponge spicules. Marcasite (disulphide of iron) is also present in the form of small spherules, cylinders, and irregular masses.

Mr. Chapman has determined 265 species and varieties of Foraminifera from the Gault at Folkestone, and 66 species of

Ostracoda are also present with them. The tests of the Gault Foraminifera have been but little altered in fossilization, and they differ but slightly in appearance from those in recent deep-sea deposits. Molluscan shell fragments and prisms occur in all Gaults, but siliceous organisms such as sponge spicules are rare. Mr. Chapman has estimated the mean depth of the Lower Gault sea at 830 fathoms and that of the Upper Gault at 866 fathoms, basing his conclusions on the Foraminifera, but Mr. Jukes-Browne considers these estimates to be excessive. The Gault, on the whole, bears considerable resemblance to the Blue and Green Muds of modern seas.

Typical Malmstone is shown by Mr. Hill to consist principally of colloid silica with usually a small proportion—10–12 per cent.—of quartz sand; other varieties are more or less calcareous. Besides quartz sand, mica and glauconite are present in varying amounts.

The characteristic organic remains of the Malm and Firestone (Gaize), and also of the beds and nodules of chert, are the detached microscopic spicules of disintegrated siliceous sponges, of which these rocks are mainly composed. In the Malmstone the spicules are mostly of colloid silica, but in the cherts they are generally of chalcedonic and crystalline silica. Frequently the spicules are partially or entirely dissolved, leaving minute empty hollows, and the rock is then of a light porous character. The dissolved silica of the spicules is, in the Malm rock, often deposited in the form of very minute globules or discs, in the cherts it forms a hard glassy rock.

The occurrence of such thick and widely extended masses of Malmstone in the zone of *Am. rostratus* and of the chert layers and nodules in the highest part of the Upper Greensand in the so-called zone of *Pecten asper*, both largely derived from the remains of siliceous sponges (they have been termed Sponge-beds by Hinde), forms the most striking feature of the Selbornian stage.

In Chapters xxvi–xxix the underground extensions of the Gault and Greensand, as shown by various deep borings in the London and Hampshire Basins and the Eastern Counties, are referred to; the characters of the equivalent formations in Northern France are given, with lists of fossils compiled by Dr. Barrois, Mr. Price, and M. Delatour; the physical and geographical conditions under which the Gault and Upper Greensand were deposited are discussed, and the water supply and economic products are enumerated.

In an appendix critical remarks on some species of fossils are contributed by Mr. E. T. Newton and Mr. A. J. Jukes-Browne, and these are followed by an elaborate and exhaustive list of fossils of the Selbornian, showing the particular zones and indicating also the localities where they occur.

III.—The Scenery and Geology of the Peak of Derbyshire. By Elizabeth Dale. pp. 166 and index, with 16 plates, 16 views, and a map. (London: Sampson Low, Marston, & Co. Price 6s.)

THIS is a tall, attractive-looking volume, with numerous illustrations and plates; the former, however, have had scant justice done to them, and the original photographs have suffered much in the process of reproduction. The plates, as is stated in the preface, are very largely borrowed from previous works; but why are they not numbered in direct sequence, and why does the map include only the southern escarpment of Kinder Scout, 'the Peak'? In the preface the authoress states that her object has been to make the book serve as an introduction to the study of the science of geology; consequently the book treats of a much wider subject than one might judge from the title, and we are dealing with a work on elementary theoretical geology, with illustrations drawn from a certain district. But even so, the authoress has not stuck to her text, for the country illustrated and described is larger than the Peak, and takes in other parts of Derbyshire and North Staffordshire. It had been better, we think, to have given the book its proper title, in the interests of the possible purchaser, who, misled by the title, finds himself let in for a *pot pourri* of bygone and current geological views and speculations, rather than a description of the glorious scenery of the Peak and its geology.

Chap. i (pp. 1–15) starts, *ab initio*, with the nebular hypothesis, and then proceeds to explain what is meant by the order of superposition, dutifully reproducing the time-honoured illustration of the pile of books. Of course there follow tables of sequence of strata, and a short account of the greater subdivisions of stratified rocks and their contents; and the last two pages conclude with a brief account of the 1 inch geological map of the rocks round Buxton, as seen in a bird's-eye view of the country from Grinlow. This is not perhaps the best way of commencing the study of geology. Miss Dale is eminently conservative, and while mentioning recent views, prefers to take the 1 inch map of the Geological Survey and the corresponding memoir as the basis of her work, many of the illustrations and several quotations from the latter publication being given.

Chap. ii (pp. 16–39) treats of the Carboniferous Limestone, and includes a long account of the swallows and underground streams so common in limestone districts. Many observations are open to criticism; for example, we are told (p. 17) that "it is unlikely that such a pure limestone could have been formed near a land area of any size." The word 'near' is not exact; but limestones are being laid down within distances of Continental coasts, which cannot be said to be far. Again, we learn that above Odin Fissure the shales are seen resting on the limestone with a junction which is called by geologists 'unconformable.' We have always regarded this section as evidence of a small landslip, for the shales are certainly not in place. At p. 19 we are told that carbonate of lime is soluble in water containing carbon dioxide or any acid. This is not chemically correct, for most acids decompose $Ca Co_3$, and do not effect a simple solution. We look in vain for any account of the stratification of the limestone or the succession of its beds; indeed, the amount of stratigraphical geology in this chapter is very small, and palæontology suffers no less. The whole subject of the fossils is scamped; the few representations given had been better omitted. But we are informed that figures have been given "that the collector may have some idea of their *original* appearance" (the italics are ours). The figures are somewhat grotesque libels on the fossils. Of what use can it be to depict *Productus giganteus*—Miss Dale prefers to keep the fossil feminine—as a shell $1\frac{1}{4}$ inch across? Or what peculiar characteristics of *Aviculopecten* are supposed to be demonstrated by fig. 16, which has not seemed worthy of a specific name? An error has arisen with regard to the shell called *Rhynchonella pugnus* (fig. 13), which is evidently *R. pleurodon*, and *Orthis resupinata* (fig. 14), which is probably a large example of *O. Michelini*, but is certainly not typical of the species it is supposed to represent. In all, eight specimens of various fossils are drawn on pl. iii, but only one has a specific name. We meet the curiously inexact statement that "of mollusca there are comparatively few. The bivalve forms are represented by several extinct species of *Pecten* and by an extinct genus called *Aviculopecten*." We have been told on the same page that "all the fossils are the remains of animals now extinct." Further on, we are told that "a genus with a straight shell has been called *Orthoceras*." We would ask in all sincerity, is this the sort of thing which will help the study of geology? Palæontologists, however, need not despair, for Miss Dale, speaking of the Carboniferous sea, tells us (p. 39) that "at the surface and in the depths of this sea, lived and died countless numbers of animals such as man has never seen"; and in the orthodox higher flights of imagination with which certain authors have seen fit in the past to close their accounts of the geology of the Coal-measures, we are told (p. 104) that "on the ground beneath is a carpet of delicate green, composed of countless smaller ferns and unknown flowerless plants, amongst which dart lizards and now and then a scorpion." One is, however, tempted to ask Miss Dale if the imperfections of the geological record are really as great as we are led to infer from these excerpts.

Miss Dale prefers to call the shales and thin limestones between the grits and the massif of limestone, Yoredale, and to them devotes chap. iii (pp. 40–59). We note that she follows the old 1 inch Survey map, and regards the beds as of great thickness and assumes faults to account for any succession where there does not appear to be room for such a mass, e.g. along the line of the London and North-Western Railway. We are tempted to ask why similar faults are not necessary on the eastern limb of the anticline near Eyam, and further south between Youlgrave and the Grits or between the Grits and the limestone boundary at Matlock and Winster. Personally we think that the thickness of this series has been greatly overestimated. Is there also a series of Yoredale sandstones as well as Farey's grit? We regret that no continuous sections of these beds from the various brooks are given, but as in the description of the limestone, it does not seem to have been part of the authoress's plan to give any original account of the local geology. The palæontology of the shales, a subject of the highest importance, is only mentioned to be dismissed, and only one locality where "chiefly species of *Goniatites*, *Aviculopecten*, and plant-remains" were found is given. A careful search will reward the worker in these beds, and a fairly large fauna, very widely spread, is to be found in them.

Chap. iv (pp. 60–84), on the Millstone Grit, strikes us as one of the best parts of the book, and included in it we find a brief account of the evolution of rivers. On p. 83 is a statement, however, which may cause misconception: "We know that even yet the Millstone Grit is of exceeding thickness, although thousands of feet have been removed by denudation." But Miss Dale surely does not mean that the Grit series was ever thicker than it is at present, i.e. between the limits of the base of the Coal-measures and the top of the Upper Limestone shales, and in the interest of accuracy one is tempted to ask—and surely one has the right to do so, for the book purports to be an introduction to the science of geology—how thick is an *exceeding* thickness? Miss Dale is fond of awe-inspiring superlatives. We are also told that the "Coal-measures once extended over the Pennine anticline." Did they? And where is the evidence for the great volcanoes which are said to have existed to the north-east and on the higher ground, round the swamps which became the coalfields?

Chap. v (pp. 85–105) treats of the Coal-measures at length; it discusses the fossil botany, various theories of the origin of coal, and the climate of the Coal period, and ends with a picturesque description of the scenery of the period. By the way, why are we told "over all the land and water hangs a thick pall of grey cloud"? Did not the Carboniferous flora require the aid of the sun to fix carbon? One plate of Coal-measure fossils is given; fig. 45 is said to be *Naiadites,* but the drawing has no resemblance whatever to any species of that genus; it may possibly belong to *Carbonicola,* though the drawing looks more like *Nuculana.* Fig. 47, a cast of the pith-cavity of the stem of a Calamite, is not very clear, because we do not quite see how the pith-cavity should bear fairly large branches; and should not the fish scale be spelled *Rhizodopsis* both in the plate and the text?

Chap. vi (pp. 106–127) deals with the Glacial Period, and we gladly appreciate Miss Dale's local work on this subject.

Chap. vii is devoted to post-Glacial deposits and early Man, and ends with an allusion to *Pithecanthropus erectus.*

Chap. viii deals with the development of geology and its relation to modern thought, and in our opinion is utterly out of place in a book of the kind. It is as equally unnecessary to allude to the past struggles between knowledge and those who demanded a literal interpretation of the Bible, as it is to talk in a volume which purports to be a description of local geology and scenery, of transcendental theology. *Timeo Danaos et dona ferentes*; somehow or other we distrust textbooks of science which have excerpts from religious books at the commencement.

The work of the book is unequal, here condescending to the almost pedantic explanation of terms, there dealing with theories which have little or no application in the Peak district proper, and we confess we cannot quite see for what class of reader this discursive book is intended. "Of the making of books there is no end," and there is a real need for accurate and thorough work on local geology and scenery, but a treatise of very elementary theoretical geology is quite another thing. W. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—December 19, 1900.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Igneous Rocks associated with the Cambrian Beds of the Malvern Hills." By Prof. T. T. Groom, M.A., D.Sc., F.G.S.

The Cambrian beds of the Southern Malverns are associated with a series of igneous rocks which have commonly been regarded as volcanic, but are probably all intrusive. They consist of a series of bosses, dykes, sills, and small laccolites intruded into the Upper Cambrian Shales and into the Hollybush Sandstone. The dykes appear to be confined to the sandstones, the sills and laccolites chiefly to the shales, while the bosses are found in both. The rocks consist of a series of ophitic olivine-diabases, a related series of porphyritic olivine-basalts, and a series of porphyritic amphibole-bearing rocks of andesitic habit, but probably to be classed with the camptonites. The three types have a different distribution, and do not appear to be connected together by intermediate gradations: the amphibole-bearing and the olivine-bearing rocks differ in their mode of occurrence. According to existing analyses, the former range in chemical composition from sub-basic to basic, and the latter from thoroughly basic to ultrabasic. All the rocks have a local stamp, but are probably most nearly related to the camptonitic rocks of the Central English Midlands. Intrusion took place at a period not earlier than the Tremadoc, and probably not later than that of the May Hill Sandstone.

2. "On the Upper Greensand and Chloritic Marl of Mere and Maiden Bradley in Wiltshire." By A. J. Jukes-Browne, Esq., B.A., F.G.S., and John Scanes, Esq.

The district dealt with is on the borders of Wiltshire and Somerset. The general succession is as follows:—

	feet.
Lower Chalk, with Chloritic Marl at the base	200
Sands with calcareous concretions	3 to 8
Sands with siliceous concretions (cherts)	20 to 24
Coarse Greensand	15
Fine grey and buff sands	about 120
Sandy marlstone	15
Grey marl and clay (Gault)	90

The chert-concretions and the sands in which they occur consist very largely of spicules of lithistid sponges. One of the sandstone-beds has yielded several species of *Necrocarcinus*, and may be the chief source of the crustacea which have been quoted from the Warminster Greensand. Above the chert-beds, and below the horizon at which *Stauronema Carteri* comes in, is a variable set of beds which include a layer of concretions known as cornstones or popple-stones. These beds are very rich in fossils, and include at Maiden Bradley a layer of phosphatic nodules. They contain the Rye Hill fauna of the Warminster Greensand, and it is proposed to call them the zone of *Catopygus columbarius*. In Southern Wiltshire there is usually a complete passage from this zone into the Chloritic Marl; and as the cephalopoda of this zone are all Chalk Marl species, the natural inference from the local evidence would be to place the plane of separation between the Selbornian and Cenomanian stages at the base of the *C. columbarius* beds. In Dorset, however, the break above these beds is so very marked and strong that the authors think that the beds with the Rye Hill fauna must be retained in the Selbornian. It is one of those cases in which the palæontological and the stratigraphical breaks do not coincide.

II.—Jan. 9, 1901.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "The Geology of South-Central Ceylon." By John Parkinson, Esq., F.G.S.

In this communication the author endeavours to give some account of the relations between the various granulitic rocks of Ceylon. A series of more or less isolated sections were studied, the rocks in each considered under separate heads, and conclusions put forward relative to the whole. Two sections are described to the west, and one to the north, of Kandy, in which the rocks are of a well-marked type. As a rule they are strongly, often coarsely, banded; and the relation of the light and dark bands is such as to leave the author to conclude that this structure arose "through the streaking together of the component parts of a magma which had undergone differentiation." The darker parts are characterized by the presence of green hornblende in varying quantity, associated with brown mica. Locally garnets are abundant, and pyroxene is found in some slides. A fourth section, south of Matalé, is of importance, since it is believed that here a granulitic rock resembling some described under the section which follows (Section V) is intrusive in a crystalline limestone. Modifications in the intruder are described, which are supposed to have arisen through the local incorporation of some of the older rock. Under Section V rocks from Newara Eliya, Ohiya, and Bandarawella are grouped together. These are often banded and vary considerably in coarseness, but are distinguished, with few exceptions, by a greenish colour accompanied by a greasy lustre, and usually by the presence of garnet. Hornblende, magnetite, and biotite are associated with this mineral, and a pleochroic augite is not uncommon. The structure of all the rocks described is granulitic; that is, characterized by the irregularity in the outlines of the grains which build up the rock, and by the inclusion of one mineral by another. Porphyritic felspars are recorded from several localities.

The author concludes that the rocks of Section V are nearly related to those described in the earlier part of the paper, and points out the close resemblance of the whole to the Charnockite Series of Southern India.

2. "Note on the Occurrence of Corundum as a Contact-Mineral at Pont-Paul, near Morlaix (Finistère)." By A. K. Coomára-Swámy, Esq., B.Sc., F.L.S., F.G.S.

The intrusive granite of Pont-Paul, near Morlaix, contains highly altered fragments of sedimentary rock. The minerals found in them are biotite, muscovite, corundum (first recorded by Professor Barrois in 1887), plagioclase, andalusite, pyrite, magnetite, sillimanite, green spinel, and zircon. The corundum forms sharply idiomorphic tabular hexagonal crystals, striated and slightly stepped on the basal plane, and blue in colour. Iron-oxide is a constant inclusion. The inclusions have probably been to some extent injected with felspathic material. The original sediment was probably poor in silica and rich in alumina, and there has been sufficient molecular freedom for the formation of well-shaped crystals of corundum, comparatively free from inclusions. Sillimanite and zircon are the only other minerals which exhibit crystalline form.

CORRESPONDENCE.

YORKSHIRE BOULDERS.

Sir,—The value of Mr. Stather's paper on the sources and distribution of Yorkshire boulders (p. 17), which is very great, is not enhanced by the concluding paragraph. The Scandinavian Ice-sheet seems to affect some geologists as King Charles' head did Mr. Dick. May I then ask Mr. Stather two questions:—(1) What route did the Scandinavian Ice-sheet take when it anticipated the Norsemen by invading England? (2) What caused it to retreat before the advance of the British Ice-sheet? It was no doubt very polite to give place to the 'weaker vessel,' but as the British hill districts are smaller than and to the south of the Scandinavian, I should have thought nature would not have allowed courtesy to supersede law.

T. G. Bonney.

OBITUARY.

FREDERICK WILLIAM EGAN, B.A.

Born July 31, 1836. Died January 6, 1901.

Mr. Egan was born in Dublin on July 31st, 1836, and was the third son of the late Mr. W. J. Egan, of Rockville, Dundrum. Receiving his early education at Mr. Flynn's school in Harcourt Street, he entered Trinity College, where in due course he took his degree of B.A. and a diploma in Engineering. Commencing professional life as a railway engineer, he did considerable work in connection with the Great Northern, Great Southern, and Dublin. Wicklow, and Wexford Railways, then in course of construction, In 1868 he quitted the somewhat desultory employment of railway engineer for a more permanent position on the staff of the Geological Survey of Ireland, being appointed assistant geologist on the nomination of the late Professor Jukes, F.R.S. In 1890 he was promoted to the grade of geologist on the recommendation of the present Director-General of the Survey, Sir A. Geikie, D.C.L., F.R.S. His work was always characterized by the great care he bestowed on it, no details being too insignificant for his attention, and while he did not seek fame as an independent essayist, his contributions to the Official Memoirs and other reports furnish a mass of information which has often proved of considerable economic value. In the Summer of 1899 he met with an unfortunate accident, being violently thrown off a car while travelling in the execution of his duties, and sustained severe injuries, from which he never fully recovered. Some six months ago his complaint assumed a malignant form, which terminated in his death, after a long period of much suffering, on the 6th January. In personal character Mr. Egan was one of the kindliest and most lovable of men, and beyond the circle of his own family and immediate friends none will regret his loss more than his colleagues of the Geological Survey, to whom he was much endeared by his unfailing amiability, obligingness, and thorough good-nature.—*Irish Times,* January 11th.

MISCELLANEOUS.

The Director-General of the Geological Survey of the United Kingdom.—The announcement has just reached us (January 15th) that Sir Archibald Geikie has intimated his intention to retire from the post of Director-General of the Geological Survey of the United Kingdom, an office which he has so ably filled for the past twenty years, on March 1st next. In 1855, at the age of 20, Sir A. Geikie became an Assistant on the Geological Survey of Scotland, and he was made Director for Scotland in 1867. In 1881 he was appointed to succeed Sir Andrew Ramsay as Director-General of the Geological Survey of the United Kingdom. He has seen forty-six years' service, but is now only in his 66th year. (See his life, Geol. Mag. 1890, p. 49.) Early in March he will be entertained by his friends at a complimentary dinner. All who wish to attend should communicate with Mr. F. W. Rudler, Museum of Practical Geology, 28, Jermyn Street, London, S.W.—We rejoice to learn that Sir A. Geikie has no intention of retiring from active participation in geological work, and that neither his hammer nor his pen are to be laid aside for some years to come.

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FIG. 1.

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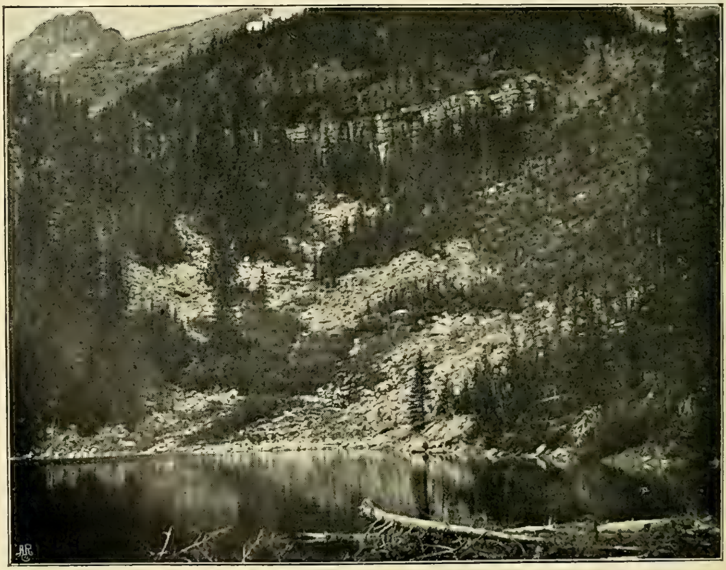

FIG. 2.

1, LAKE LOUISE; 2, MIRROR LAKE.

THE

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NEW SERIES. DECADE IV. VOL. VIII.

No. III.—MARCH, 1901.

ORIGINAL ARTICLES.

I.—Some Lake Basins in Alberta and British Columbia.

By J. Parkinson, F.G.S.

(PLATE VI.)

FOR several years careful study has been given to numerous lake basins in England and elsewhere, with the result that many previously considered as rock basins have not survived the ordeal. Professor Bonney,[1] who has always opposed this hypothesis in the case of large lakes, has described four authentic examples from the Lepontine Alps, three of which I had the advantage of visiting with him; and some few weeks before, Mr. Brend[2] described others from Caernarvonshire.

It may therefore be of interest to call attention to two lakes in the Canadian Rocky Mountains and one from the Selkirk Range which may lay claim to the rather rare distinction of being true rock basins. We will take the former first. The country between the Columbia River on the west and the infold of Cretaceous rock, known as the Cascade trough, on the east in the neighbourhood of Banff, is one of the most delightful that a traveller can enjoy. The east-bound train on the Canadian Pacific Railway, after leaving the Columbia River at Golden, the northern end of the Columbia Kootanie Valley, follows the course of the Kicking Horse River until the watershed between the Pacific and Atlantic slopes is reached a little to the west of Laggan. With the exception of a long strip of country between the Ottertail Mountains and the Vermilion Range to the south of the Kicking Horse River, which is mapped as "igneous intrusive,"[3] the whole of the country comprised in the area specified above is sedimentary. The line of the railway passes over the Canadian Quartzite series to Silver City on the Bow River, some seventeen miles to the east of Laggan. To the east of this, again, lies the north-west Cretaceous fold.

[1] Geol. Mag., 1898, p. 15.
[2] Geol. Mag., 1897, p. 404.
[3] "Reconnaissance Map of a portion of the Rocky Mountains between 49° and 51° 30′": Canada Geol. Surv., 1885.

The geological structure of this district is described by Mr. R. G. McConnell,[1] and it will be sufficient to refer to the salient points. Mr. McConnell divides this region into two nearly equal parts, taking the western side of the Sawback Range as the line of division. To the east of this line the dip is consistently to the west, due to the fact that a thrust from that direction has produced a series of roughly parallel ridges, which have been "tilted and shoved over one another into the form of a westerly dipping compound monocline." Rundle and Cascade Mountains, near Banff, are examples of this type. On the western side as far as the Columbia River no reversed faults are found, and "ordinary and overturned folds play the most important rôle." The lakes which form the subject of the present note lie in the latter division some two miles to the west of Laggan (5,008 feet). They are three in number. Lake Louise, the largest, a mile and a quarter long, lies at a height of 5,645 feet above sea-level, and Lakes Mirror and Agnes, overlooking their larger confrère, at heights of 6,500 feet and 6,820 feet respectively. They have been described from the point of view of the explorer and climber by Mr. Walter D. Wilcox, in his interesting and admirably illustrated book "The Canadian Rockies," from which the figures in Pl. VI are taken. At the end of this work an excellent map of this region is given, and he has also recently published a contour map and detailed study of Lake Louise.[2] Mr. Wilcox refers to Lake Agnes as being certainly a rock basin, and remarks elsewhere[2] that only two rock-basin lakes were observed by him, "one of which was a typical cirque lake," no doubt Lake Agnes. This little lake is about a third of a mile long and about 150 yards across, and is surrounded on three sides by mountains. The upper end is a cirque, its terminations culminating in two horn-like peaks. This occupies the upper third of the cliff, the middle third is precipitous rock, the lowest talus. On the left bank the mountain slopes are steep. A peculiar dome-shaped hill, the Beehive, 7,350 feet, and ridge, a continuation of the same, form the right bank of Lake Agnes and overlook the left bank of Lake Louise. The shape of the lake is modified by talus, but there is no possibility of hidden outlet, nor can we find sign of glacial deposits. The opening of this sack-shaped valley, with its tiny lake, is wide, and formed of thickly bedded quartzite. The outflow stream is nearer the left bank of the lake, and the rock floor slopes gently down to it. A shallow groove has been worn away in the quartzite, and the discharge stream empties as a small waterfall into Mirror Lake below. The latter is rather less satisfactory from the geologist's point of view. It is circular in shape and about 150 yards in diameter for the most part, no doubt surrounded by live rock, but modified in shape by talus and quite possibly by some glacial deposits. Whether the latter have dammed the exit is

[1] Canada Geol. Surv., 1886, N.S., vol. ii, p. 310.

[2] "A Type of Lake Formation in Canada": Journ. Geol. Chicago, vol. vii (1899), p. 253.

difficult to say, unless soundings were taken, but live rock (quartzite) outcrops on the trail leading down to Lake Louise, not far below the level of Mirror Lake. No exit stream can be found, and the overflow is said to find its way to Lake Louise by underground channels; a statement I see no reason to doubt, but the fact is unfavourable to the hypothesis that Mirror Lake is a true rock basin.

The valley in which Lake Louise lies, 850 feet below, is clearly blocked at the lower end of the lake by drift, but Wilcox states that the bottom of Lake Louise is 230 feet below the very lowest part of its dam. and the lower surface of its glacier must have ascended this slope upon entering the Bow Valley. It is possible, then, that the lake is a true rock basin.

One other example, also of a dubious nature, remains to be mentioned, viz., that from the Selkirks, near the Great Glacier, and some 1,500 feet above the station of Glacier on the C.P.R., directly overlooking the valley. It is called Lake Marian. Mountains rise abruptly, with talus strewn around their bases for nearly half the circumference of the lake; in front, where the pine-clad slopes plunge down to the valley beneath, a quartzite outcrops. This, or a crushed grit, is the common rock of the ascent from Glacier, with some outcrops of broken silvery slate. On the remaining (eastern) side live rock, if it exists, is concealed by surface soil and undergrowth, and the level is low. At first I thought Lake Marian to be a true rock basin, but subsequent reflection inclines me to the belief that glacial deposits may exist. The slopes on the south-eastern side of the lake in the direction of Mount Abbott are not precipitous, and it is possible that here a glacier left material sufficient to retain the water.

We are left, therefore, with but one clear and certain example of a rock basin, and it remains but to consider as briefly as may be what causes operated in its formation. And firstly, differential earth movements, as suggested by Mr. Brend for the Caernarvonshire tarns, may be considered. The bedding of the rocks forming the walls of the lake is remarkably well defined, and not far removed from the horizontal, but on looking at the right bank from an advantageous position, it becomes apparent that a slight dip up the lake exists which is greater at the lower than at the upper end. As the change, though slight, is abrupt, a small fault probably exists at this point.

The cirque is no doubt pre-Glacial, but it is possible that the configuration of the country has been altered in quite late times. Dr. J. W. Spencer, in his well-known work on the "Origin of the Basins of the Great Lakes in America,"[1] has demonstrated 'terrestrial warpings' more recent than the episode of the Upper Till. On the western side of the continent Dr. G. M. Dawson[2] mentions terraces

[1] Quart. Journ. Geol. Soc., vol. xlvi (1890), p. 530.

[2] "The Superficial Geology of British Columbia": Quart. Journ. Geol. Soc., vol. xxxiv (1878), p. 89. See also Dr. G. M. Dawson, "On the Physiographical Geology of the Rocky Mountain Region in Canada": Trans. Roy. Soc. Canada, vol. viii (1890), sect. 4, p. 68.

on the Fraser and Thompson Rivers in British Columbia, from 2,400 to 3,000 feet. Of these he says: "Many of the higher are accumulations along the shore of a great sheet of water; most of the lower have been carved out of deposits which at one time filled the valleys from rim to rim, and more or less completely levelled up the broken surface of the country, by the gradually receding waters of a lake or of the sea, and eventually by the rivers themselves deepening their channels to their old pre-Glacial levels" (p. 112). He concludes that the interior of British Columbia was submerged 4,000 to 5,000 feet during the formation of the Boulder-clay (p. 108).

The second hypothesis ascribes sufficient erosive power to a glacier in descending a sharp declivity such as the cirque at the head of Lake Agnes. Such plunging action is appealed to by Professor Bonney to explain the rock basins of Lakes Cadagno, Tremorgio, and others on the Lepontine Alps. In the case of Lake Agnes a glance at the map shows that here is ample gathering-ground for ice. The line of the Continental watershed lies a mile and a half to the west, with summits ranging, in the case of Pope's Peak, to 9,595 feet. Mount St. Piran, to the north, has a height of 8,580 feet. These between them form the north and north-north-west walls of the tarn. If any erosive action can be ascribed to ice, the present instance would afford an excellent opportunity for the display of its power, and it is quite possible that this is the true explanation.

At the time of my visit to Lake Agnes a third possibility occurred to me which may have some value, at least, as a contributory cause. The quartzite forms the lower bed in the walls of the lake, and must also occupy its floor, for the little waterfall of discharge passes over it for some distance below the level of the lake surface. The superincumbent beds are of a slaty nature, rather finely bedded, and broken. This, taken in conjunction with the dip of the whole up the lake, seemed to me to make it at least possible that the ordinary agents of denudation in working out the valley and its cirque-like head might form a basin which would retain water, simply from the fact that there was a greater thickness of less resisting material at the upper than at the lower end. I put this on record merely as a suggestion, but we may perhaps suppose some such process as the following. In early days the valley would incline steeply down to its lip, its bottom occupied by a stream attaining at certain times of the year to the dignity of a torrent of some dimensions. When worn down at its lower end to the level of the more resisting quartzite, the erosive action of the water would be checked at that point, but the constant freshets concentrated on its upper end by reason of the cirque-like disposition of the cliff would prevent the removing power of the water being materially lessened at the valley head. This process would go on possibly with increasing slowness, but with a tendency analogous to that ascribed to a glacier in descending a steep slope.

My sincere thanks are due to Professor Bonney for his kindness

in reading the manuscript of this paper, and for many valuable suggestions.

DESCRIPTION OF PLATE VI.

Fig. 1.—Photograph taken from the glacial deposits at the lower end of Lake Louise, and looking towards Lakes Agnes and Mirror. The cirque at the head of the former is well seen. The rounded promontory in front of the cirque is the "Beehive." To the right of this lies Mirror Lake, its position concealed by the upper part of the belt of forest. The point × is the same in both figures.

Fig. 2.—Mirror Lake. The waterfall of discharge from Lake Agnes is the white speck amongst the trees below the mark ×.

II.—A short Account of a Bone Cave in the Carboniferous Limestone of the Wye Valley.

By Dorothy M. A. Bate.

THE bones of Pleistocene mammals and birds, a list of some of which is given below, were found in a small cave in an outlying part of the Forest of Dean, close to the river Wye, where it is flanked by steep and wooded hills that rise abruptly from either bank. At short intervals along the sides of these hills limestone cliffs and boulders stand out bare and white among the surrounding trees. The slopes below are strewn, and in places completely covered, with pieces of rock of all sizes that are continually becoming loosened and fall from the outstanding crags above, in which are numerous cracks, holes, and caves, the last, as a rule, being only of small size.

The mouth of the cave in which these remains were found is situated half-way up the face of one of the cliffs. It is completely concealed from view by a thick growth of trees and bushes. This probably accounts for its being little known and not previously explored for animal remains, though, unfortunately, several human jaw-bones lying on the floor of the cave were taken away by some boys while searching for jackdaws' nests. Some time ago the greater part of the floor was dug up by miners looking for iron-ore. This was a most unfortunate occurrence, as in this way the position of the upper layers of earth and rock forming the floor of the cave has been considerably obscured. At the same time the bones contained in these deposits were mixed, specimens undoubtedly differing greatly in age being found in close proximity; furthermore, some of the bones of species now living bore a very fresh appearance.

The walls of the cave have not been disturbed, for here numerous minute bones are found in a good state of preservation. These were lying even in exposed situations where they might easily have been destroyed. This is perhaps the most curious feature of the cave, for at its inner end on every ledge and in every crevice were found small bones, most of them belonging to one or other of the smaller species of voles and mice. These remains have disappeared from the ledges near the entrance, doubtless on account of exposure to wind and wet, and to the presence of jackdaws, which nest in large numbers in all the cliffs.

The cave consists of two chambers, the larger of which penetrates the cliff for about thirty yards, only decreasing slightly in size from the entrance, which is large. The floor is partially covered with a layer of earth, which in one place is about a foot and a half thick. As already remarked, its original disposition has been more or less altered by the workings of the miners. This earth contained great quantities of small skulls and bones, the commonest among them belonging to *Microtus agrestis* and *M. amphibius*.

Owing to lack of time I was unable to penetrate below this earth except where some of the rock had already been removed. Portions of the walls several feet above the present level of the floor are encrusted with numberless small bones, impossible to extract in good condition owing to the hardness of the limestone. If pieces of rock were broken away similar bones were certain to be found loose in any soft or crumbly places. In fact, they were plentiful throughout the cave—in the earth, on the ledges, in the walls, and even on the surface of the floor. The bones embedded in the rock, as well as those concealed in the earth, were found extending right up to the mouth of the cave. These must have accumulated at a time when the cave was considerably larger than it now is. This it undoubtedly was at one time, for, as the face of the cliff has gradually been worn away, the slope below has become strewn with fragments of rock of all sizes. Another proof of this is that in its present state it would be impossible for such animals as sheep and deer to reach the cave. Yet the bones of these animals, and of others for whom it would be as difficult of access, are found buried in the earth. It is now evidently inaccessible to foxes and badgers, as there are no holes used by them here, although they are to be seen in almost every other cave I have visited in the district.

The smaller chamber opens into the main cave near the inner end of the latter, and runs almost parallel with it towards the face of the cliff. It has now no direct connection with the outside, although there is an opening in the cliff with which it was probably formerly connected. It is possible that the present entrance has only lately been made. The roof is very low, forcing one to crawl on hands and knees. Part of the floor has been disturbed in the same way as in the outer chamber, but, unlike it, there is little of the earth in which the greater number of the small bones were found. Probably the real mouth of this cave has been closed up by the roof at this point giving way, the rock having been loosened by water. At the end nearest the face of the cliff there is always a certain amount of water to be seen dripping from the wall. The rock over which it runs down to the level of the floor has been formed into a series of ridges, somewhat resembling those left on the sand by the receding tide, though they differ in being higher and sharper and closer together. This has a very striking appearance when a light is thrown on its ribbed surface, which looks black and highly polished, and is always glistening with moisture. Wherever this water penetrates it leaves a deposit of stalagmite, which causes the rock to become extremely hard, thus making any excavation a difficult task, and in some places it is impossible to detach bones from the rock intact.

The cave contained the teeth and jaw-bones of six small mammals that are now extinct in Great Britain. These are: *Microtus ratticeps, M. arvalis, M. nivalis, Lemmus lemmus, Dicrostonyx* (=*Myodes*) *torquatus*, and *Ochotona* (=*Lagomys*) *pusillus*. At the present day these species are found chiefly in colder and more northern countries, the pika being confined to the steppe regions of Eastern Europe and Siberia. No remains of the reindeer or other large northern forms were found, though from the presence of the lemmings and some of the voles this might have been expected. Remains of the reindeer and mammoth have been taken from a somewhat similar cave situated not two miles distant. See British Museum (Natural History) Coll.

Remains of the following animals were found in this cave:—

Homo.—I have already mentioned that some jaw-bones were found on the floor of the cave, but I have been unable to secure one or to trace their present whereabouts. I procured one clavicle, several vertebræ, and a number of digital phalanges. The only implements found were a bone needle, or hairpin, and a portion of a copper ring.

Bone needle, one-third less than original specimen.

The needle, which Sir Henry Howorth considers belongs to the Bronze Age, is a very fine specimen in a perfect state of preservation. It is five inches in length and has a circular hole pierced through its broader end, from which it gradually tapers to a blunt point. The larger end has the appearance of having been cut straight across with some sharp instrument.

Rhinolophus hipposideros.—Two lower jaw-bones and a portion of one skull of this bat were among the remains found in the cave.

Talpa Europæa.—One upper jaw of this species and two mandibular rami were found in the cave together with several pelvic bones. There is a considerable difference in the size of these two rami, one of which, the larger, still retained a milk tooth. Fossil remains of this mole have been found in the Norfolk Forest Bed as well as in Pleistocene deposits. Mr. W. J. Lewis Abbot found numerous bones belonging to this species in the Ightham fissure in Kent.

Sorex araneus.—The upper jaws of the common shrew were fairly plentiful, one or two skulls being found in an almost perfect state of preservation. They varied much in size, a considerable difference being noticeable between the largest and the smallest specimens obtained. The lower jaw-bones were less numerous; perhaps on account of their small size they were easily passed over when buried in the earth. Less than half a dozen were secured, all of them retaining ther full number of teeth. Remains of this shrew have been found in the Forest Bed and in caves.

Neomys (= *Crossopus*) *fodiens.*—One upper jaw of the water-shrew was found which still retained its full number of teeth. Its remains have occurred in the Norfolk Forest Bed.

Microtus amphibius.—Jaw-bones and portions of skulls of the water-vole were numerous in the cave earth. Many of the rami were preserved in an almost perfect condition. Its remains have been found in Pleistocene deposits and in a number of caves in England.

Microtus agrestis.—Remains of the field-vole were more plentiful than those of any other of the species found in the cave. Similar remains have been found in many caves in England. This vole is still living in Britain and extends over the middle and north of Europe, being commoner in the northern part of its range.

Microtus ratticeps.—One or two portions of skulls and about a dozen rami of the northern vole were found in this cave, and agree with recent specimens in the British Museum. In a few of the lower jaw-bones the teeth resemble the figure of *M. gregalis* given by Dr. Nehring in a paper published in 1875, but the presence of intermediate forms between this and the typical *M. ratticeps* makes it probable that all in this series ought to be referred to the latter species. Fossil remains of *M. ratticeps* have been found in England in the river deposit at Fisherton, in caves in Somersetshire, and in the Ightham fissure in Kent. It no longer occurs in Great Britain, but is now found in Northern Europe and Siberia.

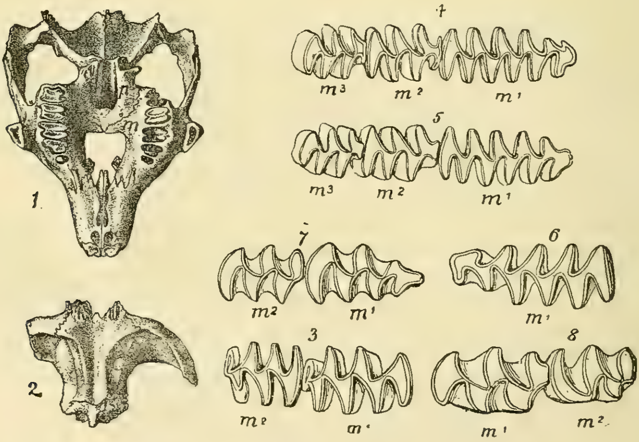


Fig. 1.—Palatal view of skull of *Ochotona* (*Lagomys*) *pusillus*.
Fig. 2.—Dorsal aspect of part of skull of *Dicrostonyx* (*Myodes*) *torquatus*.
Fig. 3.—View of upper molars of *Dicrostonyx* (*Myodes*) *torquatus*.
Figs. 4–6.—View of lower molars of *Dicrostonyx* (*Myodes*) *torquatus*.
Figs. 7, 8.—View of (7) lower and (8) upper molars of *Lemmus* (*Myodes*) *lemmus*.

Microtus arvalis.—Several jaw-bones, upper and lower, may be referred to this species. Their upper teeth are easily distinguished from those of *M. agrestis* by the character of the second molar, but the lower teeth of these two species resemble each other very closely.

Remains of this field-vole have been found in the Forest Bed and in fissures near Frome and at Ightham. It is no longer living in Great Britain, but is the commonest field-vole of Central Europe, its range extending as far as Western Siberia.

Microtus nivalis.—Two mandibular rami, which I have compared with recent specimens in the British Museum, are referred to this species. A third might possibly also belong to this vole, but is too imperfect to admit of certain identification. At the present day it is not found in Britain, but inhabits the Alps of Central Europe, where it is not found at a lower elevation than 3,000 feet above the sea-level. By Dr. Selys Longchamps it is said to occur in the Pyrenees, and may possibly also be found elsewhere. The only record of the fossil remains of this species being found in England is that of Messrs. Blackmore and Alston, who doubtfully referred to this species a jaw-bone found in the river deposit at Fisherton, near Salisbury (P.Z.S., June, 1874).

Evotomys (= *Microtus*) *glareolus.*—Part of one skull and several mandibular rami of the bank-vole were found in the cave earth. In one or two of the rami, which belonged to immature animals, the teeth had not yet developed roots. Its remains have been found in the Forest Bed, in many caves, and in Pleistocene river deposits. At the present day its range extends to the Arctic circle.

Lemmus (= *Myodes*) *lemmus.*—Portions of five upper jaws of the Norwegian lemming were found in the earth together with eight lower jaw-bones, only one of which contained the full number of teeth. This species is no longer found in Britain, its range at the present day being confined to the Scandinavian peninsula and Russian Lapland. Its remains have been found in a cave in Somersetshire and in the Ightham fissure in Kent.

Dicrostonyx torquatus.—Nearly a dozen well-preserved mandibular rami of this species were found, but only a portion of one upper jaw. The Arctic lemming occurs in the Pleistocene of England and the Continent, but is now entirely confined to the Arctic regions.

Ochotona (= *Lagomys*) *pusillus.*—Portions of eight or nine skulls of this species were found together with nineteen lower jaw-bones. The remains of this tailless hare are interesting, as no representative of the family is found in the British Islands at the present day. This pika now only inhabits Eastern Russia and Siberia. Its fossil remains have been procured from several other caves in England: at Bleadon, Brixham, and Kent's Hole.

Lepus timidus (*L. variabilis*).—Portions of a skull and lower jaws, both retaining teeth, are referred to this species. Remains of the mountain hare have been found in several caves, in the Mendip Hills, and at Knockninny and Shandon in Ireland.

Mus sylvaticus.—Eighteen lower jaw bones and portions of about seven or eight skulls are referred to this species, which is still found widely distributed over temperate Europe, and extending to Western Siberia and the Caucasus. Its remains have been found in the Forest Bed and at West Runton, Norfolk.

A great number of small limb bones, most of which probably belong to the small rodents, were found scattered over the cave and buried in the earth with the other remains. Some other remains are referred to the dog, sheep (which appears to have been considerably smaller than the ordinary domestic variety), a species of small deer, several bones of *Rana temporaria*, and three snail shells, probably *Helix hortensis*. Dr. Andrews kindly identified the remains of birds found in the cave. They belong to five species, remains of all of which have occurred in other caves in Britain. They are *Turdus* sp., probably *Turdus viscivorus*, pigeon sp., *Anas boschas*, *Lagopus scoticus*, and *Perdix perdix*.

I wish to express my thanks to Dr. Andrews and Dr. Forsyth Major for the very kind and valuable help I have received from them, especially in assisting me to determine the extinct forms, and also for Dr. Forsyth Major's kind advice in selecting those which have been figured in the text.

III.—Woodwardian Museum Notes: Salter's Undescribed Species. III.

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

(PLATE VII.)

Phacops (*Odontocheile*) *caudatus*, var. *corrugatus*, Salter. (Pl. VII, Figs. 1, 2.)

1873. Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 93 (*a* 461).

There are six specimens of this variety in the Woodwardian Museum, all of which come from the Woolhope Limestone, of Littlehope, and were labelled by Salter. Five of them are more or less perfect head-shields, and the other is a pygidium in a good state of preservation.

The head-shield shows the general characters of *Ph. caudatus*, var. *a*, *vulgaris*,[1] but the arrangement of the tubercles on the frontal lobe of the glabella is peculiar, and resembles that of *Chasmops*, for they form a V-shaped pattern, six or seven large tubercles composing each arm of the V. The arms of the V enclose an angle of about 30° to 40°. A few other large tubercles occur on the frontal lobe close to the V, and starting from its apex show an obscure radial arrangement. The margin of the head-shield, where the shell is preserved, exhibits an ornamentation consisting of closely-set, rather coarse granulations. The front margin is produced into an obtuse point.

The main characters of the pygidium are similar to those of the typical variety of *Ph. caudatus*. The axis, however, shows ten distinct rings with a less distinct eleventh one, and a short, faintly annulated, terminal piece. The rings are less strongly defined in the middle, owing to the transverse furrows being comparatively weak in the middle while deeply impressed at the sides.

On the fourth and seventh axial rings is a pair of small oval areas, slightly raised above the general surface and finely pitted (the so-called 'cutaneous glands' of Salter, op. cit.). There are faint

[1] Salter: Mon. Brit. Trilob. Pal. Soc., 1864, p. 51.

traces of similar 'glands' on several of the other rings. The whole axis, as well as the lateral lobes, is also ornamented with minute pits.

The lateral lobes show seven distinct pairs of pleuræ, ending abruptly on the smooth narrow margin, but separated by strongly raised ridges. The surface of each pleura is excavated, and bears a furrow, in front of which the surface is sharply ridged up. The furrow is close to and nearly parallel to the posterior edge of the pleura. On the ridge along the anterior edge of the furrow on each pleura, there is a so-called 'cutaneous gland' situated similarly to those figured by Salter[1] for *Ph. caudatus.* On the first pleura this gland is near the axis; on the second it is near the outer extremity; on the third it is placed half-way along the length of the pleura; and on the fourth it is near the axis. Those on the fifth, sixth, and seventh pleuræ repeat the arrangement of the second, third, and fourth. A few tubercles are also found scattered irregularly over the lateral lobes. The pygidial margin was produced posteriorly into an aculeate mucro, but it is broken off short in our specimen.

MEASUREMENTS.

	mm.
Length of pygidium	22·0 (*minus* mucro).
Width of ditto	24·0
Width of axis of pygidium (at front end) ...	8·5
Length of ditto	18·0

AFFINITIES.—Lindström's species *Ph. obtusa,*[2] from the Gotland beds, bears comparison with this variety of *Ph. caudatus*, but though the furrowing of the glabella is closely similar, the V-shaped arrangement of the tubercles seems to be absent and also the 'cutaneous glands' on the pygidium. The true significance and function of these so-called glands is at present unknown, but, if we may presume on our scanty knowledge of these structures to make a suggestion, they appear to be similar to the maculæ on the hypostomes of most trilobites which Lindström[3] after a detailed study has recently concluded had a visual function. It may be that these pygidial structures were organs of phosphorescence.

ENCRINURUS MULTIPLICATUS, Salter. (Pl. VII, Fig. 3.)

1873. *Encrinurus multiplicatus,* Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 51 (*a* 226).

1891. *Encrinurus multiplicatus*, Salter (Woods): Cat. Type Foss. Woodw. Mus., p. 144.

The original specimen is very imperfect, and consists of only a partially preserved pygidium, so that the description of this species must be somewhat incomplete. It is labelled as having been found in the Middle Bala at Barking, Dent, and is preserved in a tough dark-grey limestone. The pygidium has an elongated and pointed form somewhat like *E. multisegmentatus* (Portl.), and possesses

[1] Salter: Mon. Brit. Trilob. Pal. Soc., 1864, p. 52, woodcuts 11 and 12.

[2] Öfv. k. Vet. Akad. Förhandl., No. 6, 1885, p. 41, pl. xii, figs. 3, 4, 7, 8, and pl. xiii, fig. 1.

[3] Kongl. Svensk. Vet. Akad. Handl., B. 34, No. 8, 1901.

a long narrow axis tapering very gradually to its posterior extremity. There are sixteen complete axial rings of gradually decreasing size, extending for about two-thirds the length of the axis, and followed by about twelve much narrower rings of equal size, interrupted in the middle by a narrow smooth area, and extending to the point of the axis, which is thus segmented along its whole length.

Only one of the lateral lobes is preserved, but this shows the eleven pleuræ of which it is composed, and is bent down rather strongly towards the posterior end. The anterior pleuræ curve weakly backwards, but the posterior ones more strongly, and the last one, which starts at the level of the sixteenth axial ring, runs back alongside of the axis to the posterior margin. Each pleura appears to be provided with a shallow median longitudinal furrow.

There are obscure traces of small tubercles on the surface, but the ornamentation is very indistinct.

MEASUREMENTS.

	mm.
Length of pygidium	12·0
Width of ditto ... ... (estimated at)	10·0

AFFINITIES.—The most closely allied species might appear at first sight to be *E. multisegmentatus*, Portlock,[1] but the resemblances lie more in the large number of the segments than in the characters of the parts of the pygidium. For the segmentation of the axis is different, and the course of the pleuræ is not the same. The segmentation of the posterior part of the axis more resembles that of *E. punctatus*, though the anterior part with its complete rings is quite different, and is similar to that in Portlock's species. As far as the axis is concerned, it thus seems to share the characters of these two species.

Turrilepas ?? *ketleyanus*, Salter.

1873. *Turrilepas ketleyanus*, Salter: MS. Cat. Camb. Sil. Foss. Woodw. Mus., p. 129 (*b* 730).
1891. *Turrilepas ketleyanus*, Woods: Cat. Type Foss. Woodw. Mus., p. 132.

The two original specimens are very poorly preserved and fragmentary and the plates seem to be displaced from their original position, and the description, therefore, is far from satisfactory. The specimens are from the Wenlock Limestone of Dudley, and were presented to the Woodwardian Museum by Mr. C. Ketley.

DIAGNOSIS.—Two vertical rows of loosely arranged, alternating plates of regular (?) shape, followed above by a closely imbricated mass of irregular plates. There are four or five plates in each of the vertical rows, but their shape is somewhat doubtful, as their edges appear to be broken in most cases, but they seem to be transversely oblong (not triangular), with their upper and lower edges sub-parallel, and the outer edge rounded; they are also slightly arched from side to side, and their surface is marked by fine striæ parallel to the outer edge and by minute pits and granulations.

[1] Portlock: Geol. Rep. Lond., 1843, p. 291, pl. iii, fig. 6. Törnquist: Undersokn. Siljans. Trilobitf., 1884, p. 24, pl. i, figs. 18, 19.

In the upper mass of closely packed plates only the minute pits and granulations are visible. These upper plates appear to be triangular and to bear a carina.

REMARKS.—It is extremely doubtful if this fossil is the remains of a crustacean, and it has been suggested with much probability that it represents the column of one of the Anomalocystidæ.[1] The supposed shape of the plates in the double row cannot be regarded as of much value, owing to their imperfect condition. It is unfortunate that Salter chose to attach a specific name to such exceedingly unsatisfactory specimens.

GASTEROPODA.

SUBULITES PUPA, Salter. (Pl. VII, Fig. 5.)

1873. *Macrocheilus pupa*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 156 (*a* 869).
1891. *Macrochilina pupa*, Woods: Cat. Type Foss. Woodw. Mus., p. 106.

There is one specimen in the Woodwardian Museum from the Wenlock Limestone of Dudley (Fletcher Collection), labelled *Macrocheilus pupa* (*a* 869) by Salter. Only the three lower whorls are preserved, and these show no ornament; the two apical whorls are broken off. The shape of the mouth is also well seen. The regular, elongate, fusiform shell, the shallow suture-line, the slight convexity of the whorls and their want of ornamentation, the large body-whorl, equal in length to about half the shell, and the narrow elongate aperture, inferiorly acuminate, show that it is comparable to *Subulites ventricosus* (Hall),[2] described and figured also from the Wenlock of Sweden by Lindström.[3] It cannot be assigned to the genus *Macrochilina*, on account of the shape and characters of the mouth and the shallowness of the suture-line. This species has also been found by Professor Hughes in the Lower Llandovery of Blain y cwm.

MEASUREMENTS.

	mm.
Length of specimen	35·0
Estimated length when perfect	40·0
Width of body-whorl	18·0

TROCHUS CALYPTRÆA, Salter. (Pl. VII, Fig. 4.)

1873. *Euomphalus calyptræa*, Salter: Cat. Camb. Sil. Foss., p. 157 (*a* 862).
1891. *Euomphalus calyptræa*, Woods: Cat. Type Foss. Woodw. Mus., p. 103.

The one small original specimen (*a* 862) from the Wenlock Limestone of Dudley is all the material we possess. It is imperfect, but the body-whorl is well preserved and shows the essential features.

DIAGNOSIS.—Shell small, trochiform, obtusely conical, of several whorls (probably four or five), which are sub-ventricose. The body-whorl has an angulated, rather prominent umbilical edge, and its umbilical surface is flattened at right angles to the rest of the whorl,

[1] H. Woodward: GEOL. MAG., Dec. II, Vol. VII (1880), p. 193, Pl. VI, and Woodcut, Fig. 6, p. 197.
[2] Hall: Pal. N.Y., ii (1852), p. 347, pl. 83, fig. 7.
[3] Lindström: Sil. Gastr. Pter. Gotl., 1884, pp. 193, 194, pl. xv, figs. 19–21.

slightly raised in the centre and more so towards the aperture, which appears to be subcircular, with the inner lip strong and thickened. Surface of whorls ornamented by transverse, obliquely curved, regular, and equidistant lamellar ribs. Umbilicus small and apparently closed.

Remarks.—This form certainly does not belong to the genus *Euomphalus*. Its whole appearance is trochiform, and it bears a close resemblance to *Trochus Stuxbergi* (Lindström),[1] but differs by the umbilical surface being flatter, by the marginal ridge being less developed, and by the greater strength and regularity of the growth-lamellæ on the surface. Its ornamentation is not so coarse as in *Tr. undulans* (Lindström),[2] but the shape of this species and its umbilical surface are very similar. The characters of the mouth and umbilical surface distinguish it from *Callonema obesum* (Lindström),[3] with which at first sight it bears some resemblance in shape and ornamentation.

EXPLANATION OF PLATE VII.

Fig. 1.—*Phacops* (*Odontocheile*) *caudatus*, var. *corrugatus*, Salter. Head-shield (*a* 481), × 1½. Woolhope Limestone, Littlehope.

Fig. 2.—Ditto. Pygidium (*a* 461), × 2. Woolhope Limestone, Littlehope.

Fig. 3.—*Encrinurus multiplicatus*, Salter. Pygidium (*a* 226), × 3. M. Bala, Barking, Dent.

Fig. 4.—*Trochus calyptræa*, Salter sp. (*a* 862), × 2. Wenlock Limestone, Dudley.

Fig. 5.—*Subulites pupa*, Salter sp. (*a* 869), × 1½. Wenlock Limestone, Dudley.

IV.—Notes on the Lower Carboniferous Fishes of Eastern Fifeshire.

By Dr. R. H. Traquair, F.R.S., F.G.S.

(Read before the Royal Physical Society of Edinburgh, January 16th, 1901.)

NOT much has as yet been done in the way of cataloguing the fossil fishes of the Lower Carboniferous rocks of Eastern Fifeshire. A few species and localities were noted by the late Rev. Thomas Brown in 1860[4] and by Mr. Kirkby in 1880,[5] and the late Mr. Robert Walker published a paper in 1872[6] in which he described what he supposed to be a new species of *Amblypterus* (*A. anconoæchmodus*) from the Oil-shale works at Pitcorthy, near Anstruther. In this paper Mr. Walker drew attention to the abundance and variety of fish-remains in the oil-shale and ironstone worked at that locality, promising to describe them in detail afterwards—a promise which he was never able to fulfil. After his

[1] Sil. Gastr. Pter. Gotl., p. 147, pl. xiv, figs. 59–69 (especially fig. 62).

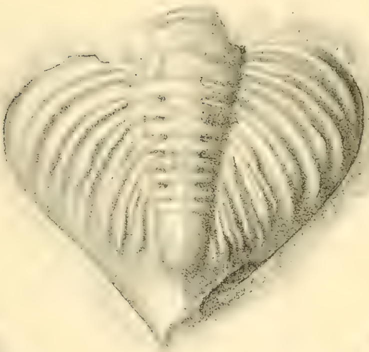
[2] Op. cit., p. 148, pl. xvi, figs. 8–10.

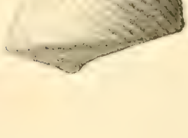
[3] Op. cit., p. 189, pl. xv, fig. 27.

[4] "Notes on the Mountain Limestone and Lower Carboniferous Rocks of the Fifeshire Coast from Burntisland to St. Andrews": Trans. Roy. Soc. Edinb., vol. xxii (1860), pp. 385–404.

[5] "On the Zones of Marine Fossils in the Calciferous Sandstones of Fife": Quart. Journ. Geol. Soc., vol. xxxvi (1880), pp. 559–590.

[6] "On a new species of *Amblypterus* and other Fossil Fish-remains from Pitcorthy, Fife": Trans. Geol. Soc. Edinb., vol. ii, pt. 1, pp. 119–124, with plate.





G.M.Woodward del. et lith.

Ordovician and

death in 1881, his important collection of fish-remains from this and other localities in East Fife was acquired by the Edinburgh Museum, and largely forms the basis of the present list. I myself have also done some collecting in this region; and a good many years ago the Museum acquired a number of specimens collected by Mr. W. T. Kinnear at Ardross, some of which are of great interest.

The district in question is comprised in sheets 41 and 49 of the Geological Survey Map of Scotland. All the species here noted are from Lower Carboniferous rocks, the horizons represented being the Upper part (Oil-shale group) of the Calciferous Sandstone Series and the Lower part of the Carboniferous Limestone Series. Here I may note that in 1890 [1] I included the Teleostomi and Dipnoi of the region in a list of the fishes of these orders occurring in Fife and the Lothians, published by the Royal Society of Edinburgh. The present list, however, includes the Elasmobranchs as well, and also a few additional species now described as new.

CALCIFEROUS SANDSTONE SERIES.

Elasmobranchii.

1. *Pleuracanthus horridulus*, Traq. Pitcorthy.
2. *Diplodus parvulus*, Traq. Pitcorthy.
3. *Cladodus unicuspidatus*, Traq., n.sp. Near Rock and Spindle.
4. *Callopristodus pectinatus* (Ag.). Rocks east of St. Andrews; Pitcorthy.
5. *Oracanthus armigerus*, Traq. Teeth, at Ardross.
6. *Gyracanthus*, sp. Rocks east of St. Andrews; Pittenweem. Not sufficiently well preserved for specific determination.
7. *Sphenacanthus serrulatus* (Ag.). Pitcorthy.
8. *Sphenacanthus Fifensis*, n.sp. Rocks east of St. Andrews.
9. *Euphyacanthus semistriatus*, Traq. Ardross.
10. *Tristychius arcuatus*, Ag. Pitcorthy.
11. *Tristychius minor*, Portlock. Pitcorthy.
12. *Cynopodius crenulatus*, Traq. Pitcorthy.
13. *Acanthodes sulcatus*, Ag. Ardross.

Teleostomi.

Crossopterygii.

14. *Rhizodus Hibberti* (Ag.). Rocks on shore east of St. Andrews; Pitcorthy.
15. *Rhizodus ornatus*, Traq. Pitcorthy; Pittenweem.
16. *Strepsodus striatulus*, Traq. Pittenweem.
17. *Strepsodus minor*, Traq. Pitcorthy.
18. *Cœlacanthopsis curta*, n. g. and sp.

Actinopterygii.

19. *Elonichthys Robisoni* (Hibbert). Pitcorthy.
20. *Elonichthys striatus* (Ag.). Pitcorthy.
21. *Elonichthys pectinatus*, Traq. Ardross.
22. *Rhadinichthys ornatissimus* (Ag.). Kiness Burn, near St. Andrews.
23. *Rhadinichthys carinatus* (Ag.). Pitcorthy; Corn Ceres, near Kilrenny.
24. *Rhadinichthys brevis*, Traq. Pitcorthy.
25. *Nematoptychius Greenocki* (Ag.). Pitcorthy.
26. *Gonatodus punctatus* (Ag.). Pitcorthy. This is the *Amblypterus anconoæchmodus* of R. Walker.
27. *Eurynotus crenatus*, Ag. Pittenweem; Pitcorthy; Corn Ceres; Kenly Mouth, east of St. Andrews.

[1] "List of the Fossil Ganoidei and Dipnoi of Fife and the Lothians": Proc. Roy. Soc. Edinb., vol. xvii (1890), pp. 385–400.

Dipnoi.

28. *Ctenodus interruptus*, Barkas. Pittenweem.

Incerta sedis.

29. *Eucentrurus paradoxus*, n. g. and sp. Ardross.

CARBONIFEROUS LIMESTONE SERIES.

Elasmobranchii.

1. *Petalodus acuminatus*, Ag. Ladedda, near St. Andrews.
2. *Oracanthus armigerus*, Traq. Largo Ward.
3. *Sphenacanthus serrulatus*, Ag. Denhead Ironstone, Denhead, near St. Andrews.
4. *Acanthodes*, sp. Denhead.

Teleostomi.

Crossopterygii.

5. *Rhizodus Hibberti* (Ag.). Denhead.
6. *Rhizodus ornatus*, Traq. Denhead.
7. *Megalichthys*, sp. Denhead.
8. *Elonichthys Robisoni* (Hibbert). Denhead.
9. *Elonichthys pectinatus*, Traq. Denhead.
10. *Eurynotus crenatus*, Ag. Denhead.

The above list contains all the species, thirty in number, which are contained in the Natural History Department of the Edinburgh Museum or in my own collection. Mr. Kirkby, however, records *Ctenacanthus*, sp., from near the Rock and Spindle, and *Pœcilodus obliquus*, Ag., from a marine limestone of Calciferous Sandstone age on the coast near Randerston Castle.

Notes on Species.

Diplodus.—I have found small *Diplodus*-teeth in shales on the shore at Pittenweem, but which can hardly be safely identified with any known form or considered as new.

Cladodus unicuspidatus, n.sp.—Base flat below, depth from back to front about two-thirds the width from side to side, contour more convex in front than behind. A single slender pointed cusp arises from the middle of the front of the base, and is erect, straight when seen from the front, sigmoidally recurved when viewed laterally, covered with delicate raised ridges, which increase in number downwards by intercalation. No trace of lateral cusps. Height of cusp of most perfect specimen $\frac{5}{16}$ inch, width of base laterally about the same.

Under the term *Monocladodus*, Professor Claypole[1] has separated from *Cladodus*, Agassiz, two species from the Cleveland shale, on account of the apparent want of lateral cusps. Allied to *Cladodus*, and also possessing only one cusp, are *Lambdodus* and *Hybocladodus* of St. John and Worthen.[2] The present teeth, however, agree so closely with *Cladodus* in all respects, save the want of lateral cusps and the comparatively short lateral extent of the base, that I prefer leaving them with that genus for the present.

A cluster of these teeth was found by myself many years ago in a septarian nodule on the shore near the Rock and Spindle, east

[1] American Geologist, vol. xi (1893), p. 329.

[2] Geol. Surv. Illinois, vol. vi.

of St. Andrews. Owing to the hardness of the matrix it was impossible to work out the superficial configuration of the teeth, except in two instances where they happened to be covered by white carbonate of lime.

Sphenacanthus Fifensis, n.sp.—Length of the largest specimen, $5\frac{3}{4}$ inches; greatest antero-posterior diameter, $\frac{3}{4}$ inch; implanted portion reaching up to $1\frac{3}{8}$ inches in front and $2\frac{3}{4}$ inches behind; form straight and tapering; posterior area slightly concave, its margins showing traces of abraded denticles; anterior margin of exserted portion formed by a sharp median ridge; sides ornamented by straight ribs or rounded ridges, which increase in number proximally by bifurcation, and are not nodose.

This spine, of which there are several specimens in the Walker Collection, Edinburgh Museum, differs from *Sph. serrulatus*, Ag., by the multiplication of the lateral ribs by bifurcation instead of intercalation. The want of nodosity of these ribs is of no consequence, as the greatest difference occurs in this respect in different individuals of *Sph. serrulatus*, and also of the closely allied Coal-measure form *Sph. hybodoides* (Egerton). In a hard calcareous sandstone from the coast east of St. Andrews.

Cœlacanthopsis curta, n. g. and sp.—Of this interesting fish only one specimen has been obtained, and that one is unfortunately deficient at the caudal extremity. What remains measures 2 inches in length, and in this the length of the head is contained three times, being also equal to the greatest depth. The head bones are crushed and scarcely decipherable. Vertebral axis notochordal; abdominal region extending for $\frac{1}{2}$ inch behind shoulder-girdle; no ribs are seen, but there is distinct evidence of the ossified air-bladder characteristic of the Cœlacanthidæ. Neural arches united with the neural spines, which are long, very slender, and closely placed; hæmal arches and spines similar in condition and configuration. On the dorsal aspect and just above the termination of the abdominal cavity a set of slender interspinous bones commences, these being short at first but rapidly increasing in length, until they are as long as the neural spines, and then the fish suddenly breaks up about 2 inches from the tip of the snout. Attached to the distal extremities of these interspinous bones are fin-rays, very short anteriorly, and still short at the point of truncation of the specimen. It is probable that similar elements existed on the hæmal aspect of the skeleton, but have been lost. Paired fins not preserved, except a few imperfect rays where the ventrals ought to be. Indications of the presence of scales feeble.

Strikingly new as this little fish is specifically, a word or two must be said as to its family and generic relationships. The ossified air-bladder and the configuration of its neural and hæmal arches and spines at once indicate that its family position is in the Cœlacanthidæ, but its differences from any known genus of this family are very strongly marked. We have, firstly, the abbreviated form of the fish, which is certainly not entirely due to *post-mortem* shortening up, as the skeletal parts in front of the place where the specimen is truncated lie nearly quite undisturbed; secondly, the great proportional length of the neural and hæmal spines; thirdly, the apparent absence of the two separate dorsal fins with their compound supporting 'axonosts,' characteristic of the Cœlacanthidæ. These *may* have been lost in the present specimen, but the tips of the neural spines come so close up to the dorsal margin that there would not have been room for the last-named elements if of the form prevalent in the genera of this family. Fourthly, the median fin which we see beginning just opposite the posterior termination of the abdominal cavity corresponds, in its relation to its supporting elements, to the caudal of *Cœlacanthus*, but is immensely further forward in its commencement. It is unfortunate that, owing to the truncation of the fish shortly after the commencement of this fin, we cannot see the extremity of the tail, but enough is shown in the specimen to prove its novelty, both specific and generic. The acquisition of more perfect specimens is, however, urgently to be desired, as it is clear that if the dorsal fins with their compound axonosts are really wanting in this form a change must be made in the received definition of the Cœlacanthidæ, as well as of the Actinistian group of the Crossopterygii.

From Ardross, collected by Mr. W. T. Kinnear, and now in the Edinburgh Museum.

Eucentrurus paradoxus, n. g. and sp.—This extraordinary little organism measures $2\frac{5}{8}$ inches in length, of which $\frac{1}{2}$ inch may be allotted to the head, $\frac{3}{4}$ inch to the body, and $1\frac{1}{8}$ inch to the tail. The head is a mass of calcareous matter, in which something suggestive of a broad curved mandible can be seen, but admits of no further description. The body, $\frac{3}{8}$ inch broad in front, is composed of a greyish film, which when examined by a strong lens is seen to consist entirely of minute, slender, slightly curved, and sharply pointed spinelets. The tail is tapering in form, consisting of amorphous-looking calcareous matter, but on each side (assuming that the creature is crushed vertically) is a conspicuous row of double spinelets arranged exactly opposite each other. From a common base arise two spinelets, which are placed close together and nearly parallel to each other; one of them, the anterior, being only half the length of the posterior one, which just behind the body may attain a length of $\frac{1}{16}$ inch, though towards the end of the tail they become smaller; both of the spinelets are slender, slightly curved, round in transverse section, smooth externally, sharply pointed, and traversed internally by a central tubular pulp cavity. No trace either of internal skeleton, or of limbs, or fins of any sort can be seen.

This strange organism is another of the problems of Palæozoic ichthyology, as it is scarcely possible to indicate its systematic position with any degree of certainty. The nature of its dermal armature would incline us to the belief that it is a Selachian, though all other evidence to that effect is wanting.

From Ardross, collected by Mr. W. T. Kinnear, and now in the Edinburgh Museum.

V.—History of the Sarsens.

By Professor T. Rupert Jones, F.R.S., F.G.S., etc.

(*Concluded from p.* 59.)

II. (8) *Kent.*—1862. Mr. W. H. Bensted, in the *Geologist*, vol. v (1862), pp. 449, 450, states: "The Druid Sandstone, of which Kit's Coty House, Stonehenge, and many other Druidical remains are composed, is found scattered in great blocks over the surface of the Chalk Hills, or buried superficially in beds of clay retained in the hollows on the summits of the escarpments." These stones, he added, are the same as the Greywethers of Berks and Wilts; and are occasionally pebbly, like the Hertfordshire Puddingstones.

1872. In Fergusson's "Rude Stone Monuments," 1872, pp. 116–120, some of the best specimens of Sarsens that remain as relics of prehistoric monuments in Kent are noticed, especially those near Aylesford, on the Medway.

1894. Thomas Wright, in his "Wanderings of an Antiquary, chiefly in the track of the Romans in Britain," 1894, pp. 176–178, describes in detail some large circular pits that have been filled with flints and capped with broad Sarsens, on Aylesford Common; these, he thought, were probably sepulchral, and may have had a chamber opening out of the side at the bottom.

1900. Some small Sarsens from the gravel of the Darent at Shoreham, in Kent, show many perforations of rootlets.—R. A. B.

(9) *Surrey.*—1814. T. Webster: Trans. Geol. Soc., vol. ii, pp. 224, 225. At Pirbright, Surrey, loose blocks of stone similar to what have been called Greywethers. Many loose masses of this rock lie scattered on the surface of the Chalk country, particularly in Berkshire and Wiltshire. Stonehenge chiefly composed of it, and found on the spot. No doubt close resemblance to the siliceous cement of the Hertfordshire Puddingstone.

1847. J. Prestwich. The position of the Sarsen Stones in the Bagshot Sands: Quart. Journ. Geol. Soc., vol. iii, p. 382. In the Lower Bagshot Sands, "a few concretionary masses of saccharine sandstone, which are more compact and harder than those in the Upper Sands," and by no means so abundant. "Sandstone concretions at *o*" in the diagram, fig. 3, of Frimley Ridge, in the Upper Sands, at p. 382.

1876. The Sarsens in the artificially picturesque rockery of the waterfall at the east end of Virginia Water are said to have been brought from the neighbouring heath: and those of the adjoining cavern or grotto from a cromlech there. Murray's "Handbook of Surrey," 2nd ed., p. 137.

1895. A Sarsen-stone footbridge over a streamlet at Frimley Green, Surrey, carries the footpath from the fields on one side of the stream that runs down a lane, to the path along the other side of the little stream, which runs beside the lane from Frimley Green, and across some fields to the border of Surrey and Hants near the Farnborough Station. The length of the bridge-stone is 4½ or 5 feet; the width is about 2¼ feet equally all along; thickness varies from 6 to 9 inches. The stones supporting the bridge and bank are laid regularly; they are all Sarsens, and others lie about irregularly. One lies near the fence just beyond the path on the further side of the bridge.—C. T. R. Jones.

1898. H. W. Monckton, Quart. Journ. Geol. Soc., vol. liv, pp. 185–193, treating of some gravels in the Bagshot district, notes that Sarsens occur at the base of these gravels, which are of the Glacial Period, and were probably of fluviatile origin. Sarsens with rootlet marks occur at Easthampstead. He doubts if any Sarsens occur in the Upper Bagshots, and supposes that probably most were derived from the Woolwich and Reading Sands. All the Sarsens must have been water-worn, or weather-worn before they were left in the gravel.

N.B.—At Camberley, in North Surrey, a Sarsen having a partial polish on one of its sides was noticed, and the polish is ascribed to the contact and rubbing of the dried stems of grasses and other plants (with siliceous tissue) moved by the wind.—T. R. J.

In Buckinghamshire Mr. Upfield Green, F.G.S., has observed both *pebbles* and prominences on *puddingstones*, smoothed and *polished*, on the sides of water holes, in the Brickearth near Great Missenden.

1900. Sarsen at Ballard's Farm, Croydon, a white saccharoidal sandstone with siliceous cement. Dr. G. J. Hinde has kindly given me the following notes on this large typical Sarsen near Croydon, which is visited by geological classes from London. Its dimensions are: length 4 ft. 10 ins.; width at one end 2 ft. 9 ins., at the other 2 feet; thickness at one end 1 ft. 8 ins., at the other 11 inches, and at another place 14 inches. It lies in a grass field on Ballard's Farm, on the south side of the bridle-path leading from Ballard's Lodge to the Addington Hills; and near to the outcrop of the sand-and-pebble beds of the Woolwich and Reading Series, of which indeed it is probably a concreted portion, like the similar blocks in the Caterham Valley.

(10) *Hampshire.*—1862. Captain H. Blundell (Staff College) noticed a large Sarsen in a ploughed field, about 4 miles from Winchester and 1 mile from Martyr Westley Rectory. It is 12 feet long, 10 broad, and 8 deep, "and bears a strong polish on a great part of one side," glaciated or polished by the friction of siliciferous stems of wheat. "The other side is hollowed out apparently by water." [1]

1898. Mr. A. E. Salter has seen a Sarsen in the gravel at Lee-on-the-Solent (Stubbington): Quart. Journ. Geol. Soc., vol. liv, p. 194.

(11) *Berkshire.*—1787. Daines Barrington made some remarks on the Greywethers in Berkshire (*Archæologia*, iii, p. 442).

1813. In W. Mavor's "Report on the Agriculture of Berkshire," 1813, at pp. 34, 35. The Sarsen Stones, or Greywethers as the country people call them, are irregularly scattered over the Berkshire and Wiltshire Downs. They are pretty numerous in a valley near Ashdown Park and on the road from thence to Lambourn.

[1] See also Lieut.-Col. Nicolls on "Sarsens," Southampton, 1866: Geol. Mag., Vol. III, pp. 296–298, Pl. XIII.

1854. T. Rupert Jones, in a lecture on the Geology of Newbury, treated of the occurrence of "the great blocks of Druidstone, Greywethers, or Sarsen-stones as the *only* remaining wreck of the Lower Tertiaries of this area"; and further broken up in the gravel of the vicinity.

1869. J. Adams, in a lecture on the Geology of Newbury (newspaper, December, 1869), referred to a traditional trace of an ancient cromlech near Hangmanstone, for people say that there was a cave made of large stones, but it was pulled to pieces by the farmer.

1869. The Sarsens of Berkshire now existing as relics of prehistoric monuments, especially in Wayland Smith's Cave, and the groups in Ashdown Park, are the subject of a paper by Mr. A. L. Lewis in the Trans. Internat. Congress of Prehistoric Archæol. at Norwich, 1869, pp. 37–46. See also Fergusson's "Rude Stone Monuments," 1872, pp. 121, etc.

1887. Mr. Walter Money, F.S.A., referring to Sarsen Stones in letters, notes that a writer in the *Gentleman's Magazine* for 1760 mentions that two Roman milliaria or milestones were to be seen near Aldworth; and this statement is confirmed by Hearne, Rowe Mores, and other authors. "These milliaria are now to be seen" (says the writer in the Gent. Mag.) "between Streteley and Alder, one of which lies a mile from Streteley, and by country people is supposed to be placed by the Giants (as they call them) in Alder [Aldworth] Church." He refers to the monumental effigies of the De la Beche family. A few years ago I investigated this subject for the late Mr. Thompson Watkin, of Liverpool, and found that one of these milliaria stood, not so many years ago, between Westridge Farm (two miles from Streatley) and Aldworth, in a bank, and that it was a large Sarsen Stone; and another I heard of as being seen in Kiddington Bottom, one mile west of Streatley. One of these, I learned, had been broken up for road-metal, and the other was said to have been taken away by a gentleman at Wallingford to be placed on his lawn.

Another statement is that many years ago the stone was taken from its original position by the side of the Roman *via* from Westridge to Streatley, and removed to a more convenient spot about a quarter of a mile distant, where probably it still remains. This stone, of gigantic size, was removed by the occupier of the farm at Westridge with a team of eight horses.

There is still a very large Sarsen Stone by the side of the Roman way from Newbury to Streatley, between Hampstead Norris and Aldworth, which was probably used as a milliarium. It is curious that in Brittany and other places on the Continent, as well as in England, where prehistoric stone structures are found, that there are stories of the imprints of giants' hands or feet, as the Friar's Heel at Stonehenge; and there is a story told at Aldworth at the present day, that one of these milliaria (that in Kiddington Bottom), between Aldworth and Streatley, had been thrown hither by one of the Aldworth giants, and that the print of the giant's hand, made when he grasped the stone, may yet be distinctly seen. This corroborates the writer of the account in the Gent. Mag. of 1760.

Last year, on going over the Lambourn Downs, I was struck by seeing a huge Sarsen Stone, evidently roughly squared, about 5 feet out of the ground, by the side of the road. It has every appearance of a milestone of the last century; and on examining its face next to the road, I found that a flat face or panel had been cut as if to receive a plate or letters; but neither Mr. Barnes, who was with me, nor myself could trace any letters at all. There is little doubt that this is a Roman milestone, as this ancient road leads direct to Uffington Castle and White-horse Hill. This stone is called 'Hangman's Stone,' the same story being told about it as of the Hangmanstone near Chaddleworth, and about similar stones elsewhere in England. The stone (4′ 6″ long, 1′ wide, and 1′ 6″ high at each end) in Hangmanstone Lane is lying down, but the Lambourn stone is vertical as with ordinary milestones. It is not known as a boundary stone.

There are a great number of Sarsen Stones in the neighbourhood of Ashbury, at the western extremity of Berks, on the northern slope of the Downs, where they enter this county from Wiltshire; and it is singular that hamlets in this parish have the names of Id-stone, Od-stone, and King-stone Winslow, and just beyond is the parish of Bishop-stone (Wilts). Possibly the boundaries of these places were indicated by stones, presumably Sarsens, from their being so abundant at hand.

At Lambourn the boundary wall of the churchyard is built of Sarsens; some of them are 5 feet in height. Others are used as stepping-stones and for margins in the Bourn at Upper Lambourn.

Large Sarsens are still visible close to some old churches, as at Compton Beauchamp, East Shefford, and Merlstone, a tithing of Bucklebury; and they may be remains of material accumulated for pagan temples, at places now occupied by Christian churches.

"There was, and probably is, a row or avenue of Sarsen Stones in Whiteknights Park, Reading, leading to the Wilderness, which were said to have been supplied by the Kennet River Navigation, in early times, from the neighbourhood of Hungerford and Marlborough."—W. M.

1887. J. R. Hedges. There are many Sarsen Stones collected by Mr. Hedges for grotto-work at Wallingford Castle. Some are perforated by rootlet marks.

1887. Numerous Sarsens, small and of irregular shape (probably from the gravel in the neighbourhood), are arranged around a flower-bed at Theale Railway Station.—T. R. J.

Dr. Silas Palmer noted several large Sarsens observable at Hill Green, about 1 mile west of Leckhampstead Street, which is 6 miles nearly north of Winterbourne, 1 mile south-west of Peasemore, and about 2 miles north-east of Poughley in Welford Wood, and 2 miles north-east of the Hangmanstone in Hangmanstone Lane. These are cared for by Mr. Harold Peake, of Westbrook House, Boxford; and Mr. Walter Money regards them as probably remnants of a chambered Long Room.

1887. In 1887 a buried or subterranean group of large Sarsens was discovered by Mr. Robert Walker at Middle Hole, a quarter of a mile north-west of Middle Farm,[1] about 2 miles north of Lambourn. Mr. F. J. Bennett (of the Geological Survey) gives the following description in his letters:—

A large leaning or nearly prostrate stone at the top of the group of stones had probably once been vertical, but had fallen down. The stones had been placed in a round pit-like hole, extending at least 10 feet north and south of the central stone (once upright).

A square excavation, more than 20 feet deep, was made, and some hundred Sarsens were taken out, weighing from a quarter to six hundredweight each; and there were left in the hole some stones of from 3 to 7 tons weight. In the hole the stones were in three irregular piles. The central heap rested on a very large flat stone; the others were at the two sides. The intervals were occupied by a stiff reddish clay with pottery, burnt and broken bones, wood-ashes, and burnt earth. There is a large flat stone lying in the valley not far off.

This north and south valley, or rather combe, in which this accumulation of Sarsens was found, has been cut down by denudation through the 'Chalk-rock' and the 'Melbourne Rock,' both recognizable in the side-slopes, and is floored with 'chalk-rubble.'

This does not appear to be one of the deep, well-like pits, lined with stones, tiles, clay, or wood, excavated for the purpose of marking boundaries in Roman times. It may have been sepulchral; for Thomas Wright, in his "Wanderings of an Antiquary, chiefly in the track of the Romans in Britain," 1894, pp. 176–178, describes in detail some large circular pits that have been filled with flints, and capped with broad Sarsens, on Aylesford Common; these, he thought, were probably sepulchral, and may have had a chamber opening out of the side at the bottom. (See ante, p. 115.)

1892. "A trail of large blocks of sarsenstone is prolonged by Hagbourne village to a line about 100 feet lower, on to the outcrop of the Upper Greensand. Other slopes along these Downs exhibit similar trails of sarsenstone." (Quart. Journ. Geol. Soc., xlviii, 1892, p. 313.)

At Newbury, Sarsens are frequent in the 'pitched' crossings of pavements at openings of yards; some are paved with squared setts. Worn, subangular, small Sarsens are plentiful in the gravel-pit south of the town.—T. R. J.

1896. W. Whitaker refers to the Sarsens at Streatley: Proc. Geol. Assoc., vol. xiv, p. 175.

(12) *Wiltshire.*—1767. Sir Joseph Banks, in his "Journal of an Excursion to Eastbury and Bristol, etc., in May and June, 1767" (reproduced with notes by S. G. Perceval in the Proceedings of

[1] Referred to at p. 149 of pt. i, 1886.

the Bristol Naturalists' Society, new series, vol. ix, pt. i, 1898), refers to the Sarsen Stones as follows: "Observed between Silbury and Marlborough the Stones called Grey weathers, which in one particular valley were scattered about in great numbers on the surface of the ground. The people in that neighbourhood were breaking great numbers of them, either to mend the roads or build houses, which gave me an opportunity of examining them and bringing away some pieces, which I found to be of a very hard and fine-grained Sand Stone. Whether it is found in beds in any part of this countrey I will not venture to say, but remember that some time ago, in seeing General Conway's place near Henley [Oxfordshire], I saw a large heap of such stones, some of them of an immense size; and, on asking where they were got from, was told that they were found scattered all over that countrey, lying on the stratum over the Chalk at different depths, and that those I saw had been got together, at a large expence, for some work to be done in the General's grounds—I think a bridge."

N.B.—This heap of large Sarsens must not be confused with the dolmen from Jersey reconstructed by General Conway in his grounds in the same locality, for the latter was necessarily only of granitic and such like rocks, native to Jersey. See also "The Channel Islands," by W. T. Austin & R. G. Latham, 1862; J. Fergusson's "Rude Stone Monuments," 1872, pp. 51, 52; and W. C. Lukis in the Trans. Internat. Congress Prehistoric Archæol. Norwich, 1869, p. 221.

1833. In the *Gentleman's Magazine*, vol. ciii, p. 542, is a notice of a paper read by Dr. G. T. Clark to the Bristol Philosophical Society, in which he alludes to the "Greyweathers" as being "scattered over the Chalky Downs of Wiltshire."

1863. W. H. Hudleston, in the Proc. Geol. Assoc., vol. vii, p. 138, gives a succinct account of the four kinds of stones that constitute the concentric rings of Stonehenge. The huge Sarsens composing the outer ring he described as consisting of a compact quartzose rock, derived from the Tertiary Sands. "These are, in fact, siliceous doggers or concretionary slabs of enormous size, which have hardened *in sitû* [in their original beds], and have resisted the atmospheric agencies of destruction. Several fragments were picked up of this material, which seemed to bear the marks of roots or something of the sort. It is by no means improbable, therefore, that the decomposition of vegetable matter, and consequent formation of *humus*, and the various organic acids which arise from its gradual alteration into carbonic acid, may have had something to do with the concretionary action. The influence of these organic acids on silica has been the subject of interesting investigations in America."

1871. Dr. Joseph Stevens, "On the Geology of North Hampshire," mentions the occurrence of a Greywether grindstone at St. Mary Bourne, Wilts. (Trans. Newbury District Field Club, vol. i, p. 86.)

1874. C. E. Davy, in a paper contributed to the Newbury District Field Club, "Letcombe Castle," 1874, p. 23, describes a naturally-shaped, angular, pyramidal, water-worn fragment of Sarsen Stone as a prehistoric sacred stone.

1876. A critical account of the lithology of Stonehenge, by N. Story Maskelyne, was published in the Wilts Archæol. Nat. Hist. Soc. Mag., vol. xvii, pp. 149, etc.

1881. With regard to the carrying and raising large blocks of stone, the late Dr. V. Ball gave details and an illustrative plate of the method used among the hill-tribes of India. ("Economic Geology of India," 1881, p. 544, pl. viii; see also note in Pt. i, 1886, p. 125.)

1887. In a Reading newspaper (July 29, 1887) it was stated that at Wardour Castle "the picturesque grounds are ornamented with a pretty grotto and rockery, constructed from a number of curious-shaped stones, which formed a prehistoric circle at Tetbury," said to have been at or near Place Farm. This circular work is recorded as having had a large central stone, 12 feet high and 4 feet wide. (Britton's Topog. and Hist. Descript. Wilts, 1814; and W. H. Jones, Wilts Mag., vol. vii, 1863.)

1887. The Stones of Stonehenge were the subject of Mr. W. Whitaker's remarks in the Proc. Geol. Assoc., vol. ix, p. 530. "Dividing them roughly into two sets, the natives and the foreigners (the former, of course, being the bigger), the latter are mostly of igneous rocks, and must have been brought from a long distance; the largest of these, the altar stone, is a sandstone, but unlike any sandstone of the neighbourhood. The natives are all greywether-sandstone, or Sarsen stones which have been shown to be derived from some of the older Tertiary beds, here probably from the Bagshot Sand, which in these western parts comes nearer to the Chalk than further east. Their occurrence, therefore, points to a vast denudation of Tertiary beds, masses of clays and sands, that once spread far and wide over the now bare plateau of Chalk, having been slowly swept away, leaving behind only those hardened parts of the sands, that could withstand the denuding agents, as witnesses of the former extension of the beds."

1890. Treating of some constructions by a prehistoric (Neolithic) people in Wiltshire, Mr. F. J. Bennet alludes to the abundant local occurrence of Sarsens ("Sketch History of Marlborough in Neolithic Times," March, 1892, pp. 4, 8). He also indicates how Sarsens were used by the Neolithic folk in the boundary walls of the terraces of cultivatable ground in Wiltshire. That they were used afterwards in the building of houses, castles, churches, etc., is well known.

1894. Pebbles and flint-breccia in some Sarsens from Marlborough Forest in Professor Prestwich's collection, seen July, 1894.

1896. From Avebury a white saccharoidal sandstone, with siliceous cement, and containing an irregular, coarse, brush-like group of sub-parallel, tubular, and filamentous cavities, probably due to rootlets, stained with iron oxide.—F. Chapman.

1901. The block that fell this Winter at Stonehenge contains a layer of flints. It is No. 17 L (the lintel) of the map of Stonehenge by the Archæological Society of Wiltshire. — W. Cunnington, January 9, 1901.

(13) *Dorset.*—1842. J. Sydenham: "Baal Durotrigensis: A Dissertation on the Antient Colossal Figure at Cerne, Dorsetshire, etc.," 1842. In a footnote at p. 18, the Sarsens at Little Mayne (referred to at pp. 136 and 161 of my paper in the Wilts Mag., 1886) are recognized as relics of circles and parts of avenues.

1871. E. H. W. Dukin, "Megalithic Remains in South Dorset," in the Reliq. Quart. Archæol. Journ. and Review, 1871, pp. 12–15 (separate copy), refers to the stones at Little Mayne. Mr. C. Warne also (1872) notices those old stones in his "Antient Dorset," quoting Sydenham's "Baal Durotrigensis."

1871. Poxwell, Pogswell, or Pockswell, is a village about 5 miles north-east of Weymouth, on the Wareham Road, and at about a quarter of a mile south-east of the church is a small circle of rough Sarsens, brown in colour, with much quartz-crystals in cavities. The stones are much split on the surfaces in squarish irregular segments, with something like gaping fissures. (Dukin, 1871, and T. R. J. 1887.)

Amongst the Sarsens of Dorset, many of them now relics of ancient structures, but originally scattered over the surface of the country, there are evidently many conglomerates. The grooved, or probably holed and broken, stone at Tennant Hill Circle, consists of a "hard puddingstone or conglomerate" (Dukin, 1871, p. 12). The circle at Winterbourne Abbas is described (ibid., pp. 4 and 5), partly after Stukeley; and it is stated there are "ten stones of a very hard sort, full of flints; the tallest to west eight feet high, the north seven feet broad, six feet high" (op. cit., p. 5). The usual ridiculous belief in devil handiwork still exists in Dorset and Cornwall (op. cit., p. 9).

1887. At Fordington Green, Dorchester, at the east end, at the corner of a house bearing the Ordnance Survey Bench-mark, is a Sarsen; the top is three-faced (4 feet where widest, and 2 ft. 7 ins. high), the sides rounded. This stone some people removed not very long ago, but others had it brought back and replaced.—T. R. J.

(14) *Somerset.*—1888. Many Sarsens in the country around Taunton along the roads and lanes, and in villages at corners, farm-gates, etc.

In the Castle grounds at Taunton, in the gardens of the Archæological Society, there is a Sarsen that has been set up as a memorial stone to one of their officers. It is somewhat triangular in outline, 4 ft. 6 ins. high, and 6 ft. 2 ins. at its widest part near the base. Smoothly rounded and irregularly pitted on one face, and flat (apparently split) on the other. It bears a tablet with inscription to the memory of W. A. Jones, who was Secretary to the Society for 20 years. It also refers to the donation for buying the grounds for the Society, made by the friends of Mr. W. A. Jones.—W. Bidgood.

1888. Numerous Sarsens are passed on the road from Taunton for about 10 miles to Staple Fitzpaine, where in a hedge-bank are several such stones, one of which, 5 feet long, and 4 feet high or thick, above ground, with its surface rounded and water-worn, is locally known as the 'Devil's Stone'; for, having knowledge of the intended building of a church there, he gathered a few rocks as he came thither, but, getting tired, slept on the bank, until he awoke in the morning, and to his astonishment saw the fine tower of the church already up and finished. In his hurry to get up, his satchel broke, the stones fell out, and one in particular remains there now! This is the most western of the Sarsens that I know of.—T. R. J.

The microscopic structure of a piece of one of the blocks at or near Staple Fitzpaine, which had the appearance of a Sarsen, is thus described by Mr. Fred. Chapman, A.L.S.:—"This rock is largely composed of angular and subangular chips of quartz and chert, cemented by a kind of paste of fine quartz sand and limonite. The included fragments are very variable in size, the angular predominating over the subangular. A fair proportion of the fragments are of secondary quartz; some clear, others with strings of gas-cavities. There are a few chips of a somewhat brecciated rock, not unlike a decomposed rhyolite in character. There is at least one fragment of flint in the section examined. The chert fragments, possibly of Cenomanian age, contain a few examples of *Globigerina cretacea.* One of the larger pieces included in this Sarsen (?) is a chert, crowded with *Radiolaria*, in a generally good state of preservation, some of the organisms bearing long spines beset with smaller spines. Dr. G. J. Hinde, who has been good enough to examine the slide, thinks that there is not enough evidence for the identification of genera, but that the chert is most probably of Palæozoic age."

1888. In the Museum of the Bath Institute I saw a somewhat water-worn block of light-coloured saccharoidal sandstone, looking very much like a Sarsen; chips of this stone show an ochreous tint and siliceous cement. The Rev. H. H. Winwood, F.G.S., Honorary Curator of the Museum, informs me that it came from the Victoria Gravel-pit, on the right of the Somerset and Dorset Railway, where the road crosses the line at South Hill. It measures 33 inches in length, 16 inches where it is broadest, and 4 to 7 inches in thickness. With other similar blocks it lay at the base of the gravel on the blue Lias clay. At first he was inclined to regard it as having been derived from the Millstone Grit of the Wick and Bristol district; but he has since seen sarsenic pebbles and blocks in the Gravel, and he noticed a large Sarsen at the Westbury Ironworks. Near Downhead, in the Mendips, he has observed numerous siliceous blocks having the appearance of Sarsens; but others just like them, lying on the north slope of the Mendips at Ashwick, contain Liassic fossils. Great caution, therefore, is necessary in determining these somewhat similar siliceous blocks of Palæozoic, Secondary, and Tertiary age respectively.—H. H. W.

(15) *Devon.*—In 1822 Dr. Buckland described the large, isolated, siliceous blocks, scattered about on the hills near Sidmouth, as being much like the Hertfordshire Puddingstone, but having the included flint "mostly angular" and not rounded. In 1826 he referred to these in Devon, and others in Dorset and elsewhere, as being the same as the recognized Greywethers. (Trans. Geol. Soc., ser. II, vol. ii, pp. 126, 127.)

Bibliographic List of Works treating of Sarsens,
Corrected, Enlarged, and Continued from the Wilts Mag., 1886, pp. 153, 154.

1644. Richard Symonds' Diary of the Marches kept by the Royal Army, etc. Edited by C. E. Long for the Camden Society, 1859, p. 151.
1656–84. John Aubrey's Nat. Hist. Wiltshire. Edited by J. Britton, 1847, p. 44.
1656–84. John Aubrey. The Topographical Collections, etc., by J. E. Jackson, 1862, p. 314.
1673. Marlborough Corporation Accounts, by F. A. Carrington. Wiltshire Archæological and Natural History Society's Magazine, vol. iii (1857), p. 111.
1787. Daines Barrington. Archæologia, vol. viii, p. 442.
1813. W. Mavor. Report on the Agriculture of Berkshire, pp. 34, 35.
1814. T. Webster. Trans. Geol. Soc. London, vol. ii, pp. 224, 225.
1819. G. B. Greenough. Critical Examination of the First Principles of Geology, pp. 112 and 293.
1823. W. Buckland. Reliquiæ Diluvianæ, p. 248.
1833. W. D. Conybeare and G. T. Clark. Gentleman's Magazine, vol. ciii, pt. 2, p. 452.
1833. G. A. Mantell. Geology of the South-East of England, pp. 48–50.
1836. W. Buckland and H. De la Beche. Trans. Geol. Soc., ser. ii, vol. iv, p. 4.
1847. J. Prestwich. Quart. Journ. Geol. Soc., vol. iii, p. 382.
1852–3. W. Cunnington. Devizes Gazette, June, 1852, and June, 1853. Quoted by W. Long, Wilts Mag., vol. iv (1858), p. 334, etc.
1854. J. Prestwich. Quart. Journ. Geol. Soc. (paper read May, 1853), vol. x, p. 123, etc.
1854. T. R. Jones. Lecture on the Geological History of the Vicinity of Newbury, Berks, p. 21.
1858. W. Long. On Abury. Wilts Mag., vol. iv, p. 334, etc., quoting W. Cunnington.
1858. A. C. Ramsay and others. Mem. Geol. Surv., Explan. Sheet 34, p. 41, etc.
1859. A. C. Ramsay and others. Catal. Rock-Specimens, etc., Mus. Pract. Geol., 2nd ed., p. 288.
1859. G. P. Scrope. Wilts Mag., vol. v, p. 110.
1859. J. L. Ross (quoting R. Faulkner). Ibid., p. 168.
1860. R. Hunt. Mem. Geol. Surv. Great Britain, Mining Statistics, p. 167.
1861. E. Hull, W. Whitaker, and others. Mem. Geol. Surv., Explan. Sheet 13, p. 47, etc.
1862. H. W. Bristow and W. Whitaker. Ibid., Explan. Sheet 12, p. 51, etc.
1862. A. C. Ramsay and others. Catal. Rock-Specimens, etc., Mus. Pract. Geol., 3rd ed., p. 163.
1862. W. Whitaker. Quart. Journ. Geol. Soc., vol. xviii, p. 271, etc.
1862. W. H. Bensted. Geologist, vol. v, pp. 449, 450.
1863. O. Fisher. Geologist, vol. vi, p. 30.
1864. W. Whitaker. Mem. Geol. Surv., Explan. Sheet 7, p. 71, etc.
1865. T. Codrington. Wilts Mag., vol. ix, p. 167, etc.
1866. W. Long (quoting W. Cunnington's paper of 1865, which was not printed in full). Wilts Mag., vol. x, p. 71, etc.
1866. A. C. Smith. Wilts Mag., vol. x, p. 52, etc.
1866. W. T. Nicolls. Geol. Mag., Vol. III, p. 296, etc.
1867. G. Maw. Quart. Journ. Geol. Soc., vol. xxiii, pp. 110, 112, 113.
1868. J. Adams. Lecture on the Geology of the Country around Newbury. *Newbury News*, December, 1868.
1869. A. L. Lewis. Trans. Internat. Congress Prehist. Archæol. for 1868, p. 43.
1869. John Adams. Wilts Mag., vol. xi, pp. 274, 277, etc.
1869. W. Cunnington. Ibid., p. 348.
1869. Anon. (Stukeley's notes.) Ibid., p. 344.
1870. T. Codrington. Quart. Journ. Geol. Soc., vol. xxv, p. 535.
1871. J. Adams. Trans. Newbury District Field Club, vol. i, pp. 104–107, 151.
1872. J. Fergusson. Rude Stone Monuments, pp. 92, 95.
1872. W. Whitaker. Mem. Geol. Surv., vol. iv, pp. 309, 323, etc.

1873. J. Adams. Geol. Mag., Vol. X, p. 198, etc.
1873. T. O. Ward. Geol. Mag., Vol. X, p. 425.
1874. Joseph Stevens. Twenty-first Annual Report, Brighton and Sussex Nat. Hist. Soc., p. 14, etc. (read October 9th, 1874).
1874. R. F[alkner]. Geol. Mag., Dec. II, Vol. I, p. 96.
1874. Bryan King. (Stukeley's notes.) Wilts Mag., vol. xiv, p. 230.
1875. Joseph Stevens. Journ. Proc. Winchester and Hampshire Scient. Lit. Soc., vol. i, pt. 4, p. 224, etc. (read March 9th, 1874).
1875. Joseph Stevens. Report of the Marlborough College Nat. Hist. Soc.
1875. T. Rupert Jones. Geol. Mag., Dec. II, Vol. II, p. 588.
1876. T. Rupert Jones. Ibid., Vol. III, p. 523.
1876. N. Story Maskelyne. Wilts Archæol. and Nat. Hist. Soc. Mag., vol. xvii, p. 149.
1876. E. T. Stevens. Jottings on Stonehenge, etc. (privately printed), pp. 128, 205, etc.
1876. W. Long (quoting Symonds, 1644). Wilts Mag., vol. xvi, p. 68, etc.
1876. H. B. Woodward. Geology of England and Wales, pp. 252, 363; 2nd ed. (1887), p. 449.
1878. A. C. Ramsay. Phys. Geol. Geogr. Gt. Brit., 5th ed., p. 350.
1878. T. Rupert Jones. Trans. Newbury Dist. Field Club, vol. ii, p. 248.
1880. A. Irving. Nat. Hist. Sandhurst, pp. 80, 87.
1881. J. A. Phillips. Quart. Journ. Geol. Soc., vol. xxxvii, p. 18.
1881. T. Rupert Jones. Proc. Geol. Assoc., vol. vi, pp. 330, 436–7.
1882. A. Geikie. Textbook of Geology, p. 342; 2nd ed. (1885), p. 329.
1883. W. H. Hudleston. Proc. Geol. Assoc., vol. vii, p. 138.
1884. A. C. Smith. Guide to the Antiquities of North Wilts, pp. 27, 28, 127–9, 134, 150, 211.
1885. W. Carruthers. Geol. Mag., Dec. III, Vol. II, p. 361, etc.
1884. A. Irving. Report Brit. Assoc. Meeting in 1883, p. 505.
1885. A. Irving. Proc. Geol. Assoc., vol. viii, pp. 156–160.
1885. W. Whitaker. Geology of the Country around Ipswich, Hadleigh, and Felixstowe, pp. 9, 15, 16, 94, etc. Mem. Geol. Surv.
1886. T. Rupert Jones. History of the Sarsens. Wilts Archæol. and Nat. Hist. Soc. Mag., No. 68, December, 1886, vol. xxiii, pp. 122–154.
1887. A. Irving. Quart. Journ. Geol. Soc., vol. xliii, p. 380.
1887. W. Whitaker. Proc. Geol. Assoc., vol. ix, p. 530.
1888. T. G. Bonney. Geol. Mag., Dec. III, Vol. V, p. 300.
1891. H. B. Woodward. Geol. Mag., Dec. III, Vol. VIII, pp. 101–121.
1894. J. Prestwich's Collection. Conglomerate and Flint Breccia from Marlborough.
1896. W. Whitaker. Proc. Geol. Assoc., vol. xiv, p. 175.
1897. Percy Richards. Quart. Journ. Geol. Soc., vol. liii, pp. 421, 426.
1897. A. Irving. Proc. Geol. Assoc., vol. xv, p. 196.
1898. A. Irving. Proc. Geol. Assoc., vol. xv, p. 236.
1898. A. E. Salter. Quart. Journ. Geol. Soc., vol. liv, p. 194.
1898. H. W. Monckton. Quart. Journ. Geol. Soc., vol. liv, pp. 185–193.
1898. W. Whitaker. Quart. Journ. Geol. Soc., vol. liv, p. 193.
1898. W. H. Shrubsole. Quart. Journ. Geol. Soc., vol. liv, p. 194.
1900. H. W. Monckton. Proc. Croydon Micros. and Nat. Hist. Club, p. xv.
1900. T. E. Lones. Trans. Herts Nat. Hist. Soc., vol. x, pp. 160, 162.
1900. H. B. Woodward. Geol. Mag., Dec. IV, Vol. VII, p. 543.
1901. J. W. Judd. Geol. Mag., Dec. IV, Vol. VIII, p. 1.

VI.—The Age of the Earth and the Sodium of the Sea.[1]

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

PROFESSOR J. JOLY, in his interesting paper estimating the geological age of the earth from the amount of sodium contained in the sea,[1] mentions in an appendix seven possible errors which may render his estimate a minimum, and seven others which may render it a maximum. Neither among the former errors

[1] Trans. Roy. Dublin Soc., vol. vii (1899), p. 23.

guarded against in the appendix, nor in the body of the paper, does there appear any reference to the possibility of sea-water being absorbed by the surface rocks of the globe, either by capillary attraction, as maintained by Daubrée, or by means of fissures, as contended by De la Beche.

The possibility—nay, the probability—of sea-water obtaining access to the deep-seated and heated regions of the globe was admitted by Lyell, De la Beche, and Daubrée, and by other eminent geologists; and although to a large extent neglected at the present time, the arguments in favour of the hypothesis seem worth considering.

My own attention was attracted to the subject as follows:—From 1879 to 1889 inclusive, I wrote seven papers on the detached blocks which lie strewn on the bottom of the English Channel. The primary object of the enquiry was to ascertain whether the blocks represented a prolongation of the Dartmoor granite, as commonly supposed, and whether they were in any way related to the metamorphic rocks of the neighbouring headlands of the Start, the Prawle, and the Bolt.

I commenced the investigation in the full expectation that the connection with Dartmoor would be proved at once.

I secured thirty-four crystalline rocks from the Channel, and a large collection from Dartmoor. Not a single speck of tourmaline or crystal of chloride of sodium did I detect in the twenty granites and gneisses from the Channel; while not a single slice from Dartmoor failed to indicate chlorides, and very few of the Dartmoor rocks from which they were cut (if any) were without tourmaline. The fluid inclusions in the Channel rocks were of a different type from those in the Dartmoor rocks. The two series of rocks seemed absolutely distinct.

This most unexpected result greatly excited my curiosity, and I sought to find some explanation. Finally, in 1889, I hazarded the suggestion that sea-water had gained access to the Dartmoor granite in Carboniferous times; and in 1892, after an examination of the South Devon schists, I, for entirely different reasons, threw out the suggestion that they also had been influenced by the presence of sea-water during their metamorphosis.

These suggestions were not only almost universally rejected by geologists, but they caused considerable umbrage, so I discontinued the enquiry, and put away my microscope.

However, before bringing my own work to a conclusion, I examined the older authorities, and found that both Lyell and De la Beche maintained the hypothesis that sea-water reached the heated rocks, and that subsequently the late Mr. J. A. Phillips and M. Daubrée were of the same opinion; and, strange to say, they all had different reasons for their belief. My own conclusions were also based on entirely independent evidence; and, indeed, so far as appears from the records, all the observers thought out the problem independently from different points of view. Lyell relied on the steam emitted by volcanoes, De la Beche appealed to his mineral veins, Phillips pointed to hot salt-springs transforming the rocks at considerable though accessible depths, Daubrée relied on experiment, while I have been impressed by the characteristics of the vein rocks of Dartmoor with their abundant sodium (as chloride and silicate), and with the chlorite, amphibole, and albite of the green schists.

The conclusions of De la Beche seem the most noteworthy, seeing that he was necessarily ignorant of the fact that the vein rocks of Devon and Cornwall are charged with salt and brine. In 1839 that acute observer wrote—"There is, therefore, nothing unreasonable in supposing that a large proportion of the Cornish and Devon fissures, now wholly or in part filled up, were opened either beneath the sea or in such situations that portions of them were so placed that it entered freely into them" (Report on Geology of Cornwall and Devon, p. 378). Subsequently De la Beche cites an instance of water filtrating through hard basalt, filling its internal cavities with liquid, and setting up crystallization of 'mesotype' (loc. cit., p. 392). In 1851 De la Beche touches on the chemical combinations of the chlorides in the fissures (Geol. Observer, p. 770).

In January, 1873, the late Mr. J. A. Phillips read a most interesting paper to the Royal Society, which was subsequently communicated to the *Philosophical Magazine*. In it the author discusses the composition and origin of the waters of a salt-spring at Huel Seton mine, with a chemical and microscopical examination of certain rocks in its vicinity. The water is shown to be derived from the sea, and to enter into chemical combination with the minerals of the rocks through which it passes, producing brown hornblende, pale-green actinolite, and chlorite. Another salt-spring, in the now abandoned Huel Clifford mine, was 1,320 feet below the sea, and issued at a temperature of 125° F. As Mr. Phillips does not refer to De la Beche, he seems to have overlooked De la Beche's views, just as I unfortunately overlooked at first both De la Beche and Phillips. The result, however, is that all three identical conclusions were arrived at independently, and all on different grounds. Had De la Beche lived to learn that the quartz in his fissures actually contained brine and crystals of salt, and that the felspar of his veins, instead of being the orthoclase of the main mass, was triclinic, and more or less a soda-felspar, he would have realized with what unerring sagacity he had hit his mark.

In 1880 Daubrée published his invaluable "Géologie Expérimentale," of which work the third chapter is headed—"Expériences sur la possibilité d'une enfiltration capillaire au travers des matières poreuses."

Daubrée shows experimentally that bottom heat greatly accelerates the passage of water through rocks in the face of a strong counter-pressure of steam. He incidentally admits that such water may be salt water, and that it would be capable of producing great mechanical and chemical effects. But this is incidental; his object is to explain the origin of volcanic steam, not to follow up the new combinations of the sodium which the steam leaves behind in the bowels of the earth.

Lord Kelvin [1] and Professor Joly agree in assuming that because melted basalt is lighter than consolidated basalt the chilled surface of a lava ocean would sink: Lord Kelvin further assumes that all minerals crystallizing out of a melted basalt would also sink: I would, however, venture to submit that the gases imprisoned in the chilled surface layers would buoy them up, and that a good many minerals, lighter than the magma, on rising to the surface would form a scum or slag which, by blanketing the glowing lava, would thereby check radiation. I have no especial interest in the controversy as to the age of the Earth, and go no further than to suggest that these points should be allowed their due weight in the argument.

The application of the above sea-water hypothesis to the cases of Dartmoor and the schists is a somewhat intricate question, and not worth discussing so long as the main principle is rejected.

VII.—Notes on Literature bearing upon the Geology of the Malay Peninsula; with an account of a Neolithic Implement from that country.

By R. Bullen Newton, F.G.S., of the British Museum (Natural History).

In view of the interest lately shown by geologists and others engaged in the Malay Peninsula through Mr. H. F. Bellamy's discovery of Triassic Lamellibranchs in that area, a brief account of the principal works on the geology of that portion of South-Eastern Asia may prove of service. More particular reference will be made to the sedimentary rocks, purely mineral papers being excluded from consideration.

One of the earliest records on this subject is by William Jack,[2] who in 1822 observed a red sandstone at Singapore which he regarded as "the chief secondary rock" of the district. He further mentioned that the Island of Penang was entirely of granitic structure. Somewhat later the following remarks were made by J. Crawford:[3] "At Singapore a secondary formation is discoverable, and varieties of sandstone and shale form the principal rocks, together with conglomerate, argillaceous sandstone and gray limestone."

In 1847 Colonel James Low,[4] speaking of the same rock at Singapore, stated that "the sandstone lies immediately under the Oolitic beds, and would be therefore New Red Sandstone." The discovery of a bituminous coal on the southern coasts of the Island of Junk-Ceylon off the Malay Peninsula was reported by J. R. Logan [5]

[1] Trans. Victoria Inst., vol. xxxi, p. 24.

[2] W. Jack, "Notice respecting the Rocks of the Islands of Penang and Singapore": Trans. Geol. Soc. London, ser. II, vol. i, pt. 1 (1822), p. 165.

[3] J. Crawford, "Geological Observations made on a Voyage from Bengal to Siam and Cochin China": Trans. Geol. Soc. London, ser. II, vol. i, pt. 2 (1824), p. 406.

[4] Col. Jas. Low, "Notes on the Geological Features of Singapore": Journ. Indian Archipelago, vol. i (1847), p. 83.

[5] J. R. Logan, "Notice of the Discovery of Coal on one of the Islands on the Coast of the Malay Peninsula": Quart. Journ. Geol. Soc., vol. iv (1848), pp. 1, 2. "On the Local and Relative Geology of Singapore, etc.": Journ. Asiatic Soc. Bengal, vol. xvi (1847), pp. 519–557, 667–684. "Sketch of the Physical

during the following year, but no geological age was assigned to the material. This author likewise contributed a number of papers between 1847 and 1851 on the geology of the Malay region, dealing more particularly with that division of it which embraces Singapore and the adjacent islands. He observed that limestone, sandstone, and clays are the predominating stratified rocks along the western coast from Junk-Ceylon to Penang; and that argillo-micaceous and argillaceous schists, associated with sandstones and common clays and shales of various colours, occur between Southern Selangor and Johore.

During 1879 Mr. Patrick Doyle[1] referred to the granitic rock of the Malay Peninsula as being "overlain generally by sandstone, and frequently also by laterite or cellular ironstone, and to the north by limestone."

In 1882 Mr. D. D. Daly[2] mentioned that "the alluvial tin deposits permeate the whole length of the Malayan Peninsula"; and among other items of geological interest, the occurrence of limestone caves at Batu in Selangor was pointed out. The following year Mr. A. H. Keane[3] remarked that "as far as has been ascertained, the main geological formations [of the Malay Peninsula] would appear to be Lower Devonian sandstones and unfossilized clay-slates, with a basis of stanniferous granite everywhere cropping out. Although no trace has been found of recent volcanic action, there are several isolated and unstratified limestone masses from 500 to 2,000 feet high, of a highly crystallised character, with no fossils of any kind." In the same year M. J.-E. de la Croix[4] alluded to the presence of three groups of rocks in the Perak district of the Malay Peninsula: (*a*) the eruptive series, which constitute the mountain masses; (*b*) the sedimentary beds, which occur at intervals in detached fragments; (*c*) the alluvium formation, which completely covers the plains. The sedimentary strata are represented by sandstone and limestone, both of which are unfossiliferous and consequently of unknown age, although stated to be anterior to the granites, which are eruptive and metamorphosed.

In 1884 the late Rev. J. E. Tenison-Woods[5] referred to a "Palæozoic

Geography and Geology of the Malay Peninsula": Journ. Indian Archipelago, vol. ii (1848), pp. 83–138. "Notices of the Geology of the East Coast of Johore": Journ. Indian Archipelago, vol. ii (1848), p. 625. "The Rocks of Pulo Ubin": Verhandel. Bataviaasch Genootsch. Kunst. Wetenschap., vol. xxii (1849) [read 1847], pp. 3–43. "Five Days in Naning": Journ. Indian Archipelago, vol. iii (1849), p. 282. "Notices of the Geology of the Straits of Singapore": Quart. Journ. Geol. Soc., vol. vii (1851), pp. 310–344, pl. xviii (=geological map).

[1] Patrick Doyle, "On some Tin-deposits of the Malayan Peninsula": Quart. Journ. Geol. Soc., vol. xxxv (1879), p. 229.

[2] D. D. Daly, "Surveys and Explorations in the Native States of the Malay Peninsula": Proc. Roy. Geogr. Soc., N.S., vol. iv (1882), pp. 393–412.

[3] A. H. Keane: "Malay Peninsula," an article in the *Encyclopædia Britannica*, 9th ed. (1883), vol. xv, p. 321.

[4] J.-E. de la Croix, "Le Royaume de Perak": Bull. Soc. Geogr. Paris, ser. VII, vol. iv (1883), pp. 342–348, with a plate containing geological map and sections.

[5] J. E. Tenison-Woods, "Geology of the Malaysan Peninsula": *Nature*, vol. xxx (1884), p. 76. "Physical Geography of the Malaysan Peninsula": *Nature*, vol. xxxi (1884), p. 152. "The Geology of Malaysia, Southern China, etc.": *Nature*, vol. xxxiii (1886), p. 231.

sandstone clay-slate" in the Malay Peninsula which he thought had not been previously noticed; and subsequently the same writer described the country as an elevated granitic axis with Palæozoic schists and slates at its base, mentioning also the occurrence of detached masses of weathered limestone without fossils.

In speaking of the gold deposits of Pahang, Mr. H. M. Becher[1] stated in 1893 that "the gold-quartz formation of Pahang traverses an extensive series of sedimentary rocks. . . . . These rocks, probably of Palæozoic age, are for the most part thinly bedded slates with some sandstones, and fewer dark-coloured, impure limestone beds." Alluvial beds of modern origin were also referred to.

Dr. Koto[2] followed in 1899 with a brief allusion to this area, and, quoting from a previous author, mentioned the occurrence of "granites, old-looking sandstones, and slates," extending down to Singapore.

Finally, the present writer[3] described and figured the Lamellibranch remains discovered by Mr. H. F. Bellamy in a sandstone obtained on the Pahang Trunk Road near the Lipis River. A study of this fauna proved it to be of Upper Triassic age (= Rhætic), the matrix being termed a 'Myophorian Sandstone,' on account of the prevalence of the genus *Myophoria*. These shells, the first recorded fossils from the Malay Peninsula, were determined as under:—

Chlamys Valoniensis, Leymerie, sp.
Pteria Pahangensis, R. B. Newton.
Gervillia inflata, Schafhäutl.
Pteroperna Malayensis, R. B. Newton.
Actinodesma Bellamyi, R. B. Newton.
Pleurophorus elongatus, ? Moore.
Mytilus allied to *M. minutus*, Goldfuss.
Myophoria ornata, Münster.
Myophoria inæquicostata, Klipstein.
Myophoria Malayensis, R. B. Newton.
Myophoria, sp.

Among unpublished observations it may be of interest to reproduce, from a letter of recent date, an account of the geology of the River Tui District, situated in the Pahang division of the Malay Peninsula, written by Mr. R. M. W. Swan, F.G.S., who is carrying out mining operations in that area. The Tui is described as a small branch of the River Jelai, which joins the Lipis River at Kwala Lipis, from which place it is about ten miles due north. Thanks are due to Mr. Swan's brother (Mr. Archibald A. Swan) for permission to include this new matter in the present paper.

"In order to explain the geology of the place where we are working it is necessary to say a few words on the geology of this part of Pahang. The common rock of the country is a clay slate, or perhaps more properly shale, for the cleavage of the rock coincides with the original bedding planes, although these have been

[1] H. M. Becher, "The Gold-quartz Deposits of Pahang (Malay Peninsula)": Quart. Journ. Geol. Soc., vol. xlix (1893), p. 84.

[2] Dr. B. Koto, "On the Geologic Structure of the Malayan Archipelago": Journ. Coll. Sci. Univ. Tōkyō, Japan, vol. xi, pt. 2 (1899), p. 85.

[3] R. B. Newton, "On Marine Triassic Lamellibranchs discovered in the Malay Peninsula": Proc. Malac. Soc. London, vol. iv (1900), pp. 130–135, pl. xii.

accentuated by pressure at right angles to them. These slates rest on a basin in granite, and by a movement of this rock they have been highly tilted, so that the average dip is about 80°. The underlie here is westward, while nearer the dividing range of the Peninsula it is eastward. The dip changes along a line about 6½ miles westward from here. The strike of the slates is extremely regular, and is parallel to the main dividing range, or 8° to 8½° west of the magnetic north. The mass of slate rock is penetrated by numerous intrusions, which consist generally of granite or greenstones. All the known mineral deposits of any value in Pahang are either included in these intersecting rocks, or occur in close proximity to them. The intrusions generally take the form of large lenticular masses, which are often some miles in width. The main axis of these masses is always parallel to the strike of the slates, and the intrusive rocks sometimes show a cleavage produced by side pressure, parallel to the cleavage of the slates.

"These intrusions are highly developed in some parts of the country. There is a granite intrusion 1½ miles to the westward of the Tui. This is succeeded to the eastward by a belt of slate about a mile in width, and then we have a belt of intrusive rock about a mile in width, and it is on this that the Tui flows.

"Overlying all these rocks, and resting on their upturned edges, is a deposit of crystalline limestone, which was originally very extensive, and of great thickness. It certainly has been some thousand feet thick, and there is some evidence which seems to show that it has overlain even the tops of the main dividing range. But only a few isolated patches of this limestone now remain, the rest having been eaten away by the comparatively rapid action of denudation. The limestone in which we are mining is a small patch which remains in the bottom of an ancient valley. Tradition indicates that the Chinese have exported much gold from this part of Pahang, and there is good reason to believe that most of this gold has been derived from the limestone, and has been left on the surface when that rock has been dissolved away. I feel fairly certain that such has been the origin of practically all the gold exported from the Tui valley.

"The clay deposit was composed of fine yellow clay, which contained some spherical nodules of iron oxide, and rarely some fragments of quartz. The gold was not distributed through the mass, but occurred in occasional streaks or veins, which could not be distinguished by the eye. . . . .

"This clay deposit, which covers the whole of the limestone in the valley to a depth of about twenty feet, is the product of decomposition of the greenstone which forms the sides of the valley, and the peroxide of iron nodules which accompany it had their source in the hornblende of that rock."

Remarks.—From the foregoing notices it would appear that the Malay Peninsula is largely composed of plutonic rocks more or less covered by sedimentary strata, of which sandstone, slates, and limestone form a very considerable part. The fossils discovered by Mr. Bellamy have enabled the writer to refer the sandstone to a Triassic age, but the horizon of the limestone and slate deposits still remains doubtful. Quite recently, some samples of the limestone were submitted to the writer for microscopical examination by Mr. Archibald A. Swan, which his brother, Mr. R. M. W. Swan, F.G.S., had collected and sent home from the River Tui District; but they, unfortunately, exhibit no organic structures, and are therefore practically useless for determining their period of deposition. This limestone[1] is of blackish colour, very much fissured with calcite and quartz, and possessing slickensided surfaces; a microscopical section with the aid of polarized light exhibiting the brilliant coloration of its partial siliceous structure. In the neighbourhood of the quartz veins, gold, blende, stibnite, and galena are more or less observable. It occurs in a basin-shaped area situated on the upturned edges of contorted slates of unknown age, which themselves rest on a granite base. It is more than probable that this limestone may crop out elsewhere in the neighbourhood of a less crystalline character, and with palæontological features; but until such a discovery takes place it is premature to assume its definite geological age. Should it ultimately prove to be of Carboniferous age, then it would probably form a continuation of that limestone found in Sumatra (Padang) which has yielded to Brady[2] and other authors the foraminiferal genus of *Schwagerina* (= *Fusulina* of Brady).

In referring again to the sandstone rocks of the Malay Peninsula it may be mentioned that they represent part of the great Triassic development which is such an important feature in the geological structure of Eastern Asia, and which extends through European countries to Northern Africa, thence to Asia Minor, the Himalayas, and to portions of the Chinese Empire, Japan, and Siberia. It is found also in the East Indian Archipelago, especially Sumatra, Rotti, and Timor; and, moreover, it is present in New Caledonia and New Zealand.[3] In all these regions the occurrence of Triassic rocks has been accurately demonstrated by the palæontological investigations of Stoliczka, Griesbach, Volz, Koken, Eugène Deslongchamps, Rothpletz, Naumann, Zittel, Loczy, and others.

NEOLITHIC IMPLEMENT.—Whilst writing on the geology of the Malay Peninsula, it may not be out of place to allude to a Neolithic implement from that country which was presented to the Geological Department of the British Museum by Mr. W. Leonard Braddon, M.R.C.S., during the latter part of 1896. Two examples exist of

[1] Specimens of the limestone have been presented to the Mineral Department of the British Museum (Nat. Hist.) by Mr. A. A. Swan, a few examples being retained for reference in the Geological Department.

[2] H. B. Brady, "On some Fossil Foraminifera from the West Coast District, Sumatra": GEOL. MAG., 1875, p. 537, pl. xiii, fig. 6.

[3] See Lapparent's map illustrating the Triassic distribution, "Traité de Géologie." 4th ed. (1900), p. 1042.

this implement celt, both of which were found in a disused mine at Tras, Pahang, having probably been utilized for mining purposes in connection with the production of tin, which largely abounds in this region.

They are similar in shape, being long, narrow, and of rectangular section, with an inclination to a convex upper surface caused by a gentle declivity at each end; widening very gradually to the cutting end, which thins off into a moderately sharp, chisel-shaped edge. The opposite and rather narrower extremity is more or less of a wedge pattern, and somewhat tapering thereby, suggestive of the implement having been fixed to a wooden handle to carry out the functions of a 'pick' or similar instrument, an idea further strengthened by the fact that near the same end are some coarse scoring marks which run in various directions, resembling furrows, most probably produced by the process of shafting with a strong vegetable fibre. Similar scored lines are observable on some Malay implements in the British Museum Collection at Bloomsbury.

The rock composing these implements outwardly resembles a material of igneous origin, but Mr. G. T. Prior, M.A., of the Mineral Department, British Museum, assures the writer that such is not the case. It is more probably a mudstone or an indurated slate, which under the microscope is seen to exhibit a fragmentary structure with occasional crystals of felspar. Nor can any organisms be traced in it such as the minuter forms of life, Radiolarians or Foraminifera. It is a rock of extreme hardness, very closely grained, and of a densely dull, black colour where fractured, and having a clear metallic ring when struck.

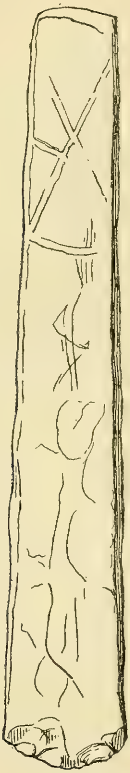
Externally, the implements are partially coated with a thin layer of light colour, which is easily powdered away by scraping, and which has possibly been produced by entombment in an alluvial deposit; in other places smooth, polished surfaces are seen, evidently the result of former handling and usage.

According to Sir John Evans, F.R.S., similar chisel-like implements, but of various rock structures, occur very rarely in Britain and Ireland, more commonly in Denmark and North America, and sometimes in Siam and the Malay Peninsula. (Vide "The Ancient Stone Implements, Weapons, and Ornaments of Great Britain," 2nd ed., 1897, p. 121.)

Beyond the occurrence of these implements nothing further appears to be known of the Neolithic period as affecting the Malay Peninsula. The cave explorations undertaken by Mr. H. N. Ridley yielded no other relics connected with man's history at that time, for we read in his report: "It was to be hoped that remains throwing light on the Stone-age men of the Malay Peninsula might have been found in the caves, but as yet nothing has been found anywhere in the Peninsula except the axes themselves" ("Caves in the Malay Peninsula": Rep. Brit. Assoc. Bristol, 1898, pp. 571–582, 1899). Although the literature on this subject is apparently very restricted, the writer would gladly welcome any additional references known to students of Ethnography.

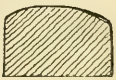
Dimensions of best example: Length, 12 inches; width of chisel end, $1\frac{3}{4}$ inches; width of narrower end, $1\frac{1}{5}$ inches; central depth, $\frac{9}{10}$ inches.

A



B

C



Illustrations of a Neolithic Implement obtained by Mr. W. L. Braddon from a disused mine at Tras, Pahang, Malay Peninsula. Figures drawn one-third natural size.

A.—Lower surface, showing scored markings.
B.—Side view showing slight convexity of upper surface.
C.—Rectangular section of the less perfect specimen, which measures 1 inch in central depth.

VIII.—Origin of Coal.

By J. R. Dakyns, Esq.

IN his interesting paper on "The Origin of Coal," published in the Geological Magazine for January, 1901, p. 29, Mr. Strahan says: "the Limestone Series generally consists of repetitions of small groups of strata, each group being composed of sandstone, followed by shale, shale followed by limestone." It is not stated whether this is intended to be an upward or downward succession; but if the former is meant, as it seems to be, the sequence is very different from that which exists in many parts of the country. Amongst the Yoredale Rocks *proper*—by which I mean the beds in the valley of the Yore and in such parts of the neighbourhood as contain rocks of a similar type—the usual upward succession is sandstone followed by limestone overlaid by shale. That is to say, the limestones very often have basement sandstones, and are nearly always immediately overlaid by shale. There are some cases in which limestone is overlaid by sandstone, but these are quite exceptional.

As it seems from recent discussions at Bradford to be not generally known, I may as well state that the Yoredale type of beds does not exist south of the Craven fault; as a matter of fact, it dies out between Kettlewell and Grassington.

Mr. Strahan also says that "underclays do not resemble soils, inasmuch as they are perfectly homogeneous." Now on many parts of the Millstone Grit moorlands in Yorkshire, the hill peat rests on yellowish clay, formed by the decomposition of the underlying rocks. This clay (which may be called the peat underclay) looks so like a Coal-measure underclay, that one is led to think that both had a similar origin, however different may have been the circumstances. Of course, when an underclay occurs in the midst of a coal, or on top of coal, it cannot have been formed by decomposition of underlying rock. In such cases, which are exceptional, it must have been drifted somewhat. But even if all underclays were drifted, that would not prevent their having been the seats on which coal-forming plants grew, and the striking resemblance of peat underclays to coal underclays makes me think that the latter clays were the seats on which the coal plants grew.

REVIEWS.

I.—Geology of the South Wales Coalfield. Part II: The Country around Abergavenny. By Aubrey Strahan, M.A., F.G.S., and Walcot Gibson, F.G.S.; with Notes by J. R. Dakyns, M.A., and Prof. W. W. Watts, M.A., F.G.S. Memoirs of the Geological Survey. 8vo: pp. 103. (London: printed for H.M. Stationery Office, 1900. Price 2s.)

THIS memoir is written in explanation of the New Series map sheet 232. It includes a brief account of the Silurian rocks of part of the Usk inlier, and a fuller account of the Old Red

Sandstone which stands out boldly in the 'Sugar Loaf.' The result of the resurvey of these rocks has been to show that there is a well-defined plane up to which a Ludlow fauna and a Ludlow type of sediment extend, while above it the Old Red type with Lower Old Red fossils only have been recognized. Locally there is no gradation from Silurian to Old Red Sandstone. On the other hand, no break has been found in the Old Red Sandstone, although the fossils show that both Lower and Upper divisions are present. It is remarked that the formation is "not necessarily purely lacustrine or fluviatile."

From the Old Red Sandstone upwards there is perfect conformity with the Carboniferous strata. The Carboniferous Limestone with its base of Lower Limestone shales is a variable group, 500 feet thick in the western part of the district and about 100 feet in the eastern part. Professor Watts describes some of the oolitic bands of limestone, and also an interesting mass of dolomite. Mr. Strahan found that the white oolitic limestone in one area underwent a considerable change in mineral character, and this proved to take place both along the outcrop and vertically. Analyses showed that the change was due to the replacement of a portion of the carbonate of lime (about 30 per cent.) by carbonate of magnesia, and to a re-crystallization of the whole rock, whereby all organic structure, even the oolitic grains, were obliterated, and the rock became a true crystalline dolomite. Reference is made to the probable connection between the dolomitization and faults which would have afforded means for the circulation of mineral waters. Full accounts are given of the Millstone Grit and Coal-measures, including the iron-ores, which are now but little worked. The coals are more extensively worked now than formerly, and are being followed southwards under the deeper parts of the basin.

In the account of the Glacial Drifts a description is given by Mr. Gibson of a transported mass of Millstone Grit which forms a small hill upwards of 200 yards in length, and was found to be based on stiff glacial till. "The hill, therefore, is merely a huge boulder, bearing witness to the great carrying power of the ice."

II.—The Geological Survey of Canada.

1.—Report on the Geology and Natural Resources of the Country traversed by the Yellow Head Pass Route from Edmonton to Tête Jaune Cache, comprising Portions of Alberta and British Columbia. By James McEvoy, B.A.Sc. Geological Survey of Canada, Annual Report, Vol. XI, Part D. 8vo; pp. 1 d – 44 d, with map. (Ottawa: S. E. Dawson, 1900.)

THIS report is descriptive of an exploration which extended from Edmonton westward through the Yellow Head Pass in the Rocky Mountains, down the Fraser River to Tête Jaune Cache, and thence to the head-waters of Canoe River, a tributary of the Columbia. A map on a scale of 8 miles to 1 inch accompanies the report; it embraces the whole of the area traversed, and extends in latitude from 52° 36′ to 53° 45′ N. and in longitude from 113° 20′ to 119° 35′ W. There are also views of the mountainous scenery characteristic of parts of the Athabasca and Fraser Rivers.

The writer enumerates the various expeditions that have penetrated this region, including those of the Hector-Palliser expedition (1859), and the better known journey of Lord Milton and Dr. Cheadle (1863, "The North-West Passage by Land"), as well as the later one undertaken by Dr. A. R. C. Selwyn in 1871.

The formations met with in the district explored were as follows :—

Tertiary	...	Paskapoo Beds.	Laramie.
Cretaceous	...	Edmonton Beds.	
		Pierre and Fox Hill.	
Devono-Carboniferous.			
Cambrian	...	Castle Mountain Group.	
		Bow River Series.	
Archæan	...	Shuswap Series.	

The *Upper Laramie* (Paskapoo Beds) were identified on the west bank of the Pembina River, and consisted of about 50 feet or more of thick beds of yellowish-grey sandstones. The Lower Laramie, as distinguished by its fossils, was met with on Sandstone Creek, a small tributary of the Athabasca River, where a section showed that the rocks consisted of clayey sandstones, associated with coarser sandstones, carbonaceous shales, and seams of coal.

Cretaceous rocks were represented by rather coarse green sandstone, interbedded near the mountains with greenish conglomerate, with (further eastward) black argillaceous shale, including thin seams of lignite. These rocks were seen in ascending Prairie Creek, a tributary of the Athabasca, the mouth of which is about ten miles from that of Sandstone Creek.

Owing apparently to the imperfect evidence afforded by the fossils the succeeding group of rocks bears the dual title *Devono-Carboniferous*. These were seen in three sections :—(1) 2,160 feet thick in Folding Mountain, the first foot-hill of the Rockies, where limestones, siliceous shales, and quartzites are brought up in a "sharply folded, slightly overturned anticline." (2) In Roche Miette, described as a notable landmark in view at a great distance, standing on the east side of the Athabasca River, a few miles below Jasper Lake. Here, in a section 3,300 feet in thickness, limestones and shales occur, the former holding the few and seemingly not very characteristic fossils which served to indicate the horizon of the beds, viz. Devonian. The following were the fossils obtained: *Atrypa reticularis*; *Diphyphyllum*, sp.; *Cyrtina*, sp.; *Spirifer* (or *Spiriferina*), sp.; cast of elongated spiral Gasteropod. (3) *Carboniferous* rocks were met with near Henry House on the Athabasca River, some 15 miles south of Jasper Lake. Here, again, the evidence upon which the age of the rocks is based is somewhat scanty, judging by the few fossils enumerated, as follows: *Reticularia setigera*?; *Productus* (very finely ribbed); *Spirifer*, sp.; *Dielasma* (cf. *D. formosa*, Hall). These were obtained in an exposure of "black shales and flaggy cream-weathering limestone," three miles below Henry House.

Rocks of undoubted *Cambrian* age were met with on the north-east side of the valley between Tête Jaune Cache and Canoe River. "The squeezed conglomerate of the lower part of the series may be without much hesitation assigned to the horizon of the Bow River Series [*Lower Cambrian*], while the overlying schists and argillites probably belong to the same series, but may include, towards the top, beds of the upper division of the Cambrian or Castle Mountain group." No granite or other plutonic rocks were met with in the vicinity of the route traversed.

A great series of mica-schists were seen on the south-west side of the valley opposite Tête Jaune Cache, on Mica Mountain. The whole series, though differing somewhat from the Shuswap Series of the southern interior of British Columbia, shows the main characteristics of that series, and may be classed as such. The age of this series, as given by Dr. Dawson, is *Archæan.* The line of contact between these rocks and those of Cambrian age on the opposite side of the valley is hidden by superficial deposits.

The glaciation of the mountainous part of the region surveyed is briefly described, and evidence is found for the statement that the valley of the Athabasca contained a large glacier flowing northward down the stream. After the glacier had disappeared the valley was occupied by a large lake standing at a level of 550 to 600 feet above that of Jasper Lake, or 3,260 feet above sea-level. A long, distinct terrace, composed of silt and sand on the west side of Jasper Lake, marks this level.

The report concludes with a brief account of the distribution of the principal trees and of the game, large and small.

2.—On some Additional or Imperfectly Understood Fossils from the Cretaceous Rocks of the Queen Charlotte Islands, with a Revised List of the Species from these Rocks. By J. F. Whiteaves, LL.D., F.G.S., F.R.C.S. Mesozoic Fossils, Vol. I, Part IV, pp. 263–307, pls. xxxiii to xlix. (Geological Survey of Canada, Ottawa, November, 1900.)

As explained in the Prefatory Note by the Director, Dr. G. M. Dawson, the present memoir is an illustrated description of two collections of fossils from the Cretaceous rocks of the Queen Charlotte Islands, made by Dr. C. F. Newcombe, of Victoria, British Columbia, in 1895 and 1897. It contains also a revision of the nomenclature of some of the fossils previously collected from the same rocks by Mr. James Richardson in 1872 and Dr. G. M. Dawson in 1878. A brief summary of its contents will suffice, and this may be taken from Dr. Whiteaves' prefatory remarks. The revised list of species at the end of the memoir shows that 89 species of marine invertebrates are now known from the Lower Shales of the coal-bearing rocks of the Cretaceous system in the Queen Charlotte Islands. Of these one is a Coral (*Astrocœnia*), three are Brachiopods, representing the genera *Terebratula* and *Rhynchonella*, one is a Crustacean (*Homolopsis*), and the rest are Mollusca. The Cephalopoda are much more numerous, both in species and individuals, than the Gasteropoda, and the Ammonites are specially abundant. The latter seem to be remarkable for the presence of several species of *Desmoceras* (inclusive of *Puzozia*), and for the absence of *Baculites*, and of the numerous species of *Pachydiscus* which are so characteristic of the Vancouver Cretaceous. The number of species of Pelecypoda appears to be much larger even than that of the Cephalopoda.

The Canadian species have been in many instances compared with the original types contained in museums in the United States and in Europe. Thus every effort seems to have been made to ensure the utmost degree of accuracy in the identification of the fossils described in this work, which, it may be mentioned, appears fourteen years after the previous (third) part. The new species are well illustrated in the seven lithographic plates by Mr. L. M. Lambe.

3.—General Index to the Reports of Progress, 1863 to 1884. Compiled by D. B. Dowling, B.A.Sc. 8vo; pp. 475. (Geological Survey of Canada, Ottawa: S. E. Dawson, 1900.)

THOSE who have researches to undertake in any subject having a voluminous literature know well the value of that time-saving adjunct, a good index. The arrangement of the one before us is as follows:—Part I (pp. 5–20) contains the Reports, so classified that any country or district in a province can be found in its chronological order, the counties being set alphabetically under their respective provinces. The reports indexed date from 1863 (a summary from the commencement of the Survey) to 1884.

Part II (pp. 21–34) contains an alphabetical list of the "special examinations" of ores, minerals, or fossils that have been subjected to assay, analysis, microscopical examination, or scientific description.

Part III (pp. 35–475) forms the great bulk of the volume, and is termed "General Index to Reports, 1863–84." The arrangement in this part under reference to a place is usually chronological, commencing with the earliest, while under a subject the references are alphabetical, or in the case of substances of frequent occurrence, as gold, iron-ores, coal, etc., the localities may be grouped under provinces.

Special publications on palæontology and botany, which are issued by the Survey from time to time, are not included in this Index, but the "List of Publications" brought out at intervals supplies this deficiency.

We doubt not that the present Index will prove of great use to all who require to consult the publications of the Geological Survey of Canada, and they will not be chary of their commendation of the compiler whose zeal and industry made its completion possible. May his example be followed by many!

Arthur H. Foord.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—January 23, 1901.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair.

After the formal business had been taken, the President, having requested all those present to rise from their seats, said: "I feel sure that the Fellows will desire to express their deep sense of the grievous loss which this nation has sustained in the death of our late beloved and most gracious Sovereign, by assenting to the immediate adjournment of the meeting."

The meeting was accordingly adjourned.

II.—February 6, 1901.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair.

Dr. F. A. Bather, in exhibiting rock specimens, microscope sections, and photographs illustrating blavierite, ophitic diabase, felsitic porphyry, petro-siliceous breccia, and other igneous and metamorphic rocks of the Mayenne, said that the specimens had been collected by him in the course of an excursion of the Eighth International Geological Congress, under the guidance of M. D. P. Oehlert. In the basins of Laval and Coëvrons were many peculiar rocks due to the folding and crushing of stratified rocks penetrated by eruptive dykes. The tectonic features were illustrated by the maps of M. Oehlert and by the photographs. The slides were prepared in the Mineralogical Department of the Natural History Museum, where all the specimens would be preserved.

Mr. E. T. Newton exhibited some graptolites, which had been obtained by Mr. Herbert J. Jessop in the course of a prospecting expedition in Eastern Peru. The locality was in lat. 13° 40′ S. and long. 72° 20′ W.; Limbani, near Crucero, in the neighbourhood of the Rio Inambari. The graptolites are closely related to *Diplograptus foliaceus*, and indicate deposits of late Ordovician age.

Mr. A. K. Coomára-Swámy exhibited and commented on a lantern slide showing spherulitic structure in sulphanilic acid. This had been described and figured by Mr. Henry Bassett, Jun., in the Geological Magazine for January, 1901, pp. 14–16.

The following communications were read:—

1. "On the Structure and Affinities of the Rhætic Plant *Naiadita*." By Miss Igerna B. J. Sollas, B.Sc., Newnham College, Cambridge. (Communicated by Professor W. J. Sollas, M.A., D.Sc., LL.D., F.R.S., V.P.G.S.)

This plant, the remains of which are found in Gloucestershire, was considered to be a monocotyledon by Buckman, but a moss by Starkie Gardner. Material supplied by Mr. Seward and Mr. Wickes has given the authoress ground for the belief that *Naiadita* is an aquatic lycopod, and that it is the earliest recorded example of a fossil member of the Lycopodiaceæ, resembling in proportions and outward morphology the existing representatives of the group. The specimens described show stems, leaves, and sporangia which appear to be borne laterally on the stem and to be embraced by the bases of the leaves. Stomata do not appear to occur, and the association of leaves of different types leads to the conclusion that the three described species are in reality but one. The stems consist mainly of long, thin-walled tubes covered with an epidermis of long rectangular cells; the leaves, in vertical section, show only a single layer of complete cells. The absence of stomata and cortical tissue may be explained, if the plant was submerged when living; but it is possible that the lower tissues of the leaf are lost, together with any stomata which may have been present.

2. "On the Origin of the Dunmail Raise (Lake District)." By Richard D. Oldham, Esq., F.G.S.

The author considers that the gap through the Cumberland hills is a natural feature whose remarkable character has not attracted the attention which it deserves. In form it is an old river-valley, now occupied by much smaller streams than that which formed it. A windgap of this character cannot have been formed by recession of watersheds or capture through erosion, for in such a case the stream on one side or the other of the watershed must necessarily fit its valley, while in the Dunmail Raise there is a misfit on both sides. The gap was in existence before the Glacial Period, and consequently cannot have been formed by ice. So, by a process of exclusion, the explanation is arrived at, which fits in with the surface forms, that the gap of the Dunmail Raise was formed by a river, which flowed across the hills from north to south, and cut down its channel *pari passu* with the elevation of the hills. The final victory of upheaval over erosion, whereby this river was divided into two separate drainage systems and the barrier of the Dunmail Raise upheaved, may have synchronized with a diversion of the head-waters and consequent diminution of volume and erosive power. It is pointed out that this explanation comes into conflict with previously published theories of the origin of the drainage system of the Lake District, inasmuch as the elevation postulated seems too slow to be explicable by the intrusion of a laccolite: and that the existence of a large river crossing the area of upheaval, and the maintenance of its character as an antecedent river-valley for a long period, show that the surface was originally a peneplain of subaerial denudation, and not a plain of marine sedimentation or erosion. From this it follows that the course of the main drainage valleys may not have been determined by the original uplift, but, with the exception of those which are old river-valleys, whose direction of flow has been reversed on the northern side of the uplift, may have been formed by the cutting back by erosion into the rising mass of high ground—in other words, that the principal valleys of the Lake District may be subsequent, not consequent in origin.

CORRESPONDENCE.

NAMES FOR BRITISH ICE-SHEETS OF THE GLACIAL PERIOD.

Sir,—It has often occurred to me that the discussion of our British Glacial phenomena would be facilitated by the adoption of regional names, such as have been found so useful in this respect in North America, for the different portions of the confluent ice-sheets by which our Islands were partly surrounded and covered at the period of maximum glaciation. I have especially felt the want of such names in describing the supposed condition of the basins of the North Sea and of the Irish Sea in Glacial times. The term 'Scandinavian Ice-sheet' often applied to the North Sea ice-field appears to me to be misleading, since it seems to imply that the basin was occupied solely by the outflow of glaciers from Scandinavia, whereas it is far more probable that it was maintained and augmented principally by the snowfall upon its own surface. The term 'Irish Sea Ice,' sometimes used to denote the ice-sheet filling that sea-basin, is likewise objectionable, as I found in a recent discussion where it was understood to imply the marine ice of a frozen sea.

After due consideration and discussion with colleagues interested in the subject, I am inclined to think that the term 'East British Ice-sheet' will be found suitable for the mass which occupied the bed of the North Sea off our eastern coasts, and spread thence, in places, inland. This will then find its complement in the term 'West British Ice-sheet' for the land-ice which filled the basin of the Irish Sea, and encroached upon our north-western lowlands.

We already speak of the 'Pennine Ice' for the great confluent glaciers which covered the greater part of the Pennine region, and of the 'Lake District Ice' for the masses of that region, and these terms need no revision.

Then, for the ice which overspread the greater part of Scotland to the exclusion of the 'East British' and 'West British' sheets, we might apply the general term 'Caledonian,' with such local subdivision as may be hereafter found convenient. And, similarly, the 'Hibernian' (or 'Ivernian') would be that which covered Central Ireland, and the 'Cambrian' that which shielded the greater part of Wales.

More restricted local terms might still be introduced to distinguish well-defined portions of these sheets, and the lobes into which they probably split towards their termination.

I shall be glad to learn whether the terms above suggested are likely to be approved of by glacialists who hold the 'land-ice theory' in regard to our drifts. G. W. Lamplugh.

Tonbridge.
January 20, 1901.

CHEVIOT PORPHYRITES IN THE BOULDER-CLAY OF EAST YORKSHIRE.

Sir,—I can confirm Mr. Stather's opinion[1] (expressed in the Geological Magazine for January, 1901) that the porphyrites of the East Yorkshire Boulder-clay were probably derived from the Cheviots. When I was stationed at Bridlington Quay on the Geological Survey, Mr. C. T. Clough, who mapped the Cheviots, came to the Quay in order to identify, if possible, the far-travelled erratics in the Boulder-clay. We examined the shore and cliffs from Bridlington Quay to Filey, and found a large number of porphyritic rocks, which Mr. Clough said might very well have come from the Cheviots. J. R. Dakyns.

Snowdon View, Nant Gwynnan, Beddgelert, Carnarvon.
February 11, 1901.

MUSEUM EXHIBITION CASES.

Sir,—The new Geological Museum now being erected here will have high windows and a long south aspect. The effect of this will be that the sun will fall suddenly on glazed cases and as suddenly pass off them, thus by the expansion and contraction of the air causing dust-carrying currents to force themselves through every chink. From this cause it costs about three times as much to keep cases and specimens clean on the side exposed to the sun as it does in the shaded part of a museum. This may be obviated by elastic diaphragms (which would hardly allow sufficient movement for such large cases as ours) or by small sliding shutters packed with cotton-wool something like Tyndall's respirators.

Can any of your readers refer us to museums in which such a system has been tried or give us any advice on the subject before our cases have been built? T. McKenny Hughes.

Woodwardian Museum, Cambridge.
February 19, 1901.

OBITUARY.

JAMES BENNIE.

Born September 23, 1821. Died January 28, 1901.

We regret to record the death of Mr. James Bennie, at the age of 79 years. For many years he was one of the fossil collectors of H.M. Geological Survey, and was well known to local geologists in the west of Scotland. In early life, before he joined the Survey, he was employed in a paper manufactory in Glasgow, where he devoted his leisure hours to the examination of the glacial, interglacial, and post-glacial deposits of the west of Scotland. He likewise collected fossils from the various Carboniferous horizons in that region. The results of his labours were published in the Transactions of the Glasgow Geological Society, and his glacial researches were communicated to Dr. Croll in 1867, as acknowledged in the "Life and Work" of that investigator. His Survey career, which commenced in 1869, was marked by his great

[1] See "The Sources and Distribution of the Far-Travelled Boulders of East Yorkshire," by J. W. Stather.

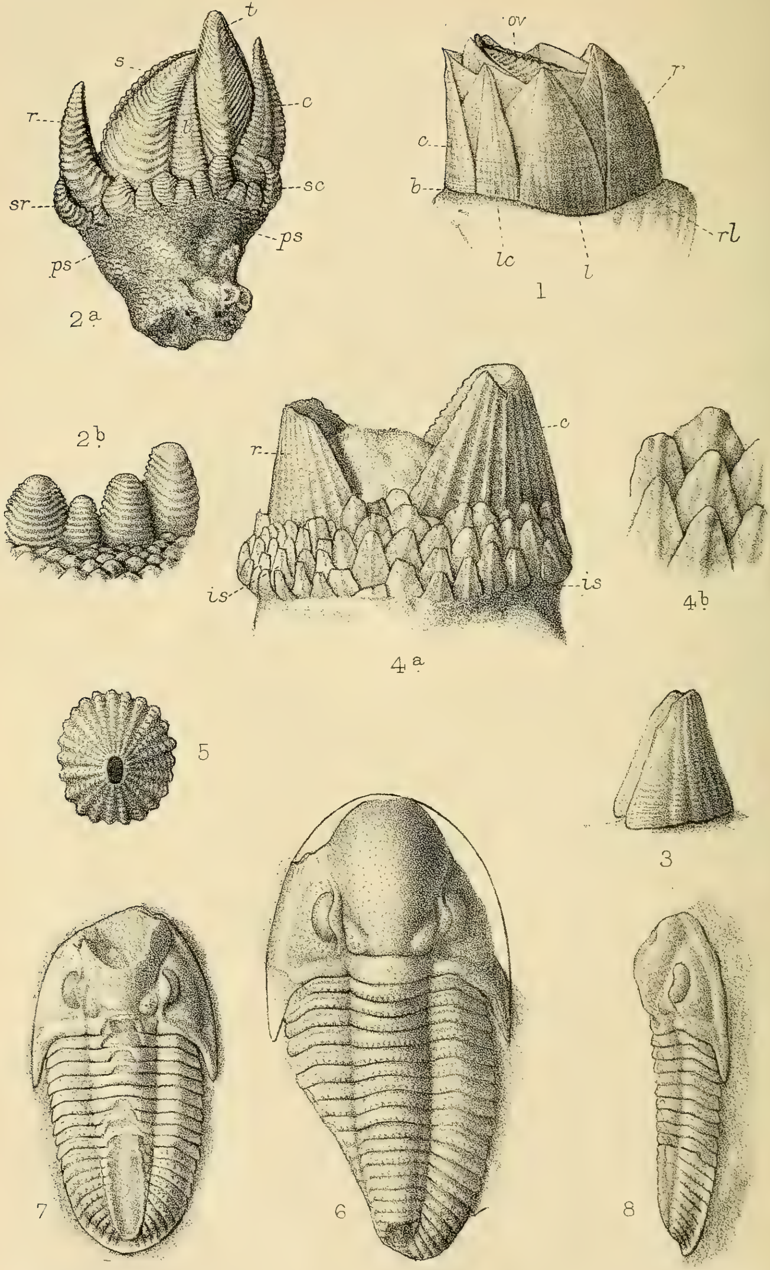
knowledge of the fossiliferous bands in the Carboniferous rocks of Central Scotland. He paid special attention to the occurrence of micro-organisms in the weathered shales of that series, which resulted in the discovery of many forms new to science, described and figured by various specialists. He was the first to record the occurrence of Holothurians in the Carboniferous rocks of Scotland, and was likewise the first to obtain the remains of Arctic plants in the silt and peat of vanished lakes that formerly occupied hollows in the Boulder-clay. With the remains of Arctic plants he discovered fragments of a phyllopod Crustacean, which is now found living only in fresh-water lakes in Greenland and Spitzbergen. Two years ago he received the Murchison Fund from the Geological Society of London, in recognition of his work. Quiet and unobtrusive in manner, and fond of literature, he showed throughout his life a keen love of nature.—*Scotsman,* January 30.

MISCELLANEOUS.

The New Director of the Geological Survey of the United Kingdom and of the Museum of Practical Geology, Jermyn Street, London.—We have just been informed that J. J. H. Teall, Esq., M.A., Vice-President of the Royal Society, President of the Geological Society of London, has been appointed to succeed Sir Archibald Geikie, F.R.S., as head of the Geological Survey. Mr. Teall is an eminent Petrologist and the author of many important papers on geology; he has published a most valuable monograph on British Petrography, with which special branch of the science his name will always be connected. He is universally esteemed amongst geologists, and especially by the members of the staff of the Geological Survey, for his geniality and urbanity to all his fellow-workers. As President of the Geological Society he has also won golden opinions.

The New Professor of Geology at University College, Gower Street.—The Rev. Professor Thomas George Bonney, D.Sc., LL.D., F.R.S., F.G.S., who succeeded Professor John Morris, F.G.S., in the chair of Geology at University College, in June, 1877, and has occupied that post with such eminent success for 24 years, retires this month and is succeeded by Mr. Edmund Johnstone Garwood, M.A., F.G.S., of Trinity College, Cambridge, a gentleman already distinguished by his geological observations and writings in the Quarterly Journal of the Geological Society, the Geological Magazine, the Royal Geographical Society's and other scientific journals. Mr. Garwood has done excellent field work in the Alps, the Himalayas, in Spitzbergen; and in writing upon the Magnesian Limestone and the 'Great Whin Sill,' and the Life-zones of the British Carboniferous Rocks. He has been for some years a Lecturer at Harrow, and as a University Extension Lecturer is well known and esteemed by the scientific public.

Although Professor Bonney is relinquishing the Chair of Geology at University College, he intends still to pursue his scientific and literary work and will continue his clerical duties as heretofore.



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

Cirripedes and Trilobites.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VIII.

No. IV.—APRIL, 1901.

ORIGINAL ARTICLES.

I.—On '*Pyrgoma cretacea*,' a Cirripede, from the Upper Chalk of Norwich and Margate.

By Henry Woodward, LL.D., F.R.S., V.P.Z.S., F.G.S.

(PLATE VIII, Figs. 1–5.)

In the year 1865 I noticed the occurrence of what appeared to be a sessile Cirripede from the Upper Chalk of Norwich, and referred it to Leach's genus *Pyrgoma*. For this unique example the name of *Pyrgoma cretacea* was then proposed,[1] and afterwards, in 1868, it was more fully described and figured by me in the Geological Magazine.[2] I also pointed out that Charles Darwin, in his Monograph on the Fossil Cirrepedia,[3] had described a fossil form belonging to this genus under the name of *Pyrgoma anglicum*, from the Coralline Crag of Ramsholt, Suffolk, a species found living off the south coast of England and of Ireland, Sicily, Madeira, Cape de Verde Islands, etc.; while Michelotti had named, but not described, a species (*Pyrgoma undata*) from the North Italian Tertiary strata.

The only other form of sessile Cirripede known, which extends back in time to the Chalk formation, is the genus *Verruca*, which M. Bosquet of Maestricht first described in 1853 from the Chalk of Limbourg under the name of *Verruca prisca*.[4] This species was likewise discovered by J. de C. Sowerby in the Upper Chalk of Norwich, and described under the same name by Charles Darwin.[5] Like the genus *Pyrgoma*, *Verruca* occurs fossil (*Verruca Stromia*) in the Glacial beds of Scotland, the Red and Coralline Crag of Suffolk, and recent on the shores of Great Britain and Ireland, etc.

[1] Brit. Assoc. Birmingham (1865), Reports, p. 321.

[2] Geol. Mag., Dec. I, Vol. V (1868), pp. 258–9, Pl. XIV, Figs. 1, 2.

[3] "The Fossil Balanidæ and Verrucidæ": Pal. Soc., 1854, p. 36, tab. ii, fig. 7.

[4] J. Bosquet: "Mon. Crustacés foss. terr. Crét. Duché de Limbourg," p. 14, figs. 1–7. Darwin makes a distinct family for this genus—the Verrucidæ.

[5] Mon. Pal. Soc., 1854, p. 43, tab. ii, fig. 10.

Darwin, in describing the genus *Pyrgoma*,[1] says:—"The shell consists of a single piece, generally without suture, even on the internal surface; and this is the case, at least, in *P. anglicum*, in extremely young colourless examples: nevertheless, in some specimens of this very species, and of *P. conjugatum*, there were traces of two, *but only two*, sutures on the sheath, one on each side towards its carinal end. The shell is often much depressed or actually flat; in *P. anglicum*, however, the shell is steeply conical. The outline is rather oval. The surface is furnished with more or less prominent ridges, radiating from the orifice, which is oval and small." (See Pl. VIII, Fig. 5.) "The shell," he adds, "is unusually thick."

"The basis, in all the species, is more or less regularly cup-formed or sub-cylindrical. In *P. grande* it penetrates the coral (on which it is fixed) to a surprising depth; but this is not the case with *P. anglicum*, in which the basis is generally exserted, as it is in a slight degree in *P. grande*."

Of the opercular valves in the Chalk species, so important and essential in the study of any of the Cirripedia, we still remain in ignorance. I should not, therefore, have ventured to reopen the previous description of the so-called '*Pyrgoma cretacea*,' had it not happened that a new and important light has been thrown upon it, quite unexpectedly, through the discovery in the Chalk of Thanet of a second specimen by my friend Dr. Arthur Rowe, M.S., M.R.C.S., F.G.S., of Margate. This gentleman's admirable researches on the zones of the English Chalk have greatly added to our knowledge of its detailed stratigraphy, whilst, by the application of the dental engine for the development of minute and delicate organisms preserved in the Chalk, he has made geologists acquainted with a host of beautiful and novel organisms, among which the present addition to our knowledge of the form hitherto known as '*Pyrgoma cretacea*' is not, as I hope to be able to show in the sequel, the least interesting and instructive contribution.

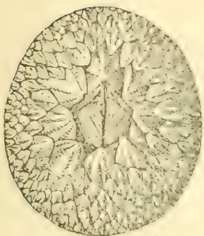
Towards the close of last year, Dr. Rowe brought me the specimen which is the subject of the present communication, and which is figured (enlarged three times) on Pl. VIII, Fig. 4*a*. The original specimen obtained from the Chalk of Norwich, and described by me in 1865 (see Pl. VIII, Fig. 3), consists of nearly half the circumference of the conical walls of the shell, the opercular valves and the basis being absent.

I attributed the absence in the Norwich specimen of the characteristic cup-formed basis, usually seen in *Pyrgoma anglicum* and other species of that genus, to the readiness with which the conical walls of the shell separate from the basis, owing to a cleft covered by a membrane which may be observed all round between the lower edge of the shell and the basis in many of the species. In referring this Cretaceous Balanid to *Pyrgoma*, I was influenced by the following considerations, namely: (1) the steeply conical form of the shell-wall (see Pl. VIII, Fig. 3); (2) the rounded approximate

[1] A Monograph of the Subclass Cirripedia, etc.: The Balanidæ and Verrucidæ, p. 355. Ray Society, 1854.

radiating ribs which ornament the surface; (3) the thickness of the shell-wall; (4) the absence of sutures.

On turning to Dr. Rowe's specimen from the Margate Chalk, we notice the close resemblance of the shell-walls (Pl. VIII, Fig. 4*a*, *c.* and *r.*) with the Norwich example, the external surface in both being marked by strong radiating vertical costæ, crossed at regular intervals by well-marked transverse rings, forming with the costæ a delicate reticulated ornamentation like basket-work on the surface. In Dr. Rowe's specimen the opposite curved portions (*r.* and *c.*) appear



2

2*a*

FIG. 1.—*Pollicipes polymerus*, G. B. Sowerby. Living: Upper California, Pacific, etc. (After C. Darwin's figure, op. cit., pl. vii, fig. 2.) "Capitulum with two, three, or more whorls of valves under the rostrum; latera regularly graduated in size from the uppermost to the lowest; scales of the peduncle arranged in close whorls." The range of the genus extends from the Rhætic beds; the Great Oolite, Stonesfield and Eyeford; the Oxford Clay, the Gault, Upper Greensand, Upper Chalk, the Eocene Tertiary, Isle of Wight; the Tertiary of Messina; and living in the seas of Europe, etc., at the present day.

FIG. 2.—*Catophragmus polymerus*, Darwin. Living: Australian Coast. (After C. Darwin's figure, op. cit., pl. xv, figs. 4*a*–4*e*.) "Interior compartments eight, with several exterior whorls of small supplemental compartments; basis membranous." "In large old specimens there are ten, or even more, whorls of compartments, but it is scarcely possible to count them with any accuracy." This genus does not occur in a fossil state.

FIG. 2*a*.—External view of one of the imbricated scales or valves, from the second whorl, counting from the inside.

at first sight to have been forced apart, or else that two additional lateral compartments of the shell-wall have fallen out and been lost; but this does not seem to have been the case. The important difference lies in the fact that, whereas in the Norwich specimen (Pl. VIII, Fig. 3) the shell-wall is exposed and bare to its basis, in the Margate specimen the base is concealed by a quite undisturbed semicircular quadruple row of shelly imbricated scales (Pl. VIII, Fig. 4*a*, *i.s.*, *i.s.*), analogous to those at the base of the capitulum of

Pedunculated Cirripedes (Lepadidæ), such as *Pollicipes mitella* (Pl. VIII, Figs. 2*a*, 2*b*) and *P. polymerus* (Woodcut, Fig. 1), but which are absent in ordinary sessile forms (Balanidæ).

Thus, in Dr. Rowe's specimen we have presented to us a Cirripede of the greatest interest, offering a most important connecting link between the more ancient PEDUNCULATA or LEPADIDÆ and the more modern OPERCULATA or BALANIDÆ.

Turning to the genus *Catophragmus* of Sowerby (Woodcut, Fig. 2), we find a sessile Balanid which assists us in the interpretation of Dr. Rowe's most interesting Chalk Cirripede, and also that Charles Darwin had, in 1854, already pointed out the significance of the structure of the shell in *Catophragmus* as a means of bridging over the interval between the sessile and pedunculated forms of Cirripedia which Dr. Rowe's specimen had suggested to my mind when he first placed it in my hands at the end of last year. "This genus of *Catophragmus*," writes Darwin,[1] "is very remarkable among sessile Cirripedes, from the eight normal compartments of the shell being surrounded by several whorls of supplemental compartments or scales: these are arranged symmetrically, and decrease in size, but increase in number towards the circumference and basal margin. A well-preserved specimen has a very elegant appearance, like certain compound flowers, which when half open are surrounded by imbricated and graduated scales. The Chthamalinæ, in the structure of the mouth and cirri, and to a certain extent in that of the shell, fill up the interval between the Balaninæ and Lepadidæ; and *Catophragmus* forms, in a very remarkable manner, the transitional link, for it is impossible not to be struck with the resemblance of its shell with the capitulum of *Pollicipes* (see Fig. 1). In *Pollicipes*, at least in certain species, the scuta and terga are articulated together; the carina, rostrum, and three pairs of latera, making altogether eight inner valves, are considerably larger than those in the outer whorls; the arrangement of the latter, their manner of growth, and union, all are as in *Catophragmus*. If we in imagination unite some of the characters found in the different species of *Pollicipes*, and then make the peduncle so short (and it sometimes is very short in *P. mitella*) that the valves of the capitulum should touch the surface of attachment, it would be impossible to point out a single external character by which the two genera in these two distinct families could be distinguished: but the more important differences in the arrangement and nature of the muscles, which are attached either to the opercular valves or surround the inside of the peduncle, would yet remain."

Although Dr. Rowe's Cretaceous Cirripede lacks the opercular valves, it enables us to conclude, from the presence of the three or four rows of imbricated scales around the base of the capitulum, that this form must at once be removed from the genus *Pyrgoma*, with which, as one of the Balaninæ, it has only a very remote affinity.

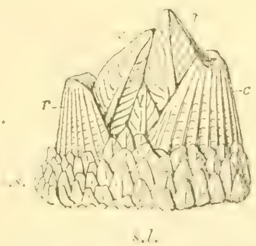
[1] A Monograph of the Subclass Cirripedia: The Balanidæ, etc., pp. 485–7, pl. xx, fig. 4. Ray Society, 1854.

Nor can we place it, as I at first conceived to be possible, in Darwin's subfamily Chthamalinæ, which embraces *Chthamalus*, *Chamæsipho*, *Pachylasma*, *Octomeris*, and *Catophragmus*, all of which are very irregular and aberrant forms of Balaninæ, of which the same author observes that they differ in many important respects from the Balaninæ proper and approach the Lepadidæ, as, for instance, in the supplemental whorls of imbricated scales or compartments in *Catophragmus*, etc.

We should, I think, rather regard this Cretaceous type as an ancient pedunculated Cirripede, which, judging from the form and thickness of its carina and rostrum, appears to be assuming a more sessile condition of growth, and by a later and further modification may have become completely so.

From the undisturbed triple or quadruple arrangement of imbricated scales enclosing the base it is quite certain that the carina (*c.*) and rostrum (*r.*) (Pl. VIII, Fig. 4*a*) could not have united to form a conical shell-wall like that in *Pyrgoma anglicum* (Pl VIII, Fig. 5), as I originally supposed, nor do I think it could have had other lateral compartments between *r.* and *c.* to complete the shell-wall on the *Balanus* type of structure, the large size of the scales in the centre suggesting rather that they were the sub-latera, as in the capitulum of *Pollicipes*. It seems much more probable that the scuta and terga and perhaps a small and narrow latus took part, as in *Pollicipes*, in building up the capitulum, the basis of which was protected by a series of imbricated shelly plates. In point of fact we have here a *Pollicipes* which has abandoned its peduncle, and whilst still retaining the rows of imbricated scales at the base of its capitulum, has settled down into the preliminary stage of becoming a permanently sessile form.

r. = rostrum.
i.s. = imbricated scales.
s.l. = sub-latera.



c. = carina.
i.s. = imbricated scales at base of capitulum.

Fig. 3.—*Brachylepas cretacea*, gen. nov. (capitulum restored). The original figure of Dr. Rowe's specimen is here reproduced and restored by the addition of *l.* latus; *s.* scutum; *t.* tergum. The rostrum (*r.*) and carina (*c.*) and the imbricated scales (*i.s.*, *i.s.*) are copied from the original figure.

As *Lepas* was the name originally given by Linnæus to embrace both the pedunculated and sessile species, the designation *Brachylepas* may serve to express the present type, which embraces characters apparently common to both divisions of Cirripedia. The trivial name *cretacea* is of course retained.

The new form should, I think, be placed in a separate family, intermediate between the Pedunculata and Operculata, as—

Family BRACHYLEPADIDÆ.

BRACHYLEPAS, gen. nov., 1901.

Non Pyrgoma (as applied by H. Woodw., 1865, Brit. Assoc. Rep., p. 321).

Valves about 100 in number; latera of lower whorl numerous; lines of growth directed downwards; peduncle absent.

BRACHYLEPAS CRETACEA, H. Woodw. (Pl. VIII, Figs. 4*a*, *b*.)

Capitulum with three or four whorls of valves under the rostrum; apparently only three rows under the carina; sub-latera larger than the rest. The base on the side figured shows about fifty-four[1] shelly imbricated plates or scales forming eighteen vertical rows, arranged partly in three and partly in four rows; they are smaller, narrower, and more pointed under the rostrum (*r.*), and largest and broadest in the centre below the *latus* (see restoration, Fig. 3, *l.*), as we see is the case in *Pollicipes polymerus* (Woodcut, Fig. 1), where the latera are regularly graduated in size from the uppermost to the lowest of the series. The scales under the carina (*c.*) are larger than those beneath the rostrum (*r.*); but they are narrower and more pointed than those of the lateral series (which are reproduced enlarged on Pl. VIII, Fig. 4*b*). The scales have a strong median ridge with lateral divaricating lines, giving the free-edges a delicately plicated border. The median ridge is narrower and sharper in the scales beneath the rostrum, and broadest on the lateral scales.

The carina (*c.*) is marked by strong vertical ridges, which are crossed by numerous finer encircling bands, running parallel to the base, giving to both the carina and rostrum a delicate reticulated surface. The walls of both are thick, and so far as can be seen quite smooth on the inner surface. On the opposite aspect of the carina to that drawn, the base of the capitulum is seen to be nearly wholly exposed and bare, save for the presence of three of the shelly scales which remain *in sitû* adhering to the carina, the largest of which is 4 mm. in length. The semicircular wall of the carina measures about 17 mm. near its base around its outer face, and its height on the side not covered by the sheath of imbricated scales is 8½ mm. The rostrum is considerably smaller than the carina; it measures 15 mm. around the outer surface near the base, and is 6 mm. in height.

The sheath of imbricated scales covers the base of the rostrum, on the side drawn in the Plate, 2 mm. deep, and extends also 2 mm. below the base of the rostrum, the whole series of scales being a little over 4 mm. deep.

Viewed from above, the body-cavity, enclosed in the convexities of the carina and rostrum, is seen to be oval, being 8 mm. long by 6 mm. broad. The walls of the capitulum are very steep, the carina, which is also much the highest, seeming almost to overhang at its summit.

[1] That is, 54 plates on the side figured; if perfect, there would have been an equal number on the other side, or about 108 in all.

The imbricated scales or plates, which extend below the base of the rostrum and carina, spread outwards at a considerably wider angle than the capitulum. The attached valve of some small mollusc is seen adhering to the imbricated scales below the rostrum.

From the disparity in the proportions of the rostrum and carina, and the absence of alæ, we arrive at the conclusion that the terga and scuta were not mere opercular valves, but formed a part of the capitulum; that latera were also present is proved by the increase in size of the sub-lateral scales, which are much larger than those of the rostral or carinal series (see Pl. VIII, Figs. 4*a*, *b*).

There can, I think, be no reasonable doubt that *Brachylepas* forms a distinct family, from which at a later period probably the modern Operculata have arisen.

The place of *Brachylepas* in the phylogeny of the subclass may be indicated as follows:—

CIRRIPEDIA.

PEDUNCULATA (*Lepadidæ*) | OPERCULATA (*Balanidæ*, etc., etc.).

Lepas \ *Scalpellum* \ *Pollicipes* \ | *Catophragmus* \ *Balanus*, etc., etc. /

Scalpellum (Gault) \ | BRACHYLEPAS (Chalk)

Pollicipes (Rhætic)

|

Turrilepas (Silurian)

EXPLANATION OF PLATE VIII, Figs. 1–5.

FIG. 1.—*Balanus Hameri*, Asc. Recent: British. (Ad nat.) ½. (See also Darwin's "Balanidæ," p. 277, pl. vii, fig. 5.) *r.* rostrum; *c.* carina; *r.l.* rostro-lateral compartment; *l.* lateral compartment; *l.c.* carino-lateral compartment; *b.* basis; *ov.* opercular valves.

FIG. 2*a*.—*Pollicipes mitella*, Linn. Recent: East Indies. (Ad nat.) ½. *c.* carina; *t.* tergum; *s.* scutum; *r.* rostrum; *l.* latus; *s.r.* sub-rostrum; *s.c.* sub-carina; between *s.r.* and *s.c.* the valves of the lower latera are seen; *p.s.* peduncular scales.

FIG. 2*b*.—Four of the lower latera, with some of the peduncular scales enlarged. Three times natural size.

FIG. 3.—'*Pyrgoma cretacea*' = *Brachylepas cretacea* (the original specimen figured GEOL. MAG., Dec. I, Vol. V, 1868, p. 258, Pl. XIV, Figs. 1, 2). From the Chalk of Norwich. Preserved in the British Museum (Natural History). Enlarged twice natural size.

FIG. 4*a*.—*Brachylepas cretacea*. Specimen obtained and developed by Dr. Arthur Rowe, M.S., M.R.C.S., F.G.S., from the Chalk of Margate. Enlarged three times natural size. Original preserved in Dr. Rowe's cabinet. *c.* carina; *r.* rostrum; *i.s.*, *i.s.* imbricated scales at base of capitulum.

FIG. 4*b*.—Sub-lateral scales, enlarged six times natural size. From the centre of series just below the latus (see restoration in text, Fig. 3, *l*).

FIG. 5.—*Pyrgoma anglicum*, Leach (viewed from above). From the Coralline Crag, Ramsholt, Suffolk. Enlarged four times natural size. Recent: Great Britain, Europe, Cape de Verde. (Copied from Darwin's "Balanidæ": Pal. Soc. Mon., 1854, tab. ii, fig. 7*a*.)

II.—NOTE ON SOME CARBONIFEROUS TRILOBITES.

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

(PLATE VIII, FIGS. 6–8.)

THE problems of life which the biologist is called upon to solve present so many and such varied aspects that they are never likely to become exhausted, or to weary by reason of their monotony. Among these the appearances and disappearances of groups in time (like the players on Shakespeare's mimic stage) are certainly not the least interesting questions awaiting solution.

In the case of the Trilobita, we are indebted to Walcott in America, Hicks in Wales, Lapworth in England, Peach and Horne in Scotland, Nathorst in Sweden, Mickwitz in Russia, and Holm in Lapland for extending the *Olenellus* zone back in time to the Lower Cambrian, thus giving to the Trilobites a vast increase in antiquity, without by any means reaching the dawn of life of this group.

The existence of Trilobites in the Carboniferous Limestone was made known as early as 1809, but no upward extension has occurred during the lapse of nearly one hundred years, save their discovery in the Culm of Waddon-Barton, Chudleigh, and Barnstaple, Devonshire,[1] still within the Lower Carboniferous series. One is tempted to ask, did they survive beyond the seas of the Lower Carboniferous period, and, if not, what was the cause of their extermination? To these inquiries our researches have at present yielded no reply.

It seems difficult to understand why the conditions which prevailed in the seas during the slow building up of the vegetable deposits of the Coal-period on the adjacent low-lying lands were inimical to the life of the Trilobita, seeing that near those old lands several species of small king-crabs (*Limuli*) were living, larger *Eurypterus* - like Crustaceans, small aquatic forms of *Cyclus*, numerous Brachyurans (the first lobsters), *Anthrapalæmon*, *Pygocephalus* (a Stomapod), with Phyllopod and Ostracod Crustaceans in great abundance: apparently offering an undoubted certificate as to the salubrity of this marine resort. Yet the Trilobites disappeared.

Although limited in the number of genera and species, the Carboniferous and Culm Trilobites form a most elegant and attractive group, but they do not display that great variety of form or ornamentation which characterized their predecessors in Silurian times.

[1] H. Woodward, "Trilobites from the Culm of Devon": Pal. Soc. Mon., 1884, Carboniferous Trilobites, pp. 59–70, pl. x. Also Quart. Journ. Geol. Soc., vol. li (1895), pp. 646–9.

Since I published my monograph on Carboniferous Trilobites (1883–1884, Pal. Soc. Mon., pp. 1–86, pls. i–x), I have given in this Magazine for 1894 (Dec. IV, Vol. I, pp. 481–489, Pl. XIV) descriptions of two new species, namely, *Phillipsia Van-der-Grachtii* and *P. Polleni*, from the Carbonaceous shale, banks of the River Hodder, Stonyhurst, Lancashire.

In November, 1895, I examined a number of specimens submitted to me by Dr. G. J. Hinde and Mr. Howard Fox, from the Culm of Devonshire and from a white siliceous rock at Hannaford Quarry, near Barnstaple. These represented forms already described as *Phillipsia Leei*, *Ph. minor*, *Ph. Cliffordi*, *Phillipsia* ? (a larval form), *Griffithides acanthiceps*, *G. longispinus*, *Proetus* sp. A, *Proetus* sp. B (Q. J. G. S., vol. li, 1895, pp. 646–649, pl. xxviii, figs. 1–8). Mr. J. G. Hamling, Miss Partridge, and Mr. A. K. Coomara-Swamy, F.G.S., have also sent me specimens from Barnstaple for examination, some of which I hope to figure and notice shortly.

Last year, when visiting my friend Mr. E. Howarth, F.R.A.S., F.Z.S., the energetic Curator of the Public Museum, Weston Park, Sheffield, I discovered that this museum possesses a most excellent series of Trilobites from the Carboniferous Limestone of Derbyshire, of the existence of which I was previously unaware.

The collection was derived from two sources:—(1) Purchased with the geological collection of the Rev. Urban Smith, vicar of Stoney Middleboro' (near to Eyam), Derbyshire, an ardent geologist who during many years' residence in this district formed a large collection chiefly obtained from the Carboniferous Limestone of his own immediate neighbourhood. The specimen H. 88. 1103, *Griffithides longiceps*, Portlock, figured on our Pl. VIII, Fig. 6, enlarged three times nat. size, is from this collection. (2) The second collection was purchased as a part of the museum of Thomas Bateman, Esq., of Middleton Hall, near Bakewell, Derbyshire. Mr. Bateman wrote several books on the antiquities of Derbyshire and Yorkshire, and his archæological and geological collections were purchased for the Sheffield Museum (see Review of Mr. Howarth's Catalogue of Bateman Collection, Geol. Mag., 1901, p. 37). The specimen H. 93. 118, of *G. longiceps*, figured on our Plate (Pl. VIII, Figs. 7, 8, enlarged three times nat. size), is from the Bateman Collection. From the Carboniferous Limestone of Wettin Hill, Derbyshire.

It is most rare to meet with specimens from the Carboniferous Limestone, such as the two here figured, in which the head, thorax, and abdomen (or pygidium) are preserved united in the same individual; the thoracic segments are very commonly absent, and the head-shield and pygidium are usually found separately, so that their description is often attended with considerable difficulty and uncertainty.

I set out with the full conviction that the above examples, the details of which are so remarkably well preserved, entitled them to specific distinction; but after more careful study I can only conclude them to represent a more slender variety of *G. longiceps*, the axis of which is distinctly narrower than that figured by me in 1883 (Pal. Soc. Mon., pl. vi, figs. 7 and 8).

The description given at pp. 33–34 closely agrees with our present specimens, save in one particular, namely, the axis is there stated to be equal to half the entire breadth of the thorax, whereas in Fig. 6 of our Plate VIII it is shown to be exactly one-third the entire breadth of the thorax. This form might therefore be recognized as *Griffithides longiceps*, var. *angusta*, H. W.

The following is a list of the Trilobites from the Carboniferous Limestone in the Sheffield Museum, all from Derbyshire:—

Phillipsia Derbiensis, Martin, sp., 1809.
 ,, *gemmulifera*, Phillips, sp., 1836.
 ,, *Eichwaldi*, Fisher, sp., 1825.
Griffithides globiceps, Phillips, sp., 1836.
 ,, *Carringtonensis*, Etheridge MS. (H. W., 1884).
 ,, *longispinus*, Portlock, 1843.
 ,, *seminiferus* (a very good specimen in 'Rotten stone'), Phillips, sp., 1836.
 ,, *longiceps*, Portlock, 1843.
 ,, ,, var. *angusta*. (Pl. VIII, Figs. 6–8.)
Brachymetopus Ouralicus, De Verneuil, 1845 (a large series of very good detached head-shields and pygidia).
Proetus, sp. ind. (some small detached pygidia).

Some large detached pygidia in this collection may be new.

EXPLANATION OF PLATE VIII, FIGS. 6–8.

FIG. 6.—*Griffithides longiceps*, Portlock, var. *angusta*, H. W. Carboniferous Limestone: Stoney Middleboro'.

FIGS. 7, 8.—*G. longiceps*, var. *angusta*. Carboniferous Limestone: Wettin Hill, Derbyshire.

Figures enlarged three times natural size. Original specimens preserved in the Sheffield Museum.

III.—Notes on the Geology of the Eastern Desert of Egypt.

By T. Barron, A.R.C.S., F.G.S., etc., and W. F. Hume, D.Sc., A.R.S.M., etc.

(By permission of the Under-Secretary of State for Public Works, and the Director-General of the Survey Department.)

The paper is divided into two parts, viz.:—

1. Sedimentary Rocks.
2. Igneous and Metamorphic Rocks.

PART I.—1. Pleistocene and Recent. (*a*) Igneous Gravel and Conglomerates.
(*b*) Newer and older Beach Deposits.
2. Pliocene. Nile Valley Limestones and Conglomerates.
3. Miocene Beds.
4. Eocene Limestones and Shales.
5. Cretaceous Limestones.
6. Nubian Shales and Sandstones.

1. (*a*) *Igneous Gravels, etc.*—These consist of granite, gneiss, and many other igneous and metamorphic rocks similar to those met with in the Red Sea Hills, and occur up Wadi Qena and spread

out in a fan-shaped delta at its mouth. Although abundant in this wadi, they are unknown in the side-valleys, even where they are now connected with the igneous hills. The explanation of this is as follows:—East of Qena the Eocene plateau has been broken up into a series of outliers, which until quite recently were connected by a long ridge, the sole break being that where Wadi Qena passes between the main plateau and the outlier of Abu Had. Previous to the formation of the latter fracture, the southern end of Wadi Qena was a bay, in which flint containing conglomerates and Pliocene limestones were being deposited, but when the above-mentioned gap was formed, the drainage from the Red Sea Hills passed through to the Nile Valley. Similar gravels cover the Red Sea Coast-plain. The age of these beds has now been shown to be Post-Pliocene, as there is a marked unconformity between them and the latter, and also because on the Coast-plain they are found underlying and overlying limestones containing Pleistocene fossils.

This throws a strong light on the age of the Nile. Mr. Beadnell found these gravels on the western side of the valley, and they are apparently continuous under the Nile alluvium, thus showing that the Nile as a river is later than these gravels, and could not have begun to flow until late Pleistocene times. These gravels are also suggested as the origin of the igneous pebbles reported by Professor Judd in the Royal Society's boring at Zaqaziq. All the rocks mentioned can be matched from the gravels near Qena. (Since this paper was read similar pebbles, but worn thin as by long rolling, have been found in cuttings in the lake deposits to the north of Heluan.) The theory of the derivation of the pebbles from the northern part of the Red Sea Hills is untenable, as it is known that Wadi Qena received all the drainage from that area in early Pliocene times.

These gravels are believed to have been deposited in a fresh-water lake, a series of which were formed as the sea retreated down the Nile Valley.

1. (*b*) *Raised Beaches and Coral Reefs.*—Five series are recognized, of which the youngest is below sea-level, their succession being as follows:—

(1) The coral reefs at present forming in the Red Sea.

(2) The raised beaches and lower coral reefs which flank the coast, varying in height from near sea-level to 25 metres above the sea.

(3) A higher coral reef series on an average four to seven kilometres from the sea, and at various levels between 115 and 170 metres.

(4) A disturbed coral reef dipping 20 degrees eastward, closely related to the previous one.

(5) An old coral reef in which the affinities are as much Mediterranean as Erythræan, regarded at present as Miocene.

Along the shore 'storm-beaches' are common; in some places the shells form well-marked zones; while the higher beaches and reefs are distinguished more or less from the lower by a different fauna. The disturbed reef has been formed previous to the formation of the parallel ranges of Jebel Esh and Zeit, thus bringing up the fault-movement to very recent times.

In this area there is an inversion of the stratigraphical arrangement, the higher beds being the older, the reefs being formed during a period of secular elevation. There is also apparently a long break between the two reefs, the explanation suggested being as follows:—

The first great Tertiary earth-movement in the Red Sea region was previous to the Upper Miocene and subsequent to the Eocene, the latter being faulted, and beds of the former deposited in the troughs produced. Later, as the result of further movements, coral reefs were formed on the sides of the igneous hills, but as soon as (owing to continued elevation and denudation) valleys had formed, down which torrents carried masses of pebbles, etc., the conditions became unfavourable for the formation of true reefs, and only gravels were deposited. This view assumes the existence of marked pluvial conditions, as maintained by previous writers, and it was only when the present desert conditions set in that the reefs again began to grow.

2. *Pliocene.*—Mayer-Eymar and Dawson have both regarded the Nile Valley as an arm of the sea in recent times as far up as Assuan. A foraminiferal limestone, found by Mr. Barron near Erment and which has been described by Mr. F. Chapman, contained two out of five species described not older than Miocene, while one is not known before Pliocene times, thus proving the above theory. Beds of the same age are found in Wadi Qena. They form a plateau consisting of flint conglomerates, white limestone, and at the base marls and fissile sandstones which vary greatly, the limestones being lenticular and thinning out to the east. The conglomerates are formed by the denudation of the Eocene limestone. The succession of these beds is as follows:—

(1) On the boundary-line with the Eocene rocks, breccias of flinty and cherty limestone with lenticles of limestone interbedded.
(2) Conglomerates of well-rounded pebbles.
(3) Pure white limestones, perhaps partly siliceous.
(4) Marls and clays.
(5) Sandy clays.

These beds are regarded as Pliocene on three grounds—(1) They have no resemblance to known Miocene beds in Egypt; (2) they are identical in all essential particulars with the foraminiferal series of the Nile Valley; and (3) the Pleistocene gravels are younger and unconformable to them.

These beds owe their origin to the faulting which produced the Nile Valley and Wadi Qena, and there must have been a subsidence of at least 400 metres to allow of their deposition.

The Pliocene has been a period of great movement marked by the formation of the great rifts such as the Red Sea, with the invasion of the fauna of the southern seas, the Gulf of Suez, the great scarp of the Red Sea Hills and its parallel ranges, and the main trend of the Nile Valley and Wadi Qena, the two latter being in part arms of the sea extending far into the land.

3. *Miocene Beds.*—There are no new facts to be added to the results obtained by Mitchell and Mayer-Eymar in this area.

4. *Eocene Beds.*—These can be divided into two main series—(*a*) a thick group of limestones which are locally named Serrai Limestones, and (*b*) a thick group of shales, marls, and marly limestones termed by the Survey the 'Esna Shales.'

(*a*) The summit of the plateau is a bed containing a small nummulite, underlying which is a nodular limestone forming a distinct, precipitous, undercut cliff 3 metres high. Beneath this are limestones with flint-bands having a thickness of 200 metres, and having at their base a chalky limestone weathering pink. The total thickness of this series is 225 metres.

(*b*) The Esna shales are composed of yellow limestones (Pecten Marls) forming the base, succeeded by green shales, in the middle of which is a limestone, the total thickness being 122 metres. The Eocene here belongs to the 'Libysche Stufe' of Zittel or Londinian stage.

By the discovery of the unconformity between the Eocene and Cretaceous strata in Wadi Hammama, the presence of hitherto unsuspected Eocene has been proved on the eastern side of the Red Sea Hills, such as the faulted area of Jebel Duwi and Nakheil, near Qosseir, and the limestone range of Jebel Mellaha, near Jebel Zeit. The former is a bold white cliff facing south and dipping away at angles of 15 to 20 degrees, and is the result of complicated folding and strike- and dip-faulting, the flinty series being sometimes tilted at angles of 40 degrees, and lying in succession against Nubian Sandstone, metamorphic rocks, and granite, as in Jebel Hamrawein. Jebel Nakheil is an Eocene and Cretaceous syncline in which the succession is the same as that near Qena. Other outliers are noted in Wadi Hamrawein, the country north of Wadi Saga, at the confluence of Wadi Safaja and Wadi Wasif, and to the north-west of Wadi Um Tagher.

Jebel Mellaha.—Professor Zittel, in his map, following Schweinfurth's researches, refers the whole series to the Cretaceous, but the latter seems to have become aware of the presence of Eocene later. This range is composed of the same beds as Jebel Nakheil.

The Eocene beds have covered the whole of the Eastern Desert north of lat. 26° N., but have been entirely removed except where let down by faults. They are everywhere unconformable to the Cretaceous rocks.

5. *Cretaceous Limestones.*—After pointing out some gross errors recently published by Dr. M. Blanckenhorn, the most important points to be noted are these:—

(1) The occurrence of a Cretaceous plateau at Wadi Hammama containing numerous Cephalopoda, *Ptychoceras*, etc., and a coprolite bed about one metre thick, and extending over 20 kilometres to the north, where it runs to ground at the foot of Abu Had. The coprolite bed contains 50 per cent. phosphate of lime.

(2) There is a distinct unconformity between the Esna Shales and the Cretaceous.

(3) *Cretaceous Plateau at the foot of Jebel Duwi.*—This was hitherto scarcely known, and differs from the previously described area in the absence of the *Ptychoceras*, etc., and by their replacement by large Nautili, associated with *Libycoceras Ismaeli* and beds of *Trigonoarca multidentata*, etc., below which comes a bed crowded with *Ostrea Villei.* A strong unconformity is also here present between these beds and the Eocene. At the north end of this range, near Saga Plain, the coprolite beds are of unusual thickness.

(4) *Confluence of Wadi Safaja and Wadi Wasif.*—Here there are two well-developed coprolite beds, and a very prominent layer of *Baculites.* The conclusion arrived at is that the Cretaceous limestones of the area described are of shallower-water origin than those occurring to the north in Wadi Araba, and entirely Campanian in age, being characterized by the abundance of their oysters, their well-marked coprolite beds, and small thickness. This main type is of great palæontological variability, the beds near Qena, Qosseir, and Mellaha differing in essential particulars.

Gypseous Deposits near the Red Sea.—These occur only in the 'Raised Beach' area, and are almost always intimately connected with the limestones of this series. They crop out from under these beds, and, by their invariable unconformity and constant height above sea-level, suggest a "plain of marine denudation." They are the Lower Eocene and Cretaceous Limestones which have been altered, not from below as has been previously believed, but from above, as will be shown in the Report on Western Sinai by Mr. Barron.

6. *The Nubian Shales and Sandstone.*—These consist of soft green and black carbonaceous shales and marls, and dark-brown and red sandstone. The former being easily weathered are accountable for the formation of the large plains which are met with in the areas occupied by this series. The sandstones show evidence of ripple-marking, sun-cracks, rain-prints, and worm-tracks. In the softer upper beds, the vertebræ of a (?) *Mosasaurus* and pieces of fossil wood in excellent condition were found. It is everywhere unconformable to the underlying igneous rocks.

The age of the deposit in this district is Santonian or Lower Senonian, as shown by a bed of oysters found in the sandstone near El Geita by Mr. Barron. No traces of Carboniferous fauna have been discovered. It is later than the igneous range, and not earlier as maintained by Floyer and Mitchell.

Part II.

Igneous and Metamorphic Rocks.—These rocks, forming a wide band running parallel to the Gulf of Suez and the Red Sea, practically constitute the mass of the Red Sea Hills. The latitude of 27 degrees N. closely agrees with an important geological boundary, the granites playing a considerable part among the components of the mountain ranges north of this line, while south of it the metamorphic rocks become increasingly prevalent as the Qena-Qosseir road is approached, the granite forming sharp isolated ridges rising abruptly from among low hills of sheared diabase or slates. Almost on the southern edge of the area, well-marked gneisses and schists give rise to the range of Meeteg, whose rugged peaks dominate the upper portion of Wadi Sodmein.

METAMORPHIC ROCKS.—In the following pages only the most important new facts can be touched upon, these being briefly as follows :—

Gneiss, etc., near Qosseir.—The northern track from Qena to Qosseir, after passing through a granite and dolerite region, suddenly enters a district composed of a grey, slightly schistose rock, breaking off into long splinters. Through it run numerous solution veins of quartz, bands of calcite and carbonate of iron, all of which have been extensively worked. These *slates, having a distinct satiny lustre*, and forming low ridges on the western edges of the two high ranges of El Rebshi and Meeteg, dip steeply south-west, but at the base of the former mountain system are replaced by underlying *green phyllites*, into which numerous dykes of dolerite have been intruded, quartz veins being also common.

The main range of Meeteg itself is composed of a still older series of quartz-mica schists, the younger members of which are of a yellowish colour, splitting readily into blocks more or less cubical in outline. Near the base of the mountain small veins of *granite penetrate into the schists*, in some places being pinched into these in a lenticular manner. The core of the range is composed of a *massive red and closely banded grey gneiss*, which, in a fine section displayed in the upper portion of Wadi Sodmein, is seen to be successively overlaid by a gabbro, mica-schists, *a massive dark dolerite*, hornblende-schists, and reddish-white mottled slates. From a little north of this point the valley wanders through a maze of hills of grey and green colour, consisting of micaceous, chloritic, and hornblendic 'schists,' capped by beds of dolerite and diabase, crushed or uncrushed. A question of terminology makes a difficulty, as the same term schist is here applied to these rocks in the foothills, which are far less compact than the typical varieties occurring in the main range.

Sheared Diabases and Dolerites.—The Wadi Sodmein section is useful because it shows the relative age of the gneiss and the sheared diabases, ashes, and other volcanic rocks, which occupy an enormous area of the southern portion of the Red Sea Hills, viz. 2,500 square kilometres approximately, being the main constituent of the region to the north-west and west of Qosseir, except where sedimentary hills have been faulted in. The sheared diabases and compacted ashes chiefly occur in this district, but further west, as in Wadi Atolla, are replaced by massive dolerites, which in many other localities are found in close association with volcanic members of many different types. This *volcanic* series is by no means limited to the area above mentioned, but reappears throughout the whole of the Red Sea region at most unexpected localities. Thus, in the central range, dolerites and other basic rocks are seen capping some of the highest granite hills, still remaining as a thin coating, which otherwise has been almost entirely removed by denudation. Again, the base of the same range is fringed by a belt of the same character, the presence of which is probably directly referable to faulting on a large scale.

South-west of the central range, too, extends the Fatiri El Iswid district, consisting of range after range, in which dolerites, serpentines, compacted ashes, now practically slates, and agglomerates play an important part. While on the south of lat. 27° N. these rocks only give rise to low hills of complex character, to the north of that line they take part in the formation of scenic features of the first magnitude, rising to 1,800 metres in Jebel Dokhan, and composing some of the principal longitudinal ranges forming the eastern boundary of the Red Sea Hills.

The members of this volcanic series are of somewhat different character from those previously mentioned, dark andesites being as conspicuous as the dolerite sheets associated with them, while the sheared diabases have been replaced by tuffs and ashes far less compact than those near Qosseir. The agglomerates, too, are very striking in the El Urf chain, where blocks of 'imperial porphyry' are included among the rock fragments. Indeed, the most interesting member of this series is the imperial porphyry of Jebel Dokhan, typical specimens of which are withamite, containing andesites, though the same mineral is present in some of the tuffs.

Relative Age of the Volcanic Series.—It has already been stated that the dolerites, diabases, etc., rest upon the *Metamorphic Schists and Gneisses*, and are younger than the latter, but it is equally possible to show that the gneissose granites and diorites, which underlie them over wide areas, are of still later date. Thus, to take a few typical cases, a mass of mica-diorite has been intruded into the agglomerate, while in Wadi Esh, near Qosseir, the sides of the valley are formed of grey granite which is overlaid by the compact dolerite, but the former has sent numerous veins into the latter. Other examples will be mentioned in the report, but one of the best is close to the pass leading from Wadi Um Sidri to Um Messaid, where a dyke of red microgranite in the andesite has for a time prevented another vein of grey granite from penetrating into the lava, but finally, after running parallel for a short distance, the latter has succeeded in bursting through, and has sent long veins and branches into the porphyry.

Granites.—The rocks of granitic character in the Red Sea Hills are sharply divided into two groups, giving rise to very different types of scenery. The most prominent variety is a *coarse red granite*, poor in mica, which forms some of the finest summits north of and on the latitude of 27 degrees N., these being usually characterized by steepness, the mountains being seamed by bouldery ravines which cause the crests to have a highly serrated outline, while nearly all the lower country consists of bouldery ridges of a *gneissose* biotite, or hornblende granite, which has its south-eastern boundary along a line joining Ras El Barud and Missikat El Qukh ranges. This gneissose granite is especially conspicuous owing to the abundance of the dykes of quartz-felsite and dolerite which vein it, in a north-east and south-west direction, the differential weathering of the two giving rise to a typical alternation of parallel ridges and sandy valleys to which the name 'dyke-country' may be applied. Where the above two varieties come in contact, it can be clearly seen that the red granite is the younger of the two.

General Recapitulation.

We are now in a position to give the general succession for the Arabian Desert between Jebel Gharib and the Qena-Qosseir line.

1. The *metamorphic* are older than the igneous rocks.
2. The gneiss of Meeteg is the oldest member of the metamorphic series, the schists coming next in order, followed by slates, grauwacké (altered ash), sheared diabases, and dolerites.
3. Volcanic action had already begun during the period of formation of the grauwackés and slates, as the sheared diabases and dolerites are in places closely associated with them, but the main mass of the dolerite is younger than the slates. Thus the next in succession is a *volcanic* series in the south, consisting mainly of dolerites and sheared diabases, and in the north of dolerites. andesites, tuffs, and agglomerates.
4. These are themselves underlain, and in most cases intruded into, by a third series, a *quartz-diorite or grey granite*, in many cases gneissose.
5. Through the volcanics and grey granite rise masses of red granite, which may be almost contemporaneous with dykes of quartz-felsite and dolerite, seaming the members of the preceding series.

IV.—Schists and Schistose Rocks in the Lepontine Alps: Reply to Criticisms by Professor A. Heim.

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

SOME three years ago, on referring to the twenty-fifth volume of the "Beiträge zur Geologischen Karte der Schweiz," I found Professor Heim had devoted a few pages (pp. 316–319) of that work to my criticisms of his attempts to prove that Jurassic rocks had been metamorphosed into schists containing authigenous garnets, staurolites, etc. Had he brought forward any new fact of importance or pointed out any serious error in my work I should have replied at once, but as he was unable to do this, and as the justice of one of my criticisms was indirectly admitted in the petrographical appendix by Dr. C. Schmidt, I allowed more pressing and interesting matters to take precedence of one which had become chiefly personal.

On reading Professor Heim's remarks I perceive that we labour under a similar disadvantage, viz., that neither is a master of the language in which the other writes. He complains of a difficulty in understanding my meaning, though I think it was plain enough to most of my English friends. I am in the same position, because he appears to me to avoid the direct issues and to repeat assertions which I have challenged. So, before going further, I will state the dispute as clearly and concisely as I can. It arose out of a paper read at the London Meeting of the International Geological Congress in 1888.[1] Then, or soon afterwards, Professor Heim made the following assertions: (1) that at Guttannen stems of a plant of Carboniferous age had been found in a gneiss; (2) that near Andermatt a crystalline marble was associated with a Jurassic limestone, so that they must be of the same geological age; (3) that in the Lepontine Alps a transition could be traced between fossiliferous Jurassic rocks and schists with authigenous garnets, staurolites, etc.

I have disputed the accuracy of all these statements. As regards (1) it is now admitted that the supposed stems are not organisms, but merely imitative markings. Hence this assertion is invalidated, but, as I have apparently made a mistake as to the nature of the rock, neither side in this controversy can 'score honours.'[2] About (2) there is nothing fresh to be said. I have discussed Prof. Heim's evidence, which he has not been able to strengthen, and think myself justified in claiming a verdict of 'not proven,' even if I have not shown his interpretation to be improbable.[3] My remarks accordingly will be confined to (3). Here sections are more numerous; the issue is simpler, and the initial difference between us largely concerns matters of fact. In the first place, Prof. Heim maintains that I have misunderstood him, and that he never affirmed those altered Mesozoic sedimentary rocks to be true crystalline schists. The very lax use of the term 'schist' by Continental and some English authors undoubtedly leads to confusion in expression as well as in thought, and I am prepared to admit that it might sometimes be difficult to draw a hard and fast line between a schistose rock (i.e. cleavage followed by a certain amount of secondary mineral development) and some foliated schists. This, however, does not really affect the present issue. Professor Heim asserted that certain schists with authigenous garnets, staurolites, etc., were proved to be of Jurassic age, not only by stratigraphical evidence, but also, where the minerals were less well developed, by the presence of fossils. I asserted that the schists with garnets, etc., were both truly crystalline and belonged to a group distinct from the Jurassic rocks in question; that this group could be shown to be much older than the Trias, and to differ in important respects from the fossiliferous schistose Jurassic rocks, which never contain authigenous garnets, etc., but only certain hydrous silicates, presenting a merely superficial resemblance to garnets, staurolites, etc. In other words, I gave reasons to show that Professor Heim's interpretation of the stratigraphical facts was untenable, and his identification of the important minerals was incorrect.

[1] Compte Rendu de la 4^{me} Session, p. 80. See also *Nature*, Sept. 27 and Oct. 4, 1888, and Quart. Journ. Geol. Soc., vol. xlvi (1890), p. 236.

[2] Geol. Mag., 1900, p. 215.

[3] Quart. Journ. Geol. Soc., vol. xlvi (1890), p. 67; vol. l (1894), p. 285; vol. liii (1897), p. 16.

Passing now to the stratigraphy, I claim to have proved—

(*a*) That the schistose and fossiliferous Jurassic rocks in the Scopi and Nufenen districts overlie the rauchwacke.[1]

(*b*) That this rauchwacke (commonly a friable yellowish limestone, sometimes including layers of gypsum, but without any marked indications of metamorphism) often contains fragments of crystalline rocks corresponding with those which are elsewhere associated with the black garnet-bearing schists. Also, that this rauchwacke differs conspicuously from the crystalline limestone or dolomite, which occurs both on the northern side of the Campolungo Pass (south of the Val Bedretto) and in association with similar dark schists above Binn in the Binnenthal.

(*c*) That the rauchwacke generally overlies the group of crystalline schists, and where it is apparently interstratified with them a closer examination always suggests that it is a later rock 'nipped' in by overfolding and thrust faulting.

(*d*) In the noted Val Canaria section, where, according to Professor Heim, crystalline schists[2] are included in a fold of which an ordinary rauchwacke forms the base, not only does this rauchwacke contain fragments of more than one variety of the schists supposed to overlie it, but also the band of black garnet-bearing schists occurs *three* times, and the other beds are not in pairs. These facts prove a simple fold to be impossible,[3] and if faults be once admitted the key of Professor Heim's position is surrendered.

In addition to this I have shown, from stratigraphical, chemical, and microscopic evidence, that the schistose Jurassic rocks and this group of schists, locally garnet-bearing (a group which I have examined in many places from the Viso to the Gross Glockner, and to which I refer in my papers as the 'Upper Schists'), are quite distinct one from the other; the only possible confusion arising from specimens either badly preserved or in which their distinctive characters have been locally obliterated by extreme pressure. This, however, is no ground for asserting contemporaneity. In such rocks the metamorphism has been destructive, not constructive.

I pass, then, to the mineral differences. The group of schists, of which the dark one containing garnets is a member, consists, as I have shown elsewhere, of truly crystalline rocks, no less in the Val Canaria section than in the rest of the Alps, and never affords a trace of a fossil. Here and there in its dark schists are little streaks of crystalline calcite. These to a lively imagination may seem the ghosts of departed belemnites, but to a more prosaic mind they appear only a vein product. The rocks are true crystalline schists, no doubt of sedimentary origin, but greatly metamorphosed. They

[1] Quart. Journ. Geol. Soc., vol. xlvi (1890), p. 219, and vol. xlix (1893), p. 89.

[2] I suppose from what I have read that Professor Heim will refuse to call these rocks crystalline schists. If so, there is no crystalline schist—either garnet-mica, calc-mica, staurolite-mica, or quartz-mica schist—in any part of the Alps that I know of.

[3] The situation of the outcrops and their breadths make it impossible to escape this difficulty by supposing one black garnet schist to have been the [illegible] and to be doubled back on itself.

have been affected by pressure, but they were crystalline schists before that acted, for the larger minerals are sometimes distorted or even crushed, the garnets in one or two localities being distinctly cleaved. Pressure, in fact, has injured more than it has originated the crystalline condition. But the Jurassic rocks are only schistose; they have been affected by pressure, and it has produced the usual mineral changes on a comparatively small scale. But besides this, in some localities a number of ovoid and of rudely prismatic bodies have formed (the *knoten* and *prismen* of Von Fritsch). These, which occur along with fossils (belemnites, bits of crinoids, etc.), are not either garnets or staurolites, but only very impure silicates, more or less hydrous; some probably belong to the chloritoid, others perhaps to the scapolite group, with possibly a third mineral of the same general character.[1] Professor Heim asks almost in a tone of triumph[2] whether I have not seen "die Verquetschungen und die Veränderung (Marmorisirung) in der Structur der Belemniten . . . . die ganz mit der Umänderung des Muttergesteines parallel geht." Certainly I have: indeed have mentioned it (loc. cit., p. 219). But by this question he shows that he can have given very little time to the study of metamorphism. Otherwise he would have known that this 'marmorosis,' notwithstanding its fine name, proves but little, for calcite is one of those minerals which are always ready to crystallize, and particularly so when it is 'organic.' We constantly see this illustrated in rocks (especially Palæozoic) from English localities. There are no signs of pressure, yet fragments of fossils may be often found under the microscope to become partially or even wholly crystalline, to the obliteration of the original structure. I have also seen tests or spines of echinids from the Chalk break as if they were crystalline calcite, and a fractured stalactite showing the cleavage surface of large crystals.[3] Professor Heim, however, seeks to minimize my criticisms by intimating that I am a prejudiced witness, and have from the first shown signs of a distinct bias (*tendenz*). Of this I am convicted by my own confession, because I stated that, when I saw the specimens on which he rested his case, and which he exhibited at Burlington House in 1888, "'Still, I was not quite satisfied . . . . for it was very difficult to understand how such a fossil as a belemnite could have retained its characteristic form while

[1] Dr. Schmidt admits the presence of clintonite (which name is now applied by Dana to the group including the species of chloritoid), and assigns the knoten and prismen to zoisite. Both minerals are so full of impurities that it is very difficult to come to any conclusion, but neither reminds me of zoisites, nor is any close relationship suggested by the analyses (quoted on p. 233 of my paper); and after reconsideration of my specimens I see no reason to change what I wrote in 1890 (Quart. Journ. Geol. Soc., vol. xlvi, pp. 232–234). Dr. Schmidt's petrographical description will be found in Beiträge, vol. xxv, Anhang, pp. 41–65.

[2] Beiträge, ut supra, p. 317.

[3] Though I think that, as a rule, I can distinguish a marble belonging to a group of crystalline schists from an ordinary Palæozoic or later limestone, even if pressure modified, I put more reliance on any silicates which may be associated with the calcite, and do not feel quite happy unless I can trace the rock into some schist composed largely of these.

molecular changes of such importance were taking place in the matrix of the rock.' Er sieht hier eine Thatsache, an der er zweifelt, weil sie ihm unerklärich vorkommt!" Well, then, I will tell Professor Heim why I was not quite satisfied. In the first place, if it be a sign of bias to reason inductively from careful and numerous observations, and to rely on the conclusions thus obtained so far as to view with some suspicion any new phenomenon which distinctly contradicts them, I admit the charge, and that unblushingly, for I believe this to be the method of science. The latter is said by a good authority to be organized common-sense. If in every-day life a number of credible persons agreed in stating that something had occurred—say a man had done an action which they had witnessed—should we not be justified in cross-questioning rather severely anyone who suddenly appeared to swear an *alibi*? Now all my work, and it was considerable, undertaken with the sole desire of discovering the truth—work which had obliged me to discard almost everything I learnt when young—had led me to conclusions different from what Professor Heim was asserting.[1] Inasmuch, then, as his "Mechanismus," while greatly impressing me in some respects, had created suspicions of his trustworthiness as a guide in petrology, I submit that I was justified in thinking it possible he might have made a mistake. The 'Thatsache' was in reality little more than his assertion.

But he will say that I was shown the specimens. Yes; and if Professor Heim had seriously worked at petrology he would know that conclusions founded on hand-specimens are much less trustworthy than those arrived at by examination of rocks in the field or under the microscope. Speaking for myself, I refuse, when the matter is difficult, to express an opinion on a hand-specimen, but require to have a slice prepared for the microscope. Moreover, it appeared to me, when looking at his specimens, that the matrix of the two sets, those with belemnites and those with real garnets, was somewhat different. Professor Heim would no doubt set down this to 'bias,' but it is really the almost unconscious effect of that experience which most persons acquire by long work at a particular subject. It is very similar to the power which enables a specialist to make a diagnosis of something which a physician, who has worked along other lines, would not perceive.

But he quotes another phrase to convict me of bias. "It was very difficult to understand how such a fossil as a belemnite could have retained its characteristic form while molecular changes of such importance were taking place in the matrix of the rock." This remark is evidently not intelligible to Professor Heim, so I will endeavour to enlighten him. The results of contact-metamorphism, to which I have paid considerable attention, most nearly resemble the crystalline schists. In them, so far as my experience goes,

[1] I may add that the general *tendenz* to minimize the effect of 'dynamo-metamorphism,' of which he accuses me (p. 316), has the same foundation. That is an important factor in producing change, but its effect has been often greatly overestimated. After ten years' work I adhere to the position adopted in 1890 (loc. cit., p. 223), which since then I have so often expressed that I am weary of repeating it.

garnet, and still more staurolite, are not formed until the materials of the rock have undergone such great molecular changes as to obliterate all traces of a sedimentary origin and convert the rock into a fairly coarse crystalline aggregate of quartz, brown and white mica, andalusite, and other minerals.[1] Under such circumstances, I believe that any calcareous organism, if it did not disappear and supply its lime to some silicate, would become unrecognizable. Only in one case, that of the Bastogne rock, have I seen well-formed garnets in a matrix apparently not very greatly altered. These, however, are rather abnormal specimens, and, as it has been lately demonstrated, occur under very abnormal circumstances.[2] My bias, then, was due to experience, which showed me the antecedent improbability of what Professor Heim was asking me to believe.

There was yet one other reason for my scepticism. In 1883 I crossed the Gries Pass to the Tosa Falls, wishing to see an Alpine route of some historical interest, and with no definite geological aim, for I had but recently begun to make any special study of the 'upper schists.'[3] Here are some extracts from my diary. Going up the Eginenthal I observed occasionally loose blocks "of a dark slaty or schistose rock, with rounded spots and irregular long darkish crystals, which I took for a kind of 'knoten schiefer' and got a specimen."[4] Later on I write—"At the head of this [upland basin] there is evidently a great piece of well-bedded rock, not highly metamorphosed, apparently folded in the more crystalline rock. To this apparently the 'knoten schiefer' belongs, for it was all about here, some of it being rather more schistose than what I had seen below." Again, on reaching the top of the pass, I record the presence of dark mica schist with garnets, "looking more highly altered than that below." From the Tosa Falls I crossed to the Binnenthal and studied the crystalline schists in that district.[5] Thus I was aware that in the Lepontine Alps two rocks existed in which some superficial resemblances were associated with real and important differences. In other words, I knew that Nature had been laying traps, so that exceptional caution was needed.

I think, then, I may claim that my 'bias' was the result of knowing certain facts in petrology and Alpine geology better apparently than Professor Heim, and thus was more than justifiable. May I ask, in conclusion, that if he thinks he can refute any of the statements in this paper he will abstain from fighting under the shelter of an official publication. There I cannot reply to him; so the combat is one *Ubi tu pulsas, ego vapulo tantum.*

[1] Quart. Journ. Geol. Soc., vol. xliv (1888), p. 11.

[2] See Miss C. A. Raisin: Quart. Journ. Geol. Soc., vol. lvii (1901), p. 55. A museum specimen labelled Pyreneite (from that mountain range) appears to be another instance.

[3] See Quart. Journ. Geol. Soc., vol. xlv (1889), pp. 96–99.

[4] This is a transcript of my field notes, in which I do not pick my phrases. I probably should not now use the words 'knoten schiefer.' What I meant to express was that it seemed in about the same state of alteration as a chiastolite slate.

[5] A fortnight later I paid my first visit to the Val Piora.

V.—Oscillations in the Sea-level. (Part I.)

By H. W. Pearson.

(PLATE IX.)

When man first began the study of the earth's surface, he encountered at the very beginning, along the borders of the sea-coasts, on the lowland plains, and even on the hills, certain puzzling phenomena, difficult of explanation. These perplexing observations seemed to testify, by means of ancient raised beaches, fossil oyster and mussel shells, dessicated salt marshes, fragments of wrecks, and even by ancient anchors in the hills, that at some unknown time in the past the sea had "formerly been where the land now was."

Straton of Lampsacus and Eratosthenes (between 200 and 300 B.C.) explained these facts by supposing that the Mediterranean and the Euxine had once been dammed by barriers at the Pillars of Hercules and at Byzantium, and that by the breaking down of these barriers "much that was formerly covered by water had been left dry."

Strabo (54 B.C. to 24 A.D.), holding Straton and Eratosthenes to be in error, insisted that explanations of these facts must be found either in inundations caused by upheavals of the sea bottom, or in actual subsidence of these lands beneath the level of the waters and their subsequent upheaval, his preference being given to the first-named cause, as he deemed that the humidity of the bottom would render it more liable to shifting.

Here was raised, in the early morning of scientific investigation, the greatest problem of geology, or of geography, and such little progress has been made in the settlement of this question during the two thousand years that have since passed over our heads, that to-day if it is asked, are these evidences of former submergence and upheaval due to changes in the sea-level itself, or are they due to movements in the crust of the earth, no man can make certain reply.

That this uncertainty has real existence can be seen from the examples of opposing opinions herein quoted.

Celsius in 1730, in explanation of the apparent upheaval of the Baltic shores, affirmed a variable sea-level. Playfair in 1802 and Von Buch in 1807, adopting the second hypothesis of Strabo, affirmed movement in the earth's crust.

Sir J. A. Picton contended that the level of the sea had not changed, that it is the land alone which has altered its level (Proc. Liverpool Geol. Soc., vol. vi, p. 38). Sir Charles Lyell insisted "that the level of the ocean was invariable," and that the "Continents are inconstant in their level, as has been demonstrated by the most unequivocal proofs again and again, from the time of Strabo to our own time" ("Principles," 9th ed., Appleton, p. 518). Le Conte says, "we may look upon the sea-level as fixed" ("Elements," p. 138).

In opposition to these statements of Picton, Lyell, and Le Conte, James Geikie says, "the more recent raised beaches may be likely enough due to oscillations of the sea-level itself, and not necessarily to movements of the land" ("Pre-historic Europe," p. 525).

N. S. Shaler also says, that some of the apparent upheavals and depressions of the land may be due to absolute changes in the sea-level ("Geological Record," 1875, p. 178); and these men are supported in their rejection of the old theory of Strabo, which had been adopted by Playfair, Von Buch, and Lyell, by Edouard Suess, Dr. Schmick, and Trautschold, the latter claiming that "many of the phenomena of sedimentation and deposition attributed by geologists to a subsidence of the crust are, in fact, due to periodic *oscillations* or *upheavals* of the oceanic surface" (*Science*, vol. iii, p. 342).

These citations demonstrate that the matter of the permanency of the sea-level is to-day one of the unsettled questions of geology, and I believe it to be more fundamental in its nature than any other unsolved geological problem. It should be of interest, then, to learn why these conflicting opinions between our great geologists have existence. Why have the teachings of Playfair, Von Buch, and Lyell, adopted for three-fourths of a century, been in the last quarter of a century questioned from every direction?

Investigation allows us to answer this question. The old beliefs, in the absence of knowledge, were based on inference. The latest beliefs, rejecting inference, are based on observation, on an enormous accumulation of facts, that were entirely unknown to Playfair and the other disciples of Strabo, and these facts it is impossible to explain through the older theory.

For instance, Playfair's argument, on which the theory of an invariable sea-level rests, is as follows:—"In order to depress or elevate the absolute level of the sea by a given quantity, in any one place, we must depress or elevate it by the same quantity over the *whole surface of the earth* [my italics], whereas no such necessity exists with respect to the local elevation or depression of the land" ("Principles," 9th ed., p. 523).

Now the very foundation of this argument, a position unimpeachable in the time of Playfair and of Von Buch, is to-day absolutely untenable. The hypothesis of Adhemar, the knowledge that great masses of ice at one time existed in the Northern Hemisphere, and that submergence of the Northern, coexistent with emergence of the Southern Hemisphere, must have been the necessary consequence, as demonstrated mathematically by Dr. Croll, by Lord Kelvin, by Archdeacon Pratt, by Fisher, Heath, Woodward, and many others,—these arguments, I say, teach us that the contention of Playfair, Von Buch, and Lyell, valid perhaps in its day, is no longer to be accepted, and if the theory of a variable sea-level is to be rejected, reasons more solidly grounded must be accorded us.

It seems now impossible to reject the idea that upheaval of the sea surface in the north, and subsidence in the south, may be going on at one and the same time, and in addition to this the writer has shown how a local *upheaval* of the oceanic surface in one hemisphere may, nay must, be coexistent with a local *depression* of this surface at some point in the same hemisphere, provided the slightest variation of flow in the oceanic currents shall take place. (See *The American Geologist,* Sept. 1899, p. 192.)

To this point my discussion has been general, my object being merely to show the present uncertainties as to our knowledge relating to changes in the sea-level, and to call attention to the fallacies on which the arguments of Playfair and Von Buch were founded. I would now introduce a branch of the same subject not alluded to in the previous argument. It is this :—

It is admitted by all, that most of the lowlands of the Northern Hemisphere have at some time in the past been submerged to less or greater depth beneath the sea. The evidences of *great* submergences, such as those discussed by Chambers in his "Ancient Sea Margins," or by Prestwich in his "Traditions of the Flood," or as shown by McGee in his "The Lafayette Formation," will not now be considered. To these submergences we are as yet unable to assign a date. I would study, then, those minor relative changes in sea and land, both of depression and elevation, that have occurred since historic times, changes upon which a date and the approximate amount of movement can be fixed, with the object of determining whether these upheavals and submergences show any evidence of being *periodic* in their nature. We may attribute these changes either to movement in the earth or to movement in the sea, it is immaterial which; the only question is, have these oscillations shown regular cycles in their occurrence.

If some period could be discovered which governed these minor changes, it would seem that the law controlling this period might be found, and the establishment of law, if such existed, and the consequent elimination of chance, might enable us to determine with more certainty than at present whether the actual responsibility for these recent changes should be placed upon an unstable earth or upon a shifting sea.

This question of recent periodic oscillations in the sea-level was forced upon me by certain facts, impossible to explain otherwise, derived from many years' study of the raised beaches of the world; these facts, owing to the nature of this paper, I cannot now set forth, but they assured me in the strongest manner *that a regular cycle had existed at the time these raised beaches were formed*, and that its present existence was almost a certainty. I therefore commenced search for this periodical vibration of the oceanic surface in the records of history and tradition, in the ancient cities of the old world, in the registered changes in the coastlines of all countries, including the American coasts since the time of Columbus.

The data thus collected are almost unanimous in their testimony; they point unerringly to a vibration period in the sea-level of about 640 years, an interval of about 320 years existing between periods of high and of low water.

The data inform us as well that at periods of high-water the submergence increased in amount going north; they tell us that at previous periods of low-water the sea stood *lower than* at present; and finally, they assure us that, following the law of change which has guided these vibrations in the past, we must expect higher water in the north in the immediate future. This raised sea-level in the north should culminate within 200 years, while the advance should be visible within a few decades.

The points in the curve illustrating the variation in level of the surface of the sea were sought for and found under a system of reasoning adopted after consideration of the results obtained from the investigation of the raised beaches before mentioned. This investigation furnished me certain testimony strongly opposed to all my prepossessions, yet, if I had interpreted the records correctly, I felt compelled to adopt as logical conclusions the following theories:—

1. Since the carving of these ancient terraces there had been no movement of the earth's crust, but these terraces lay in position exactly as originally traced.

2. The date of these beaches is unknown, but they certainly antedate the historical period. I must therefore conclude that since the dawn of history no upheaval or subsidence of the earth's crust can have occurred, and explanation of the observed recent submergence and emergence of lands must be sought for in vertical movements of the sea itself, rather than in upheavals or depressions of the crust.

3. I had reason to strongly suspect, in fact I regarded it as almost certain, that at the time of deposition of these terraces alternate rising and falling of the sea-level had occurred, that the traces of this movement were plainly discernible, that I had good cause to suspect the present existence of these same cycles of alternate ascent and descent in the sea-level, and that if these oscillations existed they should be uniform in direction of movement over one hemisphere.

Impressed, then, with the logic of the facts which had led up to these conclusions, facts which are set forth in other papers, I started on a new research, seeking for evidence of these suspected cycles, of the approximate dates of their maxima and minima, and of the amount in feet of their vertical vibration.

The apparent absurdity of entering upon such a labour as this is manifest. On all sides we see evidences of alleged upheavals or depressions of land: we know, for instance, that Scandinavia, Scotland, all of Northern Asia, Alaska, and Texas are now rising out of the sea; we are told that the coasts of New Jersey, Long Island, Cape Breton, and Greenland are now sinking beneath the sea. Here were undeniable facts directly opposed to each other and to my assumption that these movements must be universal in kind over either hemisphere.

These conflicting facts, which seemed to deny and refute these other facts mentioned, as obtained from the raised beaches, and to the accumulation of which I have devoted so many years' labour, seemed to assure me of failure from the first; but notwithstanding the discouraging outlook, search was undertaken for evidence of these periodic vibrations in the oceanic surface, no hope being entertained at that time, however, of finding explanation of those discordant motions, existing in the same hemisphere, to which attention has been called. My only hope was that these fluctuations might be found periodic in their nature.

At the beginning I had been led to suspect some physical connection between the periodic swing in the magnetic needle and these oscillations in the level of the sea; therefore, as the half-period in the motion of the agonic line is about 320 years, I commenced search for evidence of a period of universally higher water in the north, culminating about 320 years distant in the past, or about the year 1570.

As my investigations progressed I soon met an obstacle. I found that the study of the Temple of Jupiter Serapis by Babbage, Forbes, Lyell, and others, demonstrated that the high-water was receding in Italy in the years 1503 to 1511 (see "Physical Geography," by A. J. Jukes-Browne, p. 46), and consequently my culminating point of 1570 must be moved backward to some period probably anterior to 1500, and my assumption that the present low-water period was now at its central position also needed adjustment: we must have passed the low-water minimum.

I next sought proofs that the emergence of the Temple of Serapis was *coexistent* with a corresponding emergence of every part of the Mediterranean shore-line, and these proofs are in incontestable existence; many of them I submit herewith, hundreds of them for lack of space I withhold. George Maw discovered "evidence of upheaval, in a uniform rise of about 25 feet in distant parts of the Mediterranean, of an old coastline, *exactly corresponding* with the amount of emergence of the shell-bored columns of the Temple of Serapis," and this testimony of Maw (see Rep. Brit. Assoc. for Advancement of Science, 1870, p. 80) I have verified by a hundred items of evidence perhaps unknown to him.

Satisfied at length that the elevated sea-level was certainly uniform over the Mediterranean, I extended my investigations to the shores of England, France, Holland, and the Baltic, to the Americas, and to the shores of the Pacific, seeking as before for evidences of a raised sea-level, central about the year 1500.

England supplies a wealth of evidence. I found that Queen Elizabeth in 1562 was granting many descriptions of land in the bed of a creek or waterway 'swawed' or dried up, "by reason of the receding waters" ("History of Romney Marsh," Holloway, p. 141), at the same time, nearly, that Ferdinand and Isabella, for the same reason, were conveying land in Italy, that had likewise "dried up" (Brown, "Physical Geog.," p. 46).

Having thus collected much evidence that the sea-level was falling in the period subsequent to 1500, I next sought data as to its rise at some earlier date. Much evidence as to this movement was found. For instance, in 1427 we find Henry VI perplexed and disturbed "by the excessive rising of waters in divers parts of the realm," and urging that remedy should be "hastily provided" ("History of Romney Marsh," p. 130).

Testimony such as this, as to the epoch of Henry VI, combined with a great mass of similar evidence, like the progressive submergence during the same period of the Fens of England and the lowlands of Holland, led me to believe that the waters in 1427 were rising, and as I knew they were falling in England, Italy, and France about 1500, my conclusion was that somewhere between these dates, say from 1450 to 1475, I must expect to find the culminating period of that particular epoch of northern submergence.

From this preliminary examination I was led to believe that a high-water period must certainly have existed over the greater portion of the European shores, culminating not far from the year 1450. I therefore entered upon a more extended search for data, not only as to this particular epoch of an elevated sea, but for those other and more ancient changes which I had been led to suspect as stated.

For many years I pursued this search, carefully collecting and indexing every notice as to change of sea-level encountered in my readings, regardless of date or direction of movement. The data thus accumulated seem to me conclusive; periodic vibrations in the ocean level are certain beyond question. The present cycle appears to have a period of about 640 years, while the evidence points to a period of about 500 years only at about the time of the Christian era.

A portion of the data which have been used in establishing this curve (see Diagram, next page) is submitted herewith. Hundreds, however, of the facts used as ordinates are omitted, that this paper may not be swollen to unreadable size.

When this material had been mapped out, it was found that 300 points or more were aggregated in a compact body, central about the year 1475, and that each of these points bore testimony to a period of high-water at some part of the earth's surface north of the Equator; another aggregation of points, less numerous and each one indicating a low-water period, was found bunched between the years 1100 and 1200, central about 1150 to 1175. I thus laid out all these accumulated facts each in its proper place and position, and at the end found a dense haze of dots central about the years 825 and 325 A.D. and 250 B.C., these clouds representing high-water periods, and similar swarms of dots, each representing proofs of low-water, central about the years 600 and 100 A.D., with occasional and *conflicting* points, scattered indiscriminately along the line.

At this point, then, to complete my curve it was but necessary to draw a sinuous line through these preponderating masses of dots; this curve was drawn, and the result is shown in the accompanying Diagram.

I now examined as to what weight these conflicting points might have towards weakening my confidence in the general accuracy of the curve. Much labour has been given to this subject; many of these dots were removed by investigation, others I attribute with good reason to erosion of shore-lines or to accretion to shore-lines, as is now going on all over the world, and finally I decided that not one of these conflicting points could be depended upon as making serious objections to the correctness of our curve. The information was too uncertain in its nature; it lacked that element of the positive, the known, which pervaded the great mass of evidence on which the curve had been based.

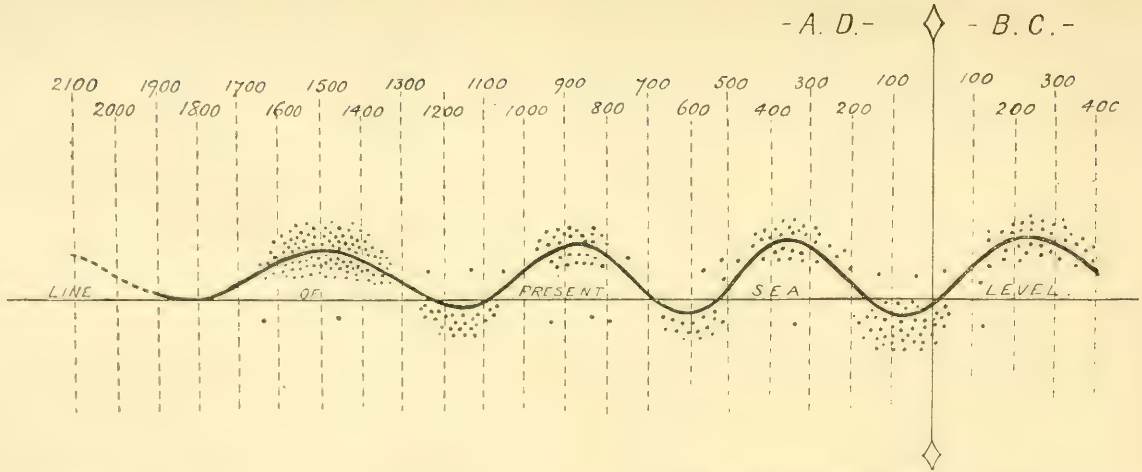


DIAGRAM to illustrate the periodic oscillations of sea-level in the Northern Hemisphere between B.C. 400 and A.D. 1900, deduced from a long series of historical records and observations by H. W. Pearson, Duluth, Minnesota, U.S.A.

For instance, Heligoland in the year 800 is shown in Myers' map to be of *great size*; this is in conflict with our curve, as the year 800 being near the high-water period, the island should have been *small* in size. On investigation we find that we have testimony equally strong that the island *was* small at that time. The description of the island by Adam of Bremen shows that it was *not much* larger than now in the time of Charlemagne (768 to 814), ("Principles," 9th ed., p. 329). (For this map of Heligoland in 800, see Von Hoff's "Geschichte," etc., vol. i, p. 56.)

Another item tending to invalidate our curve is the legend as to the submergence of lands now beneath the sea in Cardigan Bay, Wales. Pennant states that these lands—the Cantre'r Gwaelod—were overwhelmed by the sea about the year 500 (Pennant's "Tours in Wales," vol. ii, p. 274). In "The Gossiping Guide to Wales," however, we read, "We are not aware that any date is assigned" to this disaster (p. 37). It seems that what little is known of this inundation is derived from a poem by one Prince Gwyddno, who flourished between the years 460 and 520. There is no evidence that Gwyddno witnessed the event he describes, and it can be readily surmised that he merely reduced to verse the current traditions of an event that may have occurred three or four generations before his time. If this was the case, the Sarn Badrig and its attached legends would be evidence confirmatory of our curve. In any case we are assured that the date fixed by Pennant is uncertain and offers no reliable testimony against us.

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

NOTICES OF MEMOIRS.

On the Structure and Affinities of Fossil Plants from the Palæozoic Rocks. IV. The Seed-like Fructification of *Lepidocarpon*, a Genus of Lycopodiaceous Cones from the Carboniferous Formation. By D. H. Scott, M.A., Ph.D., F.R.S., Hon. Keeper of the Jodrell Laboratory, Royal Gardens, Kew.

A SHORT account of the new genus *Lepidocarpon* has been given in a note communicated to the Royal Society last August;[1] the present paper contains a full, illustrated description of the fossils in question, together with a discussion of their morphology and affinities.

The strobilus of *Lepidocarpon Lomaxi*, the Coal-measure species, is, in its earlier condition, in all respects that of a *Lepidostrobus*, of the type of *L. Oldhamius*.

In each megasporangium, however, a single megaspore or embryo-sac alone came to perfection, filling almost the whole sporangial cavity, but accompanied by the remains of its abortive sister-cells. An integument ultimately grew up from the sporophyll, completely enclosing the megasporangium, and leaving only a narrow slit-like

[1] "Note on the Occurrence of a Seed-like Fructification in certain Palæozoic Lycopods": Roy. Soc. Proc., vol. lxvii, p. 306.

opening, or micropyle, along the top. As shown in specially favourable specimens, both of *Lepidocarpon Lomaxi* and of *L. Wildianum*, the more ancient Burntisland form, the functional megaspore became filled by a large-celled prothallus, resembling that of the recent *Isoëtes* or *Selaginella*. The whole body, consisting of the sporophyll, bearing the integumented megasporangium and its contents, became detached from the strobilus, and in this isolated condition is identical with the 'seed' described by Williamson under the name of *Cardiocarpon anomalum*, which, however, proves to be totally distinct from the Cordaitean seed so named by Carruthers.

The seed-like organs of *Lepidocarpon* are regarded by the author as presenting close analogies with true seeds, but as differing too widely from the seeds of any known Spermophyta to afford any proof of affinity. The case appears rather to be one of parallel or convergent development, and not to indicate any genetic connection between the Lycopods and the Gymnosperms, or other Phanerogams.

REVIEWS.

E. Weinschenck. Zur Kenntniss der Graphitlagerstätten. III. Die Graphitlagerstätten der Insel Ceylon. Abh. k. bay. akad. Wiss., Cl. ii, Bd. xxi, Abth. 11; München, 1900.

PROFESSOR Weinschenck has examined a series of rock and vein specimens from the graphite mines of Ragedara, Ampe, Pushena, and Humbuluwa, in Ceylon, collected by Dr. Grünling. He discusses the nature of the granulitic rocks and the mode of occurrence and origin of the graphite.

A general petrographical description of the granulitic rocks is given, illustrated by three plates of microphotographs. Massive habit, granulitic structure, and variable chemical composition are characteristic. Except in the more basic varieties, intergrowths of two felspars are very noticeable. The granulitic rocks include a continuous series ranging from aplites (weiss-steine) to pyroxene-plagioclase rocks (trapp-granuliten) and even pyroxenites. A rather oily lustre and greenish colour are very characteristic features. The constituent minerals are in a remarkably fresh condition, except in the immediate neighbourhood of the graphite veins. It is interesting to note that Professor Weinschenck does not mention any pleochroic monoclinic pyroxene.

There are certain other rocks in Ceylon which include coarse-grained dolomites and 'cipolins,' containing blue apatite and contact minerals such as forsterite, chondrodite, phlogopite, and spinel, and also the peculiar andalusite, sillimanite, and corundum bearing rocks described by Lacroix.

The granulitic rocks show no trace of the operation of dynamic causes; they are regarded as an eruptive mass which may form a single unit or be compound in character. The occurrence of coarse crystalline dolomites in the midst of the granulitic series seems to show that different eruptive units are separated by contact rocks. The existence of still younger eruptive masses of granite has not yet been demonstrated, for the few rocks as yet described from Ceylon as granite are rather varieties of the granulitic series.

Professor Weinschenck compares the Saxon and Ceylon granulites, thinking with Naumann that the former are truly eruptive rocks. Had the Ceylon rocks been studied before those of Saxony this view would have been more widely held. They differ from the Saxon rocks chiefly in their non-schistose character and coarser grain. Lehmann regarded the peculiarities of the Saxon granulites as the result of dynamo-metamorphism. He regarded the microperthitic intergrowths of two felspars as the result of such a process, but as these are characteristic of quite unaltered rocks in Ceylon they may also be original in the Saxon rocks. The absence of sericite in the latter presents a difficulty to those who favour the dynamo-metamorphic view. Lehmann supposed that its place was taken by biotite, but this mineral is not infrequently an original constituent in Ceylon rocks. Garnets are characteristic of typical granulites, and their presence is the result of chemical peculiarities in the magma or peculiar physical conditions obtaining at the time of its consolidation. The chemical composition of Ceylon and Saxon granulites resembles those of truly igneous rocks. Perhaps in Saxony we are dealing only with the outer margin of an eruptive mass intruded into surrounding schistose rocks, while in Ceylon the heart of the eruptive mass is exposed. In both cases there has been extensive magmatic differentiation, and this may be considered characteristic of granulites in general.

It is only in immediate contact with the graphite veins that the granulite matrix is chemically altered and finally impregnated with graphite. Fragments of rocks included in the veins are also specially affected. In the altered rocks the felspars are largely changed to nontronite, a feature associated with the occurrence of graphite in the Passau district also. The pyroxenes change to a fine scaly material with aggregate polarization. Mica and garnet alter less readily. Impregnation with rutile and titanite is characteristic, as in the Bavario-Bohemian area. Beside the rock fragments, pieces of various minerals occur in the veins—quartz, pyrite, orthoclase, microperthite, apatite, biotite, augite—the formation of these being previous to that of the graphite, while calcite, and sometimes biotite, seem to have been deposited contemporaneously.

In the Passau district (Bavaria) the formation of nontronite and impregnation with graphite affect the whole schistose complex, while in Ceylon the graphite occurs in veins. This difference depends chiefly on the harder and more massive character of the Ceylon rocks. In Ceylon, Siberia, and Cumberland the graphite occurs in veins; in Passau and Taconderoga (U.S.A.) in veins and beds; in Bohemia in beds: these differences depend on the varied character of the matrix and not on different modes of origin of the graphite. Emanations of carbon monoxide, with or without cyanogen-bearing compounds, may have given rise to the graphite veins; while the introduction of iron oxide and manganese peroxide in their neighbourhood may argue that metal carbonyls were also present.

Finally, Professor Weinschenck would suppose the following to have been the sequence of events in Ceylon:—A fluid magma intruded into beds of unknown age consolidated as a peculiar 'schlierig' rock, while contact-metamorphic structures were developed in surrounding beds. Contraction-joints developed on cooling, allowed the formation of pegmatites, including pure quartz veins to some extent. But, contemporaneously with the formation of the pegmatite, there were emanations of carbon monoxide and cyanogen-bearing compounds, which followed the same paths as the pegmatites and then gave rise to the graphite veins. The system of veins traversing the whole massif played in later mountain movements the rôle of buffer, the soft yielding mineral absorbing the mechanical effects, and thus the Ceylon granulites remained unaltered by dynamic changes.

I have attempted in this review merely to give an abstract of Professor Weinschenck's views as expressed in his important paper.

A. K. Coomara-Swamy.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—February 15th, 1901.—J. J. H. Teall, Esq., M.A., V.P.R.S., President, in the Chair.

Annual General Meeting.

The reports of the Council and of the Library and Museum Committee for the year 1900, proofs of which had been previously distributed to the Fellows, were read. The Council stated that, although there was a decrease in the number of Fellows, the financial prosperity of the Society continued undiminished.

The report of the Library and Museum Committee enumerated the increasingly extensive additions made to the Society's Library.

The reports having been adopted, the President handed the Wollaston Medal, awarded to Professor Charles Barrois, F.M.G.S., of Lille, to Sir Archibald Geikie, for transmission to the recipient, addressing him as follows:—Sir Archibald Geikie,—

In these days of specialization few men are endowed with those faculties which enable them to contribute with marked ability to all branches of our many-sided science; but among those few Professor Barrois must unquestionably be ranked.

In the monograph on the Calcaire d'Erbray and many other papers he has established his reputation as a palæontologist; in numerous memoirs on the Granitic and Metamorphic Rocks of Brittany he figures as an accomplished petrologist; while in the many geological maps of the same district he has constructed a lasting monument to his skill and energy as a geological surveyor.

His published work represents a vast accumulation of facts carefully observed, clearly described, and lucidly arranged. More than this, it is often full of suggestiveness. He has had the satisfaction of initiating lines of research which have been followed up with great success by others.

It was he who first taught us how to zone our English Chalk by the aid of the fossils which it contains, and the friendships which he formed during the progress-of that work have been strengthened by the lapse of time. He might repeat with truth the words of another visitor to these Islands from the other side of the Channel: *veni, vidi, vici.*

In his recent publications on Brittany he has correlated the breadth and character of the metamorphic zones surrounding the granitic masses with the thickness of the cover under which the intrusions took place, and has suggested ideas that may prove of great importance in connection with such questions as the origin of the crystalline schists and igneous magmas.

But he has aided the progress of geology in other ways than as an original worker. The illustrious pupil of an illustrious master, he has contributed to maintain the great reputation of Lille as a centre of geological teaching; while his extensive knowledge and exceptional organizing ability have ever been at the disposal of the International Geological Congress and kindred associations.

Many years have elapsed since I had the privilege of making his acquaintance, and it is therefore with the greatest pleasure that I now ask you to transmit to him the Wollaston Medal, which has been awarded to him by the Council as a mark of their appreciation of the great services that he has rendered to all branches of Geological Science.

Sir Archibald Geikie replied in the following words:—Mr. President,—

It has been to my friend Professor Barrois a matter of very keen regret that he is prevented from being here to-day, to renew his personal relations with the Fellows of the Geological Society, and to receive from them the highest distinction which it is in their power to bestow. We must all deeply sympathize with him in the causes that deprive us of his presence. Bowed down by one of the greatest afflictions that can befall a father—the death of a son in the full bloom and promise of early manhood—he has manfully struggled with his numerous duties, until at last his health has given way under the strain. Let us hope that he may soon be restored to his former vigour, and be able to resume the researches in Brittany and the detailed description of them on which he has so long been engaged. He has asked me to receive this Medal for him, and I count it a great privilege and honour to be the intermediary between the Geological Society of London and one of the most distinguished and widely esteemed geologists of Europe. Professor Barrois has sent a letter of thanks, which I will now read:—

"Mr. President,—

"Allow me to express my gratitude for the new honour which the Geological Society has bestowed upon me, by the award of the Wollaston Medal, as I cannot but recall that the Council has on a former occasion encouraged me in my scientific work by the award of the Bigsby Medal.

"I have since made long wanderings along the Channel cliffs on both sides, from chalk to granite, for the sake of science, in the steps of De la Beche, Fitton, Godwin-Austen, and the founders of stratigraphical geology; and it is for me a very unexpected event to see my name written to day, for ever, with theirs, in the Proceedings of the Society.

"No distinction can be more gratifying to a geologist than to receive its highest award from the Council of the illustrious Society which for nearly a century has extended our knowledge in every branch of geology, and promoted progress in every part of the earth. I so greatly appreciate this great honour, that I feel as if the work that I have been able to accomplish was too small to merit the Wollaston Medal, granted as a reward, but rather as a friendly incitation to go on in my labour—'upward and onward.'"

Charles Barrois.

"Lille, February 9th, 1901."

The President then presented the Balance of the Proceeds of the Wollaston Donation Fund to Mr. Arthur Walton Rowe, M.B., M.S., of Margate, addressing him as follows:—Dr. Rowe,—

It will, I am sure, be a source of gratification to you to be associated with Professor Barrois on the present occasion, for you have done much to confirm and extend the principles which he first applied to the elucidation of the structure of the

English Chalk. We recognize, however, that, although your work has been of very great stratigraphical importance, your main object is biological, and that the task you have set yourself is that of working out the evolution of organic forms during the Upper Cretaceous period.

In your paper on *Micraster* you have set an example which I trust will be followed. You have shown how it is possible to deal with a vast mass of material, so as to bring out the main facts of evolution, without burdening science with hosts of new names and long lists of synonyms.

By the application of the dental engine to the preparation, and of micro-photography to the illustration, of fossils, you have also rendered signal service to science.

The Council of the Geological Society, in making this award, have been desirous of expressing their gratitude to you for the work that you have already accomplished, and their lively sense of favours to come.

In handing the Murchison Medal, awarded to Mr. Alfred John Jukes-Browne, B.A., of H.M. Geological Survey, to Mr. W. Whitaker, for transmission to the recipient, the President addressed him as follows :—Mr. Whitaker,—

Mr. Jukes-Browne, whose absence we all deeply regret, has aided the progress of geology in many ways. His numerous writings on the Upper Cretaceous Rocks are too well known to make it necessary for me to refer to them in detail. He has, from the first, recognized the enormous importance of associating palæontological with stratigraphical work, and by original research, as well as by a critical study of the writings of others, has made himself master of the geology of that period to which he has especially devoted himself.

But he possesses also a good all-round knowledge of geology. His Handbooks on Physical and Historical Geology have been of great service to students, and his suggestive work on the Building of the British Isles has been the means of directing attention to many problems of considerable theoretical interest.

There is yet another way in which he has rendered great service to geology, and that is as a stimulator of work in others. I am sure that no one will be more ready to acknowledge this than Mr. William Hill, with whom Mr. Jukes-Browne has been so long associated.

In recognition of these many services to our science, the Council have awarded to him the Murchison Medal, which I, an old College friend and fellow-student, now ask you to transmit to him with our heartiest good wishes.

Mr. Whitaker, having expressed his gratification at the privilege of receiving the Medal on behalf of an old colleague and valued friend, read the following extracts from a letter which he had received from Mr. Jukes-Browne :—

"I beg you to convey to the Council of the Geological Society my deep appreciation of the honour conferred upon me by the award of the Murchison Medal, and my great regret that the state of my health makes it impossible for me to be present in person to express my acknowledgments.

"That such work as I have been able to accomplish should be thought worthy of this high reward is not only a present gratification, but will be an incentive to show myself more worthy of such recognition. I feel also that I have been specially fortunate in my friends, and that without the assistance of two of them in particular —Mr. W. Hill and Professor J. B. Harrison—many of the investigations in which I have been concerned would have been incomplete.

"I should like further to say that the pleasure of receiving the Murchison Medal on the present occasion is much enhanced by the knowledge that the Wollaston Medal is at the same time awarded to my old friend Professor Barrois, whose zonal work among the Cretaceous rocks of England and France has added so much to our knowledge of those rocks."

The President then handed the Balance of the Proceeds of the Murchison Geological Fund, awarded to Mr. Thomas Sargeant Hall, M.A., of Melbourne, to Professor J. W. Judd, for transmission to the recipient, addressing him as follows :—Professor Judd,—

In awarding the Balance of the Proceeds of the Murchison Fund to Mr. Hall, the Council is desirous of recognizing the value of his many contributions to Australian Geology, and especially of his detailed researches on the Zonal Distribution of the Graptolites of Victoria. His work has thrown much light on the Lower Palæozoic history of Australia; while his discovery of the coincidence of the Ordovician auriferous belts with certain graptolitic zones is an illustration of the bearing of palæontological research on economic questions.

His application of the zonal method of research to the Kainozoic deposits of Victoria has done much to elucidate the later geological history of the colony, and his bibliographic labours have, I am told, greatly facilitated the work of his scientific colleagues in Victoria. We hope that this award will be of some assistance to him in further researches.

In presenting the Lyell Medal to Dr. Ramsay Heatley Traquair, F.R.S., of Edinburgh, the President addressed him in the following words:—Dr. Traquair,—

The Council of the Geological Society, in presenting you with the Lyell Medal, desires to express its sense of the great value of your many contributions to Palæontology. More than thirty years have elapsed since the publication of your first papers on Fossil Fishes, and during the whole of that period you have been giving evidence of your keen insight into the structure of these interesting forms of life. I can only refer to one or two of your more important works.

Your memoirs on the structure of the Palæoniscidæ and Platysomidæ are, I believe, masterpieces of descriptive palæontology, and must for ever remain most valuable works of reference. Of great importance, from a geological point of view, have been your researches bearing on the fish fauna of the Old Red Sandstone of Scotland. You have not only shown the complete divergence between the fauna of the Orcadian Series and that of the Lower Old Red Sandstone south of the Grampians, but you have also pointed out that in certain areas the fishes in different divisions of that formation are arranged in life-zones—a fact which has been of service to the field-geologist.

Your last, and perhaps your greatest, work is your monograph on the remarkable Fossil Fishes from the Silurian rocks of the South of Scotland. Your keen insight and wide knowledge of fossil ichthyology enabled you to show, among other points, that the group of the Heterostraci, which hitherto contained only the Pteraspidæ, must be considerably enlarged, and that a transition could be seen from the shagreen-covered Cœlolepidæ to the plate-covered Pteraspidæ. You have also arrived at the conclusion that the Heterostraci, though not actual Selachians, had in all probability a common origin with the primitive Elasmobranchs. These results must be of the highest interest to biologists.

I have great pleasure in handing to you the Medal, together with our best wishes that you may long be spared to carry on your most valuable researches.

Dr. Traquair replied as follows:—Mr. President,—

Permit me to thank the Council of the Geological Society for the honour which they have this day conferred upon me, and you, sir, for the kind words which you have spoken regarding my work.

I am much gratified to hear that some of that work has been of use to the stratigraphical geologist, as it is indeed impossible for the palæontologist who has himself collected in the field to avoid taking an interest in his subject from the geological standpoint also.

The impulse, however, which led me to take up Fossil Fishes as a speciality was entirely biological. While still a boy at school I broke open an ironstone nodule containing a piece of a Palæoniscid fish, and was thereupon seized by an intense curiosity to know how the bones of its head were arranged. As I did not find the information that I desired in the books, I resolved some day to try and work out the problem myself. Need I remark that, when in due time I got fairly to work on the subject, I found that fossil ichthyology presented a field sufficient to supply not only myself, but many others, with original work for our lifetimes?

If the work that I have accomplished in this field falls far short of the realization of early dreams, it is still gratifying for me to find that I have been able to do enough to merit this expression of the Society's approbation.

In presenting one half of the Balance of the Proceeds of the Lyell Geological Fund to John William Evans, D.Sc., LL.B., the President addressed him as follows:—Dr. Evans,—

Half the Balance of the Proceeds of the Lyell Fund has been awarded to you, in recognition of the importance of your geological work during the last ten years. Your visit to an almost unknown part of Brazil, and several years' residence in India, have enabled you to make observations and to collect specimens of great value to our science. The papers which you have already published in our Journal on the Matto Grosso district, and on the Calcareous Sandstones and Monchiquites of North-Western India, are evidence of your capacity for original work.

We trust that this award may aid you in publishing the results of investigations that you are known to have carried out while engaged in the Survey of the State of Junagarh (Kathiawar), and will encourage you in further work.

In handing the other half of the Balance of the Proceeds of the Lyell Geological Fund, awarded to Mr. Alexander McHenry, of the Geological Survey of Ireland, to Sir Archibald Geikie, for transmission to the recipient, the President addressed him as follows:—Sir Archibald Geikie,—

Mr. McHenry's claims to recognition are well known to you, and the fact that you receive the award of a moiety of the Balance of the Proceeds of the Lyell Geological Fund on his behalf is a proof that you cordially endorse the action of the Council. For forty years he has laboured to advance our knowledge of Irish Geology as a member of the Geological Survey, first as a collector of fossils and rock-specimens and afterwards as a member of the Surveying Staff. Most of his work has been published in the Maps and Memoirs of the Geological Survey, to which he has devoted himself, as you yourself have said, with admirable loyalty and enthusiasm. One of his most useful labours has been the preparation, in conjunction with his former colleague, Professor Watts, of a Guide to the Collection of Rocks and Fossils belonging to the Geological Survey of Ireland. His extensive and accurate knowledge largely contributed to make this work a most valuable compendium of Irish Geology. We hope that this award will act as an encouragement to him and be of some assistance in further work.

Sir Archibald Geikie, in reply, said:—Mr. President,—

On the part of my old colleague, I have to express to the Geological Society his best thanks for the recognition of his work which is expressed in this award. Next to myself he is the member of the Geological Survey who has been longest on the staff. His whole life has been devoted to his official duties, and he has only now and then ventured to make his appearance in non-official print. His labours are thus chronicled in the Maps, Sections, and Memoirs of the Geological Survey of Ireland, and are probably familiar to comparatively few geologists. He has been content honestly and strenuously to do his duty with a loyalty that has never flinched, and with an enthusiasm that seems to wax higher as the years go past. To such a man you may well believe that recognition from the Geological Society is as precious as it is unlooked for. It will nerve him with fresh energy for the task of revision of the Superficial Deposits of Ireland on which the Survey is about to enter; for it will show him that his work is not only known to his colleagues, but is appreciated by the leaders of Geological Science here.

In presenting the Bigsby Medal to Mr. George William Lamplugh, of H.M. Geological Survey, the President addressed him as follows:—Mr. Lamplugh,—

In 1891 the Council of the Geological Society recognized the value of your work on the Glacial Deposits of Yorkshire and on the Speeton Clay by an award from the Lyell Fund. Since that time you have still further extended our knowledge of the Lower Cretaceous rocks of Yorkshire and Lincolnshire, and have furnished Professor Pavlov with material which has enabled him to throw considerable light on the physical conditions and migrations of the Cephalopod fauna during the period represented by these rocks.

Your early work was done in the midst of an active and successful business career, which you gave up, somewhat against the advice of your friends, to join the Geological Survey and devote all your energy to the progress of science. Of late years you have been working in the Isle of Man, and the map of that island which you have produced is a striking proof of your skill as a geological surveyor. Its publication leads us to look forward with great expectations to the forthcoming memoir.

In awarding to you the Bigsby Medal, the Council feel that they are placing it in safe hands. You have done much, and they confidently expect that you will do more.

Mr. Lamplugh replied in the following words:—Mr. President,—

It is not without a proper sense of responsibility that I receive this Medal. The terms of the award leave no doubt that, while it is intended to some extent as a recognition of work already done, it is essentially intended as an incentive to further work, and implies a certain obligation in this respect, which you, sir, in your engaging words have not attempted to lighten. The recipients of this Medal in the past have always fulfilled the obligation, and it will indeed be a satisfaction to me if it be in my power to prove my fitness for the trust reposed in me by this award.

You have made reference to my altered circumstances since the time, ten years ago, when my earlier work received kindly recognition from the Council of this Society; and it may, therefore, be permitted me to confess that, in deciding to devote my whole energies to geological research, I felt some misgiving lest the studies which had proved so congenial as a recreation should take on another aspect when made the main occupation of my life. But the misgiving has proved groundless; the wider opportunity, so far from blunting my interest in these studies, has brought fresh zest, and on every side has opened up vistas of promising work for the future.

The President read his Anniversary Address, in which he first gave Obituary Notices of several Fellows and Foreign Members deceased since the last Annual Meeting, including Professor O. M. Torell (elected F.M. in 1883), Professor A. Milne-Edwards (F.M. in 1899); the Duke of Argyll (President in 1872–74); Mr. C. Tylden-Wright (elected a Fellow in 1857), Mr. G. C. Greenwell (el. in 1858), Mr. G. H. Morton (el. in 1858), General Pitt-Rivers (el. in 1867), Professor G. H. F. Ulrich (el. in 1867), Mr. J. Thomson (el. in 1868), Mr. C. J. A. Meÿer (el. in 1869), Mr. W. P. Sladen (el. in 1872), Dr. John Young (el. in 1874), and Dr. W. Waagen (el. in 1881).

He then dealt with the evolution of petrological ideas during the nineteenth century, especially as regards the igneous rocks. The discussions as to the origin of basalt and granite were referred to, and it was shown that the controversy regarding the latter rock had contributed largely to the clearing up of our ideas as to the nature of plutonic phenomena.

The solution theory propounded by Bunsen was especially emphasized, and its modern developments were briefly sketched. It was suggested that the next great advance will, in all probability, be the result of experiment, controlled by the modern theory of solutions, and carried out for the purpose of testing the consequences of that theory and discovering the modifications which may be necessary to adapt it to igneous magmas. The bearing which recent work on alloys had on petrographical problems was also referred to.

The problem of the origin of petrographical species was next considered, and the growth of ideas on the subject briefly sketched. It was pointed out that although magmatic differentiation is accepted by many as an important factor in producing different kinds of igneous rocks, it does not rest on any assured experimental basis. Differentiation dependent on, or connected with, the crystallization of definite minerals was reviewed more favourably; but it was pointed out that all theories of differentiation which are based on unaided molecular flow are subject to the criticism that the time required to effect any important differentiation appears to be too great.

Reference was also made to recent work on the modification of igneous magmas by the inclusion and assimilation of rocks through which they pass; and the conclusion was reached that the origin of species, so far as igneous rocks are concerned, is a problem the final solution of which has been handed on by the nineteenth century to its successor.

The ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—*Council*: W. T. Blanford, LL.D., F.R.S.; Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S.; Professor E. J. Garwood, M.A.; Professor T. T. Groom, M.A., D.Sc.; Alfred Harker, Esq., M.A.; R. S. Herries, Esq., M.A.; William Hill, Esq.; W. H. Hudleston, Esq., M.A., F.R.S., F.L.S.; Prof. J. W. Judd, C.B., LL.D., F.R.S.; Lieut.-Gen. C. A. McMahon, F.R.S.; J. E. Marr, Esq., M.A., F.R.S.; Professor H. A. Miers, M.A., F.R.S.; Right Rev. John Mitchinson, D.D., D.C.L.; H. W. Monckton, Esq., F.L.S.; E. T. Newton, Esq., F.R.S.; G. T. Prior, Esq., M.A.; F. W. Rudler, Esq.; Professor H. G. Seeley, F.R.S., F.L.S.; Professor W. J. Sollas, M.A., D.Sc., LL.D., F.R.S.; J. J. H. Teall, Esq., M.A., F.R.S.; Professor W. W. Watts, M.A.; W. Whitaker, Esq., B.A., F.R.S.; H. B. Woodward, Esq., F.R.S.

Officers:—*President*: J. J. H. Teall, Esq., M.A., F.R.S. *Vice-Presidents*: J. E. Marr, Esq., M.A., F.R.S.; H. W. Monckton, Esq., F.L.S.; Professor H. G. Seeley, F.R.S., F.L.S.; W. Whitaker, Esq., B.A., F.R.S. *Secretaries*: R. S. Herries, Esq., M.A.; Professor W. W. Watts, M.A. *Foreign Secretary*: Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S., F.L.S. *Treasurer*: W. T. Blanford, LL.D., F.R.S.

II.—February 20, 1901.—J. J. H. Teall, Esq., M.A., V.P.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 most profound and heartfelt sympathy in the great sorrow which has fallen on you in the death of our late beloved Sovereign Queen Victoria, and to most respectfully express the deep grief that we, in common with all your Majesty's subjects, feel at the great loss which has befallen the nation.

"While thus expressing our grief, we most humbly beg leave to offer to your Majesty our most sincere and unfeigned congratulations on your Majesty's accession to the throne of your ancestors. Our knowledge of the great interest which your Majesty has always taken in all matters relating to the welfare of your subjects makes us feel with confidence that science will continue to advance during your reign as in that of Her late Majesty of beloved memory. We recall with pride that your Majesty's father, the late Prince Consort, was for many years a Fellow of this Society.

"And we shall ever pray that your Majesty may long be spared to reign over a happy and contented people."

Professor J. B. Harrison, alluding to a series of views of parts of the interior of British Guiana, which he laid on the table, remarked that the photographs had been taken by his colleague, Mr. H. I. Perkins, F.G.S., Acting Commissioner of Mines in British Guiana, during their recent geological investigations into the structure of the goldfields of that colony. The views well illustrate the general characteristics of the densely wooded country in which the gold-bearing areas occur, and give some idea of the difficulties which affect the work of the mining prospector and of the field-geologist in that colony.

Several of the photographs illustrate rapids, cataracts, and falls which so frequently occur along the courses of some of the vast rivers of that part of South America, and show the differing forms of weathering of various igneous rocks and of horizontally-bedded sandstones and conglomerates in the tropics.

Among the photographs are several fine views of the Kaieteur Falls on the Potaro River, a tributary of the Essequibo. These falls, which were discovered by a Fellow of the Geological Society, Mr. C. Barrington Brown, in the course of his geological reconnaissance of the colony about thirty years ago, occur near the escarpment of the great sandstone formation which is so largely developed in the Guianas and in Brazil. The falls are over a ledge of very coarse siliceous conglomerate, some 18 or 20 feet thick, which overlies a thickness of about 1000 feet of almost horizontally-bedded sandstones. The river above the falls is about 400 feet broad and from 18 to 20 feet deep, and falls vertically, as a great curtain of water, for 740 feet, into a vast chasm at the extremity of a deep valley which it has eroded for a distance of about 17 miles from the escarpment of the sandstones. During the first 3 or 4 miles of its course from the falls through the valley, the river descends for about 400 feet by a series of cataracts and rapids. The valley, which is eroded in places through the sandstones into the underlying igneous rocks, is of surpassing beauty, and offers many features of marked geological interest. One of the views, taken when the water was low after a long-continued drought, shows very clearly the great cave which the spray of the falling water has cut out from the softer sandstone strata.

Others of the views show the somewhat primitive methods employed in prospecting and in working the placer-claims for gold.

Professor Edward Hull made a communication, illustrated by lantern-slides, on the submerged valley opposite the mouth of the River Congo. The position of this submerged valley has been ascertained by Mr. Edward Stallybrass and Professor Hull, by contouring the floor of the ocean with the aid of the soundings recorded on the Admiralty Charts. The sides of the valley are steep and precipitous and clearly defined, the width varying from 2 to 10 miles, and the length across the Continental platform being about 122 miles. It is continuous with the Valley of the Congo, and its slope is uninterruptedly downward in the direction of the abyssal floor. The steepness of the sides indicates that they are formed of very solid rocks.

Several other submerged valleys off the coast of Western Europe were described for comparison. In most cases the landward end of the submerged river-channel is filled with silt, etc., for some distance from the mouth of the actual river; but, farther out, its course becomes quite distinct towards its embouchure at the edge of the Continental platform. Among the valleys specified were those off the mouth of the Tagus and the Lima, the Adour, and the Loire, and those in the English and Irish Channels.

The following communication was read :—

"The Geological Succession of the Beds below the Millstone Grit Series of Pendle Hill and their equivalents in certain other parts of England." By Wheelton Hind, M.D., B.S., F.R.C.S., F.G.S., and J. Allen Howe, Esq., B.Sc., F.G.S.

Part i of this paper consists of a detailed account of the ground. Many detailed sections are given, showing in each case the exact fossiliferous horizons. The geological succession between the massif of limestone and the Millstone Grit Series on Pendle Hill is shown, by various sections, to contain a characteristic limestone series, easily distinguished by palæontological and lithological characters from the White or Clitheroe Limestone. This calcareous series is found to be very constant over a certain definite area, and to contain a zonal fauna.

By various sections the extent of the deposit is shown, and it is demonstrated that the deposit occupies a basin, of which the Pendle district covers the maximum area of deposit, for the sequence thins out rapidly north-wes and south. But although the beds thin out, a calcareous series with a typical zonal fauna is always present. Beds containing this fauna are traced from County Dublin, the Isle of Man, Bolland, Craven, the Calder and Mersey valleys, to Derbyshire and North Staffordshire. It is shown that this series, for which the term Pendleside Series is proposed, occupies a basin about the size of the area indicated above, and that the beds are lithologically distinct from the Yoredale Beds of Wensleydale, and contain a different fauna.

Part ii discusses the question in detail, from a palæontological point of view. Several goniatites and *Posidonomya Becheri* are shown to be characteristic of the lower part of the series, while *Aviculopecten papyraceus*, *Posidoniella lævis*, and certain goniatites have a wider distribution in the series.

The faunas of the Yoredale Beds of Wensleydale and the Pendleside Series, generally mapped as Yoredales, are shown to be entirely distinct; and the Yoredale Series of Wensleydale is shown, on palæontological and stratigraphical grounds, to be the equivalent of the upper part of the massif of limestone.

The migration of certain families of fossils from the north to the south, brought about by a slow change of environment, is shown by tables, and lines called 'isodiectic lines' are drawn to represent this distribution. It is shown that the Nuculidæ are found in the lowest Carboniferous beds in Scotland, but come in at successively higher horizons as the beds range southward.

These facts and comparative thicknesses are the basis of an argument as to the local distribution of land and water in Carboniferous times; and it is shown that the peculiar change in type which Carboniferous rocks undergo in passing from north to south is due entirely to physiographical conditions, and not to any theoretical assumption of contemporaneous faulting. It is shown, moreover, that the Craven Faults *per se* have had nothing to do with this change of type. The correlation of the limestone knolls of Craven with the Pendleside Limestone is demonstrated to be no longer tenable.

CORRESPONDENCE.

MR. A. R. HUNT ON THE AGE OF THE EARTH AND THE SODIUM OF THE SEA.

Sir,—In the volume of this Magazine for 1900 I reviewed Professor Joly's theory, that the age of the earth can be calculated by comparing the amount of sodium now in the sea with the time rate at which rivers are at present conveying sodium down. Among other matters I suggested that the salinity of rivers might be partly due to sodium derived from *sedimentary* rocks, which had formerly come from the sea. This would of course lengthen the computed age of the earth.

Mr. Hunt now suggests that "sea-water reached the heated rocks," and he appears to consider that much of the sodium, which the Dartmoor granites (at any rate) contain, was derived from the sea.

This is turning Professor Joly's theory round about. Professor Joly derives the salts of the sea from the igneous rocks. Mr. Hunt derives the salts of the igneous rocks from the sea.

My object in this letter is to direct attention to the difficulty of explaining the undoubted abundance of water, which is extravasated by volcanoes, to absorption from the ocean or from any other external source. I have gone into my objections to this view (whatever they may be worth) in my "Physics of the Earth's Crust" (2nd ed., p. 144), where I have, in a note, given an account of Daubrée's experiment, to which Mr. Hunt refers.

Since, alas! my two friends have passed away, it may be permissible to say, that I was on a visit to my dear friend Professor Prestwich shortly after he had published his paper on "The Agency of Water in Volcanic Eruptions," and Professor John Morris was my fellow-guest. We two were talking about Prestwich's theory that the volcanic water was derived *ab extra*, and that water could enter into combination with molten rock. Morris said, "Water would not be so foolish!" This was not a very scientific reason, but it was putting his own idea pretty strongly. He also told me that he had tried to dissuade Prestwich from publishing his views of volcanic energy, but without success.

My own opinion is that water has been a constituent of the liquid interior of the earth from the very first, and that it simply makes its escape at a tremendous pressure whenever a way is opened for it through the solid crust. O. FISHER.

HARLTON.
March 5, 1901.

NAMES FOR BRITISH ICE-SHEETS.

SIR,—May I suggest to Mr. Lamplugh that to propose names for British Ice-sheets before proving that they have existed is rather like counting chickens before they are hatched. At present we know neither the ancient extent of land-ice in our Island, nor in all cases what are indisputable traces of it. Where faith is strong this, no doubt, seems a detail, but to sceptics it appears important.

If, however, we admit that there was an East British Ice-sheet, "maintained and augmented principally by the snowfall upon its own surface," how are we to explain the presence of Scandinavian rocks at Cromer and other places on our East Coast? Of that ice-sheet the Dogger Bank would be centre and highest part. This tract is crossed (a little north of its centre) by a line drawn from Flamborough Head to the Naze of Norway. Over an area measuring about 70 miles from east to west, and 12 miles in the opposite direction, it rises above the ten-fathom contour-line (the minimum depth being 7 fathoms). The twenty-fathom line is very near to the other one at the south-west end, but then recedes from it so as to enclose a long bank which stretches in a north-easterly direction, almost half-way across the North Sea, and the thirty-fathom line on the northern side extends from the Yorkshire coast to Jutland. North and north-west of this limit are soundings down to 49 fathoms, and those over 40 fathoms are rather common. In the great channel off the south-west of Norway they are often over 200 fathoms (for particulars see this Magazine, 1899, p. 282). Thus the ice of the Dogger-fjeld (would not that have been a better name?) must have descended from its central plateau down slopes about 250 feet in vertical height on the north and north-west, and about half that amount down those from the south-west to the south-east. This mass of ice flowing outwards towards nearly all points of the compass, and buttressed on the western side by the Caledonian ice, which it would try to 'shoulder' in that direction, would surely defend our shores from the inroads of the Scandinavian ice-sheet, however nimbly it might climb the steep slope of the above-mentioned channel. Is it, then, a mistake to identify Scandinavian rocks in East Anglia; for if the Dogger-fjeld existed they could not have travelled on floating ice? T. G. BONNEY.

CONCRETIONS OF CALCITE IN MAGNESIAN LIMESTONE.

SIR,—The well-known globular concretions from the Magnesian Limestone of Durham occur in many collections under the name of 'dolomite' or 'magnesian limestone.' Professor Garwood, however, effectually showed (GEOL. MAG., 1891, p. 436) that these concretions are due to the crystallization of calcite in a ground of magnesian limestone, and that the 5 to 15 per cent. of magnesium carbonate contained in them is a mere impurity, when compared with the 30 per cent. in the matrix from which they have arisen. It is interesting to come across a similar statement made in 1817, though we waited long for Professor Garwood's numerical proofs, and for a complete account of the mode of origin of the concretions. Mr. N. J. Winch (Transactions of the Geological Society of London, vol. iv, p. 9) remarks that "botryoidal masses of fetid limestone devoid of magnesia, in balls varying from the size of a pea to two feet in diameter, imbedded in a soft, marly, magnesian limestone, are found at Hartlepool, etc." Winch had given a specimen some twelve years before to James Sowerby ("British Mineralogy," table 38), and the passage above quoted was incorporated by Conybeare & Phillips in their "Geology of England and Wales," 1822, p. 306. GRENVILLE A. J. COLE.

DUBLIN, *March* 1, 1901.

SUCCESSION OF STRATA IN THE YOREDALE ROCKS.

SIR,—Mr. Dakyns is right in his criticism on the succession I quoted for the Yoredale strata of the Yore Valley. It is true that the sequence, though there are many exceptions, is usually—

Shale.
Limestone.
Sandstone.

But this may be put in another way. The series as a whole is made up of repetitions of this threefold cycle, and may with equal correctness be regarded as consisting of repetitions of the cycle—

Sandstone.
Shale.
Limestone.

We have, therefore, the same evidence of intermittent and more or less rhythmic sedimentation which I claimed for the Coal-measures. But there is this difference, that whereas in the Yoredales the cycle commences with inactivity (limestone) and proceeds to rapid sedimentation (sandstone), in the Coal-measures it commences with activity (sandstones and conglomerates) and proceeds to stagnation (coal-seams), the order being—

Coal.
Shale.
Sandstone and conglomerate.

Both formations result from rapid sedimentation over a subsiding area, but whereas the Coal-measures are essentially estuarine, the Yoredale rocks of the type developed in the Yore Valley bear every sign of having been laid down in open sea; the one was a product of the shallowest water, the other of comparatively deep water. Herein probably lies the explanation of the reversal of order of events.

I am obliged to Mr. Dakyns for the correction.

A. STRAHAN.

March 6, 1901.

EVAPORATION AND SUBLIMATION.

Sir,—As long ago as September, 1900, I observe that the writer who reviewed my book on "The Scientific Study of Scenery" in this Magazine criticizes my use of the term *sublimation*.

He says: "In alluding to the evaporation of snow and camphor the process is referred to as 'sublimation.' In Watt's Dictionary of Chemistry sublimate is defined as 'a body obtained in the solid state by the cooling of its vapour.'"

Nevertheless, I believe that I use the term correctly, and in support of this assertion let me further quote Watt's Dictionary (1894 edition, vol. iv, p. 524). Sublimation is there defined as "The passage of a solid body, when heated, to the state of vapour without melting."

I take this opportunity of thanking the writer for the appreciative notice, which contains many suggestions which I should gladly utilize, if a second edition of my book should be called for.

J. E. Marr.

Cambridge.

MALAY PENINSULA LIMESTONE.

Sir,—Since the publication of my paper in last month's Geological Magazine,[1] where I compiled some notes on the geology of the Malay Peninsula, and took occasion to remark that in the absence of fossils it was impossible to correlate the limestones of that country with any definite horizon, some further samples of the same rock have been submitted to my notice by Dr. Henry Woodward, F.R.S.

This new material was collected a few years back by the late Mr. H. M. Becher, at Gua Sai, Penjom, Pahang, and is of precisely similar appearance to the paler-coloured limestones obtained by Mr. R. M. W. Swan from the River Tui District, which he found associated with those of a dark variety referred to in my paper.

The 'Becher' specimens are important from the fact that they exhibit organic structures, a feature pointed out by Dr. G. J. Hinde, F.R.S., on a manuscript label dated January 7th, 1899, who thus describes them:—"Very fine-grained bluish limestones. The only organisms recognizable are Crinoidal stem-joints. There are traces of other organisms with which the rock seems to have been filled originally, but they are now nearly obliterated and are not determinable."

This report, however, leaves us still without a clue as to the age of the limestone, and we shall require more accurate palæontological evidence before that desirable point can be permanently settled. In the meantime mention may be made of the presence of an obscure Crinoidal fragment on one of the weathered surfaces of this rock.

[1] "Notes on Literature bearing upon the Geology of the Malay Peninsula; with an account of a Neolithic Implement from that country": Geol. Mag., 1901, pp. 128–134.

exhibiting a portion of the stem with fragmentary brachial extensions, the whole organism covering a space of nearly three inches in length. My colleague, Dr. F. A. Bather, has kindly examined the specimen, but without any satisfactory result, on account of its poor preservation; he is, however, inclined to regard it as of Palæozoic age. Further efforts should now be made to obtain more suitable fossils from these interesting limestones of the Malay Peninsula, so that their geological age may be finally determined.

R. BULLEN NEWTON.

BRITISH MUSEUM (NATURAL HISTORY).
March 19, 1901.

OBITUARY.

DR. GEORGE MERCER DAWSON,

C.M.G., LL.D., ASSOC. R.S.M., F.R.S., F.G.S., F.R.S. CANADA,
DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

BORN AUGUST 2, 1849. DIED MARCH 2, 1901.

THIS eminent geologist, whose portrait and life we published in the GEOLOGICAL MAGAZINE for May, 1897, pp. 193–195, died at Ottawa, after an illness of only two days, at the early age of 51 years, sincerely regretted by a large circle of friends.

Dr. Dawson was the son of Sir William Dawson, F.R.S., for many years Principal of McGill College, Montreal; and was, since 1875, one of the staff of the Geological Survey of Canada, of which he speedily became Assistant-Director, and in 1894 Director. He was educated at McGill College, Montreal, and at the Royal School of Mines, London. Here he obtained the Duke of Cornwall's Scholarship, and the Edward Forbes medal and prize. He was, in 1873, on the North American Boundary Commission. On the Geological Survey he did much personal work in British Columbia and the North-West Territory, covering in his mapping many thousand miles of area. Dr. Dawson was one of the Commissioners for the Behring Sea Arbitration, spending the Summer of 1892 inquiring into the conditions and facts of seal-life, and his services were of the greatest value. He received the thanks of the Governor-General-in-Council, and was made a C.M.G. He received the Bigsby Gold Medal from the Geological Society in 1891, and in 1890 the degree of LL.D. from Queen's University and from McGill University in 1891. In 1897 he was awarded the Gold Medal of the Royal Geographical Society for his work as a whole.

Canada may well be proud of Dr. G. M. Dawson as one of her most brilliant men of science, whose loss she will long deplore, nor will he fail to be remembered in this country also as a son of that great Motherland whose name can never die.

CHRISTIAN FREDERIK LÜTKEN.

Born at Sorø, October 4, 1827. Died at Copenhagen, February 6, 1901.

Professor Lütken, whose death, some two years after his resignation of the Directorship of the Zoological Museum at Copenhagen, removes another veteran from the ranks of the admirably trained and hard-working Scandinavian naturalists, was best known as a describer and classifier of living animals. But while, in common with the leaders of palæontology, he insisted that "only from the organization of the *living* form can we learn to understand that of the *extinct*," so also he was at one with the more eminent zoologists in recognizing that only by a study of extinct forms can we perceive the true relationships of the living. And it is because he put his creed into practice for over half a century that the close of his labours calls for the affectionate regret of geologists. That a notice should appear in this Magazine is moreover specially appropriate, since it was to it that he turned on the few occasions when he desired to address English readers in their own language. We allude to his notice of Lovén's memoir on *Leskia mirabilis* (Geol. Mag., 1868, p. 179), his notes on the Ophiuridæ (1870, p. 79), and his criticism of Professor Kner's writings on the Ganoids and on *Xenacanthus* (1868, pp. 376 and 429). His own great memoir on the classification of the Ganoids appeared in *Palæontographica* (1873–75). From his many allusions to fossil Echinoderms we may select as early evidence of his penetration the constant opposition that he raised to the idea that the anus of the stalked echinoderms was a proboscis or mouth, and his severe criticism (oddly overlooked by later writers) of the division of the Crinoids into a Palæozoic and a Neozoic group. As a systematist the characteristics of his work were thoroughness, accuracy, and caution: qualities less showy than lasting. He was not a brilliant speculator on the phylogeny of unknown forms, but an advocate of, and an adept in, the synthetic method: "I mean that method which, giving up all preconceived ideas, patiently puts genus to genus, until families are formed, and family to family after their natural affinities, until the whole systematic building stands before us." It is work of this nature that will stand, that will vindicate the claims of palæontology to be heard, that will justify systematic zoology as a serious attempt to solve the problems of life, and that will keep science itself from the ridicule of the unlearned. We can ill spare such workers; but Lütken was a leader and a teacher as well as a student, and his monument is to be found not only in the books that he has left, nor even in the rich and well-arranged museum of Copenhagen, but also in the school of active and earnest zoologists that will long do honour to Denmark.

F. A. B.

ROBERT CRAIG.

We regret to record the death at Glengarnock, on the 14th January, of Robert Craig, in the 80th year of his age. Mr. Craig took an active interest in geology, and from his occupation as a quarrymaster and burner of lime he had exceptional opportunities for the pursuit of the science. During the past forty years he contributed many papers to the Transactions of the Glasgow Geological Society, more especially on the Drift deposits and Carboniferous rocks. In his own neighbourhood, from his literary and scientific tastes, he was known as "The Sage of Beith."

MISCELLANEOUS.

Geological Survey of the United Kingdom.—We have already notified the appointment of Mr. J. J. H. Teall as *Director* in place of Sir Archibald Geikie, *Director-General.* The further appointments are two *Assistant-Directors*: Mr. H. B. Woodward (for England and Wales) and Mr. John Horne (for Scotland). *District Geologists*: Mr. C. Fox Strangways, Mr. Clement Reid, and Mr. Aubrey Strahan (for England and Wales); Mr. B. N. Peach and Mr. W. Gunn (for Scotland); and Mr. G. W. Lamplugh (for Ireland).

'Blood Rain' in Sicily.—A telegram despatched from Palermo yesterday stated that since the previous night a dense lurid cloud had hung over the town. The sky was of a sinister blood-red hue and a strong south wind was blowing, and the drops of rain which fell were like blood. The phenomenon, which is known locally by the name of 'blood rain,' is attributed to dust from the Sahara Desert having been carried there by the wind. Similar atmospheric conditions are reported from Rome. The sky had a yellow tint yesterday, and a violent sirocco swept over the city. At Naples showers of sand fell, and the phenomenon of the 'fata Morgana' was observed.—*Morning Post*, March 11, 1901.

Vienna, March 12.—Red and yellow snow has fallen in many parts of Austria, including districts so far north as Prague. The coloured snow lies several inches deep, and makes a weird and unearthly effect. Scientists state that southern winds of extraordinary force have carried the red and yellow sand of the Sahara across the Mediterranean to Southern Europe in such an enormous quantity that even here in Austria the colour of the snow has thereby been changed.—*Morning Leader*, March 13, 1901.

Reptilian Remains from Patagonia.—At the meeting of the Zoological Society on March 5th, Dr. A. Smith Woodward, F.L.S., F.Z.S., F.G.S., read a detailed description of the remains of *Miolania* from Patagonia, which were briefly noticed by Dr. Moreno in the Geological Magazine for September, 1899. He regarded them as indicating a Chelonian only specifically distinct from the typical *Miolania* of the Australian region. In the same formation in Patagonia were found the skeleton of a new extinct snake and the jaws of a large carnivorous Dinosaur, which were also described. The discovery of *Miolania* in South America seemed to favour the theory of a former Antarctic continent; but it should be remembered that in late Secondary and early Tertiary times the Pleurodiran Chelonia were almost cosmopolitan.

FIG. 2.

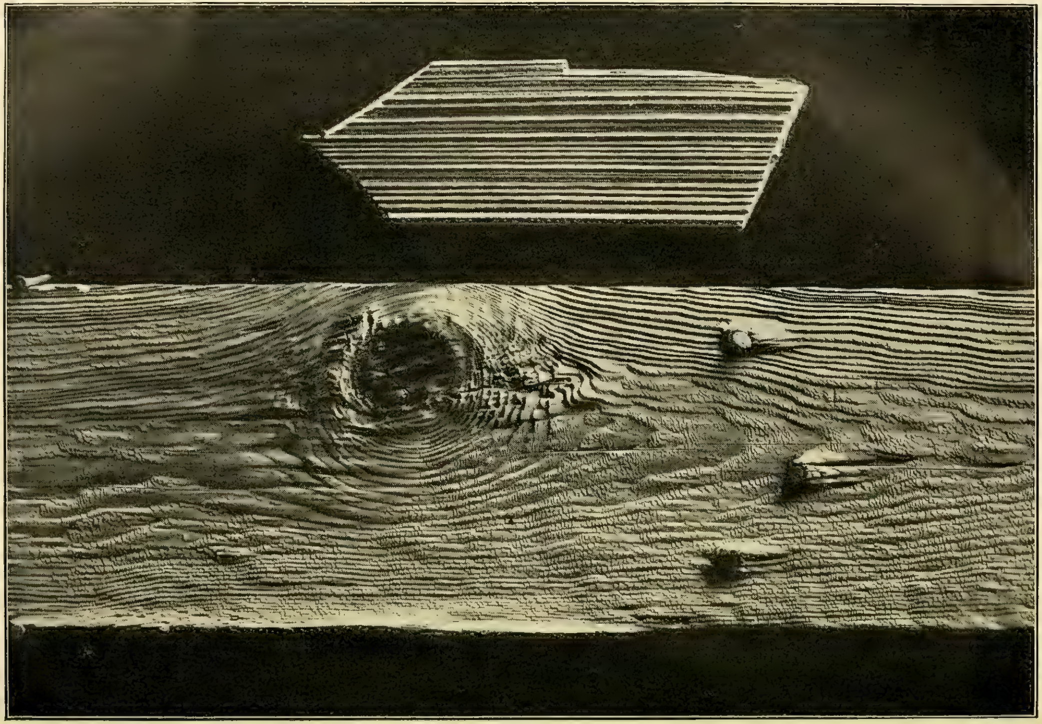


FIG. 1.

Pine board and split-oak stave, eroded by sand-blast of the shore.

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ORIGINAL ARTICLES.

I.—Sand-blast of the Shore and its Erosive Effect on Wood.

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

(PLATE X.)

THE effect of the natural sand-blast of the desert in eroding soft and hard rock has long been known, and attracted much attention, but I cannot call to mind any account of the effect of blowing sand impinging upon wood.

From seven to eight years ago a boat-house was built by the Blundellsands Sailing Club on the sandhills at the Altmouth, about 8 or 9 feet above high-water mark of spring tides. Afterwards, for better access thereto, a sloped road was built up of timbers from the shore level, leading to a level gangway about 10 feet above the shore, also made of timbers. This gangway was 6 feet wide and 12 feet long, with close-boarded sides about 2 feet high formed of roughly sawn pine boards and split-oak staves. This formed a trough having a direction about west-north-west, and really became a wind-gap.

The effect of the sand-blast on the southern face of the northern side has been most striking and curious. The boat-house has just been taken down and re-erected at a lower level, and my sons, members of the club, have brought me a sample of the pine boarding and of the split-oak staves from the north side of the old gangway. These are reproduced in the Plate from photographs by Hartley Bros., Waterloo. The general effect of the sand-blast has been to remove from one-eighth to three-sixteenths of an inch of wood over a large part of the surface of the pine board (Pl. X, Fig. 1), and to develop the structure of the wood in a remarkable manner. The grain being very irregular, the differential effect of the impinging sand-grains on the harder and softer portions is most instructive.

It will be observed that the large hard knot stands out above the general surface of the wood, and that the grain around the knot is picked out in a surprising manner. The knot itself is carved and polished. Perhaps the most instructive feature is the effect of the three nails in preserving the wood in the rear or *lee* of the nails, the course of the sand-blast having been from left to right. These are wire nails that fastened the board horizontally to the upright posts. The heads of these nails mark the original sawn surface of the board, and indicate well the amount of the general denudation the board has undergone. In the year 1875 I contributed a short article to this Magazine on "Wind Denudation," describing little ridges of sand on the shore left on the leeside of fragments of shells, or sometimes whole shells, which have protected the sand from the general denudation which always takes place in the upper moist part of the shore during a strong breeze. These little ridges I ventured to call 'eolites.' The wood ridges left in the rear of the nail heads are the counterparts of these eolites, but they are actually carved out of the board by the mechanical battering of the sand-grains, whereas the eolites are due to the wind first drying the surface of the sand and then blowing the grains away, except where protected by the shell fragments.

Another interesting feature is the rope-like appearance caused by the truncation of bundles of fibres, shown by the minute transverse markings on the photograph. This happens only where the grain is not parallel to the surface of the wood.

The effect on the oak staves is equally characteristic. Here, in consequence of the regularity and parallelism of the grain, grooves have been cut by the sand with the precision of a planing machine (Fig. 2).

Since the preceding was written another pine board has been brought to me. It measures 2 ft. 6 in. × $6\frac{3}{4}$ in. The timber is rather harder than in the one already described, and the grain more regular. The sand has cut grooves of segmental section from three-sixteenths to half an inch wide, deeply undercut on one side, the ridges between the grooves being like a knife edge. There are hardly any of the transverse markings to be seen, the grain being parallel to the surface, and the whole has a smooth polished surface to the touch.

It is interesting to find that the continual attrition of these quartzose sand-grains, many of them much rounded, in time cuts deeply into the wood and develops the structure by differential action on the harder and softer parts it operates upon, and also polishes the surface. The time the wood has been exposed to the blast is about seven years. What the velocity of the grains was in a high wind I have no means of judging, but no doubt the air currents were intensified in this wind-gap, and it must not be taken as representative of the whole shore.

EXPLANATION OF PLATE X.

Fig. 1.—Portion of a pine board, 1 ft. 1 in. × 5 in., eroded by sand-blast of the shore.
Fig. 2.—Portion of a split-oak stave, $5\frac{1}{2}$ in. × $2\frac{1}{2}$ in., ,, ,, ,,

II.—Note on Graptolites from Peru.

By E. T. Newton, F.R.S., F.G.S., etc.

Mr. Herbert J. Jessop, who has recently returned from a journey in Eastern Peru, kindly placed in my hands, for examination, some specimens of graptolites which he had obtained on the River Macho, one of the tributaries of the Inambari, near the celebrated mountain Capac Orco, or Monte Bello, in the province of Carabaya, Peru (lat. 13° 40′ S.; long. 70° 10′ W.). The locality is situated on the north-east of the main watershed, and the rivers flow eventually into the Amazon. The difficulties of travelling make it likely that a long time will elapse before other specimens are forthcoming from this locality; it seems desirable, therefore, that some account of these should be published.

Fig. 1.

Fig. 2.

Fig. 1.—Fragment of black shale with *Diplograptus*; natural size; Carabaya, Peru. From a photograph kindly taken by Mr. A. Strahan.
Fig. 2.—Specimen marked on Fig. 1; enlarged 1½ times. The virgula has been added from another example.

Mr. Jessop tells me that the pieces of black shale containing the graptolites were portions of a mass of rock about two feet square and one foot thick, which was not found in place, but loose upon the ground; its unrolled and unweathered condition convincing him that it could not have travelled far from the parent bed. Similar shaly rocks are in place near by, but he was prevented from making a careful exploration. The specimens obtained seemed to him sufficiently interesting to be brought home, notwithstanding that everything had to be carried by the men for many miles, the place being inaccessible for horses or mules.

The whole mass of shale seems to be full of these graptolites, for, wherever split open, many white examples are displayed upon the surface of the black shale (Fig. 1), all of which are referable to the genus *Diplograptus*, and although differing somewhat in width they are so similar in other respects that they can hardly represent more than one species. The longest and most perfect specimen (Fig. 2) does not exceed 25 mm. in length and 3 mm. in width at the widest part; but this example has no projecting virgula, such as is seen on other specimens extending perhaps 4 or 5 mm. beyond the thecæ. Some examples are a little narrower, while one is as much as 5 mm. wide. The polypary has a small radicle and two cornua at its proximal end, and thence increases somewhat rapidly in width for about a third of its length and then decreases slightly and very gradually to the distal extremity, from which, in several specimens, a virgula extends. In one instance the virgula may be traced throughout the length of the polypary. The thecæ diverge from each side of the axis at an angle of rather less than 45°; the apertural margin is nearly at right angles with the axis, and the outer free margin is in most cases slightly convex; but there is some variation in all these particulars, even in the same polypary. There are 11–13 thecæ in 10 mm. These Peruvian Diplograptids very closely resemble the *D. truncatus* of Lapworth,[1] and Professor Lapworth, who saw the specimens for a few minutes, was good enough to point out this near resemblance. The small differences which may be noticed, namely, the distinct virgula, the somewhat smaller thecæ, and the less oblique apertural margin, as well apparently as the shorter polypary, probably indicate that specific difference which one is led to expect from the widely separated habitats of the two forms; at the same time one hesitates to give them a new name, and would prefer to record them as *Diplograptus*, cf. *truncatus*, Lapw., and as probably of Bala age.

Little is known of the geology of the immediate area from which Mr. Jessop obtained his graptolites; but David Forbes, in his paper on "The Geology of Bolivia and Southern Peru,"[2] not only gives a large area of Silurian rocks extending from the south-east to the north-west border of his map, which is perhaps within a hundred miles of Monte Bello, but says that these Silurian strata extend as far as Cuzco, and this would be as far north and well to the west of the district now in question. David Forbes does not appear to have visited this area himself, and the fossils collected further south, which were described by J. W. Salter, were said to indicate beds of Upper Silurian age, and probably Lower Silurian also. The fossils doubtfully referred to the Lower Silurian certainly left much to be desired. No graptolites were found, and consequently a most important guide to the age of these old rocks was wanting.

D'Orbigny, during his travels in Bolivia,[3] found certain graptolites at Tacopaya, near the Rio Grand (lat. 19° S.; long. 63° 40′ W.),

[1] Proc. Belfast Nat. Field Club, ser. II, vol. i, pt. 4, Appendix, p. 133, 1876–7.
[2] Quart. Journ. Geol. Soc., vol. xvii (1861), p. 53.
[3] "Voyage dans l'Amérique Méridionale": Palæont., vol. iv (1842), p. 23.

which he named *Graptolites dentatus*; but finding that they had two branches, united them with *Graptolites* (now *Didymograptus*) *Murchisoni*; *Grap. foliaceus* was likewise included, and as this is a Diplograptid there must be much doubt as to the specific identity of his Bolivian forms, although the published figures leave little doubt as to their belonging to the genus *Didymograptus*, and consequently point to beds of Llandeilo or Arenig age; that is, if we are right in using the zonal distribution of Old World Graptolites as an index for those of Central South America.

Both Cambrian and Silurian fossils have been described from Northern Argentina (lat. 23½° and 25° S.) by Professor Kayser,[1] and from Portezuelo many examples of a *Didymograptus* are noticed which he thinks may be the same form as that brought from Bolivia by D'Orbigny, thus again pointing to Llandeilo or Arenig rocks a long way to the south-east, and confirming the occurrence of strata of that age in the central part of South America.

M. J. Balta, in his note on "Fosiles de Carabaya,"[2] mentions the occurrence of graptolites and annelid burrows at Huayna Tacuma, Santo Domingo, in the province of Carabaya. I am unable to find this locality on any map I have consulted, but Mr. Jessop tells me there is a Santo Domingo a few miles from where his graptolites were found, and this is probably the place indicated. M. Balta refers his graptolites to *Diplograptus palmeus*, Barrande, and *D. pristis*, His., and he remarks that only Lower Silurian rocks have at present been observed in South America. The genus *Diplograptus*, however, is not confined to Lower Silurian (Ordovician) deposits, and if the reference of specimens to *D. palmeus* and *D. pristis* be correct, then, while the latter points to beds of Bala age or the uppermost part of the Lower Silurian, the former, *D. palmeus*, indicates Upper Silurian rocks, that is, strata of Llandovery or Tarannon age; moreover, Salter had already in 1861 recognized Upper Silurian fossils among those brought over by David Forbes.

The *Diplograptus* obtained by Mr. Herbert J. Jessop, whether referable to *D. truncatus*, Lapw., or to a new but closely allied species, may be taken as indicative of beds near the uppermost part of the Lower Silurian.

So far as we can judge from the evidence of the graptolites now known to occur in Central South America, there are in that country deposits of Arenig or Llandeilo age with the characteristic *Didymograptus Murchisoni*; beds approximately of Bala age, with *Diplograptus pristis* and *Diplograptus* near to *truncatus*; and possibly strata of Llandovery age, as indicated by *D. palmeus*. It is to be hoped that before long definite graptolitic evidence of Upper Silurian rocks will be obtained by the discovery of some characteristic Monograptids.

[1] Zeitsch. deutsch. Geol. Gesell., vol. xlix (1897), p. 274.
[2] Rev. Cienc, Lima, vol. i (1898), p. 7.

III.—The Rift Valleys of Eastern Sinai.[1]

By W. F. Hume, D.Sc., A.R.S.M., F.G.S., etc.

In this paper the author deals with some of the results obtained in the course of a survey of Eastern Sinai during the season of 1898–99, his remarks being based on a map carefully prepared by his colleague, Mr. H. G. Skill, F.R.G.S., and on his own topographical and geological observations.

The region specially under consideration is bounded on the west by the central range of Sinai, which is familiar to every Indian traveller, forming as it does a prominent rock-wall to the east of the Gulf of Suez. This mountain mass in reality consists of a series of narrow crests separated by few but high mountain passes, and capable of being traversed only by heavily loaded camels at two points, viz. at the head of Wadi Tarfah and Wadi Hebran. If this range be crossed, and Mount Sinai (Jebel Musa) itself ascended, the view to the east is decidedly disappointing. To the north-east the long white limestone wall of Jebel Gunnah runs more or less east and west, far to the east breaking into isolated masses, and ending in the fine truncated cone of Jebel El Ain. South of, and parallel to it, extend sandy plains and precipitous plateaux of sandstone, these being succeeded by an apparently flat or undulating granite plateau (the rift-valleys in it being hidden), out of which sharp-peaked mountain masses rise as isolated projections or long ridges. To the south-west is a mountain-wall, which hides all the southern land from view, and constitutes the most important scenic feature in Eastern Sinai, extending across the country from the Central Range to the Gulf of Akaba. This *Transverse Divide* claims special attention, not only from the fact that it separates two different types of country, but also because at many points these two regions are at markedly different levels, there being an abrupt fall to the south. The divide is also crossed by five passes, which all have this remarkable feature in common, viz.: *that the valleys they connect form five roughly straight lines, all parallel to one another and to the Gulf of Akaba, that is, running in a direction somewhat west of south.* Two of these are then specially considered with a view to showing that they belong to the category of Rift Valleys, of which the Gulf of Akaba is itself a striking example, it being premised that these are not necessarily single depressions, but rather a series of basins or grooves separated by barriers, which, though higher than the main valley, are of no great altitude compared with the bordering hills. Thus, the Shelala Um Raiyig rift is shown to have a length of over 72 kilometres, being almost perfectly straight and bounded by very steep slopes throughout the greater part of its course.

The geological features are still more striking, the hills on the

[1] Abstract of a paper read by permission of Sir William Garstin, Under-Secretary of State for Public Works, and Captain H. G. Lyons, R.E., Director-General of the Egyptian Survey Department, before the International Geological Congress at Paris, August, 1900.

two sides being frequently of different geological structure, this contrast having often a very marked effect upon the scenery, as, for instance, where the rift separates the granite range of Ashara from the felsitic hills of Ferani, the former rising in sharply peaked red-coloured crests scored by wild gorges, while the latter are of dark-green colour, and possess less rugged outlines.

Still more noteworthy is the presence of sandstones in the valley itself, having all the typical characters of the Nubian Sandstone, yet situated 25 kilometres south of the main mass of that formation; similarly, at the head of Um Raiyig, a ridge of Cenomanian limestone, with sandstone at its base, block the valley, being enclosed between two walls composed of Nubian Sandstone resting on granite. Still further to the north the reverse is met with, a granite ridge running north and south, rising steeply through the surrounding sedimentaries. The examination of the relations of the beds over the area shows that the actual displacement of strata in the production of the rift varies from 200 to 600 metres (2,000 feet).

The Raib Melhadge rift is in some respects even more striking, the granite range extending far further to the north on its eastern than on its western border, which for some distance is formed by lower country, geologically a complex of granite, sandstone, and Cenomanian limestone. As a result, in the upper part of Wadi Raib, Cretaceous limestone forms low ridges dipping steeply eastward at the foot of a granite range, which rises immediately above them to a height of over 300 metres. Descending Wadi Raib the conditions become simpler, the Nubian Sandstone on the west giving way to granite cliffs, and the valley becoming a broad highway bounded on both sides by precipitous height. Yet scattered all along its course are low hills of white Nubian Sandstone, and in one place Cenomanian limestone, *so that the surprising result is realized, that Cretaceous fossils were collected from a limestone on both sides of which tower granite cliffs to a height of over* 500 *metres* (themselves in places capped by Nubian Sandstone), *the extent of dislocation being here at least* 700 *metres.* Further to the south, the same rift gives rise to a Coastal Watershed Range of some importance.

The other valleys are considered to be rifts on account of their parallelism to those already described, while they also must have been produced by the same series of movements which gave rise to the Gulf of Akaba.

Correlation of Eastern Sinai Rifts with those of neighbouring districts.—In returning from Eastern Sinai the writer was struck by the resemblance of the western valleys to those already described, the clefts, viz. Nagb Hawa and El Watiyeh, which break through the granite hills, barring the Sinai convent region to the north, being the continuations of remarkable lines of depression which can be traced far to the north-west. One of these, which includes the Convent Valley and runs to Wadi Suwig, is especially straight and well defined, but, in common with the other western valleys, is parallel, not to the Gulf of Akaba, but to the Gulf of Suez.

The conclusion arrived at is as follows:—To the *west* of a north-south line (practically longitude 34° E.) extend a series of N.W.–S.E. rifts, the *Suez* type, which include not only the Western Sinai valleys and the Gulf of Suez, but also Wadi Qena, and in all likelihood part of the Nile Valley itself; while to the *east* of this line is an *Akaba* rift-series, not only giving rise to the Gulf of Akaba, but to all the important longitudinal valleys of Eastern Sinai, and probably producing effects on the opposite coast of Midian comparable for extent and interest to those of Egypt itself. A third, or *transverse*, type of dislocation is also considered, special attention being called to the *regularity* and *parallelism* of the valley directions. Thus, in a space north of the transverse divide, the valleys run mainly east-of-north, west-of-south, or *north-east*, while in other parts of the eastern side of the peninsula the dominant trend is slightly east-of-north, west-of-south, or *south-east*. On the western side, on the contrary, they run north-west and south-east, or south-west. Many of these transverse valleys are in places deep clefts, bounded by precipitous rock-walls, but the geological evidence of rifting is wanting. The general conclusion is thus stated, after a summary of the leading results:—The principal features of Southern Sinai have been produced by *dislocation* rather than *erosion*, fracture in three directions, either directly proved or in the highest degree probable, having determined the general structure of the country. It is, in fact, the meeting-point of two great longitudinal rift-systems, parallel to the Gulf of Suez and Gulf of Akaba respectively, traversed by a third or transverse type, the result being the apparently intricate maze of sharp crest and deep valley characteristic of this region.

Note.—It should be observed that the Akaba system of rifts does not extend far south of lat. 28° N., the ranges to the east of the Red Sea being apparently also of the Suez type.

IV.—Geology of Eastern Sinai.[1]

By W. F. Hume, D.Sc., A.R.S.M., F.G.S., etc.

THE paper under consideration deals briefly with the geological features of Eastern Sinai, and more especially with the characters of the sedimentary rocks developed in that region, a short note on the igneous rocks being also appended. The subject is treated under the following headings:—

I. Pebble Gravels, Travertine, etc.
II. Coral Reefs.
III. Cretaceous Limestones of Cenomanian age.
IV. Nubian Sandstone.
V. Igneous Rocks, etc.

I. Pebble Gravels.—Attention is here again called to the remarkable development of high gravel terraces in the principal

[1] Read by permission of the Egyptian Government before the International Geological Congress, August, 1900.

valleys, these being often over twenty metres high, the gravels being characterized by the fact that they contain fragments of all shapes and sizes derived from the surrounding hills, largely embedded in a sandy matrix consisting of materials of the same derivation, their source being thus strictly local. While found in almost all the principal valleys and many of the side tributaries, they are often particularly well developed at points where longitudinal and transverse depressions cross one another. Their probable *age* can be but determined on the coast of the Gulf of Akaba, where they are found to overlie raised coral-reefs containing such typical Pleistocene or recent forms as *Laganum depressum* and *Heterocentrotus mammillatus.* The gravels are therefore not earlier than the Pleistocene, thus agreeing with the conclusion arrived at by Mr. Barron for those on the west coast of the Red Sea.

One of the most striking features connected with these gravel plateaux is the perfectly flat nature of their upper surfaces, even in the upland wadis, a character which appears inconsistent with their having been produced by rushing torrents, but in accordance with the hypothesis of their formation in lakes or marine fjords. Unfortunately, no shells having been obtained in these beds, their mode of origin still remains doubtful.

Attention is also called to several special varieties of these gravels, the most notable being :—

(*a*) The *Manganiferous Pebble Gravels of Sherm,* in which the cementing material of the conglomerate consists of the hydrous black oxide of manganese, psilomelane, the beds being in places as much as four metres thick, while underneath are strata coloured red by ferruginous ochre. These gravels are closely connected with a core of red granite, ending abruptly where the latter is no longer exposed at the surface, and only overlying it along the edge where it faces the sea. It is of interest to note that the S.S. "Pola" expedition found manganiferous deposits forming on the floor of the Gulf of Akaba, a fact which also suggests the marine origin of the Sherm Gravels.

(*b*) *Oolitic Valley Deposits.*—An oolitic rock is described from the neighbourhood of Ras Muhammed, whose components closely agree in their characters with oolitic grains found by Professor Walther at the mouth of Wadi Dehêse, near Suez, and which he believed to be a marine deposit *in statu nascendi,* mineral fragments being enclosed by successive calcareous layers.

In Wadi Hashubi, where these beds are best developed, they are composed of grains of quartz and orthoclase, cemented by carbonate of lime, which frequently surrounds them in a series of concentric coats, while the strata themselves also show traces of ripple-marking and very fine sun-cracks. In the lower part of the valley they are often strongly current-bedded, and contain lenticular masses of pebbles, while in its upper part they give rise to striking ravines, bounded on both sides by vertical walls of the light-coloured sand-rock. An interesting feature, too, is the height at which these beds are met with, a typical example being still present at 696 metres above sea-level, so that, if its marine origin be admitted, a differential movement of at least 2,000 feet has taken place in the southern end of the peninsula during comparatively recent times.

(*c*) *Gravels cemented by Calcite.*—At the mouth of Wadi Nasb, near Dahab, the gravels composed of igneous rocks are cemented together by crystalline calcite developed in scalenohedra (dog-tooth spar), while in the hills themselves the igneous fragments are enclosed in well-marked *travertine*, especially in the smaller water-courses.

The theoretical deductions which may help to explain the presence of the various types of gravels are thus summarized:—

1. In South-Eastern Sinai earth-movements have produced three high watershed lines, only one of which is now broken through. If these were formed at the same period all the water draining into the basin enclosed by them would collect to form narrow lakes. This would account for—

(*a*) The flat character of the plateaux.

(*b*) The absence of marine organisms.

2. A marine depression, resulting in the invasion of the sea, and amounting to at least 700 metres, is also suggested, and might account for—

(*c*) The oolitic beds of Wadi Hashubi.

(*d*) The manganiferous gravels of Sherm.

(*e*) The travertines of the higher valleys.

(*f*) The calcite-cemented gravels of Nasb.

This hypothesis would also account for their flat character, and only the absence of marine organisms prevents the absolute acceptance of the view that many of these gravels were laid down beneath the surface of the sea. Indeed, it is of interest to note that Mr. Beadnell has obtained these calcite-cemented gravels and travertines in his Nile Valley lacustrine series, thus affording an additional reason for not arriving at hasty conclusions regarding the marine origin of those in Sinai.

3. A subsequent elevation, accompanied by earth-movements resulting in the uptilting of the older coral-reefs, brought the formation of these special features to a close, the gravels subsequently formed being now distributed irregularly over the surface, in places overlying the oolite beds, and being interbedded with the younger Pleistocene coral-reefs.

II. Coral Reefs and Raised Beaches.—This portion of the paper opens with a correction of Professor Walther's statement that the Gulf of Akaba is poor in coral-reefs, it being pointed out by the author that his colleague, Mr. Skill, had now practically mapped continuous reefs from Dahab to Ras Muhammed. This *Fringing Reef* and the isolated coral terraces, up to 25 metres high, standing only a little way back from the sea-shore (viz. the *Lower Coral Series*), are first considered, and shown to be typically Pleistocene, the raised beaches which in many places line the shore being closely associated with them. The *Upper Coral Limestone* or Older Fossil Reef of Walther, though *apparently* overlying the lower one, is evidently of older date, the coral having undergone much alteration and being now of a dirty brown colour, though still in large measure possessing the cavernous character of a modern reef. The fauna of these beds has not yet been fully studied, but there is sufficient evidence to show that we have here a remarkable combination of Pectens of older aspect and Mediterranean character, associated with modern Erythræan species similar to that revealed by a study of Mr. Barron's collection of shells from the older reef on the west side of the Red Sea (see R. Bullen Newton, Geol. Mag., Dec. IV, Vol. VII, pp. 500–514 and 544–560, Nov.–Dec., 1900). Thus, in one bed of this series, *Pecten Vasseli*, Fuchs, and *Chlamys latissima*, Brocchi, are associated in the same bed as *Echinus verruculatus*, previously only recorded from Mauritius (identified by Dr. Gregory). South of Sherm there is a tilted series of coral-reefs, rising nearly 200 metres above sea-level, whose fauna, although very obscure, is probably very early Pleistocene, judging from similar beds occurring on the west side of the Gulf of Suez. It is of special interest to note that these older reefs are only present at the southern end of the Gulf of Akaba.

After maintaining the general proposition that the coral-reefs here are formed in a region of elevation, the question is raised (on the ground of the observation made by Walther that an apparently dead coral-reef was present 6 metres below the present one), whether this elevation is being continued, and it is pointed out that the formation of bays at the mouths of several of the principal valleys suggests that a small local depression is at present taking place in the Gulf of Akaba, which thus differs from neighbouring regions. The writer then considers the series of questions which Professor Walther set himself to answer in his "Die Korallenriffe der Sinai-halbinsel," and agrees with him—(1) that a coral-reef (*sensu stricto*) does not attain any great thickness; (2) as to the rôle which detrital materials play in filling up a coral-reef; and (3) the passage of coral limestone to dolomite by the increase of magnesia. On the other hand, he has been unable to accept Walther's view as to the basis of a coral-reef, the latter laying stress on the importance of compact sedimentary rocks as a base compared with igneous rocks, while in the paper under discussion, after pointing out that the fringing reef of the Gulf of Akaba is largely founded on igneous or metamorphic rock, the writer maintains that the deposition of a coral-reef is practically independent of the nature of the rock forming its base, red granite, diabase, sand-rock, and marls (probably also gneiss and hornblende-granite) having been noted as its basal members.

III. Cenomanian Limestones; IV. Nubian Sandstone.—This is a description of the relations and characters of the strata at the northern end of the area examined, limestones forming the main escarpment of Jebel Gunnah overlying a highly characteristic striped series of green marls containing such typical Cenomanian fossils as *Hemiaster cubicus*, *Pseudodiadema variolare*, and *Heterodiadema libycum*. These marls are themselves only the surface capping of a thick series of white sands, which are now cut deeply into by ravines, giving rise to battlements and castellated ridges, sometimes over 100 metres high, forming one of the most striking features on the road from Sinai to Akaba. These are based on a series of variously coloured ferruginous sandstones, forming broad, low, smooth plateaux, themselves resting on a planed-down surface of granite. Unfortunately these sands and sandstones are all unfossiliferous.

The thicknesses in Jebel Gunnah are as follows :—

	metres.
Compact limestones, with few fossils ...	100
Striped Cenomanian marls	20
Sands and sandstones	207
Total thickness ...	327 (over 1,000 feet).

The most important points noted are:—(1) The Nubian sandstones resting on a planed-down surface of granite; (2) the Cenomanian beds belong to Professor Zittel's 'Africano-Syrian' series, which since Mr. Beadnell's discovery of these beds in Baharia Oasis are shown to have an enormous extension north of latitude 28° N., while Dr. Schweinfurth has shown them to be of great thickness to the north of the Red Sea Hills; (3) the dip and present position of the beds show that these strata once extended over the whole of the present igneous mountain region; (4) the Carboniferous sandstones of Western Sinai are apparently absent.

V. The Igneous Rocks of Eastern Sinai. — After a brief general description this portion of the paper lays stress on the importance of *dykes* of every petrographical variety, which, though the youngest members of the igneous series, never pass into the Nubian Sandstone, so that they are at least Pre-Cretaceous. While generally trending N.N.E. and S.S.W., there is frequently a second system, running practically at right angles to this direction. Though in general aspect resembling the mountains on the opposite side of the Red Sea, the fundamental rocks of the central axis of the peninsula are *granitoid gneiss* and *hornblende-granite*, not the *red granite* which forms many of the main summits in the Red Sea Hills. The latter is, however, also widely distributed in the peninsula itself.

Of special interest are beds of andesite, tuff, and agglomerate, which form some of the principal summits, capping the granite and gneiss, while in the Ferani range, etc., this *Volcanic* series is closely associated with a metamorphic type, varying from spotted slates and slightly foliated mica-schists to dark-green chlorite and hornblende-schists pierced by innumerable dykes of dolerite. Some special points are dealt with in closing, such as the development of gneisses on a magnificent scale in Wadi Um Gerat, the importance of *tourmaline-granite* in some of the southern summits, the presence of *spherulitic* felsites forming dykes in many parts of the district, and the probable absence of the *basalt* recorded near Sherm by Burckhardt.

V.—The Connection of the Glacial Period with Oscillation of the Land, especially in Scandinavia.

By Dr. Nils Olof Holst. Translated by F. A. Bather, D.Sc.

[In a recently published paper [1] Dr. N. O. Holst, of the Geological Survey of Sweden, has given a detailed description of the Post-Glacial deposits of the Baltic Sea and the Gulf of Bothnia. The paper is accompanied by a map showing the chief points of observation. The determination of the different horizons depends on (1) the stratigraphy; (2) the sub-fossil diatomaceous flora; (3) the sub-fossil higher flora. The stratigraphical evidence is in the form of numerous sections, taken all along the coast. The diatoms are used chiefly, but not solely, to distinguish the marine from the fresh-water deposits: their determinations, nearly 3,000 in number, are due to Professor P. T. Cleve and his daughter, Dr. Astrid Cleve. The remains of the higher plants have been determined by Dr. Gunnar Andersson.

The fresh-water (*Ancylus*) epoch and the salt-water (*Litorina*) epoch are divided by the author as follows:—

1. The oldest *Ancylus* epoch, the deposits of which age in southern Sweden partly are barren, partly contain Arctic plants.
2. The middle *Ancylus* epoch, of which the deposits contain the remains of fir and birch. During this epoch the land-ice melted away from the lower parts of central Sweden, and the sea came into the Baltic, making the water temporarily salt.
3. The youngest *Ancylus* epoch, or the older half of the oak epoch.
4. The *Litorina* epoch, or the younger half of the oak epoch, when the present communication with the sea was opened, and the water of the inland sea, which during the *Ancylus* epochs had been fresh as a rule, now became salt.

The fact that the climate became temporarily colder in the middle of the *Litorina* epoch is established by finds of boreal diatoms: *Navicula semen, N. amphibola, Pinnularia streptoraphe*, etc.

Wider interest attaches to the concluding pages (113 et sqq.), in which the author deals with the question of oscillation of the land in Scandinavia and with the explanation of the Glacial Period, on which matters he expresses some new views. We therefore offer a full translation of this part of Dr. Holst's memoir.]

I HAVE elsewhere [2] shown that the events immediately connected with the melting of the Scandinavian land-ice occurred in rapid succession. The same was the case with the oldest Post-Glacial events. Thus it has been demonstrated in the present paper that the Glacial marine clay and sand, deposited along the present coast

[1] "Bidrag till kännedomen om Östersjöns och Bottniska Vikens postglaciala geologi": Sveriges Geologiska Undersökning, Afhandl., ser. C, No. 180. 8vo; 128 pp., 1 map; 1899 (published March, 1901).

[2] N. O. Holst, "Har det funnits mer än en istid i Sverige?": Sver. Geol. Unders., 1895, ser. C, No. 151, see pp. 36–39. German translation by W. Wolff, "Hat es in Schweden mehr als eine Eiszeit gegeben?" pp. 38–42; Berlin, 1899.

of Blekinge and of the Kalmar district, were exposed by elevation of the land and were weathered before the deposition of Post-Glacial beds upon them had begun. It was this elevation of the land that connected Scania with Denmark and permitted the immigration of the larger land animals.[1] It appears as though not only this elevation, but also the succeeding depression, during which the oldest *Ancylus* beds were deposited in the government districts of Blekinge and Kalmar, took place in the former district before the Arctic plants had found time to immigrate thither. But when this depression reached the neighbourhood of Kalmar, the Arctic plants were already there. In Blekinge and the Kalmar district there followed an elevation, probably of less importance, and it was not until the succeeding depression, which marks the beginning of the middle *Ancylus* epoch, that southern Sweden saw the deposition of beds that can be paralleled with the oldest Post-Glacial beds of central Sweden. But these latter lie without break conformably on the Glacial beds. This implies that southern Sweden incurred two elevations and their succeeding depressions, in which central Sweden had no share. No explanation of these facts is more natural than that *southern Sweden, relieved of its ice-load, rose*[2] *and began to oscillate, while the land-ice continued to keep central Sweden depressed.* In other words, this means that there was a clear and definite connection on the one hand between the weight of the land-ice and the depression of the land, on the other hand between the removal of the weight and the elevation of the land. But this is a result pregnant with the most important consequences for the whole of glacial geology.

It is clear that the depression, if dependent on the weight of the land-ice, should yield evidence of having been greater the nearer one comes to the centre of the ice; in other words, the nearer one comes to those regions where the ice-load was greatest. A glance at a map indicating the extent of the depression shows at once that such was the case.[3] While in the south the curve of depression

[1] That the aurochs already existed in the province of Kalmar at the beginning of the fir period, i.e. at the beginning of the middle *Ancylus* epoch, has been proved on a preceding page. But the only Post-Glacial elevation of importance that occurred in southern Sweden before that period was the very one that immediately followed the deposition of the Glacial marine beds.

[2] It is quite probable that this elevation during the oldest Post-Glacial Period also reached northern Germany. If such was the case, may it not in part have been the reason why the Vistula and Oder during that period did not flow into the Baltic but had their outlet through the Elbe? Cf. F. Wahnschaffe, "Die Ursachen der Oberflächengestaltung des norddeutschen Flachlandes"; Stuttgart, 1891.

It is also very probable that the same upward pressure of the land outside the periphery of the land-ice took place in North America, and that this affords the correct explanation of many phenomena which otherwise appear inexplicable.

[3] See Gerard De Geer, "Om Skandinaviens geografiska utveckling," 2. Kartor, pls. 2, 3, 4; Stockholm, 1896. The criticism must, however, be passed on these plates that they do not, as they profess, give the depression-curves for different epochs of the melting of the ice, but that all three show only the same thing, namely, the extent of the depression at the time of the final melting of the ice. According to the plates, the depression during the melting of the ice remained the same for a long period, while, on the contrary, all the facts tend to prove that throughout that time the extent of the depression altered very rapidly.

that crosses the southern Baltic, and in the east that which passes by the southern end of Lake Ladoga, both mark zero, as one proceeds from south to north or from east to west the curves mark higher and higher numbers, until the greatest depression known, so far as established by tracing the highest Glacial marine coastline, attains in northern Sweden no less than 280 metres.[1] Lately, indeed, it has been said that in Norrland the Glacial marine coastline is at a lower level in the interior than near the present coast. But if that is the case, we may recall the fact that the highest Glacial coastline was formed at different times in different places. It is therefore quite possible that the apparently abnormal conditions in Norrland spring from nothing else than the formation of the Glacial coastline, first at the coast and afterwards at the interior, for the simple reason that "the ice did not melt from the interior of Norrland until the elevation had been in progress for some time."[2] The conditions in Norrland are therefore in no way opposed to the rule that increased depression and increased ice-load point in the same direction.

Scandinavia under its load of land-ice may be compared to a depressed spring. When the load is removed the land tends to resume its original position. This explains the great rapidity with which the land rose at the close of the Ice Age, a rapidity for which in my above-quoted paper of 1895 I gave conclusive evidence, although I then did not fully understand what caused the rapid rise of the land. But although this demands a certain elasticity in the crust of the earth, yet it cannot be supposed that this elasticity was so great as to permit the land, pressed down as it was during a large part of the Ice Age, to regain the state of equilibrium in which it was at the beginning of the Ice Age; some of the upward tension must in the meantime have been neutralized. The highest Glacial marine coastline therefore marks only the final result of the depression at the moment when the ice melted. Now the position of this line no less than 280 metres above sea-level is alone enough to show that the depression was considerable. But for the reason just mentioned this height indicates *only a part* of the Glacial depression. This line of argument has already led us to the conclusion that at the beginning of the Ice Age Scandinavia lay much higher than now. But that this elevation was in itself enough to afford a simple and natural explanation of the Glacial Period will be proved in the sequel by more conclusive evidence.

From what has been said it is clear that the Glacial and Post-Glacial changes of level in Scandinavia (and the same applies to North America) are due to a special cause, and therefore cannot be compared with volcanic or continent-building oscillations. All attempts to generalize from such comparisons are foredoomed to failure.

[1] A. G. Högbom, "Till frågan om den senglaciala hafsgränsen i Norrland": Geol. Fören. Stockholm Förhandl., 1899, xxi, p. 595.

[2] A. G. Högbom, "Om högsta marina gränsen i norra Sverige": Geol. Fören. Stockholm Förhandl., 1896, xviii, p. 488.

No better success has attended the attempts to discover the cause of the Glacial Period in directions other than that here indicated. Especially is this true of the struggles after some far-fetched astronomical explanation of this terrestrial phenomenon. The geologist who perambulates the universe in search of such explanations may be likened to an erudite bookworm who turns his study upside down in search of his pencil, which all the time is behind his ear.

To the view here stated as to the cause of changes of level in Glacial and Post-Glacial times, I have been led by my own researches, and my ideas already tended in this direction before I realized that T. F. Jamieson, and other geologists after him, had expressed views almost identical with my own. Subsequently I have perused Jamieson's writings on this subject more closely, and, with sincere admiration for his acumen, have found that so early as 1865,[1] supported by comparatively few observations, he put forward the leading idea which in 1882[2] he developed in more detail, and which, confirmed as it now is by more numerous observations, can without hesitation be accepted as the only correct one.

From the papers by Jamieson I think it right to make the following instructive extracts :—

"It has occurred to me [Jamieson] that the enormous weight of ice thrown upon the land may have had something to do with this depression [the great glacial depression]. . . . . We don't know what is the state of the matter on which the solid crust of the earth reposes. If it is in a state of fusion, a depression might take place from a cause of this kind, and then the melting of the ice would account for the rising of the land, which seems to have followed upon the decrease of the glaciers." (Q.J.G.S., loc. cit.)

"Assuming the specific gravity of the ice to have been 875, compared with water as 1,000, or in other words to have been seven-eighths of the weight of water, then the weight of a mass of ice 1,000 feet thick would be 378 pounds to the square inch, or equal to fully 25 atmospheres, and would amount to 678,675,690 tons on every square mile. If the ice was 3,000 feet thick, it would at this rate amount to over 2,000 million tons on the square mile." (Geol. Mag., 1882, p. 403 ; Jamieson here quotes some geologists who have supposed that the thickness of the ice has been much greater, and then he continues as follows :—) "It is evident that a thickness of even 3,000 feet of ice will give us a weight by no means despicable, a weight which would require a marvellous rigidity indeed in the earth beneath it to sustain such a load without yielding in some degree" (p. 404).

"That the crust of the earth is flexible and elastic the phenomena of earthquakes sufficiently demonstrate. The surface heaves like the billows of the sea, sometimes causing trees to bend so as to

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

[2] "On the Cause of the Depression and Re-elevation of the Land during the Glacial Period": Geol. Mag., 1882, Dec. II, Vol. IX, pp. 400 and 457.

touch the ground with their tops, or tossing up flagstones into the air so as to make them come down bottom upwards," etc. (p. 404.)

"If upheavals and depressions of the land have not been caused by changes of pressure, it may be asked, what is it they have been caused by?" (p. 405.)

"If beneath that part of the surface which was affected by the heavy pressure of the ice, there happened to be a quantity of lava in a fluid state, the result might be to cause an outburst of the lava to take place at some more distant point. This would relieve the tension and lead to a permanent depression of the ice-covered area. For example, in North America the great fields of ice that lay on certain portions of that continent by their downward pressure may have occasioned some of those extensive eruptions which seem to have taken place in the region of California after the commencement of the Glacial period. The volcanic phenomena of Iceland in like manner may have been affected by similar causes. That there has been a considerable permanent depression of some of the most heavily glaciated regions since the commencement of the Glacial period, I think there is much reason to believe. The features of the fjord districts of Norway and the West Highlands of Scotland, and of British Columbia, for example, seem to show this; for these coasts have all the appearance of depressed mountain lands, which have been cut and carved by streams and glaciers far beneath the present level of the sea." (p. 405.)

"It seems likely that there might be a tendency to bulge up in the region which lay immediately beyond this area of depression; just as we sometimes see in the advance of a railway embankment, which not only depresses the soil beneath it, but also causes the ground to swell up further off." (p. 461.)

So far Jamieson. His ideas have, before me, been shared by Whittlesey, N. S. Shaler,[1] and Warren Upham,[2] the last-mentioned having developed them further. Upham calls our special attention to the indisputable glacial formations that date from the Carboniferous or Permian periods, as that in South Africa at 30° S. lat.,[3] in India at only 20° N.,[4] as well as in Australia,[5] and he correlates these phenomena with the mountain-building that took place during that time. Of the glaciated areas here mentioned I have myself visited that in Australia, in the neighbourhood of Bacchus Marsh, just west of Melbourne (37°–38° S.), and can confirm the correctness of the descriptions given. Here occurs a typical boulder-clay, of blue

[1] "Fluviatile Swamps of New England": Amer. Journ. Sci., 1887, ser. III, vol. xxxiii. See pp. 220, 221.

[2] "Probable Causes of Glaciation," Appendix A to G. F. Wright's "The Ice Age in North America"; New York, 1891. See also Amer. Geol., 1890, pp. 327 et sqq.; and Amer. Journ. Sci., 1891, vol. xli, p. 33.

[3] A. Schenck, "Ueber Glacialerscheinungen in Südafrika": Verhandl. des VIII deutschen Geographentages in Berlin, 1889.

[4] R. D. Oldham, "A Manual of the Geology of India," Calcutta, 1893. See pp. 157 and 198.

[5] T. W. E. David, "Evidences of Glacial Action in Australia in Permo-Carboniferous Time": Quart. Journ. Geol. Soc., 1896, lii, p. 289.

colour, containing glacially striated stones of many kinds of foreign rocks. This boulder-clay is overlain by sandstone with *Gangamopteris*, belonging to the Carboniferous or the Permian system. What cast suspicion on the glacial deposits of Australia was the great thickness ascribed to them, namely, as much as 5,000 feet. But this estimate, which sounds so fantastic, is really founded on a mistake that arose in the following way:—In the valley where this thickness was calculated the morainic beds are obliquely inclined one above the other. By measuring each of these beds and adding the apparent thicknesses together a total was obtained which naturally was not the true vertical thickness. That this in reality is not so extraordinarily great is clear from the fact that the solid Silurian rock crops out both at the bottom and on the side of the valley in question. For a 5,000 foot thick moraine to find room between these outcrops, it must lie in a very deep hollow of most unusual and inexplicable shape.

For my part I think Upham must be accounted right in his contention that the glacial phenomena of South Africa, India, and Australia can be explained only on the supposition that these districts formerly lay much higher than now. Especially does this apply to the Indian glacial district, situate only 20° from the equator. There is no place here for the interglacialist hypothesis, and if a former elevation be not admitted for this district we may justly ask what else can have produced glacial phenomena so near the equator. On the other hand, we may adduce the fact that Kilima Ndjaro in East Africa, said to be about 6,000 metres high, exhibits glaciation although only 3° from the equator.

But if an elevation of the land in equatorial regions can produce glaciers, what glacial results may we not expect from an elevation in the latitude of Scandinavia, Greenland, and North America? The question is reduced to this: Can we show that during Quaternary times such an elevation really did take place in the three great glacial districts? It is as a rule difficult to prove former elevation of the land if the region once raised now lies sunk below sea-level; but in proportion as the oceans that bound North America and Scandinavia have been more closely investigated this proof has been forthcoming, and a considerable elevation of Quaternary age is now fully established both for North America and Scandinavia.

As regards North America, many geologists, of whom I shall cite only J. W. Spencer,[1] have demonstrated that the larger rivers on the eastern side of the continent, from the Mississippi up to the St. Lawrence, have channels clearly excavated beyond the coast to a depth below the sea of "3,000 feet or more"; and this naturally indicates that formerly the land was elevated to a corresponding height. Similar observations have been made on the Pacific coast of North America. That this elevation took place at a relatively recent period follows from the fact that the submarine channels are not filled up as they would otherwise have been.

[1] "The High Continental Elevation preceding the Pleistocene Period": Bull. Geol. Soc. Amer., 1890, i, p. 65.

Like observations have been made on the coast of Norway, where the deep fjords continue as submarine valleys beyond the present coast to a great depth. For these to have been carved out by the rivers of a past age, the land must of course have lain much higher than now. The so-called 'Norwegian Channel,' if, as is probable, it represents an ancient river-bed, proves the same thing.

The Scandinavian Pre-Glacial elevation, however, was not confined to the coast of Scandinavia, but evidently affected a large part of the bottom of the present North Atlantic, both westwards to the east[1] coast of Greenland and southwards to the south part of England. So far as Great Britain is concerned this elevation is undeniable. The mere existence in this country of a Pre-Glacial mammalian fauna, obviously exterminated by the Ice Age[2] and partly reminiscent of more southern regions (elephants of various species, mammoth, mastodon, lion, hyæna, etc.), is enough to presuppose a land-connection between the continent and England and Ireland, so that the animals could cross to these islands.[3] But these mammals did not merely *wander across* the English Channel and the southern parts of the North Sea; they also *inhabited* the districts now sunk beneath the waters, as may be inferred from the "almost incredible" "quantity of teeth and bones belonging to the mammoth, woolly rhinoceros, horse, reindeer, and spotted hyæna, and other animals, dredged up by the fishermen in the German Ocean" (op. cit., p. 365). That the animals lived here at no distant date follows from the fact that their bones are found on the very surface of the sea-floor, as well as from the mixture of remains of Pre-Glacial animals with those of the reindeer, as to whose contemporaneity with the Ice Age there can be no doubt. Finds of this boreal species on the floor of the North Sea show further that the elevation still existed when the Glacial Period was setting in.

Furthermore, submarine peat-bogs along the coast of England, as well as the discovery of the fresh-water bivalve, *Unio pictorum*, and *shore* shells at a greater depth than 200 feet in the English Channel (op. cit., p. 364), bear clear witness to an elevation of the land in Quaternary times.

But the depth of the English Channel and of the southern part of the North Sea is not very great—at the southern end of the Dogger Bank not more than 13–16 metres—and a raising of the sea-bottom from 30 to 50 metres would be enough to bring a large

[1] 'Västra' (west) in original; correction by the author.

[2] H. H. Howorth, "Did the Mammoth live before, during, or after the Deposition of the Drift?": Geol. Mag., 1892, Dec. III, Vol. IX, pp. 250 and 395.

In England the so-called interglacial occurrences of the larger mammals seem to rest only on mistakes or on the estimation of secondary occurrences as primary. Of course they disappear at the same time as the so-called 'interglacial' deposits cease to be interpreted as interglacial, and this is already the case with the majority. Thus the 'middle sand,' formerly the most important of the interglacial formations, is now very generally regarded as glacial. And, so far as I could discover from conversation with English geologists, the idea of a true 'interglacial' period is now almost abandoned by them.

[3] W. Boyd Dawkins: "Cave Hunting, etc."; London, 1874. See p. 362.

part of it above the surface. It may therefore be objected that, even though the land-connection in question may really have existed, still it is in itself no proof of any considerable elevation, certainly not of one great enough to explain the severe climate of the Glacial Period. And this, no doubt, is perfectly true.

But there are other evidences for a much greater elevation in the north-west of Europe. That the agreement between the floras of Scandinavia, Scotland, the Faeroes, Iceland, and Greenland necessarily presupposes a land-connection in Quaternary times, has been long understood. Such a connection involves an elevation of the sea-floor between Scotland and Greenland of about 3,000 feet (891 metres).[1] But did such an elevation really take place during the Quaternary Period? Conclusive proof of it was given by A. S. Jensen,[2] when he demonstrated the logical consequences of the discoveries made by the Ingolf expedition in 1896 during the investigation of the sea-floor between Jan Mayen and Iceland. Here the expedition found at a great depth, reaching as much as 1,309 Danish fathoms,[3] such *shallow*-water bivalves as *Astarte Banksii, A. borealis, A. compressa, Cardium ciliatum, C. groenlandicum, Cyrtodaria siliqua, Macoma calcaria, Saxicava arctica,* and *Yoldia arctica.* These marine molluscs, which can live only at small depths, according to Jensen in not more than 100 fathoms of water, occur in great numbers, and it is quite clear that they have lived where their shells now are met with. These discoveries therefore prove that the sea-bottom between Scandinavia and Greenland once lay more than 1,200 fathoms (2,138 metres) higher than now. As for the date of the elevation, Jensen justly observes that the occurrence of *Yoldia arctica* is enough to show that it took place during the Glacial Period. During which part of that period the elevation existed is not discussed by Jensen, but it is most reasonable to refer it to the beginning of the period, when an elevation is established both for England and Scandinavia.[4] If this elevation started from the Archæan district of Scandinavia and of Greenland, as there is good reason for supposing, then the elevation of Scandinavia must have been greater than that demonstrated by Jensen for the sea-floor between Scandinavia and Greenland. But if the elevation was only of the same, or even approximately the same magnitude, it was still quite enough to afford an explanation of the Glacial Period itself.

But this elevation of the sea-floor between Scandinavia and Greenland carried with it another important consequence, in that it changed this part of the ocean into an inland sea, comparable with the Mediterranean, and united with the body of the Atlantic only by the deep channel between the Shetlands and Faeroes.[5]

[1] See the map to W. H. Hudleston's paper "On the Eastern Margin of the North Atlantic Basin": Geol. Mag., 1899, Dec. IV, Vol. VI, p. 97.

[2] "Om Levninger af Grundtvandsdyr paa store Havdyb mellem Jan Mayen og Island": Vidensk. Meddel. Naturhist. Foren. Köbenhavn, 1900, p. 229.

[3] 8,087 English feet; 2,465 metres.—Translator.

[4] The same elevation also reached Iceland. See Th. Thoroddsen in Geol. Fören. Stockholm Förhandl., 1900, xxii, p. 546.

[5] Cf. Hudleston's map cited above.

From this in turn it followed that the Gulf Stream was completely shut off from the Arctic Ocean and forced to turn south and west of the British Isles, and thus to concentrate its heat-giving energy on central Europe. This explains the mild climate found in a portion of Europe during a stage of Pre-Glacial time.

As shown above, it may be considered as a fact confirmed by known phenomena, that at the beginning of the Quaternary Period portions of the North American continent lay at least 1,000 metres, and Scandinavia still more, perhaps 2,000 metres, higher than now. As for the intervening Greenland, it seems probable that it could not be unaffected by these changes of level, but that it took part in them.[1]

We meet here the legitimate question: What is it that produced such a great elevation in these particular parts of our earth? The answer is that North America, Greenland, and Scandinavia, not merely taken together, but each separately, are the largest areas of Archæan rocks in the world.[2] The remarkable coincidence of the great glaciated districts with the Archæan districts has long since been commented on as peculiar. No explanation, however, has been given of this fact. What it really means I shall here show.

During the Silurian Period Scandinavia was partly covered by the sea, as clearly proved by the numerous patches of Silurian rock. Possibly the same was the case during a part of the Devonian Period. But before the close of that period Scandinavia rose above the water, and probably went on rising right up to the Quaternary Period. At all events the Archæan area of Scandinavia never again sank beneath the sea, as clearly demonstrated by the absence of younger marine formations from within its boundaries. Examination of a geological map of Europe shows that the shore of the later Palæozoic, and still more that of the Mesozoic, sea moved eastwards further and further away from Scandinavia, which seems to imply that, during the long ages that elapsed after the Silurian (or Devonian) Period, Scandinavia continually rose, and involved in its rise a part of the surrounding area.

The course of events on the North American continent was precisely the same. Here the shore of the later Palæozoic and Mesozoic sea moved southwards ever further and further from the rising Archæan area of the north.

On what can this harmony of events have depended?

If so late as the Quaternary Period the crust of the earth was found to yield to the pressure of the land-ice, still more must it have yielded to burdens during the earlier stages of the earth's development. That this was actually the case is shown in Scandinavia itself by numerous instances from Cambro-Silurian times. For some years it has been well known that faults, often accompanied

[1] During my journey to Greenland in 1880 I saw from the sea south of Ivigtut supposed beaches in a situation exposed to the sea at a great height on the mountain slopes. Time, however, did not permit me to examine them. Numerous similar observations are mentioned in "Meddelelser om Grönland."

[2] See Berghaus' "Physikalischer Atlas," Maps 7/8, 9, and 13; Gotha, 1892.

by breccia-formation, may be observed in Scandinavia at many points on the boundary-line between the Archæan and Cambro-Silurian deposits, as on Bornholm, in Scania, on Lake Vetter, in Ostrogothia, Nerike, Dalecarlia, Gestrikland, Jemtland, on the Christiania fjord, on the Kola peninsula, and other places.[1] Even the quite insignificant occurrence of Silurian at Humlenäs in the province of Kalmar can show a similar fault with accompanying breccia-formation. For my part I do not think that any explanation of these phenomena will ever be found more satisfactory than that the earth's crust, which during the Cambro-Silurian periods was much thinner than now, yielded beneath the weight of the Cambro-Silurian sediments. If such were the conditions, we can also understand the immense thickness which the Palæozoic rocks occasionally attain, and which may have arisen by the gradual sinking of the sea-floor in proportion as the formation of sediment proceeded.[2]

But if sedimentation tends to depress the earth's crust, and actually has depressed it in certain places, then to such a sinking there must have corresponded elevation in another place[3]; and it is precisely this elevation above all that has affected the Archæan areas, and particularly the greater ones — those that could, so to speak, move independently—because these areas have not merely formed the thinnest parts of the crust, but have lacked the strengthening influence of the stratified deposits.

This, then, seems to have been the way in which elevation of the Scandinavian and North American Archæan areas was brought about and carried on, until at the beginning of the Glacial Period they had reached such a height that each formed the centre for an ice-sheet.

If the conception put forward in the preceding pages is the right one, it follows that the phenomena which accompany the appearance of an ice-sheet involve such radical and manifold changes within the glaciated area that an Ice Age cannot, so to say, come and go unmarked, but must leave the most obvious traces behind it. Therefore it is that the idea here propounded is utterly opposed to the interglacialist view, and therefore it has been attacked by champions of the latter.[4] The chief objection raised by them to the present explanation of the Ice Age is the following.

Granted, they say, that this might be quite a satisfactory explanation of the Scandinavian, Greenland, and North American ice-sheets, still it is not enough to explain the former small glaciated areas in the Pyrenees, the Alps, the Caucasus, and so forth. To

[1] See "Generalregister" to vols. vi–x of Geol. Fören. Stockholm Förhandl., p. 34. A fault in Jemtland is described by A. Högbom in his paper, "Om förkastnings-breccior vid den Jemtländska silurformationens östra gräns": Geol. Fören. Stockholm Förhandl., 1886, viii, p. 352.

The Palæozoic faults on the Kola peninsula have been described by W. Ramsay, Fennia xvi, No. 1, pp. 2 and xv; No. 4, pp. 7 and 11.

[2] The same views were expressed by James Hall in the "Palæontology of New York," iii, pp. 69 et sqq.; Albany, 1859.

[3] Cf. J. Hall, op. cit., p. 95.

[4] J. Geikie: "The Great Ice Age," 3rd ed., p. 792; London, 1894.

this, however, it may be replied that these smaller peripheral glacial areas were perhaps directly due to the general sinking of temperature produced by the North European ice-sheet during its maximum extension.

That such a fall in temperature really took place may be considered as proved by the fact that so boreal an animal as the reindeer, during a part of the Glacial Period, had a wide distribution in southern Europe. And, as regards the cause of the smaller peripheral glaciated districts, it may once more be recalled that if a mountain chain be sufficiently raised, no matter by what cause, a glaciated area may be produced when and where you please.

But there is another objection, which, at first glance, seems more weighty. Besides the oscillations of Glacial age, there have in Sweden also been some of Post-Glacial age, partly during the *Ancylus* period, partly during that of *Litorina*. Now, if the pressure of the land-ice and the removal of that pressure afford a valid explanation of the former—and it can hardly be denied that such is the case—still it seems quite impossible that they can explain the latter. Surely the ice-sheet cannot produce oscillations of level some ten thousands of years after its disappearance. So no doubt it seems; and yet this is exactly what the ice has done.

Nowadays it is well known that the Glacial and Post-Glacial areas of depression almost entirely coincide. Not only do the zero curves on the periphery of these areas follow the same course, but the maxima or centres themselves are on the whole the same.[1] It is only the amount of the depression that was different, the Glacial sinking reaching 280 metres, the *Ancylus* sinking exceeding 200 metres (?), and that of the *Litorina* period being about 100 metres.[2]

The conformity now demonstrated between the Glacial and Post-Glacial changes of level points to a common cause. This has long since been perceived, and A. G. Högbom, who remarked the fact, expressed it as follows: "The same factors have governed the oscillations of the land continuously from the Ice Age to the present day."[3] But what can the common cause or common factor have been? To this I reply: Nothing else than the removal of the ice-pressure. When this ceased the Scandinavian area of depression was set in a swinging motion, like a pendulum set free. This area, depressed somewhat lower than the highest Glacial coastline, rises for the first time as the land-ice disappears. This is the late Glacial elevation. It sinks afresh in the *Ancylus* period, and during this depression the highest *Ancylus* beach is formed.[4] But again the area rises, and finally sinks for the third time to the level marked

[1] Gerard De Geer: "Om Skandinaviens geografiska utveckling," 2. Kartor, pls. 4, 5, and 6; Stockholm, 1896.

[2] The arithmetical progression from 100 to 200 and 280 is not regular. May not this indicate that the last figure is too low, and that the Glacial depression was greater than is shown by the highest Glacial marine coastline?

[3] "Om högsta marina gränsen i norra Sverige": Geol. Fören. Stockholm Förhandl., 1896, xviii. See p. 487.

[4] There is no reference here to the undulatory motion of the land-oscillations, but only to their final result.

by the highest *Litorina* beach. The elevation consequent on that is still going on.[1] And it is not too rash to predict that these oscillations will continue until the ever-weakening effect of the impulse given by the land-ice is neutralized by the other terrestrial factors that produce land-oscillations.[2]

From the foregoing pages it appears that "the *Post-Glacial* geology of the Baltic Sea and the Gulf of Bothnia" stand in the closest relation to their Glacial geology. Therefore I have been unable to make the former clear without at the same time throwing some light on the latter.

VI.—On the Fish Fauna of the Millstone Grits of Great Britain.

By Edgar D. Wellburn, L.R.C.P., F.G.S., F.R.I.P.H., etc.

Introduction.

On June 10th, 1898, whilst on an excursion with the Yorkshire Geological and Polytechnic Society, I found three specimens of fish remains in the Millstone Grits at Summit in Lancashire. Subsequently, on several occasions, I again visited the district and succeeded in collecting a large number of fish remains, and on these, together with a few other specimens which had been found in these rocks at rare intervals, I have based the following paper.

General Remarks.

Brief Description of the Millstone Grit Rocks.

The Millstone Grit rocks may be naturally grouped into three divisions, viz.: (1) the Rough Rock at the top; (2) the Kinder or Pebble Grits at the base; with (3) between them the Middle Grits, which are composed of thick beds of shales alternating with bands of grit rock. The Middle Grits may again be subdivided into four groups, viz., A, B, C, and D beds, A being the uppermost.

The great Pennine Anticline, between Lancashire and Yorkshire, is mostly composed of these rocks, and on the Lancashire side, south-west of Walsden, at the head of the Calder Valley, there are on the south side several splendid exposures of these rocks; in one quarry near Summit, Lancashire, there is a very good section of the D beds of the Middle Grits, and in the shales near the base there are a number of nodular masses composed of impure limestone; it is from these nodules that I have collected the majority of the fish remains.

The nodules are of peculiar conformation, and vary in size, many being 24 inches in length, 18 in width, and 9 or 10 inches

[1] Each successive swing was naturally not only less extensive but shorter than the preceding. From this it may be inferred that the *Litorina* depression prevailed a shorter time than the *Ancylus* depression.

[2] Here, of course, it is only Scandinavia that is alluded to. But the same remarks are largely applicable also to North America, although it is not unlikely that the North American ice-sheet, being much larger than that of Scandinavia, melted later than it. In that case the Post-Glacial epoch must have been shorter in North America than in Europe. Herein may lie the reason why many North American geologists, in their estimates of Post-Glacial time, have arrived in harmony at such low figures as 7,000 to 10,000 years—a far shorter time than that in which the Post-Glacial deposits of Scandinavia were formed.

in depth. At the base of the nodules there is a layer of cone-in-cone, two to three inches in thickness, at the top three to four inches of hard dense limestone, which breaks with a conchoidal fracture, whilst between these the stone is more impure, there being a certain admixture of arenaceous matter, and here the rock will split into laminæ of from a third to half an inch in thickness. The majority of the fish remains were found on these slabs, but others, in a more fragmentary condition, occur in the upper layers of the nodules.

That the nodules were formed under marine conditions is proved by the fact that mixed among the fish remains are shells of *Goniatites*, *Orthoceras*, *Aviculopecten*, *Posidonomya*, etc. In some rare instances plants are found, but only in a very fragmentary and eroded condition, and in the upper portions of the nodules I have in rare instances found corals and crinoids. These taken together point to the fact that the fish-bearing nodules were formed under estuarine conditions.

I have found similar nodules at Wadsworth Moor, Yorkshire, where the late Captain Aitken [1] collected his fish remains, and feel certain that his specimens were obtained from the same horizon as the one at Summit.

Fish remains have also been found in the D Shales of the Middle Grits at the following localities in Yorkshire, viz., Eccup, near Leeds; Boulder Clough, Sowerby, and Kilne House Wood, Luddenden, both near Halifax; and the late Mr. James Spencer, of Halifax, mentions [2] *Elonichthys Aitkeni*, Traq., as occurring in the Rough Rock and the B and C beds of the Middle Grits, but unfortunately he gives no localities.

The collection is of great interest, both from a geological and a zoological point of view—both as largely increasing our knowledge of a fish fauna in a group of rocks whose yield of fossil fish has hitherto been extremely limited, and zoologically in the fact that one genus and several species are new to science, whilst others are placed on record as obtained from these rocks for the first time.

Concerning the appended list of genera and species the following facts stand out as worthy of special mention (in addition to those mentioned above), viz.: (1) the occurrence of the genus *Climatius*, a fish that has hitherto occurred only in the Lower Old Red Sandstones of Forfarshire; (2) the appearance in the Millstone Grits of the genera *Orodus*, *Psephodus*, *Pristodus*, etc., for the first time; and (3) the occurrence of the peculiarly interesting Ichthyodorulites, for which I have felt compelled to institute the new genus *Euctenodopsis*.

Remarks on the Fish Remains.

Family CLADODONTIDÆ.

Genus CLADODUS, Agassiz, 1843.

Cladodus mirabilis, Agassiz, 1843.

The late Mr. Aitken,[3] of Bacup, found teeth of this genus in the

[1] Trans. Manchester Geol. Soc., vol. xiii, p. 36.
[2] Proc. Yorks. Geol. and Polyt. Soc., vol. xiii, pt. 4.
[3] Aitken, op. cit.

D Shales of the Middle Grits at Wadsworth Moor, Yorkshire, and there is also a tooth in the Woodwardian Museum, Cambridge,[1] which shows the characters of the above species. It is from the same locality and horizon.

Family PRISTODONTIDÆ.

Genus PRISTODUS, Davis (*ex* Agassiz MS.), 1883.

Pristodus falcatus, Davis, 1883.

I have found one tooth of this species.

Form. and loc.: D Shales, Middle Grits, Summit.

Family COCHLIODONTIDÆ.

Genus PSEPHODUS, Agassiz, 1862.

Psephodus, sp. nov.

Among the fish remains from Summit there is a series of three lower (?) dental plates of *Psephodus*, having the following characters, viz.:—The plates increase in size from before backwards, and have the following measurements: anterior plate, anterior posterior measurement 0·0008 m., transverse 0·0015 m.; median plate, anterior posterior 0·001 m., transverse 0·002 m.; posterior plate, anterior posterior 0·001 m., transverse 0·0025 m. The margins, where the teeth are in juxtaposition, are nearly straight, the anterior one being very slightly convex, whilst the posterior one is very slightly concave; the posterior margin is greater in transverse measurement than the anterior; the outer margin is straight, the inner one gently curved throughout its length. The crown is gently arched from side to side, and the anterior external angle being somewhat inrolled gives a slight obliquity to the coronal ridge. The crown is covered with a dense layer of ganoine. The base is thick and strong, and conforms with the surface of the crown.

Remarks.—Although the plates are so small, their characters are so well displayed that I am not inclined to consider them as plates of a young fish, but rather, from the fact that they do not appear to agree with the specific diagnosis of any of the known species of *Psephodus*, I am inclined to treat them as dental plates of a new species, for which, on account of their small size, I propose the specific designation *minuta*.

Form. and loc.: D Shales, Middle Grits, at Summit.

Genus PŒCILODUS, McCoy (*ex* Agassiz), 1855, amend. A. S. W., 1889.

Pœcilodus Jonesii, McCoy, 1855.

Anterior half of a dental plate.

Form. and loc.: D Shales, Middle Grits, Summit.

Family CESTRACIONTIDÆ.

Genus ORODUS, Agassiz, 1838.

Orodus elongatus, Davis, 1883.

I have found two well-marked teeth of this species, one being almost identical with *O. elongatus*, the other with *O. angustus*, as figured by the late Mr. J. W. Davis, F.G.S.[2]

Form. and loc.: D Shales, Middle Grits, Summit.

[1] Wellburn, op. cit. [2] Trans. Roy. Dublin Soc., vol. i, sect. 2, pl. li, figs. 1, 4.

Insertæ sedis.

I here place certain small Helodont teeth, one of which shows the characters of *H. triangularis*, Davis, the latter, from its unsymmetrical form, being in all probability a medio-lateral, and others, which are smaller and more symmetrical, being symphyseal teeth of *Psephodus* or some other Cochliodont fish.

Form. and loc.: D Shales, Middle Grits, Summit.

Family ACANTHODIDÆ.

Genus ACANTHODES, Agassiz, 1833.

Acanthodes Wardi, Egerton, 1866.

The best specimen of this fish I found at Summit; it shows the fish from a point a short distance in front of the pectoral fin spine, the basal portions of which are preserved, to a point some little distance behind the dorsal fin spine, which is also present. The body is clothed with small quadrate scales, which I am unable to distinguish from those of *A. Wardi*, Egert., of the Coal-measures. Besides the above, fragments of the fish and many fin spines have been found.

Form. and loc.: D Shales, Middle Grits, Summit; Boulder Clough, Sowerby; and Kilne House Wood, Luddenden, near Halifax.

Acanthodes, sp. nov.

One fragment of *Acanthodes* shows characters which appear to entitle it to specific distinction, viz., the scales are very minute and are ornamented with fine diagonal striæ. The only species of *Acanthodes* that I know of with this scale sculpture is *A. concinnus*, Whiteaves,[1] but in this species the fin spines are ornamented with "about four longitudinal grooves," whereas the present species shows no evidence of these grooves, the fin spines being broad and elongated, having a single groove and ridge running parallel with the anterior border. On account of the scale sculpture I propose the specific designation *striatus* for this species.

Form. and loc.: D Shales, Middle Grits, Summit.

Genus CLIMATIUS, Agassiz, 1845.

Climatius, sp.?

Among the fish remains there is the crushed body of a small Acanthodian fish of about 50 mm. in length. The body, which appears to have been of a somewhat slender form, is covered with smooth quadrate scales, and there are several fin spines present, some being detached from the body but lying in close proximity to it; the majority of the spines are broad and robust, the others being straight, narrower, and more elongated, and all are ornamented with coarse longitudinal ridges, and in general characters agree very closely with those of the Old Red Sandstone fish *Climatius* as figured and described by Sir P. Egerton[2] and Mr. J. Powrie, F.G.S.[3] I have also carefully examined the specimens of *Climatius* in the

[1] Trans. Roy. Soc. Canada, vol. vi, sect. 4.
[2] Mem. Geol. Survey, Fig. and descrip. organic remains, dec. x.
[3] Trans. Edin. Geol. Soc., vol. i.

British Museum (Natural History), Cromwell Road, and consider that the above fish should be placed in this genus, but the crushed condition of the specimen renders the determination of its species one of some difficulty, and it appears best to leave this question for later consideration. Besides the above I have found several detached spines of this fish.

Form. and loc.: D Shales, Middle Grits, Summit.

ICHTHYODORULITES.

Genus ACONDYLACANTHUS, St. John & Worthen, 1875.

Acondylacanthus, sp.?

One spine shows the characters of this genus, but it has suffered so much from erosion that the determination of its species is impossible.

Form. and loc.: D Shales, Middle Grits, Summit.

Genus EUCTENODOPSIS, gen. nov.

Euctenodopsis, sp. nov.

This Ichthyodorulite is most interesting, and at first sight might easily be mistaken for a specimen of the nearly allied genus *Euctenius*, Traquair. However, on a more careful examination it is at once apparent that it does not agree with the generic diagnosis of that genus, as given by Dr. Traquair,[1] in the important fact that, instead of having one end (the proximal) "rounded or blunt," this portion is drawn out and forms a more or less spatulate extension, which appears to differ somewhat in texture from that of the other portions of the spine. I say spine, as I consider the Ichthyolite was a dermal defence of some Selachian fish, and that the spatulate extension was its point of insertion. Although the spine is narrower and more elongated than any of the known species of *Euctenius*, still, in many of its characters it agrees with that genus, being more or less elliptical in form, laterally compressed, one side concave, the other convex, one extremity produced into a long narrow extension, and the convex margin is divided in a comb-like manner into a number of closely arranged blunt-pointed denticles.

On account of the above-mentioned peculiarity—the spatulate extension at its proximal end—I venture to place the spine in a new genus, for which I propose the name *Euctenodopsis*, and, on account of its narrow and elongated form, with the specific designation *tenuis*.

Form. and loc.: D Shales, Middle Grits, Summit.

Family RHIZODONTIDÆ.

Genus STREPSODUS, Young, 1866.

Strepsodus sulcidens, Hancock & Atthey, 1870–1871.

Mr. Aitken[2] in his paper refers to a tooth of *Strepsodus*. Mr. John Ward, F.G.S., of Longton, who has seen the specimen, informs me that it was a tooth of *Strepsodus sulcidens*.

Form. and loc.: D Shales, Middle Grits, Wadsworth Moor.

[1] Geol. Mag., Dec. II, Vol. VIII (1881), pp. 36–334.
[2] Aitken, op. cit.

Family CŒLACANTHIDÆ.

Genus CŒLACANTHUS, Agassiz, 1836, 1843.

Cœlacanthus, sp. nov. ?

I have found several slabs showing the remains of this genus, but am as yet not satisfied as to the species, although I am inclined to regard it as new on account of the proportion and ornamentation of the head bones and the sculpture of the scales.

Form. and loc. : D Shales, Middle Grits, Summit.

Family PALÆONISCIDÆ.

Genus RHADINICHTHYS, Traquair, 1877.

Rhadinichthys, sp. nov.

Form. and loc. : D Shales, Middle Grits, Summit.

Rhadinichthys, sp. nov. ?

Form. and loc. : D Shales, Middle Grits, Summit.

Genus ELONICHTHYS, Giebel, 1848.

Elonichthys Aitkeni, Traq., 1886.

Several fragments of this fish have been found.

Form. and loc. : D Shales, Middle Grits at Summit and Wadsworth Moor[1] (also B and C Shales, Middle Grits and the Rough Rock, localities not given[2]).

Elonichthys, sp. nov.

Form. and loc. : D Shales, Middle Grits, Summit.

Elonichthys, sp. nov.

Form. and loc. : D Shales, Middle Grits, Summit.

Genus ACROLEPIS, Agassiz, 1833, 1844.

Acrolepis Hopkinsi, McCoy, 1855.

Several fine fragmentary specimens of this fish have been found, notably those from Wadsworth Moor which are in the Woodwardian Museum, Cambridge.[3]

Form. and loc. : D Shales, Middle Grits at Summit and Wadsworth Moor.

Note.—I intend to fully describe the new species later. Mr. John Ward, F.G.S., who has seen the specimens, quite agrees with me that they are undoubtedly new. The fish remains, with two or three exceptions, are in the author's cabinets.

Before concluding, I must acknowledge, with warmest thanks, the great obligation I am under to Dr. Henry Woodward, F.R.S., etc., and Dr. A. Smith Woodward, F.L.S., for allowing me to examine and compare my fish remains with those in the Natural History Museum, Cromwell Road. I am also indebted to Mr. John Ward, F.G.S., for giving me his opinion on the new Palæoniscidæ.

[1] Wellburn, op. cit.
[2] Spencer, op. cit.
[3] Wellburn, op. cit.

TABLE OF LOCALITY AND STRATIGRAPHICAL DISTRIBUTION.

	D Shales, Middle Grits, Summit, Lancashire.[1]	D Shales, Middle Grits, Wadsworth Moor, Yorkshire.	D Shales, Middle Grits, Boulder Clough, Sowerby, Yorkshire.	D Shales, Middle Grits, Kilne House Wood, Luddenham, near Halifax, Yorks.	D Shales, Middle Grits, Eccup, near Leeds, Yorkshire.	B Shales, Middle Grits. Locality ?[2]	C Shales, Middle Grits. Locality ?[2]	Rough Rock. Locality ?[2]
Subclass **Elasmobranchii.**								
Order Ichthyotomi.								
Cladodus mirabilis, Agassiz	?	*						
Order Selachii.								
Pristodus falcatus, Davis...	*							
Psephodus, sp. nov.	*							
Pœcilodus Jonesii, McCoy	*							
Orodus elongatus, Davis	*							
Helodus, sp. ?	*							
Order Acanthodi.								
Acanthodes Wardi, Egerton	*	*	*	*	*			
Acanthodes, sp. nov.	*							
Climatius, sp. ?	*							
Ichthyodorulites.								
Acondylacanthus, sp. ?	*							
Euctenodopsis, gen. et sp. nov.	*							
Subclass **Teleostomi.**								
Order Crossopterygii.								
Strepsodus sulcidens, Hancock & Atthey	...	*						
Cœlacanthus, sp. nov. ?	*							
Order Actinopterygii.								
Rhadinichthys, sp. nov.	*							
Rhadinichthys, sp. nov. ?...	*							
Elonichthys Aitkeni, Traquair	*	*	...	...	...	*	*	*
Elonichthys, sp. nov.	*							
Elonichthys, sp. nov.	*							
Acrolepis Hopkinsi, McCoy	*	*	...	...	*			

* New to the Millstone Grit rocks.

[1] This is the first time that fish remains have been described from this locality.

[2] These three horizons given on the authority of the late Mr. James Spencer, of Halifax (op. cit.).

VII.—Oscillations in the Sea-level. (Part II.)

By H. W. Pearson.

(*Continued from the April Number, p.* 174.)

IN the "Gallery of Nature," Milner, p. 388, it is stated that Brighton (then a mere village) in the time of Elizabeth (1558–1603) "stood upon a site where the sea now rolls, and where the chain pier stands." We might infer from this statement that at Brighton the sea, since the date mentioned, had been elevated over the land. We cannot draw this conclusion, however, with certainty, for the reasons following:—

During the last century the eastern coast of England has been constantly eaten into by the sea; churches, farms, and towers have been repeatedly devoured by the waves. In this district, however, we know that these results have not been caused by a rise in surface-level of the waters; we know that erosion by waves and currents has been the sole cause for these changes. It is absurd, therefore, to assume that Brighton during the last few centuries has alone suffered submergence, while all Britain has elsewhere undergone continual upheaval. Erosion, then, is the more probable explanation of this item, and it should not be held as evidence conflicting with our curve.

A conflicting point of great weight was found in Rear-Admiral Smyth's statement, that the city of Spina in the time of Scylax "was about 2½ miles from the sea, but in less than 600 years afterwards Strabo describes it as being 90 stadia, or more than eleven miles inland" ("The Mediterranean," p. 47). This remark of Smyth's as to the 600 years disturbed me. Our period of vibration in the sea-level at the time mentioned being perhaps a little short of 600 years, there should have been little change in Spina's distance from the sea at these two epochs. On investigation, however, I found that there were two or three writers of this name. I believe, therefore, that Smyth, like others before him, has confounded Scylax of Caryanda, author of the "Periplus" of the Mediterranean, who wrote about 335 B.C. (Müller) or 352 B.C. (Niebuhr), with the Scylax of Caryanda who explored the Indus for Darius perhaps 515 B.C. or a little later. (See Encyc. Brit., article *Scylax.*)

It seems much more probable to me that information as to the shores of the Adriatic should be found in the writings of the later Scylax. I therefore, with some reason, assume that in this case I am more liable to find *two points confirmatory of my curve*, one for the low-water period of the epoch of Strabo, the other for the high-water period of the later Scylax, rather than a conflicting point as it first appeared on my diagram.

Strabo (Bk. xvi, chap. 4) describes the harbour of Charmothas, Arabia, as, at the time of his writing, apparently in actual existence. Under the same chapter, however, in a footnote from Gossellin, we learn that to-day, from the accumulation of soil, this harbour "is more than a day's journey into the interior of the country." This recession should not be; no retreat of the sea, if our curve is to be depended on, can have occurred since Strabo's epoch; this observation is therefore strongly antagonistic to our conclusions.

On investigation, however, we learn that Strabo's statement was borrowed from Artemidorus, who in his turn had borrowed his description from Agatharchides, 146 B.C. or thereabouts. We find, when we thus trace the observation to its true date, that all antagonism disappears. Agatharchides flourished during a high-water period, consequently the observed recession could have been foretold from inspection of our curve. (For discussion of true date see Hamilton & Falconer's Translation, vol. iii, p. 192.)

On theoretical grounds, the high sea-level culminating about 250 B.C. may, it seems to me, need moving back perhaps 50 years or thereabouts. This idea is derived from the following considerations:—

Our curve was drawn centrally through the preponderating masses of dots. Now it is well known that information such as used in this work becomes more and more scanty as we go backwards in time. While much evidence exists between the era of Augustus and the fall of the Western Roman Empire, 476 A.D., it rapidly decreases as we pass to the period before Cæsar; therefore we must anticipate that our observed points will be relatively greater in number for the same high sea-level as we approach from 250 B.C. to the time of Christ. The greater accumulation of points at the later dates consequently has probably brought the apex of our curve somewhat too near the time of the Christian era. How much distortion there may be found properly due to this cause further research may determine.

If later investigation shall allow this shifting of the curve at the epoch 250 B.C. as suggested, it would result in removing one more of our conflicting points, viz., that Reclus tells us at the time of the Battle of Thermopylæ (480 B.C.) the sea extended much farther into the land than now. The curve as now drawn would show the sea-level at the date of battle but slightly above the present level; this shifting would increase considerably its altitude at that time, and would better satisfy the requirements of Reclus' remark.

A few points I am at present unable to explain: for instance, Rear-Admiral Smyth calls attention to certain ruins near the town of Nettuno, Italy, "among which is Astura, so long the residence of Cicero . . . . now submerged in the sea." During the later years of Cicero (106–43 B.C.) our curve calls for a sea-level differing but little from the present; a sea-level, in fact, slightly above that of to-day. No building, therefore, then above the sea should be now submerged. I feel confident that some mistake will eventually be found in this statement. It may be that the residence of Cicero has not been identified with certainty, or it may be that near Nettuno, as in the Bay of Baie, foundations of buildings were erected in the sea. At present however, this item remains a conflicting point, antagonistic to our curve. I have no item more unyielding than this.

The above analysis illustrates the character of the examination bestowed on the testimony found conflicting with our curve. Lack of space now forbids a more complete discussion of this matter. I will say, however, that a recent canvass of over 500 manuscript pages of these changes demonstrates that the conflicting points, accumulated during many years of continuous search, aggregate less than 4 per cent. of the total items collected. Over 96 per cent. of the testimony thus indiscriminately gathered falls into harmony with our curve.

It seems impossible that the extraordinary method appearing in this matter should be the result of chance. I believe firmly, therefore, that law prevails in these oscillations, and while this preliminary examination has as yet not been carried far enough to establish this position, it renders our conclusions most extremely probable. When this work was first entered upon, some years since, I had little knowledge of what had been done before me in this field, but I soon found much had been done; I am far from being the first to announce "Oscillations in the Sea-level."

Aristotle (384–322 B.C.) had suspected them; he stated "there is reason for thinking that these changes (replacement of land by sea, and *vice versâ*) take place according to a certain system and within a certain period" ("Principles," 9th ed., p. 13).

Ovid (43 B.C. to 17 A.D.) makes Pythagoras say in regard to these oscillations—

> "The face of places and their forms decay,
> And that is solid earth which once was sea:
> Seas in their turn retreating from the shore,
> Make solid land what Ocean was before;
>
> . . . .
>
> Antissa, Pharos, Tyre, in seas were pent,
> Once isles, but now increase the continent;
> While the Leucadian coast, mainland before,
> By rushing seas is severed from the shore,
> And men once walked where ships at anchor ride,
> Till Neptune overlooked the narrow way,
> And in disdain poured in the conquering sea."
>
> *Metamorphoses*, Bk. xv, Addison's translation.

Ovid has introduced here events that occurred both before and after the time of Pythagoras (580 to 500 B.C.). They all bear testimony, however, to the ever recurring nature of these changes, even if the dates and order of sequence be somewhat confused. (See "Popular History of Science," Routledge, p. 17.)

Sir Charles Lyell ("Principles," 9th ed., p. 526) had reason to suspect that the upheaval of Scandinavia, in progress at the time of his visit, had not always proceeded at the same rate, and that the motion had not been invariably in one direction. He says: "Some phenomena in the neighbourhood of Stockholm appear to me only explicable on the supposition of the alternate rising and sinking of the ground since the country was inhabited by man."

Mr. R. C. M. Brown has many times denied the doctrine of upheaval of coastline, and has urged change in absolute level of the sea from astronomical causes in its stead.[1]

[1] See Report Brit. Assoc. Ad. of Science, 1890, p. 824; Quart. Journ. Geol. Soc., vol. xlvi, p. 122.

Elisée Reclus, in "The Earth," discusses at length the subject of upheaval and depression of shore-lines; he shows the inability of sedimentary processes to account for the shoaling of the many ports of the Mediterranean or for the advance of the coastlines into the sea; he says, in these matters, "we are witnessing the phenomena of a vertical impulse" (p. 539); on p. 542 he shows us that this "vertical impulse" has affected the entire area of the Mediterranean. The study of these and similar upheavals and depressions over the earth's surface leads him to say: "As will be understood, these regular oscillations must take place in obedience to some general law still unknown, although none the less certain" (p. 566). We should note here, that while Reclus attributes these oscillations to movements of the earth, it is impossible to distinguish such movements from oscillations in the sea; the effect is precisely the same in either case.

Rear-Admiral Smyth seems to have noted these oscillations; he says: "It is decided, upon what appears to be sound geological evidence, that a great part of the Italian coast has been raised and lowered *several times* within the historical era, while the sea must have ever maintained the same level" ("The Mediterranean," p. 26). Again, on p. 28 he remarks: "It may be safely concluded that the land has *risen and fallen twice* since the Christian era, and that each movement of elevation and subsidence has exceeded twenty feet."

Mr. P. Thompson, in "The History and Antiquities of Boston," has shown that these same oscillations have occurred in the Fens of England. On p. 660 he demonstrates these changes to have been four in number since the time of the Romans, two periods of inundation and two periods of desiccation, but these periods can also be determined from the data attached to this argument. Oscillations of the sea-level have also been shown at Rye and Winchelsea and in the English Channel, the latter by Peacock.

We note, however, that the above quoted authorities, although they may have suspected these oscillations, or may have actually observed them, have in no case attempted to control these phenomena by law or to determine the period of vibration. Law has been invoked, however, by Professor Edouard Suess and by Trautschold, a quotation from this latter having been previously given, notwithstanding the "resolve to abandon the doctrine of secular oscillations of continents" (Suess), and the adoption of periodic fluctuations in the sea-level in its stead. I am unable to learn that either of these gentlemen has attempted determination of the period of these fluctuations; it may therefore be possible that this is the first attempt in that direction.

I show no curve beyond the 400 B.C. At this period the evidence which I have been able to collect becomes uncertain, scanty, and the dates are very unreliable. The Deucalion Deluge, the Ogygian Deluge, and the Deluge of Samothrace furnish data at remote and uncertain periods. The books of Homer, of Herodotus, of Strabo, of Ptolemy, and other ancient writers supply much information as to the position of the sea-level at periods from 600 to 200 B.C.; but owing to the habit those ancient writers had of describing a city, an island, a peninsula, or a coastline, in terms borrowed from some still earlier and more ancient writer, it is at times difficult to decide as to the particular date at which the description fitted the object. The testimony so gathered is therefore very conflicting in its nature. I believe, however, that we find the amplitude of vertical vibration in the waters very much greater at that time than now, and the period of change reduced to approximately 500 years.

It is evident from what has gone before, that these oscillations have had a continuous existence for the last 2,400 years. In this paper we show strong evidence that these phenomena are periodic in their nature, and that the periods of these cycles are capable of determination. It is also equally evident, if any weight be attached to the facts herein contained, that the whole Northern Hemisphere, during the last three hundred years or more, has been subject to a general protrusion above the level of the sea.

Let us now consider, then, those evidences as to present opposing movement of shore-lines, to which attention has already been called; movements which, at the first glance, seem to deny so positively the conclusions arrived at in the above discussion.

To open the argument, I believe we maintain with great reason, that if there has been a bodily transference during the last few centuries, of a considerable mass of water from the Northern Hemisphere to the Southern, there must, coexistent with this transfer, have been considerable *decrease* in flow of currents running to the north and corresponding *increase* in currents flowing to the south.

Now then, acting on this assumption, the writer has shown in the *American Geologist* for September, 1899, perfect explanation of these apparently irregular motions; it is there shown that every observed case of apparent upheaval on one coastline, coincident with subsidence on another, can be foretold by law, and that instead of these motions being opposed to our conclusions, they are directly confirmatory thereof, it being demonstrated that no transference of water to the south can occur, no upheaval of northern shore-lines can take place, without a corresponding subsidence on the coasts of the Eastern United States, and also on the borders of such other lands as may be similarly situated with regard to ocean currents.

I will not repeat all the arguments used in the paper mentioned, but will state that our case hinges on the law of deformation of ocean levels by ocean currents, as announced by William Ferrell in *Science*, vol. vii. He says: "In the North Atlantic the tendency to flow eastward in the middle and higher latitudes causes a slight heaping up of the water and a rise of surface-level adjacent to the coast of Europe, and a drawing away of the water and a depression of sea-level along the north-east coast of the United States" (p. 76).

I have shown in the periodical mentioned that the waters around the British Islands and on the Scandinavian shores are now piled, certainly 5 feet (probably much more on the coast of Norway) above the normal sea-level, and that the waters on the eastern borders of the United States are correspondingly depressed. It follows, therefore, that if the Gulf Stream—that force which now restrains these waters in their abnormal position—should decrease but slightly in its velocity of flow, the oceanic surface would at once return in part towards that normal level from which it has so long been displaced; in other words, Scandinavia and the British Islands would enter upon an epoch of upheaval, the Carolinas upon an epoch of subsidence. As we have seen, the recent protrusions of the north renders certain the fact that a great mass of water has recently disappeared from this hemisphere. The transfer of this water to the south makes an equal certainty that coexistent with this removal all northward-flowing currents should have decreased in their velocity of flow. It is clear, therefore, that these opposing motions in our coastlines can be reduced to law and foretold in advance of observation.

We have reason to believe, however, that apparent upheavals or subsidences due to this cause will not at any time exceed 2 or 3 feet in vertical movement, and they consequently are of little importance as compared with the periodic vibrations of 15 or 20 feet over an entire hemisphere, as developed herein. It nevertheless is important to detect and eliminate these minor deviations, when we attempt the general investigation of coastal phenomena. For a more extended, although still very incomplete discussion of Ferrell's law, see the *American Geologist*, as before mentioned.

To those who may wish to extend these investigations—and there is great opportunity for such extension—caution should be given against relying on evidence as to changes in the sea-level gathered near the mouths of great rivers or in deltas like those of the Nile, Po, Rhone, Rhine, Mississippi, etc. These delta deposits, independent of their surroundings, are all sinking bodily and spreading laterally, probably under some process of disgorgement of their water contents. Much evidence of this exists. For instance, E. L. Corthell says the delta lands of the Mississippi are unstable both in vertical and lateral direction. A base-line 700 feet long, measured accurately, had in five years increased to 712 feet. He also quotes from the Report of the Mississippi River Commission: "Discrepancies in beach marks, level heights, and gauges could only be satisfactorily accounted for by the most plausible explanation of the subsidence of the whole delta" (*The National Geographic Magazine*, December, 1897).

M. Staring is of the opinion that the gradual depression of Holland "is caused only by the subsidence of the alluvial ground, the weight of the dikes, and the incessant passage of men and cattle" (Reclus, "The Earth," p. 547). Regions like the northern and western shores of the Adriatic, the deltas of the Rhine and Mississippi, should thus be avoided; the settlement of these delta deposits may obliterate the vertical movements in the aqueous envelope; observations made along rock-bound coasts only are trustworthy.

From the argument preceding it seems necessary to conclude that in future study of changes in the sea-level, discrimination must be made between each of the following causes which may affect the oceanic borders :—

1. Seek the effects produced by the bodily transference of water to and from the north. These effects would be *universal* over *one hemisphere.*

2. Detect and eliminate those movements of upheaval or depression due to variation in flow of ocean currents under the operation of Ferrell's law. These effects are local in their nature.

3. In deltas always suspect that any observed depression may be due to a local settlement of the ground itself, and such data there gathered may offer no argument whatever in favour of a rise in sea-level.

4. Eliminate and avoid such coastal changes as may be due to erosion of or accretion to shore-lines. In changes of this century it is generally possible to do this. In changes that have occurred in the distant past we shall find much difficulty in separating results of erosion or accretion from the results of real changes in the sea-level; therefore, in past ages much testimony will be found accumulated against us which our analysis will be unable to remove; we must expect, therefore, many of these apparently conflicting observations.

All the evidence discussed hereto has been gathered on the oceanic coastlines ; these data, as we have seen, testify to a recent protrusion of the entire north, and that this apparent vertical uplift increased in amount as we approach the Pole. There is, however, evidence in existence, obtained from our great lakes, showing the same law of greater elevation to the north.

Mr. G. K. Gilbert, in the 18th Ann. Rep. U.S. Geol. Survey, has shown that this excess of upheaval at the north has been of recent occurrence in the interior of our continent. A careful study of the changes in level, during the present century, of the great lakes enables Gilbert to announce this law with certainty.

With his inferential conclusions, however, in the light of our own investigation, we are compelled to differ. He assumes that this motion may continue indefinitely, and if so, he shows that in time the Niagara Falls will cease their flow, and a new outlet to the great lakes be placed in operation near Chicago. This result he reaches in a logical manner from the data examined, but we see that observations reaching back only one hundred years allow us to form no certain opinion as to whether this motion will continue indefinitely in one direction or otherwise. Then, again, the area of investigation was of too limited a character. We have seen that to obtain the law governing these risings and sinkings, it is not only necessary to study at one field of view the entire Northern Hemisphere, but to carry our investigation back in time as far as history or tradition will allow. When this has been done we see that Gilbert's observed changes in level fall into line as part and parcel of one complete system, universal over the entire North.

The cause of this vibration in the oceanic waters it is perhaps too early to discuss; the oscillations should be first established beyond a doubt. The most plausible explanation of the last change, however, would seem to rest in a possible continued *increase* in growth of the South Polar glaciers during the last few centuries, contemporaneous with that general *decrease* in nearly all Northern glaciers which, during the period mentioned, we know has been in progress. If we could invoke this cause, the recent oscillation mentioned would then be a physical necessity.

The question raised in this paper, and the results that have been reached, seem to warrant certain inferences or speculations, some of which are liable to be of considerable importance. For instance, we know that the landing-place of Columbus in 1492 has not yet been positively identified; our curve, however, calls for a sea-level at that latitude and date some 12 to 15 feet higher than at present. The question is, would the change in topography produced by assuming the sea at its old position aid us in reaching final conclusion in this matter.

As our curve for time past indicates a series of regular cycles with a period of about 640 years, must we not suppose our oceanic surface will again rise in the north, reaching its maximum shortly after the year 2100. If we prolong this curve, as suggested, we must conclude that disaster, as repeatedly in the past, will soon again overwhelm our northern coastlines. Are such cities as London, Liverpool, and New York ready for this advancing sea, and has such a region as Holland any too much time for preparation?

If our curve has been correctly mapped out, we must suppose that the northerly movement of the waters has already commenced, or that it will very shortly appear. This movement should be first shown in cessation of the so-called upheaval of Scandinavia, and that region should soon appear to be undergoing subsidence, while, at the same time, the coasts of New Jersey will enter an epoch of upheaval. We might, with great propriety, be on the look out for these changes.

Lord Kelvin has shown us how one inch of water taken from the surface of the sea, and piled up as ice at the Pole, would appreciably affect the rotation of the earth; we can reasonably expect, therefore, that these oscillations to and fro from the Poles to the Equator of 15 or 20 feet, as our arguments and facts seem to require, should have considerable effect in altering the length of our day. In fact, in this discussion we may, and probably will, find confirmation of Newcomb's surmise, that the hitherto unexplainable irregularities in the moon's motions may be due to slight changes in the earth's axial rotation, which rotation perhaps "varies from time to time in an irregular manner" ("Popular Astronomy," p. 101).

We thus see that there are reasons, many and weighty, inducing us to pursue this investigation to greater extent. Notwithstanding the considerable attention given to the subject by this writer, a research involving the labour of many years, we are as yet merely on the threshold of the inquiry. Years could be devoted to the comparison of ancient and modern maps and charts. A lifetime could be expended on the emerged and submerged ruins of Ostia, Carthage, Utica, the Piræus, Alexandria, the Bay of Baie, Tyre, Miletus, and other places too numerous to mention on the ancient elevated or depressed coastlines of the Mediterranean. This task is far beyond the capacity of an individual. Law, if once established in this matter, is of universal value and importance. The obscurity shrouding these emerged and submerged cities already seems less dark than before.

I earnestly hope, therefore, that some scientific body will undertake to assist in extending this investigation, thus enabling us to shed still additional light on these perplexing oscillations of the sea which we have been considering.

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

REVIEWS.

Sur les Fouilles de 1899 de débris de Vertébrés dans les Dépôts Permiens de la Russie du Nord. Par V. Amalitzky. pp. 25, with 5 plates. Exposé fait à l'Assemblée générale de la Soc. Imp. des naturalistes à St.-Pétersbourg, le 28 Décembre, 1899. (Varsovie, 1900.)

PROFESSOR AMALITZKY has for several years past been engaged in working out the structure and history of the fresh-water deposits of Palæozoic age in the northern governments of Russia, and in the present paper he treats of some general questions in connection with his investigations, and further gives a detailed account of some explorations in Upper Permian strata on the banks of the Little Dwina, which resulted in the discovery of numerous plant and animal remains of considerable interest from their close relationship to the flora and fauna of the Gondwana beds in India, the Karoo formation of South Africa, and deposits of corresponding age in Brazil and Australia. Some of the reptilian remains, moreover, present a close resemblance to the genera *Elginia* and *Gordonia* described by E. T. Newton from the Elgin sandstones.

The lowest fresh-water deposits recognized by Amalitzky in the north of Russia are red sandstones situated at Mount Andoma, on the east side of Lake Onega, and, more to the east, at Oust-Pinéga on the Northern Dwina. They contain lamellibranch shells belonging to the genera *Carbonicola, Anthracosia, Archanodonta,* etc., allied to the Anthracosidæ of the Russian Carboniferous. The beds are of Upper Devonian age, and may be ranked with the Old Red Sandstones of Scotland, the Kiltorkan beds of Ireland, and the Catskill formation of North America. The only fresh-water formations of Carboniferous age observed by the author are the sands of the Lower Carboniferous at Mount Patrova, in the Vytégra district, which have been shown by Inostrantsev to be a direct continuation of the Devonian sandstones of Andoma. Higher up in the geological series, exclusively *marine* deposits persist from the Lower Carboniferous sandstones with *Productus giganteus* in the

Vytégra district, and more eastward at Oust-Pinéga, from the Upper Carboniferous sandstones with *Spirifer mosquensis,* quite up to the Lower Permian. The Upper Permian deposits, on the other hand, shown on the banks of the lower part of the River Suchona and near the sources of the Little Dwina of the North, exhibit fresh-water characters very distinctly. They consist of nearly horizontal beds of marl with intercalated lenticular beds of sand and sandstone. For a long period these strata were considered to be destitute of fossils; none were found in them by Murchison, Keyserling, or Blasius, and they were neglected by the Russian geologists by reason of this reputed barrenness.

Professor Amalitzky has, however, demonstrated by his discoveries during the last four years that they contain a rich flora and fauna. Amongst the plant remains the most important are *Glossopteris indica, Gl. angustifolia,* (*Vertebraria*), *Gangamopteris major, Tæniopteris, Sphenopteris, Callipteris* cf. *conferta,* besides *Equisetum, Noeggerathiopsis,* and forms like *Schizoneureæ.* The fauna includes a number of fresh-water lamellibranchs, such as *Palæomutela Inostranzewi, P. Keyserlingi, P. Verneuili, Oligodon, Palæanodonta, Carbonicola, Anthracosia,* and *Anthracomya*; the Crustacean genera *Estheria* and *Cypris,* together with the plates and impressions of Ganoid fishes. Land animals are represented by amphibians approaching *Melanerpeton* and *Pachygonia,* and a great number of bones of theromorphian reptiles belonging to the Pareiasauria and Dicynodontia, amongst which *Pareiasaurus* and *Dicynodon* have been definitely determined, and also forms much resembling *Elginia* and *Gordonia.*

These discoveries have confirmed the opinion of the author as to the great resemblance from a palæontological point of view between the Continental fresh-water deposits of the Upper Permian and those of the Lower Karoo in Africa and of the Gondwana in India; and he is led to conclude that the compact continent which during the Permian epoch occupied Central and Southern Africa, India, Australia, Argentina, and part of Brazil extended as far as European Russia, and that the bond which united these countries was on one side the Continental deposits of Gondwana in India and on the other the similar deposits of Kouzniets in Siberia.

The explorations carried out by Professor Amalitzky during the Summer of 1899, which form the main subject of the present paper, were made at a spot on the steep right bank of the Upper Dwina of the North, near the village of Kotlas. For a distance of about ten kilometres the river bank is composed of Permian rocks overlain by beds of clay, with pebbles and large stones of crystalline rocks, of Post-Pliocene age. The Permian beds have a slight dip towards the N.N.E.; they consist of a series of marls of very uniform characters; the upper beds are of a reddish-brown tint, with a persistent layer of white siliceo-dolomitic limestone, in some places becoming dolomitic, in others a siliceous rock. These upper marls rest with a slight discordance on lower marls, also reddish-brown, and not dissimilar to the upper beds; a thickness of about

24 metres is exposed of the lower marls. At the line where these marls come together there is a series of remarkable lenticular beds of sand resting in trenches eroded in the lower marls and unconformably overlaid by the upper beds. Five of these lenticular sand beds are shown in section in the steep river banks in the course of the ten kilometres referred to. The particular bed excavated, situated at Sokolki, was 12 metres thick in its central portion, with a breadth of about 80 metres. The bed contained numerous irregular, hard concretions of sand cemented with carbonate of lime, and in some of these the reptilian bones were enclosed. As the bank at this place was vertical, and the higher portions were even overhanging, the only practicable means of reaching the fossiliferous lenticular deposit was by digging down to it from above, which entailed much labour, and a further difficulty was caused by the fact that at a depth of 1·5 m. from the surface the soil, at the end of June, was frozen hard, and the small fissures and cavities were lined with ice.

Many impressions of large fronds of *Glossopteris* were met with in some of the sandy beds, but they broke up on exposure to the air. The position of the fossiliferous concretions was discovered only after several fruitless trials. Some of the concretions contained only single detached bones, whilst in others all the bones of a complete skeleton were embedded together. Three skeletons were found side by side, evidently of predatory animals allied to *Rhopalodon*; under these were three, more or less imperfect, skeletons of Pareiasauria. The sand surrounding the concretions was carefully removed and the surface of each layer exposed so that the positions of the skeletons could be distinguished. They appeared to be all extended in the same direction as if they had been carried down and deposited in the bed of a stream heavily charged with sediment. The skeletons in the central portions of the lenticular deposit were heaped together as if they had been buried up with silt before the flesh had decomposed, whilst those nearer the margins seem to have been exposed long enough for decay to have set in, so that the bones became detached.

No fewer than thirty-nine groups of concretions were discovered; about twenty of these contained complete or imperfect skeletons, whilst in the others the bones were detached and commingled together. These concretions have not as yet been properly examined, and their contents are but partially known. Of the remains of Amphibians, there are skulls and other bones of forms allied to *Melanerpeton* and *Metopias*.

Both in numbers and importance the reptilian remains form the chief part of the collection. They nearly all belong to the Theromorpha, and the three suborders, Anomodontia, Pareiasauria, and Deuterosauria, are represented. The Pareiasauria are the most abundant; amongst them are some small forms with skulls not more than 30 centimetres in length, whilst others are 4–5 metres long with skulls 1 m. in length and 0·66 m. in width. Some have their heads and part of their backs covered with shield-shaped plates, like the Pareiasauria from the Karoo beds; others possess horn-like projections on their heads like the *Elginia* from the Triassic deposits of Scotland. All are characterized by the good preservation of their notched, spatula-shaped teeth. The Deuterosauria, though sometimes 3 metres in length, do not attain the proportions of the Pareiasauria. Their dental apparatus is very powerful and of a distinctly rapacious type. They belong to *Rhopalodon*, Fischer. The Anomodontia are represented by small forms of *Dicynodon* about the size of a bear, with two powerful tusks on the sides of the head. Some of the skulls and skeletons discovered probably belong to altogether new species of reptiles.

The only invertebrates mentioned from this lenticular deposit are lamellibranch shells belonging to the Anthracosidæ, whilst the plant remains, though numerous, are limited to forms of *Glossopteris*.

The plates accompanying the paper show the position of the lenticular sandy beds in the cliffs of Permian marls, and the manner in which the concretions with the bones embedded in them occurred in the sands. G. J. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—March 6th, 1901.—J. J. H. Teall, Esq., M.A., V.P.R.S., President, in the Chair.

The following communications were read:—

1. "Recent Geological Changes in Northern and Central Asia." By Professor George Frederick Wright, F.G.S.A.

The present paper is the outcome of a journey made by the author in company with Mr. Frederick B. Wright in 1900–1901.

In North America an area of about 4,000,000 square miles was brought under the direct influence of Glacial ice during the Glacial Epoch. The result of six weeks spent in Japan was to show that there are no signs of general glaciation in Nippon or Yesso. Neither is there any sign of glaciation along the border of the Mongolian Plateau, where the general elevation is 5,000 feet, but the whole region is covered with loess. This has usually accumulated like immense snow-drifts on the south-eastern or lee-side of the mountains, and in it houses and villages are excavated. In the mountainous region, strata of gravel and pebbles are so frequent in the loess, that it is necessary to invoke both wind and water in order to explain fully the origin of the deposit. At the present time the loess in the interior is being washed away by streams much faster than it is being deposited by the wind. The journey across Manchuria from Port Arthur along the Lao-Ho and Sungari rivers was through valleys choked with alluvium, and there was no evidence that the drainage of the Amur had ever been reversed by ice, like that of the St. Lawrence; nor was there any other evidence of glaciation. The lower course of the Amur indicates subsidence. Again, there are no signs of glaciation on the Vitim Plateau.

Lake Baikal appears to be of recent origin; it is 4,500 feet deep, and has not been filled by the great quantities of sediment brought down by the Selenga and other rivers. Although glaciers could frequently be seen on the mountains which border the Central Asiatic Plateau to the north-west, there was no evidence that the glaciers had ever deployed on the plain. The loess-region of Turkestan, and indeed the whole area from the Sea of Aral to the Black Sea, appears to have been recently elevated, in some places as much as 3,000 feet. Desiccation took place at the same time, so that the larger lakes are only brackish or still fresh. Direct evidence of this in the form of deposits is given. The author thinks it likely that the absence of glaciation in Northern Asia may have been due to the rainlessness of the region, and that while America was elevated, Asia was depressed during the Glacial Epoch.

2. "The Hollow Spherulites of the Yellowstone and Great Britain." By John Parkinson, Esq., F.G.S.

A recent journey to the National Park of the United States, resulting in a study of the obsidians and rhyolites in the field and at home, suggested a direct comparison between the hollow spherulites characteristic of these rocks and those of the rhyolites of Shropshire, Jersey, and elsewhere.

The first part of the paper is concerned with the spherulites of the Yellowstone region. A brief description is given (i) of the small bluish-grey solid spherulites common in the obsidian of Obsidian Cliff, and (ii) of a hollow variety in which radial structure is barely discernible. In the latter, the spherulitic part is represented by a whitish, rather crumbly material consisting of felspar, tridymite, and quartz.

The hollow spherulites proper are divided into two groups—(i) those containing cavities without definite form, and (ii) those in which the cavities are related to the shape and structure of the spherulite. The latter include the well-known lithophysæ. The manner in which these occur, and the relation of the cavities to the enclosing spherulite, are described. Attention is drawn (*a*) to the porous character of the latter, and (*b*) to the network of felspathic fibres, studded with crystals of tridymite, which usually distinguish the spherulite near a cavity.

Hypotheses framed to account for these varying structures would take one of two directions:—(i) Hollow spherulites are the result of some property of the original magma, or (ii) are due to the decomposition of an originally solid spherulite by heated waters. Taking the second alternative first, a description is given of the effect of solfataric action on the rhyolites of the Yellowstone Cañon. The conclusion reached is "that the action of hot waters charged with silica may be to remove portions of the rock, or to permeate it without destroying its characteristic structure; that we obtain, however, no evidence to show that the spherulites are most easily attacked, but rather the reverse." Explanation, therefore, is most naturally sought in some property of the original magma, and that propounded by Professor Iddings appears the nearest in accord with facts. Exception is taken to certain physical processes postulated by Professor Iddings in a recent memoir, but with his earlier work the present writer is substantially in agreement.

In the second part of the paper direct comparison is drawn between the structures exhibited by the hollow spherulites from Obsidian Cliff and those of examples from Shropshire, Jersey, and other localities. Attention is called to the presence in the latter of quartzose amygdaloids, crescentic in shape, and having a relation to the edge of the nodule. Sometimes a series of such are found parallel one to the other, not infrequently (at Wrockwardine) becoming more or less completely circular. Projecting into such an amygdaloid, or occupying an end, we find in many instances a network of felspathic fibres comparable with the fibrous structure which characterizes the American examples.

A description is given of a series of rocks from Boulay Bay, once very vesicular, and containing the remains of crystals—probably felspars—analogous to the crystals found encrusting the cavities of lithophysæ from Obsidian Cliff. Traces of a mineral which resembles the tridymite from the latter locality are described from Wrockwardine.

Taking into consideration the resemblances between the hollow spherulites of the Yellowstone region and those of Great Britain, the conclusion is drawn that the hypothesis of corrosion is as inapplicable to the latter as to the former. On the contrary, the author believes that the cavities of the spherulites are the result of the hydrous state of the magma.

II.—March 20, 1901.—J. J. H. Teall, Esq., M.A., V.P.R.S., President, in the Chair.

Mr. H. B. Woodward called attention to a polished slab of Landscape Marble, or Cotham Stone, from the Rhætic Beds near Bristol, which had kindly been lent for exhibition by Mr. Frederick James, Curator of the Maidstone Museum. The specimen showed that after the arborescent markings had been produced in the soft mud, some irregular and partial solidification took place in the upper layers of the deposit; and then during contraction a kind of subsidence occurred of the upper and harder portions into the lower and softer materials. This subsidence was accompanied by a breaking up of the harder portions, suggesting a comparison (in miniature) with 'broken beds' and even crush-conglomerates. The specimen was of considerable interest as illustrating the mechanical changes produced during solidification.

The following communications were read :—

1. "On a Remarkable Volcanic Vent of Tertiary Age in the Island of Arran, enclosing Mesozoic Fossiliferous Rocks."

(Communicated by permission of the Director-General of H.M. Geological Survey.)

Part I.—"On the Geological Structure." By Benjamin Neeve Peach, Esq., F.R.S., L. & E., F.G.S., & William Gunn, Esq., F.G.S.

The rocks which form the subject of this paper cover an area of about 7 or 8 square miles, and culminate in Ard Bheinn A'Chruach and Beinn Bhreac. They are in contact with formations ranging from the Lower Old Red Sandstone to the Trias, and are later in date even than the important faults of the area. They are made up partly of fragmental volcanic materials, and partly of various intrusive masses, confined within an almost unbroken ring of intrusive rocks. In addition to igneous fragments, the clastic volcanic rocks contain fragments derived from the surrounding formations; and also masses of shale, marl, limestone, and sandstone belonging to formations not now found *in situ* in the island. One of these is several acres in extent, contains fossils, and is in part of Rhætic age; a second is a fragment of Lias; and a third is of limestone and chert resembling the Antrim Cretaceous rocks, and yielding fossils. The absence of Oolitic and older Cretaceous seems to indicate a resemblance between a former succession in Arran and that now seen in Antrim. If these fragments fell into the vent from above, the igneous rocks must be of Post-Cretaceous age, and they give an impressive picture of the amount of denudation which has occurred since the period of vulcanicity.

Part II.—"Palæontological Notes." By E. T. Newton, Esq., F.R.S., F.L.S., F.G.S.

The masses of Rhætic strata yield *Avicula contorta*, *Pecten valoniensis*, *Schizodus* (*Axinus*) *cloacinus*, etc.; those of Lower Lias, *Gryphæa arcuata*, *Ammonites angulatus*, and new species of *Nuculana* and *Tancredia*, which are figured and described. Thin slices of the Cretaceous limestones prove to be very like those of the Antrim Chalk, and the rocks yield determinable Foraminifera. *Inocerami*, Sponges, and Echinoderms.

2. "On the character of the Upper Coal-measures of North Staffordshire, Denbighshire, South Staffordshire, and Nottinghamshire; and their Relation to the Productive Series." By Walcot Gibson, Esq., F.G.S.

(Communicated by permission of the Director of H.M. Geological Survey.)

The Upper Coal-measures of North Staffordshire are capable of a fourfold subdivision, the groups representing a definite sequence of red and grey strata:—

4. The Keele Series. Red and purple sandstones and marl with occasional seams of coal, and bands of entomostracan limestone.
3. The Newcastle-under-Lyme Series. Grey sandstones and shales, with four thin seams of coal, and at the base an entomostracan limestone.
2. The Etruria Marl Series. Mottled red-and-purple marls and clays, with thin green grits; a thin coal occurs 150 yards above the base.
1. Black Band Series. Grey sandstones, marls, and clays; numerous thin seams of coal and Blackband ironstone; one of many thin bands of limestone is constant, 36 to 40 feet above the base.

Spirorbis- and entomostracan limestones attain a maximum in the Upper Coal-measures, but are not unknown in the productive measures below. Indeed, the two sets of measures are closely allied lithologically, palæontologically, and stratigraphically in this region. The chief movements are pre-Triassic and post-Carboniferous.

No attempt has been made to recognize the Black Band Series in the Denbighshire, South Staffordshire, and Nottinghamshire coalfields, as they are indistinguishable from the productive measures in the absence of Blackband ironstones. In each of these areas there are divisions in the Upper Coal-measures which correspond with the three highest divisions in North Staffordshire, and in all cases, except near the margin of the basin, where overlap occurs, they are underlain by ordinary Coal-measures with coal-seams. It is therefore concluded that these higher Coal-measures were deposited in one basin which included all the four areas dealt with, and that whatever movements occurred were of a local, and not of a regional character. Judging by published descriptions, the higher series of measures appear to be present in other Midland and North-Western coalfields, and in most of them the Keele Series corresponds to the Salopian Permian of Professor Hull.

OBITUARY.

JOHN HOPWOOD BLAKE,

ASSOC. M. INST. C. E., F.G.S., OF THE GEOLOGICAL SURVEY OF ENGLAND AND WALES.

BORN JULY 22, 1843. DIED MARCH 5, 1901.

MR. J. H. BLAKE was a son of Mr. George John Blake, of the firm of Messrs. Allen & Blake, Wine Merchants, and was born in Great Tower Street in the city of London. After completing his education at King's College, London, he was apprenticed to Mr. R. P. Brereton, M. Inst. C. E., under whose directions he was engaged for several years with Mr. S. H. Yockney in railway work in Cornwall and South Wales. Having been attracted to the science of geology while at King's College, he became further interested in the subject during his engineering experiences, and was thereby tempted to join the Geological Survey in April, 1868, at a time when the staff under Murchison was considerably augmented. During the first few years of his official career he was engaged in the re-survey of portions of Somerset, along the Mendip and Polden Hills, at Shepton Mallet, Street, Chewton Mendip, and Axbridge, and subsequently at Watchet and Minehead. He was also occupied for a time in the first detailed Drift Survey of the area north-west of London. Later on he was transferred to Suffolk, to survey the country around Stowmarket, and that bordering the sea north and south of Lowestoft, whence he proceeded to Yarmouth and continued his investigations inland and along the coast as far north as Palling in Norfolk. Much time was then devoted to a careful study of the Forest Bed Series, and his published section of the cliffs at Kessingland, Pakefield, and Corton (1884) bears evidence of the painstaking character of his work. East Dereham then became his home, and much fieldwork was done in that part of Norfolk until 1884, when the primary one-inch Geological Survey of England was completed. Mr. Blake then removed to Reading, and was for many years occupied in the re-survey on the six-inch scale of that neighbourhood, giving especial attention to the Drifts, which before had only been partially mapped. A few years ago he proceeded to Oxford, from which important and interesting centre he laboured with much quiet enthusiasm, until on March 5 he suddenly and quite unexpectedly succumbed to angina pectoris at the age of 57.

The record of his geological work is chiefly embodied in the geological maps of the districts he surveyed, and in sundry Survey memoirs. He contributed notes to the Geology of East Somerset (1876), to the Geology of Stowmarket (1881), the Geology of Norwich (1881), and the Geology of London (1889); and he personally wrote "The Geology of the Country around East Dereham" (1888) and "The Geology of the Country near Yarmouth and Lowestoft" (1890). He had also prepared, in conjunction with Mr. Whitaker, a Memoir on the Water Supply of Berkshire, which is in the press, and had made some progress with a Memoir on the Geology of Reading.

Mr. Blake's extra-official contributions to geological literature were by no means large considering his long experience. In 1872 he contributed (with H. B. Woodward) "Notes on the Relations of the Rhætic Beds to the Lower Lias and Keuper Formations in Somersetshire" (GEOLOGICAL MAGAZINE, Vol. IX, pp. 196–202). In 1877 he published in the same Magazine (Dec. II, Vol. IV, pp. 298–300) an article "On the Age of the Mammalian Rootlet-bed at Kessingland"; and in 1881 he contributed to the Proceedings of the Norwich Geological Society (vol. i, pp. 126–128) a paper on a "Well-boring at East Dereham Waterworks." To these may be added his addresses to the Norwich Geological Society (of which he was elected President in 1880–81), dealing with the Age and Relation of the so-called 'Forest-Bed,' and with the Conservancy of Rivers, Prevention of Floods, Drainage, and Water Supply; and also his Presidential Address to the Reading Literary and Philosophical Society in 1885, when he discoursed on the Coalfields of the United Kingdom with special reference to the Royal Commission on Coal. From 1885 until near the close of his life he conducted a number of excursions of the Geologists' Association, on three occasions to Reading, and on other occasions to Henley-on-Thames and Nettlebed, Taplow and Bowsey Hill, Lowestoft and Kessingland, Goring, and Silchester, reports of which were contributed to the Proceedings of the Association.

Mr. Blake's early training as an engineer had made him an excellent draughtsman, so that his maps and the sections he constructed were models of neatness and precision. This training in the exact methods of topographic surveys to some extent hampered his field-work, as his constant aim to secure positive evidence for geological boundaries led often to prolonged and inexpedient investigation. Thus he would return again and again to obscure tracts in the hopes of gaining exact information, a process theoretically laudable, but practically detrimental to the progress of work. This timidity in forming conclusions, perhaps to a certain extent constitutional, had proved such a serious bar to official advancement, that it caused him grave anxiety. Imbued, however, with a true love of science he laboured on with infinite patience to the end, and it is distressing to think that he did not live to partake of the benefits which quite recently accrue to the Survey through a reorganization of the staff. Personally his colleagues and many others will long lament the loss of a genial and tender-hearted friend. H. B. W.

MISCELLANEOUS.

International Geological Congress, Paris, 1900.—The pupils, friends, and admirers of Professor Albert Gaudry, who in 1852 started his scientific career with his "Thèse de Géologie: Sur l'origine et la formation des Silex de la Craie," intend to present him with a commemorative medal. Whilst heartily associating ourselves with this proposal, we venture to suggest that something more might be done. In one of his books Professor Gaudry terminates the description of his new palæontological gallery with the following words:—"J'aimerais que, pour terminer notre galerie, on plaçat une statue représentant une figure humaine, figure douce et bonne, figure d'artiste et de poète, admirant dans le passé la grande œuvre de la Création et réfléchissant à ce qui pourrait rendre le monde encore meilleur."[1] Apart from his eminent scientific attainments, Professor Gaudry has revealed himself as an artist and a poet as well, especially in his "Essai de Paléontologie philosophique"; and whoever has approached him can testify that the 'douce' and 'bonne' expression of his face truly reflects his character. We therefore think that his own bust would be the most suitable *couronnement d'édifice* of the palæontological gallery, which in the main is his own work.

Professor Albert Gaudry, President of the International Geological Congress for 1900, announces that the Committee appointed by the International Congress of Geologists to award the International Spendiaroff Prize of 456 roubles (£48) has proposed as subject for 1903, "Critical Review of the Methods of Rock-classification." Two copies at least of any work competing for the prize should be sent before August, 1902, to Dr. Charles Barrois, Secretary of the Congress, 62, Boulevard Saint-Michel, Paris.

Erratum.—*Brachylepas* (*Pyrgoma*) *cretacea*, H. Woodw.: Geol. Mag., April, 1901, pp. 145–152, Pl. VIII.—Dr. Arthur Rowe, F.G.S., calls attention to an error in Dr. Woodward's paper as to the locality of his new specimen of this Cirripede, which, like the original specimen described in 1868, was also obtained from the zone of *Belemnitella mucronata* in the *Norwich Chalk*, and all references to Margate and Thanet should be deleted and the word *Norwich* substituted.—Edit. Geol. Mag.

[1] A. Gaudry: "Les ancêtres de nos animaux dans les temps géologiques," p. 296; Paris, 1888.

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No. VI.—JUNE, 1901.

ORIGINAL ARTICLES.

1.—On the Evidence of the Transference of Secondary Sexual Characters of Mammals from Males to Females.

By C. I. Forsyth Major, M.D., F.Z.S.

When Darwin stated in the first edition of the "Descent of Man," "as probable that horns of all kinds, even when they are equally developed in the two sexes, were *primarily* acquired by the male in order to conquer other males, and have been transferred more or less completely to the female,"[1] the "various facts" from which he drew this inference did not include any palæontological evidence. At the present day we are familiar with the notion that, as regards the deer family, the oldest members known, from the Oligocene, were absolutely devoid of antlers, and that the subsequent phylogenetic evolution of the latter has a close parallel in their ontogenetic development.

Except in the case of the reindeer, fossil Cervidæ cannot be expected to throw any direct light on our special subject of inquiry, since up to the present day the females of the great majority of Cervidæ are, as a rule, devoid of antlers. The generally received view is that amongst recent Cervidæ the females of the reindeer always have antlers, and the females of other deer never have.

According to a statement by Eversmann, quoted by A. Brandt,[2] the female wild reindeer in the Orenburg district are devoid of antlers. With regard to the Cervidæ generally, there is abundant testimony, to be found amongst older writers especially, of antlers occurring in females of *Capreolus* and *Cervus elaphus*.[3] Rütimeyer states that traces of pedicles are never absent in the doe;[4] and Nitsche confirms that this is in fact the rule in old individuals.[5]

[1] Charles Darwin: "The Descent of Man and Selection in relation to Sex," 1871, vol. ii, p. 248.

[2] Eversmann: "Naturgesch. v. Orenburg," ii, p. 251. Cf. A. Brandt in "Festschrift f. Rudolf Leuckart," 1892, p. 412.

[3] See the numerous bibliography, together with original observations, in A. W. Otto, "Lehrb. d. pathol. Anatomie d. Menschen und der Thiere," 1830, i, p. 167 and note 18.

[4] L. Rütimeyer: "Beiträge zu einer natürl. Geschichte der Hirsche," i: Abh. schweiz. palaeont. Ges., 1881, viii, p. 42.

[5] H. Nitsche: "Studien über Hirsche, 1898, i, pp. 23, 49, 50.

The phenomenon, however, is by no means restricted to senility. Otto himself dissected an antlered doe pregnant with two fœtuses,[1] and Nitsche shows that *the presence of antlers in the female Capreolus is independent of senile sterility.*[2]

Instances of the occurrence of antlers in the female Virginia and Columbia deer are adduced by Caton.[3]

If we survey the cases recorded in the literature, no doubt remains that the capacity of developing antlers is latent in the female Cervidæ, and only an impulse is required.

In a case recorded by W. Blasius, of a doe, the abnormal antler on the right side could be traced to a mechanical lesion produced by the presence of a piece of glass, and Blasius is probably right in supposing that the exostosis occasioned by the lesion assumed the shape of an antler, owing to its occurring in the region where the antlers are developed in the male.[4]

The remarkable case communicated to the Linnean Society by James Hoy on December 16th, 1791, is a curious parallel to the male plumage exhibited in female game-birds as a consequence of a lesion of the ovaries. "A hind, the female of *Cervus elaphus*, was shot by the Duke of Gordon, which had one horn perfectly similar to that of a stag three years old. It had never had a horn on the other side of its head, for there the corresponding place was covered over by the skin, and quite smooth. It did not seem to have ever produced a fawn, and upon dissection the ovarium *on the same side with the horn was found to be schirrous.*" [5]

Next in order comes the constant presence of rudimentary pedicles in old does, viz. at a time when the sexual functions have ceased.

Moreover, it appears, especially from Nitsche's observations alluded to above, that the females of *Capreolus*, at any rate, are beginning to develop antlers before senile sterility sets in; so that this new character of the doe has every chance of being transferred to her offspring, independent of the sex, and to become general in the does also, as it has become already almost general in female reindeers.

Giraffidæ.—For reasons formerly given,[6] I agree with Lydekker, by including in the family Giraffidæ the *Sivatherium* group of Ruminants from the Sivaliks (*Sivatherium—Brahmatherium—Hydaspitherium—Vishnutherium*).

The two recent species of *Giraffa* develop horns in both sexes.

Gaudry made known a hornless form, *Helladotherium Duvernoyi*, from the Upper Miocene of Pikermi; the skull described by him

[1] A. W. Otto: "Seltene Beobachtungen zur Anatomie, Physiologie, und Pathologie gehörig," 1816, i, p. 71 (xxx).

[2] Op. cit., p. 50, where is quoted also a former paper by the same author in Tharander forstliches Jahrbuch, 1883, xxii, p. 118.

[3] J. D. Caton: "The Antelope and Deer of America," 1881, 2nd ed., pp. 232, 233.

[4] Jahresber. d. Vereins f. Naturw. zu Braunschweig, ix, Sitzungsber., pp. 11–13 (1894–95).

[5] Trans. Linn. Soc., vol. ii, p. 356.

[6] Forsyth Major, "On the Fossil Remains of Species of the Family Giraffidæ": Proc. Zool. Soc. London, 1891, p. 315.

is the only one known of this genus, although various large-sized Giraffoid hornless skulls have in turn been called *Helladotherium*, and even united with the Pikermian species. For the present it cannot be decided whether the *Helladotherium* was hornless in both sexes or in the female only. The Giraffoid genus from the contemporary deposit of Samos—which occurs also at Maragha in Persia—has been founded by me on a form provided with supraorbital horns and on a hornless form, which otherwise agrees perfectly with the former; I therefore have considered them to be male and female forms respectively of one species, *Samotherium Boissieri*, Maj. A smaller, closely allied form, *Palæotragus Rouenii*, Gaudr. (Pikermi, Samos, Maragha), originally believed to be an antelope, is also represented by a form provided with, and one devoid of, horns.

"In the skull of an aged specimen of *Samotherium*, just above the orbits, where the large horns are placed in the horned specimens, there occur very small processes separated by a suture from the underlying part of the frontal."[1] The explanation I then submitted was, that in aged individuals of the female *Samotherium* male characters occasionally make their appearance. Another specimen,[2] of which but a portion of the frontal is preserved, exhibits above the *right* orbit only a similar epiphysis as the one just mentioned; its height is no more than 9 mm., with a longitudinal extension of about 32 mm. To judge from the size of the fragment and the texture of the bone, it belonged to an adult, although not an aged individual. It cannot therefore be considered to be a young specimen of the horned form; in the latter the horn attains a size of upwards of 210 mm.[3] Several other adult hornless skulls of *Samotherium*, one of which is in the British Museum, show no trace of an incipient horn.

From the foregoing we may conclude that in this Tertiary member of the Giraffidæ the females are beginning to develop horns, which primarily were male sexual characters of the *Samotherium*, whether used as weapons or purely ornamental.

Bovinæ.—With regard to all their salient characters the Bovinæ are the most terminal group of Ruminants. No instance of the occurrence of hornless females in recent *wild* bovine animals is known.

When working in the Palæontological Museum at Florence I came upon the hornless skull of a Ruminant from the Pliocene of the Val d'Arno, which had been discovered a few years previously and variously interpreted; the statement published somewhere that in the Val d'Arno fauna occurred a Ruminant closely allied to the camel, refers to the skull in question. On close examination I found that the fossil presented all the cranial and dental characters of Falconer's *Bos etruscus* from the same deposits, with the essential difference that no traces of horn-cores were present. My conclusion was that the skull was that of a female '*Bos etruscus*.' I published

[1] Forsyth Major, op. cit., p. 319.

[2] Nos. 712, 712*a* of my first collection from Samos, which is the property of Mr. William Barbey in Geneva.

[3] No. 17 of the Swiss Collection.

the fact at the time,[1] and also ventured to transmit the information to Charles Darwin, who embodied it in the second edition of his "Descent of Man."[2]

Unaware of my previous statement, Rütimeyer announced in 1878 as a novel fact the discovery of a hornless fossil member of the Bovinæ.[3] The skull in question, B.M. No. 48,037, from the older Pliocene of the Sivalik Hills, he described and figured as *Leptobos Falconeri*, Rüt. From the absence of horn-cores, from the great extension of the parietal zone, and from its general slender and elegant build, the skull is considered to be that of a female. But at the same time it is conjectured that part of the horned skulls attributed to the same species might equally be of the female sex; this on account of their weaker horns.[4]

The skull from the Val d'Arno is described and figured in the same memoir, together with the cast of a second equally hornless skull from the same locality, the original of which is preserved in the private collection of the Marchese Strozzi. Rütimeyer's conclusion is very different from mine; the hornless skulls from the Val d'Arno are named *Leptobos Strozzii*, and thus placed in a different genus and group from Falconer's *Bos etruscus*, which becomes the *Bibos etruscus*.[5] As Rütimeyer was indisputably the highest authority in this particular branch of palæontology, my previous most positive statement must have been considered in the light of a rather rash proceeding.

Years afterwards my excavations at Olivola (Upper Pliocene) brought to light several hornless bovine skulls, and made it incumbent on me to reinvestigate the whole matter, the more so as some additional horned skulls from the Val d'Arno had in the meantime enriched the Florence Museum. The result arrived at[6] was a confirmation of my former view, that the hornless and horned bovine skulls from the Upper Pliocene of Italy are one and the same species. This species is nearly related to the Sivalik *Leptobos*, as Rütimeyer had already shown with respect to the hornless form of the Val d'Arno. The obvious conclusion was to collocate the bovines from the Italian Pliocene in the genus *Leptobos*: *Leptobos elatus* (Croiz.).[7]

Stehlin, another pupil of Rütimeyer, has quite recently studied the Florentine collections; with regard to the above question, he declares that after repeated examination of the materials he agrees with my view that Rütimeyer's '*Leptobos Strozzii*' is nothing else than the female form of his '*Bibos etruscus*.'[8]

I do not think it necessary to enter into the particulars of the case, which are published. For the present purpose it is sufficient

[1] Palæontographica, 1873, II, 2 (xxii), p. 123. [2] 1874, p. 505.

[3] L. Rütimeyer, "Die Rinder der Tertiaer-Epoche," etc.: Abh. schweiz. palaeont. Ges., 1878, p. 162.

[4] Op. cit., p. 164. [5] Op. cit., pp. 167–175.

[6] Forsyth Major, "L'Ossario di Olivola in Val di Magra": Proc. Verb. Soc. Tosc. Sc. Nat., March 3, 1890, pp. 71–75.

[7] Forsyth Major, op. cit., p. 75.

[8] Abh. schweiz. palaeont. Ges., 1900, xxvii, p. 466, note.

to point out that in the earliest known—Pliocene—representatives of bovine animals, part, at any rate, of the females were devoid of horns, whereas, as stated before, the females of all the wild recent species, without exception, have acquired them. The occurrence of hornless forms in domestic races has been explained by Rütimeyer as a reversion.[1]

Suidæ.—The male weapons of Suidæ are the tusks. Stehlin has recently shown that the male *Potamochœrus provincialis* (Gerv.) from the Lower Pliocene of Montpellier was already provided with equally strong developed canines as the recent species. In the female fossil form they are about equally developed as in *Sus scrofa.*[2] Some years ago I figured on two plates male and female skulls of recent species of *Potamochœrus*,[3] from which it can be seen that in the Malagasy and East African *Potamochœri* the canines of the females are almost equal in size and shape to those of the males. The same occurs in the case of the Bornean *Sus barbatus*,[4] and, to judge from a skull described and figured by Rolleston,[5] may occur also in the female of *Sus andamanensis.*

In the West African *Potamochœrus*, according to Stehlin's observation, the canines of the female are weaker than in the eastern species.[6]

Stehlin has strongly insisted upon the importance of this instance of transmission of male sexual characters to the female, in *Potamochœrus.* "Dieselbe ist in doppelter Hinsicht von allergröstem Interesse. Einmal darum weil durch sie im allerletzten Abschnitt der Erdgeschichte nochmals ein evidenter Fortschritt gegenüber dem Pliocaen erzielt wird, sodann aber auch in rein morphologischer Hinsicht, insofern als mit ihrem Eintreten ein völlig neuer, bis dahin unbetretener Weg in der Umformung und Weiterbildung der ganzen Species betreten wird."[7] ("It is of the greatest interest, firstly, because by means of this transmission there is again an evident progress in the last chapter of the earth's history, as compared with the Pliocene; secondly, from a purely morphological point of view, because by it a hitherto completely new and untrodden road in the transformation and progression of the whole species is now opened.")

In our own species the modern aspirations of women are, to all appearances, the incipient signs of the same natural law. Physical and mental characters of man, originally acquired in the struggles of the males, are apparently being slowly transferred to women. They only require time for their full evolution.

[1] Op. cit., p. 173.

[2] H. G. Stehlin, "Über die Geschichte d. Suiden-Gebisses": Abh. schweiz. palaeont. Ges., 1899, xxvi, pp. 256, 257.

[3] Proc. Zool. Soc. London, 1897, pls. xxv, xxvi.

[4] Stehlin: op. cit., xxvii, p. 466.

[5] Trans. Linn. Soc. London, 1876, p. 286, pl. xli, fig. 3.

[6] l.c., xxvi, pp. 255, 256.

[7] Abh. schweiz. palaeont. Ges., 1900, xxvii, p. 466.

II.—Woodwardian Museum Notes: Salter's Undescribed Species. IV.

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

(PLATE XI.)

GASTEROPODA (*continued*).

Horiostoma discors (Sowerby), var. Mariæ (Salter MS.). (Pl. XI, Figs. 5 and 6.)

1873. *Euomphalus Mariæ*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 156 (*a* 859, *a* 860).

1891. *Euomphalus Mariæ*, Woods: Cat. Type Foss. Woodw. Mus., p. 103.

There are four specimens of this form in the Woodwardian Museum, labelled *a* 859 and *a* 860 by Salter, and all come from the Wenlock Limestone of Dudley. Salter (*loc. cit. supra*) says of it: "Related to *E. discors*, but with most regular ridges of growth. A beautiful shell, dedicated to a most worthy lady—the patient preparer of this collection [Mrs. Fletcher]." All four specimens belong to the Fletcher Collection.

Diagnosis.—Shell nearly discoidal; spire short, usually low and depressed; whorls rounded, five or six in number, ornamented on their apical surface by four or five weak and inconspicuous longitudinal keels, which are crossed nearly at right angles by prominent transverse, equidistant, and regular sharp lamellæ, not very closely set together, and only very slightly undulated where they cross the weak keels. As they pass round to the umbilical surface of the whorls they bend back gently, but again curve forward to the line of contact of the whorls. The umbilical surface of the whorls is devoid of longitudinal keels, except in young individuals. Umbilicus deep, wide, open, exposing all the whorls. Aperture not preserved.

Measurements.

	mm.
Breadth of one specimen (*a* 859)	50·0
Approximate height of the same	20·0
Average distance of varices on upper surface	1·5
Breadth of specimen (*a* 860) showing the under surface of shell	64·0
Depth of umbilicus of same...	12·0

Remarks.—The distinguishing feature of this form is the regularity and prominence of the transverse lamellæ and their slight undulation in crossing the keels. Otherwise it closely resembles *H. discors* and its varieties, including *H. rugosum*, Sowerby.[1] It does not seem possible to retain it as an independent species, as it nearly approximates many specimens of this very variable species *H. discors*, and transitional forms with intermediate characters are not uncommon.

Horiostoma discors (Sowerby).

1873. *Euomphalus pacificatus*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 156 (*a* 861).

1891. *Euomphalus pacificatus*, Woods: Cat. Type Foss. Woodw. Mus., p. 103.

[1] Lindström: Silur. Gastrop. Pterop. Kongl. Sv. Vet. Akad. Handl., Bd. 19, No. 6 (1884), pp. 157–159, pl. xvi, figs. 20–26; pl. xvii, figs. 1–10.

There is only one specimen of this form in the Museum thus labelled by Salter (*a* 861), and it comes from the Wenlock Limestone of Dudley.

Diagnosis.—Shell discoid; spire short; whorls six? (only three are preserved), angulated slightly by longitudinal keel near margin of flattened apical surface; sides of whorls ornamented by two weaker, equidistant, longitudinal keels. No keels on umbilical surface. Surface of whorls crossed by small, closely-set, transverse growth-lamellæ, slightly undulated and irregular, and curving backwards from the mouth outside the inner longitudinal keel of apical surface. Umbilicus not seen. Aperture apparently oblique. Breadth 36 mm.

Remarks.—There is no feature by which this form can be separated from the variable *H. discors*, and the species therefore must be dropped. The indentation on the outer whorl of the specimen is manifestly due to an injury to the shell, and cannot be considered as a character of any specific importance. It is not even desirable to separate this form as a definite variety of *H. discors*, a conclusion I have reached after examining a large series of the latter species.

Pleurotomaria Fletcheri, Salter. (Pl. XI, Fig. 4.)

1873. *Pleurotomaria Fletcheri*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 154 (*a* 851).

1891. *Pleurotomaria Fletcheri*, Woods: Cat. Type Foss. Woodw. Mus., p. 112.

There is only the one original specimen (*a* 851) in the Woodwardian Museum from the Wenlock Limestone of Dudley and belonging to the Fletcher Collection. It is not quite perfect and is slightly compressed laterally, but the shell is preserved on the five whorls. The figure of a *Pleurotomaria* given by Salter (*op. cit. supra*, p. 154) in the margin closely resembles this species.

Diagnosis.—Shell broadly conical; apical angle 50°–60°; whorls six in number (only five are preserved), convex, with slit-band grooving middle of body-whorl, but situated below middle line of other whorls though above suture-line. Two weak longitudinal keels, of which the lower is the stronger, are present on apical surface of body-whorl above slit-band at equal distances between it and suture-line. On the upper whorls the keel nearer the slit-band is more prominent and slightly angulates the apical surface of the whorl, but the other keel nearer the suture-line is almost obsolete. Slit-band concave and sunken as a groove between sharp, prominent, narrow borders; crescents fine, closely packed, sharply curved. Ornamentation of apical surface consists of obliquely transverse, slightly sigmoidal striæ, and wrinkles bending back sharply near the slit-band to meet it as an acute angle. The ornamentation below the slit-band is similar, the striæ being sharply curved back to meet it. Aperture not preserved. Height of specimen *ca.* 45 mm.

Remarks.—The broadly conical shape of the shell and the position of the slit-band on the whorls, as well as its groove-like nature, are features found also in *Pl. biformis* (Lindström),[1] but the ornamentation of the surface is quite distinct, and only one keel is figured in that species above the slit-band.

[1] Lindström: op. cit., p. 98, pl. vii, figs. 39–42.

Pleurotomaria cyclonema (Salter). (Pl. XI, Figs. 1–3.)

1873. *Murchisonia cyclonema*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 155 (*a* 848, *a* 849, *a* 850).

1891. *Murchisonia cyclonema*, Woods: Cat. Type Foss. Woodw. Mus., p. 107.

There are in all fourteen specimens labelled *Murchisonia cyclonema* by Salter, varying in size from 10 mm. to 36 mm. in length. Several are in an excellent state of preservation, and all come from the Wenlock Limestone of Dudley and belong to the Fletcher Collection.

Diagnosis. — Shell conical, turbinate; whorls five, ventricose. Apical angle 50°–60°, being smaller in the older and larger individuals. Body-whorl large, equal to half the length of shell or even more. Slit-band a little above middle line of body-whorl, but in other whorls half-way between the suture-lines. Apical surface with distinct swollen band immediately below upper suture-line of each whorl, and with one rounded, prominent, longitudinal keel between this band and the slit-band. Six or seven longitudinal keels below slit-band on body-whorl, of which the uppermost three or four are prominent rounded ridges, usually nearly equal in size, and nearly equidistant. The other three or four longitudinal keels on the body-whorl are on the umbilical surface, and grow successively much narrower, fainter, and less prominent. On the upper whorls the uppermost three longitudinal keels are alone developed in the adult, the number varying from one to three according to age. Slit-band prominent, of moderate width, bordered on each side by narrow ridge. Surface concave, but marked along centre by longitudinal keel, varying in degree of development, but making profile of slit-band very characteristic. Crescents not very numerous, gently arched backwards, but strongly marked, and in some of the smaller individuals sub-lamellar. Apical surface of whorls crossed obliquely by fine sigmoidal thread-like raised lines, at regular distances apart in young individuals but more closely and less regularly packed in adults. Below slit-band the whorls are ornamented by similar transverse lines, but crossing the keels nearly at right angles instead of obliquely. On both sides of the slit-band the lines are sharply bent back.

Mouth large, subcircular or oval, slightly oblique to axis of shell.

Measurements.

	I	II	III
	mm.	mm.	mm.
Length	36·0	21·0	17·0
Breadth (across body-whorl) ...	25·0	15·0	13·5
Apical angle	50°	55°	60°

Remarks.—This species bears much resemblance to *Pleurotomaria laqueata* (Lindström),[1] from the corresponding beds of Gotland, in its general shape, in the distribution and number of the keels, and in the position of the slit-band, but differs in the minute characters of the latter, which is an important point.

It has the general aspect of *Pl. Lloydi*, Sow., but differs in having only one keel above the slit-band and fewer and larger keels

[1] Lindström: op. cit., p. 102, pl. ix, figs. 4–6.

G.M. Woodward del. et lith.

West, Newman imp.

Gasteropoda, Wenlock Limestone, Dudley.

below, and in the lower position of the slit-band and its minute characters. The slit-band, in fact, resembles more closely that of *Pl. bicincta* (Hall)[1] than that of any other species in the presence of the keel along the middle of the band and its sharp borders.

EXPLANATION OF PLATE XI.

FIG. 1.—*Pleurotomaria cyclonema*, Salter, sp. Nat. size.
FIG. 2.—Ditto, showing mouth. Nat. size.
FIG. 3.—Ditto, slit-band. × 5.
FIG. 4.—*Pleurotomaria Fletcheri*, Salter. Nat. size.
FIG. 5.—*Horiostoma discors*, var. *Mariæ*, Salter, sp. Nat. size.
FIG. 6.—Ditto, umbilical surface. Nat. size.

III.—SOME SECTIONS IN THE CRETACEOUS ROCKS AROUND GLYNDE, AND THEIR FOSSIL CONTENTS.

By J. P. JOHNSON.

IN the memoir recently published by the Geological Survey[2] on the Selbornian strata of England, no mention is made of an interesting section in the Gault near Glynde, which was certainly in existence up to 1898, when I last visited the district. The object of the present note is to put this section on record, together with some observations on two chalk quarries, from which I have at various times collected fossils.

The pit in the Gault is situated on private land about a quarter of a mile from the railway station, with which it is connected by a railroad. As far as I can remember, it showed some 15 feet of slate-blue clay, containing an abundance of pyrites, and consequently a quantity of selenite, though in small crystals. The only organic remains that were at all plentiful were the ammonites, *Schlœnbachia varicosus*, *Hoplites denarius*, and *Ancyloceras spinigerum*. The finding of a big tooth of *Protosphyræna ferox* is noteworthy.

The large quarry in the Chalk at the railway station exhibits a fine section of the well-known limestone, which here contains a very small proportion of clayey matter and occasional nodules of marcasite. It is of Cenomanian age, as shown by the occurrence of *Schlœnbachia varians*. The commonest fossils are the Selachian remains, amongst which I may especially mention a nice series of the teeth of *Scaphanorhynchus subulatus* and forty-seven associated teeth of *Ptychodus decurrens*. It was from here that I obtained the fine mandibular ramus of *Pachyrhizodus Gardneri* which is in the British Museum.

Just outside the village, on the right-hand side of the road to Lewes, and joined to the above-mentioned quarry by a railroad, is another large excavation in the Chalk. This is at a higher level, and is in the face of the escarpment. The Chalk differs from that already described in being free from argillaceous matter; it also yields nodules of marcasite and, in the topmost beds, a few flints. It is mostly of Turonian age, as shown by the abundance of *Rhynchonella Cuvieri*, *Inoceramus mytiloides*, *I. Cuvieri*, and *Lima*

[1] Lindström: op. cit., p. 106, pl. viii, figs. 21 and 23.
[2] "The Cretaceous Rocks of Britain," vol. i (1900); by A. J. Jukes-Browne.

spinosa, but a little is probably Senonian, for the hard sub-crystalline band known as the Chalk Rock, which in this country stratigraphically separates the two periods, is certainly present, though I have not been able to determine its exact position, as the section has always been obscured during my visits by the talus resulting from blasting operations. I have a series of thirty-nine associated teeth of *Ptychodus mammilaris* from here in Chalk Rock matrix.

LIST OF FOSSILS.

	S.	C.	T.
PISCES.			
Pachyrhizodus Gardneri, Mason		*	
Cimolichthys Levesiensis, Leidy		*	
Protosphyræna ferox, Leidy	*	*	
(*Scaphanorhynchus* ?) *subulatus*, Ag.		*	
Lamna appendiculata, Ag.		*	*
'*Oxyrhina angustidens*, Reuss'		*	
Oxyrhina Mantelli, Ag.		*	*
Corax falcatus, Ag.		*	*
Notidanus microdon, Ag.		*	
Ptychodus mammilaris, Ag.			*
Ptychodus decurrens, Ag.		*	
CEPHALOPODA.			
Nautilus (*sublævigatus*, D'Orb. ?)		*	
Ancyloceras spinigerum, J. Sby.	*		
Scaphites Hugardianus, J. Sby.	*		
Acanthoceras navicularis, Mant.		*	
Hoplites denarius, J. Sby.	*		
Schlœnbachia varians, J. Sby.		*	
Schlœnbachia varicosus, J. Sby.	*		
Desmoceras Beudanti, Brong.	*		
GASTROPODA.			
Aporrhais Parkinsoni, Mant.	*		
Pleurotomaria perspectiva, Mant.		*	
PELECYPODA.			
Nucula pectinata, J. Sby.	*		
Pholadomya decussata, Mant.		*	
(*Lima* ?) *spinosa*, J. Sby.			*
Plagiostoma globosa, J. Sby.		*	
Inoceramus Cuvieri, J. Sby.			*
Inoceramus mytiloides, Mant.			*
BRACHIOPODA.			
Terebratula biplicata, J. Sby.		*	*
Rhynchonella Cuvieri, D'Orb.			*
CRUSTACEA.			
Enoploclytia Sussexiensis		*	
ECHINOIDEA.			
Peltastes clathratus, Ag.		*	

Skirting the Chalk escarpment westwards, one at length arrives at the classical Lewes quarries. They do not need to be dealt with here, as they have already been described, but I think it desirable to mention three quartz pebbles which I obtained from one of the workmen. They were all in pieces of chalk, and one is encrusted with a species of Bryozoa. From the finder's description I gathered that they had either come from the highest of the Turonian beds or from the oldest of the Senonian.

Annexed is a list of the organic remains which I have collected from the above-described sections. The nomenclature of the Selachians is that employed by Dr. A. S. Woodward in his "Notes on the Shark's Teeth from British Cretaceous Formations." [1] With regard to the teeth termed '*Oxyrhina angustidens*,' they are of two kinds—those in which the back portion is smooth and those in which it is striated. I venture to think that these should be referred respectively to *Scaphanorhynchus subulatus* and *S. rhaphiodon*. Like the Selachians, *Protosphyræna ferox* is represented by teeth only, while *Cimolichthys Levesiensis* is indicated by a single example of its peculiarly barbed pterygoid teeth.

IV.—Note on a Chalk Ammonite, probably referable to *Ammonites Ramsayanus*, Sharpe.

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

In 1856 Sharpe [2] founded the species *Ammonites Ramsayanus* upon a single deformed specimen (in the collection of J. Wiest, Esq.) that was obtained from the "Chalk with silicious grains, at Chardstock, Somersetshire."

His description is as follows:—

"A testâ discoideâ, costatâ, tuberculatâ; anfractibus paucis, subcompressis: costis continuis, bi-tuberculatis, ad dorsum bifurcatibus: dorso lato, rotundato, costato, utrinque tuberculato: umbilico parvo: aperturâ oblongâ.

"Shell discoidal, with few, slightly flattened whorls, and a broad rounded back: the whorls are ornamented on the sides by twenty ribs, each of which rise from a small tubercle at the edge of the umbilicus, and has another larger tubercle near the back; at the latter tubercle each rib divides into two smaller ribs, which continue across the back, and unite again at the corresponding tubercle on the other side of the back: umbilicus small, allowing nearly half of the inner whorls to be seen: aperture oblong: the septa have not been seen."

Respecting the type-specimen Sharpe wrote:—"The only specimen which has been seen of this species is deformed, owing, without doubt, to an accident met with when very young. In consequence of this malformation, the two sides have very little resemblance to each other; and the specific character given above may prove incorrect when more perfect specimens are met with."

Mr. Jukes-Browne has recently called my attention to an Ammonite [3]

[1] Proc. Geol. Assoc., vol. xiii (1894).

[2] D. Sharpe: Foss. Moll. Chalk (Mon. Pal. Soc.), pt. iii, 1856, p. 51, pl. xxiii, ff. 4*a–c*.

[3] For the loan of this fossil my best thanks are due to the Rev. H. H. Winwood, M.A., F.G.S.

belonging to the Bath Museum that I think is referable to Sharpe's 'species.' The specimen is labelled "Chalk marl: Evershot." The dimensions of the type-specimen as given by Sharpe are:—Diameter, $1\frac{1}{2}$ inch [or about 38 mm.]; height of the last whorl, $\frac{5}{8}$ inch [or about 16 mm.]; width of the aperture, $\frac{1}{2}$ inch [or about 12·75 mm.]. On account of the malformation of the specimen the width of the umbilicus is not quite the same on the two sides, but according to Sharpe's figures, which from their other measurements appear to be drawn of the natural size, the width of the umbilicus on the side represented in his fig. 4*a* is 11 mm. These dimensions expressed in terms of the diameter, when this is taken as 100, are:—Diameter, 100; height of last whorl, 41·66; width of the aperture (or thickness of the last whorl), 33·33; width of umbilicus, 30.

The dimensions of the present specimen, of which rather more than half the outer whorl belonged to the body-chamber, are:—Diameter, 35·5 mm. (100); height of the outer whorl, 14 mm. (39·43); thickness of the outer whorl (or width of the aperture), 13·5 mm. (38·0); width of umbilicus, 11 mm. (32·27). The specimen is well preserved and very nearly symmetrical, each side closely resembling the lateral view depicted by Sharpe in his fig. 4*a*, and the transverse section of the whorl agreeing very closely with his fig. 4*c*.

Compared with Sharpe's type-specimen, however, the present example exhibits some differences. It has a slightly wider umbilicus; the ribs on the lateral area are more distinct and regular even up to the anterior end of the specimen, but less numerous, being only sixteen in number on the outer whorl, and, in passing from the umbilicus towards the periphery, are more forwardly inclined, whilst the lateral tubercle is nearer the middle of the lateral area. The greatest difference, however, is in the character of the periphery. The whole of the periphery of Sharpe's type-specimen is broadly rounded from side to side. This is not quite the case in the present specimen. The periphery of the earliest portion of the outer whorl is on the whole broadly rounded but not regularly convex; one side is convex, but the other is somewhat flattened and in part depressed, so that the periphery of this portion of the outer whorl bears a feeble groove which is not quite in the median line. At a subsequent stage, i.e. at a short distance from the commencement of the outer whorl, two broad shallow grooves, about 3·5 mm. apart, appear (one a little earlier than the other) one on each side of the median line, and almost close to the margin, of the periphery; these gradually deepen as the whorl increases in size, and at the anterior end of the specimen are about 5 mm. apart.

The ribs on the two sides are not opposite but alternate; each bears a rather small compressed transversely-elongated tubercle at the umbilical margin, and a similar but more prominent tubercle at about the middle, or rather outside the middle, of the lateral area. On about the first half of the outer whorl each rib bifurcates, though not very distinctly, at the lateral tubercle, and the broad feeble branches cross the periphery, sometimes a little irregularly, and join the branches from the opposite side, each branch being slightly thickened into an obtuse tubercle at the margin of the periphery. On the rest of the outer whorl each rib, instead of actually bifurcating, bends slightly backward at the lateral tubercle and passes straight to the peripheral margin, where it is slightly thickened into a blunt obtuse tubercle; whilst in the space between each pair of lateral tubercles, but somewhat nearer the periphery than the tubercles themselves, an obscure rib arises and also passes to the peripheral margin, where it is also similarly thickened; the tubercles on the intermediate ribs are frequently stronger than those at the extremities of the principal ribs. In a few instances the ribs are raised into a very obtuse tubercle on the median line of the periphery. On the peripheral area of the earliest portion of the outer whorl, i.e. the portion bearing the single feeble groove, the ribs on one side of the median line are slightly inclined backwards, whilst on the other side they are nearly direct. Although portions of the septa can be seen, a complete suture-line cannot be made out, but from the parts that are visible the septa appear to be fairly symmetrical.

On the whole I think there cannot be much doubt about the present example being referable to Sharpe's *Ammonites Ramsayanus.* Notwithstanding the apparent symmetry of the specimen, its periphery presents certain appearances which suggest that the fossil is deformed.

One side of Sharpe's specimen, viz. that represented in his fig. 4*b*, looks something like a deformed *Ammonites Salteri*,[1] which Sharpe also described from the "Chalk with silicious grains, at Chardstock, Somersetshire," but the opposite side appears to be quite different.

Sharpe's type-specimen certainly was deformed, and I think the Bath specimen is also, but being unable to refer them to any other species which has hitherto been described from the Chalk, it seems desirable to retain, at least provisionally, Sharpe's name *Ammonites Ramsayanus.*

V.—Oscillations in the Sea-level. (Part III.)

By H. W. Pearson.

(*Continued from the May Number, p.* 231.)

Data used in showing a Period of High Sea-level in the North, culminating about the years 1475 *to* 1500.

NORWICH, England, is represented as situated on the banks of an arm of the sea even in the thirteenth and fourteenth centuries (Lyell's "Principles," 11th ed., vol. i, p. 521; S. Woodward[2]). Early in the fourteenth century Pagham Harbour was formed by a sudden inroad of the sea (Encyc. Brit., vol. xxii, p. 723).

[1] D. Sharpe: Foss. Moll. Chalk (Mon. Pal. Soc.), pt. iii, 1856, p. 50, pl. xxiii, ff. 3*a*, *b*, *c*, and 5*a*, *b*.

[2] "History and Antiquities of Norwich Castle," 1836. Plates showing the 'Yarmouth Hutch Map,' A.D. 1000, and at various other periods, earlier and later: drawn from local records and geological observations.

Town of Rye "situated upon a rocky eminence which two or three centuries ago was washed on all sides by the influx of the tides, but now, in consequence of the gradual recession of the sea, lies two miles inland" (Encyc. Brit., vol. xxi, p. 117). In Charles II's time (1660–1685) a 64-gun frigate could ride in the harbour of Rye; now a ship of half that size could not obtain an entrance (Clark's "Guide and History of Rye," p. 63). Between 1292 and 1340 upwards of 5,500 acres were submerged by the sea in Sussex (Encyc. Brit., vol. xxii, p. 723). "It is said that old Winchelsea contained 50 inns and taverns and 700 householders: here 400 sail of the tallest ships, it is said, anchored in the Camber near Rye, where sheep and cattle now feed." Three hundred houses destroyed by rising of the sea in the year 1250, and the destruction made total by the great inundation of 1287 (Clark's "Guide and History of Rye," pp. 64, 65).

Great portions of the English Fens were drowned in the years 1248, 1250, 1257, 1286, 1292, 1322, 1357, 1358; Marshland drowned in 1287, 1289, 1292, 1294, 1295, 1297, 1334, 1339, 1378, 1422, 1520, and 1569 ("The Fenland Past and Present," p. 146). "In the year 1362 the unfortunate Marshlanders show that the Lynn River, which formerly was only 12 perches broad, was then a full mile in breadth; but in the years 1378, 1565, and 1608 we find notices showing that the river was growing wider" (p. 212). Raveneserodd destroyed by the sea, thirteenth and fourteenth centuries. "1377 and 1393 appear to have been critical years in the waste of this coast" ("Lincolnshire and the Danes," pp. 239, 240). Hugh of Levens, in a petition to the Archbishop of York shortly after 1339, says, "Whereas our manors and lands of Saltagh, Tharlesthorp, Frysmerske, Wythfleet, Dymelton, and Raveneserodd were so destroyed every day and night by increasing inundations of the waters," etc. (p. 46). Towns of Holton, Northrup, and Newton destroyed at the same time (p. 49). "When Henry IV landed at Ravenspurn, June, 1399, the towns of Ravenser and Raveneserodd had long been engulfed by the waters" (p. 57). "In that time (1249 to 1269) the sea inundated and passed over its coasts almost throughout the whole eastern part of England, and the Humber, exceeding its limits, covered the land even to our fishing and wood of Cotyngham" (p. 67, quoting "Chronicles of Meaux"; Boyle, "The Lost Towns of the Humber").

"In the thirteenth century the river [Fleet River in London] was of such breadth and depth that ten or twelve ships at once with merchandise were wont to come to the bridge of Fleet and some of them to Holborn bridge" (Whealey, "London Past and Present," p. 52). After the great fire (1666) "the citizens had it deepened between Holborn and the Thames so that barges might ascend with the tide as far as Holborn as before" (p. 53). See copy of drawing on stairway of St. Martin's Free Library, London, by Anty' van den Wyngaerde (original in Bodleian Library, Oxford). Date of picture, 1543. This shows Moats of Tower on a level with the Thames and full of water. Shows also Fleet River with bridges at Fleet and

Holborn streets. There is no possible method of explaining the peculiarities of this drawing, except by the assumption that the Thames at that time stood 12 to 15 feet higher than at present.

In the History of the City of Chester, by Joseph Hemmingway, we read, "The New Water Tower was erected in the year 1322" (p. 133). "At the outside of this Tower are fixed great iron rings, being of use heretofore for mooring the ships" (p. 356). "It is certain that long before the period at which this was written [about 1706] vessels had ceased to approach this tower" (p. 356). Quoting Fuller from his "Worthies of the City" (pub. 1662), "and now being about to take our leave of this ancient and honorable city, the worst that I wish it is that the distance between the Dee and the New Tower may be made up—that the rings on the New Tower (now only for sight) may be restored to the service for which they were first intended," etc.

Castle Huntley (in the Carse of Gowrie, Scotland) was erected in 1452 (Encyc. Brit., vol. xviii, p. 667). "This castle once had rings fixed to it for mooring the boats formerly sailing on the surrounding waters" (Chambers, "Ancient Sea Margins," p. 20). This castle is now some miles from the sea, and the ordnance map of that region shows that it would be necessary to elevate the sea-level 20 to 24 feet to again allow these rings to be put to their original use. "Yet we have internal evidence from the marginal observations in one of the set of books (Records of Tide Gauges, Leith, Scotland) that in the year 1810 mean tides rose to a point 2 ft. 10 ins. higher than they do at present" (Mr. Thomas Smyth, Geol. Mag., 1866, Vol. III, p. 427). Mr. Smyth, in conclusion, stated that "The upheaval which is at present taking place on the shores of the Firth of Forth and in Berwickshire has its counterpart in Caithness, which is rising at nearly the same rate" (p. 427). The low-water level in Glasgow Harbour has fallen 8 feet since 1758: alleged cause, improvements in bed of Clyde; real cause, the so-called upheaval as shown above by Smyth (*Geological Record*, 1876, p. 10). "The encroachments of the land upon the sea are strikingly exhibited in the sandbanks and deltas of the principal bays and estuaries of the island [Arran], and there can be little doubt that a few centuries ago the ships of the islanders found a secure harbourage within the creeks and bays, where the heath and brushwood now luxuriate" (McArthur, "The Antiquities of Arran," p. 105).

The Gulf Stream Islands were discovered in 1871. "In the spot where these now are, the Dutch in 1594 found and measured a sandbank in soundings of 18 fathoms, showing an upheaval here of 100 feet in 300 years" (Journ. Roy. Geog. Soc., 1873, p. 253). We note as to this that we have no evidence that the Dutch found the shoalest water, therefore this estimated upheaval is probably considerably too large. Diomed Island (on Siberian coast), described by Chalavrof in 1760, no longer exists; it now forms a part of the main (p. 256). "From 1730 to 1839 the upheaval of Loeffgrund amounted to 2 ft. 11 ins. only" (Reclus; Harpers, "The

Earth," p. 531). "Borre, a village (in Denmark) now lost amidst the Fens, stood on the beach in 1510" ("The Earth and its Inhabitants," Europe, vol. v, p. 54). "These mountains [of Spitzbergen] increase in bulk every year, so as to be plainly discoverable. Leonin was surprised to find on the hill, about a league from the seaside, a small mast of a ship with one of its pulleys still fastened to it" (written in 1646; see Journ. Roy. Geog. Soc., 1873, p. 252). "The waters over which the French expedition measured an arc of the Meridian (Tornea, Sweden, 1736–1737) are now replaced by meadows" (Phillips, "Manual of Geology," p. 326). The general and recent so-called upheaval of Scandinavia, having been demonstrated so thoroughly through modern textbooks, I will make no further reference thereto.

Caligula erected A.D. 51 a huge tower a mile from the coast near Boulogne, France; in 1544 this tower was only 200 yards from the coast ("Antiquities of Hastings," p. 13). Aigues Mortes, a seaport in the thirteenth century, is now five miles inland (Smyth, "The Mediterranean," p. 13). "Some of the present vineyards of Agde were covered by the sea only a century ago" (written about 1850; ibid., p. 13). "The Tower of Pignaux (Lyell, Tignaux) erected on the shore in 1737; now a French mile from it" (Milner, "Gallery of Nature," p. 398). "The old port of Talmont, where Henry IV embarked his artillery (1411), has become dry land" ("The Earth and its Inhabitants," Europe, vol. ii, p. 210). The tower built by Michael Angelo in 1567 on the very edge of the coast (at mouth of Tiber) is now 2,250 yards inland (Lanciani, "Ancient Rome," p. 235). On the west side of the Gulf of Taranto a tower erected by the Angevine kings (fourteenth and fifteenth centuries) on the coast is now above a mile distant from shore (Smyth, "The Mediterranean," p. 36). Poingdestre, writing in 1685, says, "A portion of the Jersey Isles became submerged in 1356." "The Ecrehous and Dirouilles, on the north-east of Jersey, are known to have been much more extensive than at present; they also sunk probably in 1356" (R. A. Peacock in Rep. Brit. Assoc., 1865, p. 70).

The city of Foah at the commencement of the fifteenth century was on the Canopic, mouth of the Nile, now more than a mile inland (Quart. Journ. Geol. Soc., vol. iv, p. 346).

J. E. Davis says that embankments built near Tremadoc, Wales, since the sixteenth century now rendered useless by the recession of the sea (ibid., vol. ii, p. 74). Captain Marcus Jones, of Portmadoc, Wales, informed me April 12th, 1898, that his father, he thinks about the close of last century or the first of this, went with a boat to a place under Tynyberllan, a short distance to the south-east of Wern, Tremadoc, to fetch a load of American timber. To allow this to be done the sea must necessarily have stood several feet higher than at present, Wern being now at least three miles from the sea. Mr. F. L. Edwards, Harlech, Wales, in April, 1898, informed me that he saw, twenty years before, an old lady who, when she was a little girl, visited an aunt in a cottage (Cafinrhyn) about 2½ miles north of Harlech. During the night the tide came up and she jumped out of bed into water up to her knees. Now the tide does not come within three miles of this place. At Castle Hotel, Harlech, a picture of Harlech Castle (printed by Alex. Bogg, 16, Paternoster Row) is exhibited, showing the sea reaching to the base of the castle. Sea is now one mile distant. It would be interesting to learn the date of this picture.

The Zuyder Zee was opened at the expense of the land in the first years of the thirteenth century, "and never ceased to enlarge itself during 200 years" (Reclus, "The Ocean," p. 154). In 1230 occurred the terrible inundation of Friesland, costing the lives of 100,000 people; in 1231 the lakes of Haarlem overflowed, and gradually increasing united with each other toward 1650. In 1277 the Gulf of Dollart began to be hollowed out. It was only in 1537 that the invasion of the sea, which had devoured the town of Torum and fifty villages, could be arrested; in 1287 the Zuyder Zee drowned 60,000 persons; in 1421 seventy-two villages were submerged at once ("The Ocean," p. 154). The island of Wieringer, part of the mainland in 1205, was detached by floods in 1219, 1220, 1221, 1246, 1251. The Biesbosch, Holland, formed in 1421, twenty-two villages drowned. Inundations of the Gulf of Dollart, 1277, 1278, 1280, and 1287. The western coast of Schleswig swallowed up in 1240. Fourteen villages in Isle of Cadsand, Zealand, submerged in 1337. Kortgene Island engulfed in 1530 ("The Gallery of Nature," p. 389).

The record above given of the devastation wrought by the sea in Holland between the years 1200 and 1500 is but partial; it might be extended tenfold, but it is sufficient to show exactly what occurred on these shores during the period named. The history is plain to read; about the year 1200 the rising sea-level began to overtop the barriers erected by the people of the lowlands for the protection of their homes. Those barriers which yesterday were found ample will to-morrow be found deficient in height. The progressive rising of the sea exceeding the ability of man to elevate the embankments. The result is that during the 250 years or more which elapsed before these waters reached their highest level, the history of Holland forms one long chapter of horrors. We can see also that during the period when Holland was sinking beneath the waves the English coast was undergoing the same ordeal, as illustrated in the history of Rye, Norwich, Winchelsea, Ravenser, and the Fens, only, more fortunate than Holland, she had little low-lying lands along her borders liable to submergence; her losses, therefore, during the epoch of the advancing sea were less extensive.

The haven in which the Chinese Admiral anchored his fleet (in Formosa, 1661) "is now a dry, arid plain, over which there is a road and several canals cut to communicate with the old port of Tai-wan-fu" (Journ. Roy. Geog. Soc., vol. xliii, p. 99). "The Dutch fort of 1624, originally built on an islet at some distance from the shore, now forms part of Formosa, and under its ruins the water is so shallow that passengers land with much difficulty where was formerly deep water" (*Science*, vol. v, p. 262). Newchang (China), once a seaport, abandoned for Taitze, on account of recession of the sea. Taitze in its turn abandoned during the present century, and Yingtze established owing to the shoaling of the water (Journ. Roy. Geog. Soc., vol. xliii, p. 258).

Indian Survey shows "it is almost certain that the mean sea-level at Madras is a foot lower than it was sixty years ago" (*Science*, vol. iv, p. 212). Gaur, or Gour, India, subject to inundation in 1590; not so now (Encyc. Brit., vol. x, p. 113). "Very curious evidence of the gradual elevation of the land, or rather of the constant retrocession of the sea, is afforded by the traditions of the community of Verawow" (India). "It is several generations since any sea-borne ships have been near this ancient port" (Journ. Roy. Geog. Soc., 1870, pp. 194–5). Adam's Bridge, connecting Ceylon and India, breached by high water in year 1480 (Encyc. Brit., vol. xx, p. 266).

Investigation near the site of the Temple of Jupiter Serapis (Bay of Baie) informs us that about 1503 and 1511 the level of the Mediterranean Sea at that point stood 20 to 22 feet higher than at present (A. J. Jukes-Browne, "Physical Geography," p. 46). "The period of deep submergence was certainly antecedent to the close of the fifteenth century" (Temple of Jupiter Serapis), (Lyell's "Principles," 11th ed., p. 173).

Henry Hudson in 1610 wintered in an arm of Hudson Bay, now impassable except for small boats. In 1674 sloop sailed through between island and the main west shore of James Bay. In 1886 it was difficult to get through this passage with canoes (Journ. Science, ser. IV, vol. i, p. 224).

This part of the island [Isle of Pines, off south-west coast of Cuba] seems to have been upheaved in relatively recent times, for even within the historical period (i.e. since 1492) various islets on the coast have been merged in continuous land ("The Earth and its Inhabitants," North America, vol. i, p. 364). "Interesting examples of recent elevation are believed to occur in the neighbourhood of Washington, D.C. In colonial times Bladensburg and Dumfries could be reached by sea-going ships, but now they are decidedly above tide-level. The change is generally supposed to be due to silting up of the creek, but this appears not to be the case, for there is little alluvium resting upon the bed-rock of the channels" (W. B. Scott, "Introduction to Geology," p. 67).

In the second volume of the Maryland Geological Survey, Mr. Edward B. Mathews discusses at length the difference existing between the ancient maps of Chesapeake Bay and the modern maps. He examines Captain John Smith's map of 1608, Herriman's map of 1670, etc. As to these differences Mathews remarks as follows:—"He [Smith] clearly mistook the deeply indented peninsulas of Dorchester and Talbot Counties for islands" (p. 354). "The rest of the shore-line indicates either a loose generalization of marshy lowlands, or that some of the smaller points and islands are of *recent development*" (p. 355). "It may be suggested that part of the present land was then marshland" (p. 356). "A study of the shore of Somerset County (Herriman's map) seems to indicate that considerable filling in has taken place since the date of the map" (p. 381). "Portions of the coast, such as James Island Marsh, Hazard Point, and Deals Island, and possibly Nauticoke Point, are represented by Herriman as *islands clearly separated from the mainland*" (p. 381). "Seavorn River is too broad" (p. 382). South and west rivers "show the constant error of being too broad. This, however, is a feature which is common to the rivers of this and many other maps of the seventeenth and eighteenth centuries" (p. 381).

Now these data so clearly shown by Mr. Mathews lead to but one conclusion. We cannot believe that these ancient geographers made mistakes of observation always in one direction; they mapped out the present peninsulas as islands, because the sea stood higher at that time, and they were islands; they mapped out the rivers broader than now, because at that time they *were* broader, owing to the higher sea-level. The filling in has taken place; the "recent development" of islands and points and marshes has occurred, simply because the sea has fallen in the last two hundred years, and the observed change in the topography of these shores is the necessary consequence.

Zagoskin says "that the spot where the fort now stands [Fort Yukon, Alaska] has been covered by the sea within the memory of the Indians living at the date of his visit in 1842 and 1843" (Howorth in Journ. Roy. Geog. Soc., vol. xliii, p. 246). Mr. H. W. Elliot, in "The Seal and Salmon Fisheries of Alaska," vol. iii, states that when the natives first came to the Pribilof Islands, Novastoshnah was an island by itself; it now forms a portion of St. Paul's Island. (The natives came to these islands immediately on their discovery in 1766.) "The lagoon (near village of St. Paul) was then an open harbour, in which the ships of the old Russian Company rocked safe at anchor. To-day, no vessel drawing ten feet of water can get nearer than a mile from the lagoon" (p. 21).

Further to the north, at Colon and at Santa Marta and several other points of the coast of New Granada, the ground has visibly risen since Europeans first landed on the Continent (Reclus, "The Earth," p. 552). The marshes [of the Vendée, France] raised above the sea-level within historic times four centuries ago (Encyc. Brit., vol. xxiv, p. 137). "In the reign of Edward III (1327–1377) it was unlawful to bathe in the Fosse or in the Thames near the Tower, the penalty being death" ("Authorized Guide to the Tower of London," p. 11). This would show a full moat at that period. The ditch was dry in 1140. Longchamp spent a large sum of money in 1190, "but he failed to fill the ditch with water" (p. 149). The easiest explanation of the presence of water in the moat at the above date lies in the high-water period then in existence. The moat to-day contains no water whatever.

Data indicating a Period of Low Sea-level about the year 1175 A.D.

Omar, who wrote about 1050 A.D., had satisfied himself that "the extension of the sea had been greater at some former periods." He was the author of a work, "The Retreat of the Sea." We can infer, then, that he had observed indications of a recent recession of the sea—in other words, he must have lived during a *low-water period*, or at such time as the sea had already made great recession from the high-water position of 875. Bede says the Channel between the Isle of Thanet and balance of Kent was three furlongs wide in the eighth century, and it is supposed it began to grow shallow about 1066 ("Principles," vol. i, p. 529). Dantzic at the same level now as in the year 1000 ("Principles," vol. ii, p. 182). Heligoland in 1072 extended over a space of 900 square kilometres ("The Ocean," p. 153). Island at the mouth of the Bay of St. Malo formed a portion of the mainland in the twelfth century ("The Earth and its Inhabitants," Europe, vol. ii, p. 251).

Henry of Huntingdon says about 1134, "This fennie countrie [the Fens, England] is passing rich and plenteous, finely adorned with woods and islands." William of Malmsbury, who wrote about the year 1140, says, "The Fens were a very paradise, the very marshes bearing goodly trees which for tallness strived to reach up to the stars" ("History and Antiquities of Boston," p. 660). "It seems to show that Lincolnshire was then [time of William the Conqueror, 1068] a fertile corn-bearing district" ("The Fenland Past and Present," p. 98). We have already shown how this paradise, this fertile corn-bearing district—these terms describing the condition of this region during the low-water period—was later, during the advance of the sea between the years 1250 and 1500, submerged and devastated; this devastation being contemporaneous with the inundation of Holland. Dirk II received in 983 a broad district that is now covered by the Zuyder Zee (Encyc. Brit., vol. xii, p. 71). "There was [in the strait between the Isle of Thanet and coast of Kent] a considerable passage for ships till about the time of the Norman Conquest, very soon after which the inhabitants began to reclaim the land that had been formerly under water" (Wilson, "The Isle of Thanet Guide," p. 7).

Data showing the High-Water Epoch of about 875 A.D.

"In the time of Charlemagne the island [Heligoland] was not much larger than now" ("Principles," vol. i, p. 559). In the year 800 the sea carried off large quantities of soil from Heligoland ("Gallery of Nature," p. 388). In the years 800 to 900 "Tempests change the coasts of Brittany; valleys and villages are swallowed up" (loc. cit.). Channel between the Isle of Thanet and mainland was three furlongs wide in the eighth century ("Principles," vol. i, p. 529). In 660 the Rhine inundated the country ("The Ocean," p. 153). "Some antiquarians maintain that the submarine trees that occur along the coast between St. Malo and Cape La Hogue are the relics of a broad belt of forest land, which was overwhelmed by the sea in the year 709, although the submergence was not completed until 860" (Jas. Geikie, "Prehistoric Europe," p. 481). "Migulon and Psalmody were islands in the year 815, and in 1820 they were two leagues from the sea" ("The Mediterranean," p. 13). Ferd. de Lesseps shows that eleven centuries ago (about 800) the mean level of the Red Sea was about three metres higher than now (*Geological Record,* 1874, p. 146).

Certain ancient documents now existing in the Town Hall of Rye (Charter of King Richard I, 1194, etc.) plainly show that prior to that date the sea had surrounded the town of Rye (Rep. Brit. Assoc., 1890, p. 825). "A deplorable state of the Fens (England) is depicted by some who wrote of that period (early part of eighth century). Dugdale shows that the fresh waters were of wide extent and deep" ("The Fenland Past and Present," p. 71). Again, "The Isle of Ely was, even at that early period (870 A.D.), a place of refuge; parties detached from the fleet (Danes) passed up the river in quest of booty, for such was the depth of the water, which extended to the sea, that they had an easy access into it by shipping" (p. 82). (Now Ely is 30 miles from the sea.) "The tide then, 1,000 years ago, flowed up the river Witham to Lincoln" ("Lincolnshire and the Danes," p. 195).

In the years 800 to 950 the isles of Ammiuno and Costanziaco, near Venice, disappear ("Gallery of Nature," p. 388). Notre Dame des Ports "was also a harbour in 898, but is now a league from the shore" (p. 393). Saugus Island, at mouth of River Ganges, at one time contained the largest city in India; this city was entirely destroyed by the sea 1,000 years ago (from card on exhibit in Memorial Hall, Philadelphia; authority quoted, Sir Wm. Jones). "This seems to place Lydd on the shore (year 774), though it is now nearly three miles from the shore" (Greenwood, "Rain and Rivers," p. 63). "The present position of several edifices situated in the island of Munkholm, near Trondhjiem, proves that during a thousand years the elevation of the ground has been less than 20 feet" ("The Earth," p. 532). Verawow, India, was settled more than 800 years ago. "At that time sea-going ships came with ease to the vicinity of the present town, and they still show the stone posts to which the ships were moored" (Journ. Roy. Geog. Soc., 1870, p. 195). "About the year 850 there occurred a fearful inundation of the Tigris" ("The Remains of Lost Empires," p. 260).

Data as to Low-Water Period of about 600 A.D.

The Archipelago of Chausey is stated in the "Lives of the Saints" to have formed part of the mainland in the beginning of the eighth century, the area now covered by the sea being then occupied by a vast forest (Reclus, "Europe," vol. ii, p. 251). It is well known that previous to A.D. 709 the whole Bay (Bay of Mont St. Michel) as far as Chausey rocks, and for a considerable breadth northwards as far as Cape La Hague and the country southwards as far as Dol, was the forest of Scisey (Rep. Brit. Assoc, 1865, p. 70). "It is certain that Mont St. Michel, which contains now only about 20 acres, was immediately previous to A.D. 709 six miles long by four broad and covered by forests" (loc. cit.). Abbey of Whitby, erected in 658, is reported to have been a mile from the sea. The distance in 1816 was little more than 200 yards ("Gallery of Nature," p. 394). The passage between the Isle of Thanet and the coast of Kent, which remained in "perfect state" so long as the Romans remained in Britain, "in Bede's time (circ. 675 to 735), and perhaps an age before that, began to decline by diminishing its breadth, etc." (S. R. Wilson, "The Isle of Thanet Guide," p. 6).

Data as to High-Water Period of about 350 A.D.

Norwich, "in the time of the Saxons, was situated on the banks of an arm of the sea, an estuary which has since become a region of cultivated fields" ("Gallery of Nature," p. 396). "The former Roman port of Alaterva (Cramond, Scotland), the quays of which are still visible, is now situated at some distance from the sea, and the ground on which it stands has risen at least 24½ feet." In other places the débris scattered on the bank show that the coast has risen about 26½ feet. Now by a remarkable coincidence the ancient wall of Antoninus, which at the time of the Romans served as a barrier against the Picts, comes to an end at a point 26 feet above the level of high tides" ("The Earth," p. 537). The Isle of Thanet was separated from the rest of Kent in the time of the Romans by a navigable channel, through which fleets sailed ("Principles," p. 529). During the course of the third century tradition tells us that the island of Walcheren was separated from the Continent (Reclus, "The Ocean," p. 153). "The Hythe coast must have risen quite 30 feet since Roman times" (Geol. Mag., April, 1885, p. 145). Valerius Maximus states that a bank was erected in 230 A.D. to keep out sea and storm from the Temple of Serapis (Quart. Journ. Geol. Soc., 1847, p. 213). Note this is evidence that the sea was rising at that time, and had reached an elevation about equivalent to its present level.

Sir Charles Lyell and Sir Archibald Geikie believe with many others, including Smyth, that there had been a considerable upheaval of the shores of the Firth of Forth since the period of the Roman occupation (Geol. Mag., 1866, p. 426). Mr. Smyth shows on the same page that the upheaval must have been at least 24½ feet. Mr. G. A. Lebour argues from the standpoint of geology, tradition, and history that the city of Is in Lower Brittany was submerged in the reign of King Gradlou, in the fourth or fifth century (Geol. Mag., 1871, p. 300). Sir J. A. Picton describes a Roman wharf in the Rood-eye (Chester), now the racecourse, but formerly a haven for ships, with a considerable depth of water (Proc. Liverpool Geol. Soc., vol. vi, p. 39). Note ordnance map (6 in.), No. 38–11–16; seems to show that a rise of the sea-level equivalent to 24 or 25 feet would be necessary to allow this ancient dock or this old haven to be again put to their original uses.

Hengist and Horsa, the Saxons, landed at Ebb's Fleet, Thanet, in 449; as this point is now $1\frac{1}{2}$ to 2 miles back from the present coastline, it would seem that the sea must have stood at least 15 feet higher on those coasts at that date than it does to-day. Mr. J. E. H. Thomson draws attention to a passage in the "Acta Petri et Pauli," which passage leads him to suggest that the submergence of the Temple of Serapis probably occurred between the "middle of the third century and the middle of the fourth" (Bonney, "The Story of our Planet," p. 203).

Data as to Low-Water Period of 80 A.D., *showing also that the sea-level was then lower than at present.*

Septimus Severus between 194 and 211 A.D. decorated the Temple of Jupiter Serapis. Alexander Severus did the same between the years 222 and 235 A.D. These facts indicate a low-water period at that time ("Principles," 11th ed., vol. ii, pp. 171, 172). Pliny (before 79 A.D.) visited the Straits of Gibraltar, and speaks of a low-lying island upon which were the remains of the Temple of Hercules. Pomponius Mela about the same time describes the straits as broken by a number of small islands; all these islands are now submerged. In 1728, during an extraordinary low tide the remains of this temple were clearly seen, and souvenirs obtained from the ruins (*Science Record*, 1876, p. 543). St. Paul embarked from Assus over a mole now visible under the clear water (Encyc. Brit., vol. xxiii, p. 580). At date of 9 B.C. St. Michael's Mount, Cornwall, seems to have been at the same level with regard to the sea as now ("Principles," vol. i, p. 544). In the island of Capri one of the palaces of Tiberius (14 to 37 A.D.) is now covered with water (vol. ii, p. 176). He (Strabo, about 54 B.C. to 20 A.D.) has brought together a large amount of material to throw light upon the changes which have passed over the face of the earth owing to the retirement of the sea (Tozer, "History of Ancient Geography," p. 251). The island of Batavia, inhabited in the days of Tacitus, is drowned (Journ. Science, ser. III, vol. xliv, p. 179).

Mr. R. A. Peacock, in Rep. Brit. Assoc., 1865, shows that in the time of Ptolemy (say 100 to 175 A.D.) the coast of Normandy probably extended seventeen miles west of its present position, that Mont St. Michel at one time was ten leagues from the sea, and states his belief that "Jersey was not an island until after Ptolemy's time." The entrance to the Gulf of Corinth, which in the time of the Peloponnesian War (1st, 2nd, and 3rd, between years 431 and 404 B.C.) had a width of seven stadia, had become reduced in Strabo's time to a breadth of five stadia ("The Earth and its Inhabitants," Europe, vol. i, p. 50). "From which account it sufficiently appears that the most considerable part of the great level (in Fens of England) was anciently sound dry land by nature, well furnished by timber, trees and woods. That this was the state of the great level when the Romans entered the island, is highly probable" ("The Fenland Past and Present," p. 29, quoting from Estobb; Romans invaded England 43 A.D.). Caligula's tower, previously mentioned as showing the high-water period of 1500, and which was undermined by the sea in 1644, can also be used to show the low-water stage at its time of erection (51 A.D.), as it was then a mile from the sea. Pliny counted twenty-three islands between the Texel and the Eider. Now only sixteen, and those greatly diminished in size ("Principles," 9th ed., p. 329). "Pliny states that the city of Apologos (at the head of Persian Gulf) was originally only ten miles from the sea, but that in his time the existing place was so much as 120 miles from it" (McCrindle, "The Com. and Nav. of the Erythræan Sea," p. 104). Jersey was probably part of the Continent in Cæsar's time and still later (Peacock, "Vast Sinkings of Land," p. 13).

Data as to High-Water Period of about 250 B.C.

The two piers of the port of Phalasarna, a city of late Hellenic date, are now 22 feet above their original level (Prestwich, "Tradition of the Flood," p. 57). The Gulf of Poitou (France) 2,000 years ago was 18 to 20 miles wide, now but a small bay known as the creeks of Aiguillon (Reclus, "The Earth," p. 541). Bay of Tunis, once a deep and open harbour, now has only 6 or 7 feet of water. Shaw identifies at a point now inland, but which must anciently have been on the seashore, the 'Port' (now village of El Mersa) as the ancient harbour of Carthage (Smith's Dict. Greek and Roman Geog., pp. 531–2). It is certain beyond question that the high-water stage shown above for the Bay of Tunis and harbour of Carthage was in existence during the period of the three Punic wars, or from 264 to 146 B.C. Aleria or Alalia (a city of Corsica), a seaport in Roman times, captured by the Roman fleet 259 B.C., is now above half a mile from the coast (ibid., p. 94). At the time of Herodotus (died 425 B.C.) the mountain of Lade was an island; at the present time it forms part of the mainland ("The Earth," p. 542).

Admiral Smyth shows in "The Mediterranean," p. 73, that this island of Lade sheltered the Athenian fleet A.C. 412 or 341 B.C., and alleges as the cause of junction between the islands and the mainland the silting action of the Meander River. On the other hand, Reclus ("The Earth," p. 542) denies the competence of silting to explain the changed topography of the shores of Asia Minor, and says, "It must therefore be in consequence of a slow upheaval of the earth's crust that the ruins of Troy, Smyrna, Ephesus, and Miletus have gradually become more distant from the coast and appear to be receding still further inland." Tyre was an island up to the time of Alexander's siege (322 B.C.). The present harbour is not so large as it once was. The other ancient harbour has disappeared (Encyc. Brit., vol. xxiii, p. 711).

The town of Putai (China), said to have been on the coast twenty-one centuries ago, is now over forty miles away ("The Earth and its Inhabitants," Asia, vol. ii, p. 104). In twenty-two centuries the Rhône delta has run out 26 kilometres into the sea (*Geological Record*, 1875, p. 82). The coastline of Tunis has increased outwards nearly 100 square miles in area since the third century B.C. This has led Th. Fischer to include Tunis in the lists of rising coasts, with Sicily, Sardinia, and South-Eastern France. Dr. J. Partsch, of Breslau, questions this conclusion, and alleges the cause to be delta growth in combination with wind action, by which sand has been blown inland from the shore (*Science*, vol. ii, p. 142). The position of Dr. Partsch seems refuted by the same arguments used by Reclus, in the case of Sicily and coasts of Italy, Greece, Malta, Rhodes, Cyprus, Crete, Asia Minor, Lisbon, Issa, Antissa, etc. In all these cases the silt carried by the rivers is entirely inadequate to explain the facts ; it is necessary, therefore, to invoke either upheaval of the ground or recession of the sea (see "The Earth," p. 542).

"The Cimbrian Deluge (submergence of Jutland) is supposed to have happened about three centuries before the Christian era" ("Principles," 9th ed., p. 331). A portion of the walls of the city of Utica washed by the sea at siege by Scipio Africanus about 205 B.C. (Livy, Book xxix, chap. 34). Sea now many miles distant. "Scipio was obliged to transfer his camp to an adjoining tongue of land (Ghella), then washed by the sea, but now far inland, which was known for centuries afterwards as the Castra Cornelia. So ended the year B.C. 204" ("Carthage and the Carthaginians," p. 296). Lake Mareotis in the time of Alexander the Great a large body of water navigable for the largest vessels, but now little more than a swamp (Professor Wheeler in Century Mag., May, 1899, p. 28). In the time of Alexander great inundations in Arem (Arabia) compelled eight tribes to fly their dwellings in Yemen and migrate to other lands ("The Cottage Cyclopedia," p. 61). Helice and Bura in Greece were swallowed up by the sea during an earthquake in 373 B.C. ("The International Atlas," p. 11). At the capture of Tarentum by Hannibal, about 213 B.C., the sea washed the greater part of the citadel (Livy, Book xxv, chap. 11).

NOTICES OF MEMOIRS.

I.—Petroleum in California. Professor E. W. Claypole: The American Geologist, vol. xxvii, pp. 150–159, March, 1901.

THE Californian oil-wells supplied the amount of 12,000 barrels in 1870 ; but a progressively larger quantity has been obtained, until in 1899 it was 2,665,709 barrels. It is remarkable that the wells are relatively shallow, and that none of the oil-bearing strata are older than the Cretaceous age : thus, at Stockton they are Quaternary ; at Puente, Los Angelos, and Kern Co. they are Pliocene ; at Ventura, Los Angelos, Kern Co., and Newhall they are Miocene ; at Ventura, Fresno, and Kern Co., Eocene ; at Colusa Co. and Sacramento Valley they are of Cretaceous age. The strata of California have been greatly disturbed in comparatively recent times. The final elevation of the Sierra Nevada and the Coast-range is apparently of not earlier date than the Pliocene period. The oil-bearing beds usually consist of sandstone interlaminated with shale; and is chiefly stored in the former. Professor Claypole states that the anticlinal theory explained by Professor I. C. White in Pennsylvania holds good for California. —T. R. J.

II. — Maryland Geological Survey: Alleghany County. (Baltimore, 1900, pp. 323.) — William Bullock Clarke and his staff have produced one of those interesting volumes we are so accustomed to see from the United States, and which are so well printed in comparison with those published by our own Government. The Physiography, by Cleveland Abbe, is illustrated by a photograph of a model of the county, from which the student can see at a glance the general features of the land, and thus clearly follow the descriptions of the author. Next comes the Geology, by C. C. O'Harra. This includes Silurian to Permian beds overlain by alluvial and other late deposits. The Minerals, Soils, Climate, Hydrography, Magnetics, Forests, Flora, and Fauna are all treated of in detail. The whole is illustrated in the usual manner by excellent reproductions from photographs, and a bibliography of 175 items is furnished. Among the maps provided are, one showing the wooded areas, another showing the magnetic declination, and a third showing structural sections. These latter are geological sections across the county at regular intervals, and give the reader a better idea of the features than pages of descriptive writing. A good index completes the volume.

III. — The Carboniferous System in Eastern Canada.— Dr. H. M. Ami writes in the Trans. Nova Scotia Inst. Sci., vol. x, on the subdivisions of the Carboniferous system in Eastern Canada, with special reference to the position of the Union and Riversdale formations of Nova Scotia, referred to the Devonian system by some Canadian geologists. He discusses the evidence afforded from a study of plant and animal life, and of the marine sediments. He has come to the conclusion that the two formations mentioned above belong properly to the earliest times of the Carboniferous, and proposes to include them in that system under the name of Eo-Carboniferous. Dr. Ami seems to have taken a good deal of trouble in arriving at his conclusions, and has submitted collections of the fauna and flora to certain specialists so as to get independent opinion as to their several ages.

IV. — Edinburgh Geological Society. (Transactions, 1901, vol. viii, pt. 1.)—Petrology is to the fore in this part. Kynaston has a paper on contact metamorphism round the Cheviot Granite, and writes on Tuffs associated with the Andesite Lavas of Lorne. Mackie gives seventy analyses of rocks chiefly from the Moray area, and has a paper on differences in chemical composition between the central and marginal zones of granite veins, with further evidences of exchanges between such veins and the contact rocks. Hinxman describes spherulitic felsite from Glen Feshie. Stratigraphy is handled by Goodchild, who deals with recent exposures of rock in Edinburgh, one section being under the site of the new offices of the *Scotsman*; by Wallace, who writes on the geology of Strathdearn; Kirkby, on Lower Carboniferous of Randerstone in Fife; and Cadell, on the geology of the oil shales of the Lothians. Jessen, of the Geological Survey of Denmark, has an interesting paper on the Pleistocene shell-bearing clays in Kintyre, clays which were investigated by a committee of the British Association in 1895–6. Palæontology is poorly represented: Kirkby deals with Ostracoda from the *Scotsman* section mentioned above, but nothing new is recorded; Simpson and Hepburn write on mammalian bones found during excavations at Hailes Quarry, near Edinburgh. These consist of fragments referable to red deer, horse, ox, goat, and field-vole. Mr. James Simpson, who died before the publication of his paper, receives a sympathetic notice from his colleague. Some notes on the distribution of erratics over Eastern Moray, by Mackie, concludes the contents of this part.

V.—Journal of the Geological Society of Tokyo: vol. viii, No. 89, Feb. 20th, 2561.—Things move fast in Japan; here we are still in the twentieth century. The publications of the Japanese Survey are too well known to require mention to the readers of the Geological Magazine, but we may certainly call attention to the opening of the twelfth volume of the Journal of the Geological Society of Tokyo. The Journal, which, with the exception of the "Table of Contents" upon page 1 of the cover, is all printed in the usual Japanese characters, opens with "A Geological Disturbance near Handayama," by K. Inoue, but from the text we are uncertain whether or not it was of Old Red Sandstone age. Mr. Iki has a paper on the geology of the Middle Kiushiu, and Hirabayashi writes on the province Kian Si. The Shidara Tertiary Basin in Mikawa is continued from the last part by Ishikawa, and Yoshida contains his report on the southern part of Higo. Those suffering from Ammonititis will find a fascinating paper on the Genealogy of the Genera *Puzosia* and *Desmoceras* by H. Yabe. In this paper full justice is done to previous authors, the various species are discussed and grouped, and their development carefully considered. Perhaps to a Western eye the relationships of the various characters seem a little mixed, but they are very clearly printed.

VI.—Geology of Hawaii.—As might be expected, the newly annexed Hawaiian Islands have been descended upon by United States geologists, and we have for notice a report by C. H. Hitchcock on the geology of Oahu. This was read before the Geological Society of America, August 22nd, 1899, and issued in the *Bulletin* February, 1901. The author can scarcely complain of hasty publication. Naturally the bulk of the geology is volcanic, but there is an interesting chapter on certain calcareous and tufaceous beds near Diamond Head, by W. H. Dall. Dr. Dall considers the conditions to be incompatible with the reference of these fossiliferous beds to a period as late as the Pleistocene, but the fossils have every characteristic of those generally assigned to the Pliocene or Upper Miocene in their general aspect and state of fossilization. There is a breccia in the same locality, 25 feet thick, which is full of fossil land-shells, all such as have their representatives in the valleys of Oahu, though some of the species may be extinct. Professor Lyons, who first noticed these shells, concludes that "the fossils belong to a period previous to that of the receding of the ocean to its present level. That event may have been coetaneous with the change of level in the circumpolar area which marked the close of the great Glacial period, and the evidences that our climate was, previously to that time, more humid than at present, are confirmatory of that view." Towards the north there is a ledge of coral 79 feet above the sea, at Kahe, and 730 feet distant from the water, south of Puu o Hulu, he mentions another ledge 56 feet above the sea and a quarter of a mile inland. At the south end of the ridge, called Mailiilii, the limestone reaches the height of 81 feet; and at other localities on the coast, limited areas of the same substance more or less elevated have been observed. The volcanic areas are fully described and illustrated.

VII.—Glaciation in South Africa.—The Orange River Ground Moraine forms the subject of a communication to the Transactions of the Philosophical Society of South Africa (vol. xi, pt. 2, Sept., 1900), from the pen of A. W. Rogers and E. H. L. Schwarz. They give four excellent photographs. The deposit covers a wide area in the Prieska and Hope Town divisions of the Colony, and consists of a peculiar conglomerate, first noticed by Wyley in 1859. The authors arrive at the following conclusions :—"The appearances seen in the three localities, Jackal's Water, Klein Modder Fontein, and Vilet's Kuil, at considerable distances apart, can be satisfactorily explained only on the supposition that the country was traversed by land-ice; and the presence of the till-like variety of the conglomerate in the same district, probably about the same localities, confirms that explanation. Unfortunately the exact nature of the conglomerate at the three localities is unknown, that is, whether it is a true till or whether it is a stratified rock with glaciated pebbles. We only know that the rock contains numerous scratched pebbles and boulders; but this is a small point and does not affect the confirmation. It is evident that the country was depressed under water after the formation of the till of Prieska, and it is quite possible that sedimentary rocks were deposited on a floor consisting partly of till and partly of the floor from which the soft till had been removed, or on which no accumulation had taken place."

VIII.—Geology of India.—From the "General Report on the work carried on by the Geological Survey of India for the period from the 1st of April, 1899, to the 31st of March, 1900," we gather a favourable impression of progress. In the Museum the minerals have been rearranged and the rock collections put in stratigraphical order in accordance with the new edition of the "Manual of Indian Geology." A large amount of time was occupied by the preparation of the specimens for the Exposition at Paris, which were placed in the charge of Mr. T. R. Blyth. The palæontological work of the year is as follows:—Dr. Noetling has finished the Miocene fossils of Burmah, a work which has proved that an intimate connection must have existed between the Eocene fauna of Europe and the Miocene of Burmah, a connection which can only be explained by the theory of a migration of species from west to east, which commenced with the Eocene period and lasted probably up to quite recent times. Dr. Noetling also made a magnificent collection of Permian and Triassic fossils from the Salt Range and from the Tertiary of Sind. Dr. Krafft made an examination of the Triassic fossils of the Himalayas. These consist for the greater part of Cephalopods, and include representatives of the whole series of the Trias. The chief stratigraphical result to which these palæontological researches have led is, that the *Otoceras* beds of the Himalayas do not, as was hitherto believed, correspond to the beds at the base of the lower Ceratite marls and the lower Ceratite sandstones, and very probably include also the lower Ceratite limestone; while, on the other hand, the upper division of the Lower Trias of the Himalayas ('*subrobustus* beds,' Diener) does not correspond to the whole of the Ceratite sandstones, but merely to the two upper divisions of the same, viz. the *Stachella* beds and the *Flemingites flemingarius* beds. Large collections were made by La Touche, Smith, and Walker from the Kumaon Himalayas, and a quantity of Silurian or Devonian fossils were obtained from the Shan Hills, Burmah, by La Touche, Middlemiss, and Dutta. The economics consist of enquiries into the gold of Burmah and of Southern India, and for this purpose Dr. Hatch was specially appointed for one year on March 31st, 1900. Nothing important as regards coal was done last year, but it is noted that sufficient coal is in sight for the requirements of the Jodhpur-Bikanir Railway for a space of 15 years. Mr. Holland has suggested measures to prevent the occurrence of landslips in Darjeeling in the future, and a good deal of attention has been given to the important subject of irrigation. Reports of the progress made with the surveys of Burmah, the Madras Presidency, Central Provinces, Punjab, Himalayas, Sind, and Baluchistan are included; and special reports on the auriferous reefs of Wainad, by Hayden; the auriferous tract of Wuntho, by Stonier; the Rampur Coalfield, by Reader; Sohagpur Coalfield, by Reader; Geology of the Northern Shan States, by La Touche; Geology of the Mandalay-Kunlon Ferry Railway, by Datta; Southern Shan States, by Middlemiss; Ganjam District, by Smith; Jeypore Zemidari, Vizagapatam, by Walker; Spiti, by Hayden; Mesozoic Rocks of Spiti, by Krafft; and the relationship between the *Productus* Limestone and the Ceratite Formation of the Salt Range, by Noetling, complete this very interesting report.

IX.—Former Extension of Rhætic Strata over Arran. (Transactions of the Edinburgh Geological Society, vol. viii, pp. 1 and 2.)—Mr. Goodchild contributed a paper dealing with the hæmatite which occurs in the joints of the basalt on the summit and other elevated parts of Arthur's Seat, and gave reasons for regarding it as due to some cause which, in other parts of the Lothians and Fife, has locally stained the Carboniferous rocks various shades of Indian-red.

and has converted the limestones into dolomites. Such effects, he explained, could elsewhere be traced with certainty to ferruginous and magnesian infiltrations, which had soaked down from the New Red rocks into the strata upon which they might happen to lie. He was therefore disposed to refer the hæmatite in question to deposition from such a source, and to regard the summit of Arthur's Seat as the modified descendant of the surface over which, in past times, the New Red rocks had extended.

X.—Ancient Volcanos in Arran.—On the Upland between Brodick and Drumadoor Bays, in the island of Arran, Messrs. B. N. Peach and W. Grinn, of the Geological Survey, have discovered the site and ruins of a very large volcano, covering an area of seven or eight square miles. It is represented by an accumulation of old scoriæ, broken rocks, and intrusive lavas, such as are usually found in similar basal wrecks of volcanos, whether of Jurassic, Cretaceous, or Tertiary age, in the Hebrides and Western Scotland. In this case, however, Mr. E. T. Newton has detected Rhætic fossils in some of the fragments embedded on the ruined volcano, and constituting the only record of strata once extending from Mull to Antrim. Thus they supply one proof of the enormous denudation which has taken place on the west coast of Scotland during the later part of the Tertiary era.

XI.—Geology of India. (Memoirs of the Geological Survey of India, vol. xxx, pt. 2, 1900; vol. xxxiii, pt. 1, 1901.)—The first of these memoirs contains Thomas H. Holland's Geology of the neighbourhood of Salem, Madras Presidency, with special reference to Leschenault de la Tour's observations. Leschenault collected petrological specimens from the district early in the last century (1816–1821), and it seemed desirable to obtain information concerning the geological relations and exact localities of his specimens. Lacroix described the rocks, which are preserved in Paris. They may be divided into (1) fundamental biotite-gneisses, (2) schists, (3) pyroxene-granulites (charnockites), (4) younger igneous intrusions. The exact localities have been traced and the specimens identified. A map accompanies the paper. The second memoir is by F. H. Hatch, and deals with the Kolar Goldfield, with a description of quartz mining and gold recovery as practised in India. The field bears a striking resemblance to the gold districts of Rhodesia. It consists of a belt of schists containing quartz-veins, and is part of the Transition Rocks, separated by Bruce-Foote and given the name of 'Dharwar System.' There is an appendix on the petrology by T. H. Holland.

XII.—Fossil Foraminifera of Servia. (Pavlovic, P. S. "Foraminiferi iz drugho-mediteranskikh slojeva u Srbiji paleontologhka studija." Spomenika (being the Trans. Acad. Sci. Belgrade), vol. xxxv, 1900, pp. 61–91.)—Professor Pavlovic is already known to us by a previous publication on the above subject, which appeared in *Ghlasa*, vol. lvi, 1898. This appears to be a report on the II Mediterranean beds, so far as relates to Servia, and will be of value for comparison with the fauna of those beds in Austria. Professor Pavlovic has carefully consulted previous authors, and thereby avoided the wholesale founding of new names; but unfortunately he does not figure his new species, and we are not sufficiently acquainted with his language to rightly comprehend his descriptions. We hope that in future he will be able to furnish a German, French, or English translation of the diagnosis of new forms, as otherwise his labours will be a closed book to most. The publications of the Servian Academy contain much important matter on the little-known geology and zoology of the country.

XIII.—Geology of Egypt. (Geological Survey Report, 1899, pt. ii. Survey Department, Public Works Ministry. Cairo, 1900.[1] "Kharga Oasis: its Topography and Geology." By John Ball. 116 pp., 19 maps and plates.)—This is the second of a series of reports on districts in Egypt, the first of which has not yet reached us. The district dealt with lies between the parallels of 26° and 24° north latitude, to the west of the Nile. The geological formations met with are the Cretaceous, represented by Nubian Sandstone and clays, *Exogyra Overwegi* series, 'Ash-grey Clays,' White Chalk with *Ananchytes ovata*; Eocene, represented by Esna shales, *Lucina thebaica* and *Operculina libyca* limestones, Upper Limestone; Pleistocene and Recent, calcareous tufa and sand dunes. The topography of the Oasis is described in chapters under the general headings of "The Limiting Escarpments," "The Hills within the Oasis," "The Floor of the Oasis, with its Villages and Wells," "Antiquities." Some twenty pages are devoted to the descriptive geology; the Cretaceous beds are correlated with the Senonian (?) and the Upper and Lower Danian; the Eocene beds seem to belong to the lowest fossiliferous beds of the system. Mr. Ball gives an interesting observation on the denuding power of the sand in windy weather: a piece of tin plate exposed for two days had all its tin coating removed, and a bottle was rendered quite dull in the same time by the scratching. Where objects are protected from the sand, as at Dush, where are inscriptions in red ochre on hard white chalk, painted some 1,400 years ago, they remain in perfectly fresh state; rain being unknown, and frost practically so. The maps and sections appear to be excellent, and the whole report is of much value to the geologist and Egyptologist. We trust that the whole of Egypt will be described in a like manner.

XIV.—Shorter Geological Notes.—Mr. James Mansergh delivered an interesting Presidential Address to the Institution of Civil Engineers on November 6th, 1900. His subject was Water and Water Supply. After a capital sketch of the works of the ancients in this direction, especially those of the Romans, he dealt with the law of underground water, dowsing, typical city waterworks, etc. Mr. Mansergh approved of the Duke of Richmond's Commission for buying out the London Water Companies, which reported in 1869, and also considered the finding of Lord Llandaff's Commission of 1899 a workable scheme.

[1] This Report, though dated 1900, was *not issued until* April, 1901.

Sir John Evans, at the opening meeting of the 147th session of the Society of Arts, November 21, 1900, read an address on "The Origin, Development, and Aims of our Scientific Societies." Among other matters of interest, he mentioned that in England the Society of Antiquaries seems to be the oldest body which met for definite purposes of enquiry. About the year 1572 "divers gentlemen of London, studious in antiquities, formed themselves into a College or Society of Antiquaries." The address gave an excellent general account of the various London Societies.

Dr. Gregory's "Plan of the Earth and its Causes" is appearing in the monthly numbers of the *American Geologist.* To the March number of this journal J. B. Hatcher contributes an exceedingly useful account of the Lake Systems of Southern Patagonia, with a map.

Among the recent publications of the Royal Dublin Society (Sci. Proc., ix) will be found two papers of special interest to geologists by Professor Joly. One is on the inner mechanism of sedimentation, and deals with the fact that the presence of dissolved salts accelerates the precipitation of finely divided matter, such as clay, etc., suspended in water; the other concerns the theory of the order of formation of silicates in igneous rocks.

With the view of throwing further light on the strength and durability of slate as a roofing material, Messrs. Mellard Reade and Holland have compared the Phyllades of the Ardennes with the slates of North Wales in the Proc. Liverpool Geol. Soc., 1899–1900. The object of the authors has been, "amongst other things, to discover, if possible, upon what composition or causes the perfection of slaty-cleavage depends, and furthermore, to find out to what qualities and composition the characteristics and enduring properties of roofing slates can be attributed."

MM. Lohest and Forir, in their study of the relative age of the rocks composing the Cambrian *massif* of Stavelot, have arrived at the conclusion that the *massif* is formed of a succession of sharp and reversed folds, becoming stronger towards the north, and consisting of Devillian, Revinian, and Salmian deposits, mainly quartzites and phyllades. The paper appeared in the Bull. Sci. Assoc. Élèves Écoles Special Liège, 1900.

Captain Hutton read before the Otago Institute a general but up-to-date account of the geology of New Zealand. The paper was published in the Trans. New Zealand Inst. for 1899. There are a few footnotes of critical value.

Mrs. Gordon's paper on "The Crust-Basins of Southern Europe" has appeared in English in the Verh. VII Internat. Geogr.-Kongress. Berlin, 1899 (1900). In general terms Mrs. Gordon states that "Cross movements in the Earth's crust have as resultants a spiral movement in one sense, accompanied in a neighbouring region by a spiral movement in the opposite sense." The paper must be read to be understood; an abstract would be of little use to the student.

Dr. Henry M. Ami has published in the *Canadian Record of Science,* vol. viii, under the title of "Progress of Geological Work in

Canada during 1899," a list of papers, arranged alphabetically under authors, published in 1899.

The Bulletin of the Natural History Society of New Brunswick, No. 19, 1901, contains papers on Cambrian Fossils from Cape Breton, by G. F. Matthew; on a new genus (*Acrothyra*) of Etcheminian Brachiopods, from the Eo-Palæozoic of Cape Breton, by the same—it is near *Acrotreta*; and on the physiographic origin of our Portage Routes, being a note on the physiography of New Brunswick, by W. F. Ganong.

Sir Archibald Geikie has recently issued a third edition of his well-known work on "Scenery in Scotland," viewed in connection with its Physical Geology.

According to the Annual Report of the Yorkshire Philosophical Society, the York Museum has acquired a collection of rocks and minerals which belonged to the late Professor Piazzi Smyth. No new fossils were purchased during 1900.

From the Report of the Rugby School Natural History Society, we learn that Mr. Beeby Thompson has assisted in the arrangement of the collection of local fossils, and has presented a series found during the cutting of the Great Central Railway in that neighbourhood.

The geology of the Isthmus of Panama forms the subject of a paper by O. H. Hershey in the Bull. Dept. Geol. Univ. California, vol. ii, No. 8, 1901. The author inclines to the belief that the earliest stratified rocks are of Jurassic age; the next, the Montijo conglomerate, seems to be of early Cretaceous age; while between this and the Tertiary basal conglomerate come the Santiago sandstone and shale. The fossils apparently are too poor to allow of exact determination at present. The Tertiaries and the Pleistocene seem well developed, and there has been a recent depression of the coastal land, especially on the Pacific side. A curious fact mentioned by the author is that about a third of the paving blocks in the town of Santiago, whose population is about 6,000, are silicified wood of pre-Pleistocene age. This paper is really a supplement to that published by R. T. Hill, in 1895, in Bull. Mus. Comp. Zool. Harvard, vol. xxviii.

The Report of the Bristol Museum for 1890 notes the acquisition of a large number of fossils from the Great Oolite of Minchinhampton, and a cast of the *Archæopteryx*.

Mr. R. A. Buddicom reprints from the *Border Counties Advertizer* for last December, a short article which states that the collections at the Shrewsbury Museum have been entirely remounted and rearranged by himself and Dr. Callaway. We are glad to hear it, and hope that Owen's type-specimen of *Rhynchosaurus* is now better cared for than it was a few years ago.

In the Proc. Cotteswold Nat. Field Club, vol. xiii, pt. 3, S. S. Buckman reports the excursions for 1899 from the point of view of the features of rivers and their valleys; in part 4 (1901) the same author writes on Homœomorphy among Jurassic Brachiopoda, a paper we hope to notice in due course.

REVIEWS.

I.—Catalogue of the Mesozoic Plants in the Department of Geology, British Museum (Natural History). The Jurassic Flora: I. The Yorkshire Coast. By A. C. Seward, M.A., F.R.S., F.G.S. With 21 plates, and 53 figures in the text.

MR. SEWARD'S Catalogue of the Fossil Plants of the Wealden, published for the Trustees of the British Museum in 1894 and 1895, is already well known to palæontologists, who will welcome the present further instalment of his valuable investigation of the British Mesozoic Flora. The Inferior Oolite of the Yorkshire coast district from Filey to the north of Whitby is peculiarly rich in vegetable remains, which have been well known since the days of William Bean and the elder Williamson. Indeed, Mr. Seward tells us that nearly the whole of the material at present available was obtained by these early investigators, and that very little serious collecting has been undertaken during the last half-century. Consequently, the author's work has consisted in the revision of material already rendered classical by the investigations of a series of palæontologists, chief among whom was Adolphe Brongniart, to whom a number of the specimens were submitted in the early days of his long scientific career. Owing to the energy of the Yorkshire naturalists during the first half of the past century, specimens are abundant, and to be found in nearly every museum in this country as well as in several of the Continental collections. Under these circumstances many novelties are not to be expected, and, as a matter of fact, only two out of the fifty-five species described are new. The value of the Catalogue consists in accurate discrimination and judicious estimation of affinities, and in its affording a connected view of the whole flora, so far as at present known. Such a revision was urgently needed.

The fine illustrations form a striking feature of the volume. The 21 plates have been beautifully drawn by Miss G. M. Woodward, while some of the numerous figures in the text are the work of Mrs. Seward. The figures afford ample proof of the fine preservation of many of the specimens. The only matter for regret is that none have been found in a petrified condition, so that the study of internal structure has been impossible. Hence, many questions of affinity have had to be left open which might have been cleared up if anatomical evidence had been available. In certain other localities the student of Mesozoic Botany is more fortunate in this respect, and indirect evidence derived from such petrified specimens has proved all-important, especially in the interpretation of the Cycadean remains.

After a short historical sketch, and a rapid survey of plant-bearing deposits of similar horizon in other parts of the world, the author proceeds to the systematic description of the fossils. No Algæ remains worth consideration have been discovered, and the record begins with the Hepaticæ, to which one thalloid species—*Marchantites erectus*—is referred. The great mass of the specimens, however, is divided between the Pteridophytes and the Gymnosperms, Angiosperms being so far entirely unrepresented, as is still the case even in the more recent Wealden beds.

Under the Equisetaceæ two species of *Equisetites* are described, plants wonderfully similar in aspect to the recent Horsetails, but often of enormous dimensions, *E. Beani* attaining a circumference of 30–40 cm. (not millimetres as erroneously printed on p. 64). The author finds reason to believe that these large stems, like their still larger Palæozoic allies, probably grew in thickness by the development of secondary vascular tissue.

One species—*Lycopodites falcatus*—is referred to the Club-Mosses, and regarded as more nearly allied to the genus *Selaginella* than to *Lycopodium*. The apparently heterophyllous character, on which this conclusion is based, is not, however, a decisive argument, heterophyllous species also occurring in the genus *Lycopodium*.

The Ferns are, of course, abundantly represented; the author describes twenty species, and less cautious taxonomists would add largely to their number. The Matonineæ, a family of which the author has treated at length elsewhere, are illustrated by some splendid specimens of *Matonidium* and *Laccopteris*. The evidence appears fully to justify the author in his opinion that this group, now so restricted, played an important part in the earlier Mesozoic vegetation.

Todites Williamsoni is referred on good grounds to the Osmundaceæ, while species of the genus *Coniopteris* approach wonderfully closely, in the characters both of the sterile and fertile pinnæ, to the recent Cyatheaceous genus *Thyrsopteris*, of which a single species survives in the island of Juan Fernandez.

The genus *Dictyophyllum* is placed, with *Protorhipis*, in the Dipteridinæ, which the author regards as distinct from the typical Polypodiaceæ, while *Klukia* and *Ruffordia* represent the Schizæaceæ. The presence of true Polypodiaceæ is more doubtful, though several genera, including *Sagenopteris*, often regarded as a Marsiliaceous plant, are provisionally referred to this family.

Among the numerous remains showing Cycadean affinities, two genera, *Williamsonia* and *Anomozamites*, are placed in the family Bennettiteæ, a remarkable group, with flowers far more complex than those of the true Cycads, the characters of which have been revealed to us by the investigations of Carruthers, Solms-Laubach, Lignier, and others, on petrified specimens. Mr. Seward showed, in his Wealden Catalogue, how close is the affinity between *Williamsonia* and *Bennettites*, and, indeed, treated the former as a subgenus of the latter; in the present volume, however, the generic rank of *Williamsonia* is again recognized. Mr. Seward has also previously shown that the leaves of the old '*Zamia gigas*' really belonged to the same plant as the *Williamsonia* flowers, and has thus completely confirmed Williamson's original restoration of the plant.

The genus *Anomozamites*, characterized by the almost entire or imperfectly segmented leaves, is referred to Bennettiteæ on the evidence of specimens described by Nathorst from the Rhætic of

Sweden, in which the characteristic foliage is borne on the same stem with *Williamsonia*-like fructifications. The habit, however, as shown in Nathorst's restoration, with a slender, repeatedly forked stem, is totally different from anything known among the Bennettiteæ or other Cycadales.

The genus *Ctenis* is one of those which has oscillated, in palæobotanical works, between the Ferns and the Cycads. The author has succeeded in observing the microscopic structure of the epidermis, and has proved that the supposed sori, held to indicate Filicinean affinities, are not really of a reproductive nature, but represent mere elevations of the epidermal cell-walls.

The account of the Ginkgoales, now solely represented by the Maidenhair-tree, itself almost extinct in a wild state, is particularly interesting. The evidence for the great antiquity of this group, once more critically examined by the author, appears to be quite conclusive. The remarkable seed-bearing fructification, named *Beania gracilis* by Carruthers, and usually regarded as a Cycadean strobilus, is considered by Mr. Seward to belong more probably to the Ginkgoaceæ. In the course of his argument on this question, the author makes the striking statement that "we have no satisfactory instance of a female Cycadean flower of Mesozoic age which can be reasonably connected with a plant bearing Cycadean foliage" (p. 274). In other words he considers that all the evidence indicates the Bennettiteæ, and not the true Cycadaceæ, as the family to which Mesozoic Cycadales belonged, while other authorities have always admitted the co-existence of the two groups in Mesozoic ages.

Several Coniferæ are described, the most striking, perhaps, being *Pagiophyllum Williamsoni*, with fairly well preserved cones *in sitû.* With the exception of some Araucarian cone-scales, none of the Coniferous remains can be referred with any certainty to a special family.

In his concluding remarks the author lays stress on the close agreement between the European Jurassic flora and the Gondwana flora of India and Australia. "In Jurassic times there was no doubt a much greater uniformity in the vegetation of the world than exists at the present day" (p. 306). Attention is also called to the great similarity between the Lower Oolitic and the much later Wealden flora, a similarity which in a few cases even appears to amount to specific identity.

Mr. Seward's new volume will be recognized as one of the most sound and valuable contributions to Palæobotanical Taxonomy.

D. H. S.

II.—Jurassic Fauna of Cutch: The Brachiopoda. By F. L. Kitchin, M.A., Ph.D. (Memoirs of the Geological Survey of India, 1900, ser. ix, vol. iii, pt. 1, pls. i–xv, pp. 1–87.)

THIS is a painstaking and very critical work, which deserves every commendation. The author has fully realized the responsibility of the task, and he strikes the right note in his introduction (p. 4). He says in regard to cases of resemblance to European forms: "It has been considered more expedient to apply a new 'specific' name than to ascribe the doubtful form as a 'variety' to the respective European 'species.' This has been done in the belief that the application of the term 'variety' is not admissible in cases where the direct relationship to the 'species' either cannot be definitely proved or at least does not appear very highly probable, for it surely commits us to the opinion that such relationship exists, whereas the use of a 'specific' name, while fulfilling the requirements of convenience, leaves the question of relationship open."

This is evidently the correct course. For it must be confessed that among our English Jurassic Brachiopoda, as well as among other fossils, too few names have been far more hindrance to our knowledge than too many. Especially regrettable has been the placing by study geologists as 'varieties' of well-known 'species' forms which lived long before those species, a course taken against the express wishes of the field geologists, but taken to satisfy the lumping tendency so prevalent in the middle of last century. Anyone can lump, but to lump correctly is the difficulty—that is a paraphrase of the words of a German palæontologist. And now it may be said in dealing with similar forms—where there is any marked difference of horizon or locality what has to be proved is the combination, not the separation. The former is the rash course, and it must be justified by very clear evidence; the latter is the course which experience has so frequently proved to be correct, and therefore its adoption is justified by analogy.

It is the latter course that Dr. Kitchin has rightly followed. He has found among these Jurassic Brachiopods of Cutch many forms with striking resemblances to European species; but the chronological difference is great, and so is the difference of locality. Remarking on the fauna as a whole the author says, "it would thus appear that the Middle Jurassic Brachiopoda are less adapted to serve as indices to the detailed stratigraphical comparison of remotely separated areas than the Cephalopoda" (p. 79). This is, of course, what would be expected, though remoteness is not always a necessary factor. There is the remarkable case in our English Jurassic Brachiopoda fauna, the notable discrepancy for a portion of Inferior Oolite time of the Cotteswold species from those of Somerset–Dorset, and even from those of Dundry, only a few miles away; whereas both before and after this time the same species of Brachiopoda are found in all these districts, and even from Gloucestershire to Würtemberg the Brachiopods are good indices for detailed stratigraphical comparison.

The resemblance, which the author notices, of later Cutch species to European forms earlier in date need not destroy the value of the Brachiopods for stratigraphical work, though it may make direct comparison difficult. But the same thing is known in Europe. Many examples might be cited, but sufficient will be *Zeilleria Mariæ* of the Middle Lias, *Zeilleria bullata* of the Fuller's Earth, *Zeilleria perobovata* of the Cornbrash; or *Terebratula submaxillata* of the Inferior Oolite and *T. maxillata* of the Great Oolite. Such cases, though unsatisfactory from the stratigraphical standpoint, are of great biological interest; they indicate the independent development of similar forms at successive dates. So the similarity which the author has noticed in the Indian species to earlier European forms probably illustrates the same law.

This, however, suggests a query. The author remarks that his *Terebratula euryptycha* persists throughout the series of strata he describes. But has he not put into one 'species' too many varied forms? Are not these forms independent uniplicate developments—the intermediates between non-plicate and biplicate forms? Such is the case with the European fauna; non-plicate, uniplicate, biplicate mark three stages in serial development, and such development is repeated at different dates.

In drawing to a close this notice of a most interesting work it is advisable to call the author's attention to one unfortunate oversight: the references in the explanations of the plates do not correspond with the pages of the text. S. S. B.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—A special general meeting was held on Wednesday, March 27, 1901, at 8 p.m., the President in the chair, on the requisition of the following five or more Fellows, namely: The Rev. J. F. Blake, Dr. Henry Woodward, Dr. A. Smith Woodward, Sir Henry H. Howorth, Dr. F. A. Bather, Mr. R. Bullen Newton, Mr. H. A. Allen, Mr. C. Davies Sherborn, Dr. F. L. Kitchin, Mr. Upfield Green, and Mr. G. E. Dibley; for the purpose of considering the following matters :—

1. The present state of the Society's Museum.
2. The steps necessary to be taken for putting the collections therein contained into a satisfactory condition, if retained in the Museum; or otherwise the desirability and conditions of their disposal elsewhere, as may be decided on.
3. The arrangements necessary to be made, in order to keep the collections constantly in a satisfactory condition, if their retention is decided on.
4. The amount necessary to be expended (*a*) in the first instance, and (*b*) annually, to carry out the decisions of the Meeting. Also to authorize the Council to incur this expenditure; and finally, to make such order concerning the estates or revenues of the Society as to the Fellows assembled in such General Meeting shall appear useful for the purpose of carrying out their decisions.

The Rev. J. F. Blake proposed and Mr. R. Bullen Newton seconded the following resolutions :—

1. That the general collection in the Society's Museum be limited to such specimens as have been or may hereafter be definitely referred to, by name, description, or figure, in the Society's publications, or in such other works as may be agreed upon by the Council.
2. That the specimens retained be thoroughly cleaned, provided with fresh labels additional to the old ones, placed in drawers or boxes designed to exclude dust, and arranged with reference to the papers or works wherein they are referred to, and that a catalogue of such retained specimens be printed.

3. That the remaining specimens be disposed of in such a way as the Council may direct.
4. That the Council be authorized to expend, either out of capital or income, so much as may be necessary to carry these resolutions into effect.

The following amendment was moved by Sir Henry Howorth, F.R.S., and seconded by Professor W. Boyd Dawkins, F.R.S. :—

That in the opinion of this Meeting the time has now come when this Society shall transfer its collections to some other museum.

The amendment was put, and there voted for it 22, against 19.

The amendment was therefore carried, and on being again put as a substantive resolution there voted for it 26, against 19.

The amendment was therefore declared carried as the resolution of the meeting.

II.—April 3rd, 1901.—Horace W. Monckton, Esq., F.L.S., Vice-President, in the Chair.

The following communication was read :—

"The Igneous Rocks and Associated Sedimentary Beds of the Tortworth Inlier." By Professor Conwy Lloyd Morgan, F.R.S., F.G.S., and Sidney Hugh Reynolds, Esq., M.A., F.G.S.

It has long been known that igneous rocks occur in the district under consideration, but opinions are divided as to their intrusive or contemporaneous character. Evidence is here brought forward to show that the igneous rocks form two bands, the lower interbedded with Upper Llandovery strata and the upper overlain by Wenlock, and that both bands are probably contemporaneous lavas.

The igneous rocks appear at two horizons, both in the Charfield Green district and also in the district which includes Avening Green, Damery, Micklewood, Daniel's Wood, etc. At Charfield their general run is north-north-west and south-south-east, and the upper band is associated with a bed of calcareous ash. The ash contains lapilli, felspar-crystals, quartz-grains, small shaly patches, and fossils, cemented by calcareous matter. The fossils, determined by Mr. Cowper Reed, probably indicate the Wenlock age of the rock. The associated trap would thus seem to be interbedded—a conclusion strengthened by its uneven surface and highly amygdaloidal character.

At Daniel's Wood the higher bed of trap is overlain by limestones which contain Wenlock fossils, and underlain by rocks with Upper Llandovery fossils. The dip of the rocks appears to indicate the existence of an anticline. The rocks underlying the trap-band of Damery Quarry are not seen, but above the trap are rocks bearing Upper Llandovery fossils. This trap occupies a large area near Woodford Farm. The same band of trap at Middle Hill underlies an ash-bed in which fossils of Upper Llandovery age have been found. The rocks, as a whole, follow the north-eastern and northern boundaries of the Bristol Coalfield.

The microscopic examination of the lower igneous rock shows that it is a basaltic andesite containing plagioclase (acid andesine or oligoclase), pseudomorphs after enstatite, with chloritic and iron-oxide patches. The higher bed sometimes contains fresh augite, and both bands frequently contain rounded grains of quartz. In other examples the felspars appear in three forms, with augite and enstatite, and the rock ranges from an andesite to a porphyritic basalt. The quartz-grains present appear to be xenoliths. The silica-percentage of the rocks on a moisture-free basis varies from 61 to 67, while the specific gravities are from 2·74 to 2·99.

III.—April 24th, 1901.—J. J. H. Teall, Esq., M.A., V.P.R.S., President, in the Chair.

The Secretary read the following letter, which had been received from H.M. Secretary of State for the Home Department:—

Home Office, Whitehall, 3rd April, 1901.

Sir,—

I am commanded by the King to convey to you hereby His Majesty's thanks for the Loyal and Dutiful Address of the President, Council, and Fellows of the Geological Society of London expressing sympathy on the occasion of the lamented death of Her late Majesty Queen Victoria, and congratulation on His Majesty's Accession to the Throne.

I am, Sir,
Your obedient Servant,
Chas. T. Ritchie.

J. J. H. Teall, Esq.,
Geological Society of London,
Burlington House, W.

The President drew attention to a framed and glazed copy of the Table of the British Strata by Dr. Henry Woodward, F.R.S., F.G.S., and Horace B. Woodward, Esq., F.R.S., F.G.S., which the authors had kindly presented to the Society.

In exhibiting a specimen of *Crioceras occultus* from the Snettisham Clay of Heacham, near Hunstanton, Professor H. G. Seeley said that he had no doubt that the *Trigonia hunstantonensis* and *Crioceras occultus*, originally described as from the Hunstanton Limestone, were from the clay at Heacham. The example of *Crioceras* now shown was found by Mr. F. Deighton, of Cambridge. It differs only as a variety from the type figured in 1865.

The following communications were read:—

1. "Notes on two Well-Sections." By the Rev. R. Ashington Bullen, B.A., F.L.S., F.G.S.

The well-section at Southwark passes through sand and gravel, etc., 34 feet, London Clay 75 feet, Woolwich and Reading Beds 56 ft. 9 ins., and Thanet Sand 36 ft. 6 ins., into Chalk which was bored to a depth of 148 feet.

The well-section at Dallinghoo Post-Office, near Wickham Market (Suffolk), penetrated 53 feet of blue Chalky Boulder-clay, into 20 feet of sand and gravel, water being found at a depth of 79 feet. Liassic and Oxford Clay fossils were found in the Boulder-clay and stones, one of which is considered by Professor T. Rupert Jones to have probably come from the Carboniferous rocks and one from the Bunter. The Sands contain no Crag fossils. Mr. F. Chapman, A.L.S., determined fossils from some of the boulders, from fragments of stone found in the Sands, and from the Sands themselves. The last consist of Cretaceous Foraminifera.

2. "On the Geological and Physical Development of Antigua." By Professor J. W. Spencer, Ph.D., M.A., F.G.S.

Antigua and Barbuda rise from the bank which occupies the north-eastern portion of the chain of the Lesser Antilles. The part of the bank on which these two islands are founded is submerged to the very uniform depth of about 100 feet, but from other island-groups it is separated by depressions of 1,800 to 2,500 feet. The margins of the bank are abrupt and precipitous, and are indented by deep valleys extending to the more profound depressions. The igneous basement-rocks of the island form the south-western mountain-belt. They are porphyritic andesites or porphyrites, with breccias and ashes which dip north-eastward. Associated with these rocks, and probably overlying them, are limestones which have not yet yielded fossils. The second and median belt of the island consists of stratified tuffs, which included marine and fresh-water cherts. From the evidence of fossils these rocks may be Upper Eocene or Lower Miocene, and they manifestly are closely related to the rocks which follow them. The succeeding formation consists of earthy marls associated with beds of white limestone, and is apparently conformable to the underlying tuffs. A list of fossils is given, from which it is concluded that the beds are of Upper Oligocene age. Next follows a creamy-white, calcareous sandstone, and then the Friar's Hill Series of conglomerates and marls, resting unconformably on the white limestones, and considered to be of late Pliocene or early Pleistocene age. These are succeeded by the Cassada Garden Gravels, recent marls containing land-shells some of which are extinct, and coral reefs, none of which are raised.

An account of the erosion features of the region is given, and from this the following conclusions are drawn:—The region was an extensive land-surface, probably at least 2,000 feet higher than now, during the Mio-Pliocene period, and was reduced by denudation to a comparatively low elevation before the close of that time. This was followed by a submergence (the Friar's Hill) to a depth of 200 feet below the present altitude. At the close of the Pliocene period there was another elevation to an extent probably exceeding 3,000 feet, as shown by the channels on the submarine plateau between Antigua and Guadeloupe. This did not continue sufficiently long to complete the dissection of the tablelands. and consequently the Antigua-Barbuda mass remains intact. Then followed a subsidence culminating in a 75-foot submergence, a re-elevation to 100 feet above the present level, when the shallow channels in the submarine bank were formed, and possibly one or two other small movements.

3. "On the Geological and Physical Development of Guadeloupe." By Professor J. W. Spencer, Ph.D., M.A., F.G.S.

The Guadeloupe group is separated from the Antigua and Dominica groups by depressions 2,000 feet deep. Much of Guadeloupe itself consists of eruptive rocks, evidently as old as the igneous base of Antigua. The lowest beds of Grande Terre are yellow tufa, surmounted by 75 or 80 feet of volcanic sand of early Tertiary age. A calcareous formation conformably follows, dipping north-eastward. These two formations seem to correspond with the Oligocene rocks of Antigua. The Lafonde Gravel and Marl succeeds them unconformably, and it is possible that the limestone of the Usine of Pointe à Pitre is of about the same general age. In addition to these formations there are raised coral-reefs, consolidated calcareous sands, alluvia, the loams and gravels of the Petit Bourg Series, and various fragments of calcareous groups. The tooth of a small *Elephas*, allied to the Maltese type, and found in Grande Terre, is mentioned.

The land-surface during the Mio-Pliocene period appears to have been 2,000 feet above the present level, but it was submerged 200 feet at the close of the Pliocene period during the accumulation of the Lafonde and Lower Petit Bourg gravels and loams. There was a re-elevation of about 3,000 feet in the early Pleistocene period, and during this epoch *Elephas* could have crossed from the continent. This was followed by a depression to 100 feet or more below the present level, a re-elevation to 150 feet, submergence below the present level with growth of corals, and the elevation of these to 6 or 8 feet above the sea.

4. "On the Geological and Physical Development of Anguilla, St. Martin, St. Bartholomew, and Sombrero." By Professor J. W. Spencer, Ph.D., M.A., F.G.S.

Deep channels, not less than 1,800 feet deep, separate the bank on which this group is founded from the banks to the north and south. The oldest rock of St. Martin and St. Bartholomew consists of greenstone or dioritic porphyry usually much decayed, followed by altered limestones, and volcanic ashes and breccias. The calcareous divisions are associated with chert and deposits of manganese. Fossils found in these rocks in St. Bartholomew determine the age as equivalent to the Middle Eocene of Europe. A white limestone formation, which appears to correspond with the limestone series of Antigua, follows unconformably. The limestone is partly phosphatized at the surface and is pitted by caverns. It is apparently succeeded by upper strata, with a modern fauna, similar to that of the Pointe à Pitre Limestone of Guadeloupe. The limestones are unconformably covered by mantles of breccia, gravels, and sand, which may be regarded as the equivalent of the Columbia formation of the American Continent. The St. Martin plateau was a land-surface throughout the Mio-Pliocene period, during the earlier part of which it appears to have stood 2,500 feet above its present level, and was probably connected with the now neighbouring insular masses, from which it was disconnected by denudation during a very long period of atmospheric activity, followed by a subsidence, so as to bring the present surface of the submarine banks to a level so low that the undulating features of a base-level of erosion could be formed on them; for, during the period when the deep and broad depressions on the Antillean chain were being fashioned, the now isolated island-groups stood out as table-mountains, which were slowly being eaten away by atmospheric agents. There was next a subsidence to about 200 feet below the present level, about the close of the Pliocene period, followed by a re-elevation to 3,000 feet, as shown within the area, but in reality much more. It was during this early epoch of the Pleistocene that the great rodents described by Professor Cope reached here from South America, but the race continued to live here sufficiently long to give rise to distinct species. The submergence of the mid-Pleistocene period was to the extent of about 200 feet, and the subsequent elevation was marked by moderate denudation with the production of shallow watercourses, traceable across the sunken banks to depths of 150 or 180 feet. Again there was a moderate depression sufficient to bring the surface a few feet below the present level, succeeded by a rise during which the low shell-bearing sands were formed.

5. "On the Geological and Physical Development of the St. Christopher Chain and Saba Banks." By Professor J. W. Spencer, Ph.D., M.A., F.G.S.

The St. Christopher (St. Kitt's) ridge rises from 2,000 to 2,800 feet above the submarine Antillean plateau, and is for the most part covered with shallow water, except between St. Kitt's and Montserrat, where a depression reaches 2,592 feet, and between Statia (St. Eustacius) and Saba, where it reaches 1,200 feet. Relics of old igneous formations are found on the islands, but in most places they are covered by more recent volcanic formations.

The Brimstone Hill Limestone is the succeeding formation, which appears to be newer Pliocene or Pleistocene, and to correspond with the Upper Marls of Anguilla and those at the Usine of Pointe à Pitre in Guadeloupe.

The St. Kitt's Gravels succeed, and in beds of apparently the same age shells of living species have been found at an altitude of 300 feet. The main volcanic activity belonged to the mid-Pleistocene period. It is inferred that the group underwent the same physical history as the neighbouring groups of islands. First there was elevation, followed by subsidence. Then came the second great elevation to about 3,000 feet and erosion of the region, when the deep valleys and cirques indented the margins of the tablelands, and at the same time the great volcanic ridges were built. Next followed another subsidence to about 300 feet below the present level, and during this epoch the volcanic domes of Brimstone Hill and the 'Quill' of Statia were formed. The succeeding upward movement carried the land 60 feet or more above the present level, when ravines and small channels in the sunken shelf were excavated.

Another depression to 40 or 50 feet filled up these ravines. Then came final re-elevation, and it is possible that a downward movement is now in progress.

CORRESPONDENCE.

NAMES FOR BRITISH ICE-SHEETS.

SIR,—Although Professor Bonney does not, I believe, at present allow himself to be included among "glacialists who hold the 'land-ice theory,'" to whom my letter on the above subject (GEOL. MAG., March, 1901, p. 142) was addressed, his comments (GEOL. MAG., April, 1901, p. 187) are particularly welcome as he shows, by practical application of two of the terms, that the proposed nomenclature may have its advantages even to the opponents of the 'land-ice theory.' Granting that the former existence of ice-sheets in this country is a disputed inference, we may nevertheless find the suggested terminology convenient in the discussion, even when it is denied that the terms represent anything more than an ill-founded conviction. From Professor Bonney and those who think with him I ask no more than that the nomenclature of the British Ice-sheets be accepted on this basis.

By the way, I will seek Professor Bonney's permission to amend his simile; surely, in this case it is not that the glacialist is counting his birds before they are hatched, but after they are flown, by the indications in the roost.

In his playful suggestion of 'Dogger-fjeld' as a name for the 'East British Ice,' and in his accompanying argument as to the direction of ice-flow, Professor Bonney seems to have taken for granted that the Dogger Bank was a *pre-glacial* feature. But there is much reason to believe that this Bank is of *glacial* origin, while of the *pre-glacial* contours of the floor of the North Sea we know nothing. In areas of low relief the radial point of ice-flow must depend principally upon the incidence of maximum snowfall, and under changing conditions of climate may not remain fixed in the same place. I have elsewhere set forth facts indicating that the East British Ice underwent great changes in this respect during the progress of the Glacial Period.

The issue raised by Professor Bonney as to the transport of the Scandinavian boulders to our eastern coast has been frequently discussed in my writings on the Yorkshire drifts; and it seems almost superfluous to reiterate my opinion that the presence of these boulders does not imply their direct transport across the North Sea basin by land-ice. I was convinced by my prolonged examination of the Basement Clay of East Yorkshire that the invading ice-sheet had ploughed up a sea-bottom already strewn with boulders from the shores,—"wherefrom it follows that we must not place much confidence in the evidence gleaned from its erratics as to the actual direction and distance which the ice-sheet has traversed."

By another friendly critic a well-grounded objection has been raised to the proposed term 'Cambrian Ice-sheet,' on account of the risk of confusion with the common stratigraphical use of 'Cambrian.' It would, perhaps, be safer to fall back upon the phrase 'Welsh Ice-sheet' (with subdivision into 'North Welsh' and 'South Welsh' if found desirable).

As previously stated, my more immediate object is especially to urge the adoption of names for the (hypothetical ?) ice-sheets of our sea-basins, for which I have recently felt the pressing necessity. On the terms proposed for the land-areas I do not at present lay much stress, though it would be convenient if these could be fixed at the same time. G. W. LAMPLUGH.

TONBRIDGE.
April 6, 1901.

THE SODIUM OF THE SEA.

SIR,—I am extremely obliged to Mr. Fisher for his kindly notice of my communication concerning the "Sodium of the Sea," but feel at a loss how to reply, owing to uncertainty as to whether Mr. Fisher has considered and rejected De la Beche's articles on Granite and Elvan, Divisional Planes, and Mineral Veins and Faults; or, has possibly overlooked such an ancient authority.

In addition to all that De la Beche and Dr. Sorby have written, and since the last edition of the "Physics of the Earth's Crust," we have the additional fact that all the types of fluid inclusions found in granites may be matched in different quartz-veins, so that all the arguments based on the fluid inclusions in igneous magmas must be prepared to meet the cases of the veins. My object in writing was not so much to defend the sea-water hypothesis, as to remind geologists that it existed. Throughout my own early training I was never allowed to forget that the weakest link in a chain is the measure of its strength, and I knew full well that the slightest slip in fact or argument involved public castigation in the Transactions of the Devonshire Association. If any of the younger geologists in Devonshire erred in discipline our captain, William Pengelly, rarely failed to pipe all hands on deck to witness punishment. Mr. Fisher, I expect, will agree with me that in the present day it is considered of far more consequence that a theory should present a solid appearance than that each link should be tested, and if defective, rejected, not only by the purchaser but by the chainmaker himself.

A. R. HUNT.

FOXWORTHY, MORETONHAMPSTEAD.
May 7, 1901.

INTERNATIONAL GEOLOGICAL CONGRESS.

SIR,—I regret that I omitted to express my thanks in my paper, "Geological Notes on Central France," published in the GEOLOGICAL MAGAZINE (February, 1901, p. 59), to the Directors, MM. Boule, Fabre, and Martel, for their kindness and consideration during the

Congress excursion to that region. I did not intend the notes as a narrative of the excursion, only as a small help to friends interested in geology who may not possess that most admirable guide, the "Livret Guide," provided by the Committee for members of the International Geological Congress, over which so much labour must have been expended.

I desire now through the medium of the GEOLOGICAL MAGAZINE to tender my sincere thanks to the Directors, to whom we were all greatly indebted for their kind attention and able discourses.

M. S. JOHNSTON.

HAZELWOOD, WIMBLEDON HILL.
April 24, 1901.

THE FISH FAUNA OF THE MILLSTONE GRITS.

SIR,—May I point out to Dr. Wellburn that the value of his work on Palæozoology will be enhanced if he will take a little more trouble in his method. I read *Psephodus*, sp. nov., *Acanthodes*, sp. nov., *Euctenodopsis*, sp. nov.; but in all these cases I have to dig the specific names out of the text. They should follow the generic name; if they do not they are likely to be overlooked. Those forms which are described, and to which specific names are given by the author, should also have been properly entered up in the table. The specialist will, no doubt, read such papers right through, but that will certainly not be the case of the

OVERWHELMED RECORDER.

OBITUARY.

EDWARD CRANE, F.G.S.

BORN NOVEMBER 22, 1822. DIED APRIL 25, 1901.

EDWARD CRANE, youngest son of Wright Edward Crane, Esq., landowner, of Thorney, Cambridgeshire, and Mary, his wife, was born November 22nd, 1822. He was educated at Wisbech Grammar School, spent two years fishing and shooting in Ireland, and before he was of age had settled down to the pursuit of agriculture as a tenant farmer on the Duke of Bedford's model Thorney estate. In 1851 he married Jane Turnell, eldest child of a neighbouring farmer, and remained in Thorney until 1866, when he retired and went to live at first in the vicinity of the Crystal Palace. Soon afterwards, accompanied by his wife and daughter, he visited the continent of Europe, and, returning to England in November, 1867, settled in Brighton; having purchased a house in Wellington Road, he resided there until his sudden death on April 25th, 1901.

When the town Museum was removed from the Pavilion rooms to the present building in Church Street, Edward Crane assisted in arranging the geological gallery. He became a member of the Museum Sub-Committee in 1873 during the Chairmanship of his old friend Dr. Thomas Davidson, F.R.S. On the death of the latter in 1885 he was elected Chairman of the Committee, in which capacity he served the interests of science in the town of Brighton very faithfully for eight years. Increasing age and deafness led him to resign the Chair, but he was annually re-elected a member of the Committee, and although rarely attending the meetings, continued to be actively interested in the Museum, and assisted the curators in every way. Edward Crane published in the Brighton Public Museum Report for the years 1891–92 (Brighton, 1892) a "List of the Type Specimens in the Brighton Museum." He was elected a Fellow of the Geological Society of London in 1872, and frequently attended the meetings in London until his age and deafness denied him the pleasure. He was an enthusiastic visitor at the Natural History Museum, and also visited the principal museums of Central Europe and Scandinavia. In 1881, accompanied by his daughter, he made an extended tour in the Eastern and Western United States and Canada, and in the Winter of 1884–5 visited Spain, Cuba, Mexico, and the Southern United States. He had formed warm friendships with scientists of that great country, which he dearly loved. Edward Crane remained deeply interested in scientific literature up to the last, and was keenly enjoying Macnamara's "Origin and Character of the British People," and his dear friend Mrs. Zelia Nuttall's "Fundamental Principles of Old and New World Civilizations," during the last week of his life. Edward Crane passed suddenly away from heart disease of long standing at St. John's Lodge, Wellington Road, Brighton, on April 25th, 1901, and was cremated and interred on April 30th at Woking, Surrey (No. 458, facing north-west), by his written directions. His widow, Jane Crane, survives him, and he leaves issue an only daughter, Agnes Crane, who has been a frequent contributor to the pages of the Geological Magazine and other periodicals.

MISCELLANEOUS.

Complimentary Dinner to Sir Archibald Geikie, D.C.L., F.R.S., etc.—Sir Archibald Geikie, who retired from the position of Director-General of the Geological Survey on February 28th, after forty-six years of public service, was entertained on May 1st at a complimentary dinner held at the Criterion, Piccadilly Circus. The Right Hon. Lord Avebury took the chair, and among those present were Major-General Sir John Donnelly, Sir George Stokes, Sir John Evans, Sir Frederick Abel, Sir Norman Lockyer, Sir Henry Craik, Sir William Turner, Sir Michael Foster, Sir Henry E. Roscoe, Sir Lauder Brunton, Sir Henry Howorth, Sir John Murray, Admiral Sir William Wharton, Major-General Festing, Prof. E. Ray Lankester, Mr. S. E. Spring-Rice, Prof. T. McK. Hughes, Mr. Digby Piggott, Colonel Johnston, Prof. Bonney, Prof. Lapworth, Prof. Watts, Prof. J. Geikie, Prof. Wiltshire, Prof. Hull, Dr. W. T. Blanford, Lieut.-General McMahon, Dr. Horace T. Brown, Major Craigie, Dr. H. F. Parsons, Dr. J. S. Keltie, Prof. Galloway, Mr. Hudleston, Dr. P. L. Sclater, Prof. Joly, Prof. Garwood, Mr. Marr, Prof. C. Le Neve Foster, Mr. Whitaker, Prof. Sollas, Mr. Bauerman, Prof. G. A. J. Cole, Prof. Corfield, Mr. Monckton, Mr. Herries, Mr. G. Griffith, Mr. Teall, Mr. Horace B. Woodward, Mr. F. W. Rudler, and other members of the staff of the Geological Survey and Museum of Practical Geology, Mr. G. Murray, Dr. H. R. Mill, etc. Lord Avebury gave an interesting account of the scientific career of the guest, and Sir Archibald Geikie made an eloquent reply.

On the menu-cards was printed the coat of arms of "The Royal Hammerers," designed by the late William Hellier Baily in 1849, which we are enabled to reproduce here.

International Geological Congress, Paris, 1900: An Apology.—In printing "Notes on the Geology of the Eastern Desert of Egypt," by T. Barron, A.R.C.S., F.G.S., etc., and W. F. Hume, D.Sc., A.R.S.M., etc., published in the April number of this Magazine (pp. 154–161), the words "Abstract of a paper read before the International Geological Congress, Paris, August, 1900," were, by accident, omitted to be printed as a footnote to the title, for which the Editor offers his sincere apologies.

Death of Professor Gustav Lindström, For. Mem. Geol. Soc. Lond.—In a letter dated 20th May, 1901, addressed to Dr. F. A. Bather, of the Geological Department, British Museum (Natural History), Dr. E. W. Dahlgren, Librarian of the Swedish Academy of Science, Stockholm, writes:—"I have the painful duty to inform you of the decease of our common friend, Prof. Gustav Lindström, on the 16th inst. He had been suffering from erysipelas in the face, but his doctor said it was not dangerous, and no anxiety was felt about him. On the evening of the 15th, however, he became suddenly worse, and early next day he expired." Dr. Lindström was so closely associated with English palæontologists, and was in such intimate relations with geologists in every country, that his loss will be keenly felt by a wide circle of attached friends. We hope to give a suitable notice of Dr. Lindström's life and work in the July number of the Geological Magazine.—H. W.

May 25, 1901.

Sincerely Yours
Charles Lapworth

THE

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ORIGINAL ARTICLES.

I.—Eminent Living Geologists: Professor Charles Lapworth, LL.D., F.R.S., F.G.S., of the Birmingham University.

(WITH A PORTRAIT, PLATE V.)

CHARLES LAPWORTH was born in 1842 at Faringdon, in Berkshire. Five years afterwards his parents removed to Lower Newton, one of the farms rented by his grandfather. He attended the country school at Buckland village, about two miles off, and the vicar of the parish, the Rev. Joseph Moore, finding him an omnivorous reader, generously lent him books from his own library and practically directed his early education. At the age of 15 he became a pupil teacher in the school, and in the year 1862 entered the Training College at Culham, near Oxford, passing out thence in 1864 with a first-class Government certificate. Of the posts as schoolmaster which were then offered him he selected that connected with the Episcopal Church at Galashiels, because it would give him a home and work in the fascinating borderland of Sir Walter Scott. This post he retained for eleven years, and was married in 1869 to the daughter of Mr. Walter Sanderson.

His holidays were spent in wandering over the Border region, and in the year 1869, in company with his friend Mr. James Wilson, he began the study of the geology of the district round the town, zest being given to the work by the discovery of fossils in rocks which had hitherto been considered barren. His first paper, "On the Silurian Rocks of Galashiels," was read before the Geological Society of Edinburgh in 1870, and was published by that Society and in the pages of the Geological Magazine. While at Galashiels he wrote his paper "On an Improved Classification of the Rhabdophora" (1873).

In 1875 he was appointed to one of the assistant masterships in the Madras College, St. Andrews, and from that year until 1881 he continued to teach subjects which, though not absolutely uncongenial to him, gave little or no scope for scientific teaching or scientific methods. But the post afforded much that he wanted, longer holiday-time for research, greater leisure for reading, and, above all, frequent association with such friends as Nicholson and the literary and scientific men of the place. His holidays were spent in continuing his work on the stratigraphy and fossils of the Scottish Uplands. Here he wrote his papers on the Moffat Series, the Scottish Monograptidæ, the Distribution of the Rhabdophora, and others.

But in 1881 came a welcome change, and he was able to throw his entire energy into science, scientific teaching, and geology. His researches and papers had by this time made his name familiar to workers in the older fossiliferous rocks, and, backed by many of the most famous British and foreign geologists of the day, he applied for, and was elected to fill, the newly established Chair of Geology and Mineralogy at the Mason College, Birmingham, his title being afterwards modified at his own request to Professor of Geology and Physiography. He at once plunged into the teaching work of his Chair, but the greater leisure and opportunities the post afforded allowed him to complete and publish his Girvan paper, to carry out serious field-work in the Highlands of Scotland, to make discoveries in the Midland district, and, later on, to begin that work in the Ordovician districts of Shropshire which was to lead him down, stage by stage, to the uttermost depths of the Longmyndian rocks. As the years have gone on he has practically devoted all his energies to geological and geographical work—not only as a teacher, investigator, and writer, but as outside lecturer, textbook writer, university examiner, scientific adviser, and in the other multifarious obligations which appertain to the Geological Professor of modern days.

Lapworth was elected a Fellow of the Geological Society of London in 1872, was awarded the Murchison Fund in 1878, the Lyell Fund in 1882 and 1884, the Bigsby Gold Medal in 1887, the Wollaston Medal in 1899, and went on the Council of the Society in 1894. The honorary degree of LL.D. was conferred on him by the University of Aberdeen in 1884. In 1888 he was elected a Fellow of the Royal Society, receiving a Royal Medal in 1891, and serving on the Council in 1895–1896. He has acted as examiner in Geology to the Universities of Oxford, Cambridge, London, Victoria, and Wales, was President of the Geological Section of the British Association in 1892, is an honorary member of the Geologists' Association and other scientific societies at home and abroad, and is now President of the Geological Society of Glasgow.

In considering the general scope of Professor Lapworth's work and the bearing of its results, it will be well to divide it into four branches, Field Geology, Geology in the Laboratory and Study, Teaching, and Applied Geology.

1. *Work in the Field.*

The development of the geology of the Southern Uplands may be said to form the keynote of Lapworth's field-work. The stratigraphy of highly complicated districts had already been frequently studied in outline; and in mountain districts it had been pointed out again and again that the apparent sequence was not to be trusted. But the detailed unravelling of such districts had been seldom attempted with any success. It is well known that previous to Lapworth's researches the Silurian rocks of the Southern Uplands had been considered to be a normal ascending sequence of greywackés, of enormous thickness, interrupted by occasional thin seams of black, graptolitic shale. As the graptolite fauna of each shale mass was broadly the same as that of every other mass, it was naturally considered that the Upland series had been rapidly deposited, without any important organic change taking place from base to summit; and that, consequently, graptolites were of no use for zone work. Important negative conclusions in the matter of evolution followed as a corollary.

One of the first things that made Lapworth suspect that things were not as they seemed was, that graptolites of highly divergent types, though found near together, were never met with on the same slab of rock; and this was followed by the discovery that there was always a difference, sometimes generic and always specific, in the faunas of contiguous and successive bands in each shale mass.

When he had discovered that on proceeding downwards from the greywacké of Dobb's Linn a definite sequence of graptolites was met with down to a certain point, he hit upon the important fact that a corresponding and practically identical sequence was met with also, but in inverted order, in descending beyond this point until greywackés were again reached. It is said that, on first suspecting this, Lapworth rushed into the field and, reaching Dobb's Linn in the twilight, he rapidly collected one series of graptolites in descending to the critical point which he placed in his right-hand pockets, and another in descending below it which he put in the left-hand pockets; he then carried both series off to his lodgings to compare in the lamplight. The comparison verified his hypothesis, and he now held the proof that in this locality, at all events, half the rock succession was inverted. Indeed, he had got hold of the right end of the clue which subsequently enabled him to unravel the complicated stratigraphy of the region. To this task he now devoted his spare time for seven or eight years, nor did he stop until he had followed the divisions of the Moffat Shale from sea to sea, mapping the critical areas in great detail, sometimes on the 6 inch scale, but in most instances surveying and constructing his own larger scale maps of the special localities, in which he could insert the zones as they occurred in the field. At the same time he acquired the large collection of graptolites necessary to verify his conclusions and complete his knowledge of the fauna.

Although probably himself satisfied that the hypothesis of a chronological sequence of graptolite zones, which worked so well in elucidating the complicated structure of the Moffat region, must be in the main a correct one for the Uplands generally, Lapworth proceeded to apply the severest test that he could think of to his conclusions. For that purpose he selected next the Girvan area, where the rocks have a different facies and graptolite-bearing seams are rare or subordinate, but where it was already known that there is a vast array of other Silurian fossils and very great lithological variety in the strata. Here Lapworth found his work much facilitated by the rich collections of fossils already made from this district by Mrs. Robert Gray, and he was free to devote himself to working out the stratigraphy and collecting graptolites. The outcome of the stratigraphical work on the Girvan succession was published in a paper to the Geological Society in 1882, but the publication of some of the broader structural questions connected with the surrounding area and the Uplands as a whole was deferred for some years, and was then published as a paper on the Ballantrae Rocks in the GEOLOGICAL MAGAZINE in 1889.

It is needless to say that the Girvan work entirely confirmed that of Moffat in all particulars. The succession of rocks in the new area, although more than twenty times the thickness, was found to tally with that of Moffat, the chronological order of the fossils common to the two areas agreed, the succession of physical changes was coincident, and the type of structure indicated that Moffat and Girvan were parts of the same grand region of deposition and of the same great system of earth-movement. It is characteristic of Lapworth, however, that not one of these coincidences is so much as hinted at in his first Girvan paper. The local facts were described and the local inferences drawn, but the reader was left to compare the Girvan and Moffat phenomena, and to draw from them the inevitable conclusions for himself.

Needless also to remind readers of the GEOLOGICAL MAGAZINE that the officers of the Geological Survey, unhampered in their methods and possessed of detailed maps to work with, have in the course of time entirely confirmed Lapworth's conclusions in the two areas, and, by adopting the zonal method which he initiated with such success, they have been able in some particulars to advance beyond his original conclusions. The great Survey Memoir on the Scottish Uplands is not only the record of a fine piece of survey work, but a monument to the genius of the man who made it possible.

This Upland work, together with its demonstration of the value of the graptolite as a zone index, brought Lapworth into conflict with the views of many of the established authorities of the time. Particularly was this the case with the veteran Barrande, whose well-known theory of 'Colonies' had been founded to get over difficulties almost precisely similar to those which existed in South Scotland. Barrande devoted his final "Defense des Colonies, No. 5," to the matter, but, far from subscribing to Lapworth's views, he maintained the validity of his colonies and even named a new one after his antagonist. But, neither on this nor on any other occasion, has Lapworth turned aside from his course to indulge in controversy; he has simply gone straight on with his work.

Having demonstrated that the Southern Uplands were the relic of a wide area of orogenic movement, Lapworth was next naturally drawn to a region in which earth-movement had had even greater play than in the Uplands. The experience already gained would constitute the basis of his researches and enable him to get over preliminary difficulties, while he would learn the effects of a much more complicated movement, carried on through a longer period, over a greater area, and to a higher degree than in the south. Hence he started work in 1882 in the Durness-Eriboll district of the Scottish Highlands, working after the same model as before, by selecting definite bands of rock, zoning them, and running them as clues through the complex. Here, however, fossils ceased to be the guide, and it was only by noticing lithological differences that the selected strata could be individualized and recognized from point to point. These were mapped in detail, as before, in order to bring out the structure. In a short time Lapworth had ascertained the true succession amongst the unaltered rock-formations, and made out enough of the tectonic facts to destroy once for all the old idea of an upward succession into the so-called 'newer gneiss.' The structure was of Alpine character, and "the stratigraphical phenomena identical with those developed by Rogers, Suess, Heim, and Brögger in extra-British mountain regions." These results were published in 1883 in the earlier pages of "The Secret of the Highlands." In the later pages he introduced, summarized, and discussed the phenomena and principles of mountain structure developed in Heim's great work on "Gebirgsbildung," in preparation for the understanding of the higher stages of the Highland work. Corresponding stratigraphical results had been simultaneously obtained by Callaway in the Assynt district, and the Geological Survey began their mapping of the North-West Highlands. The Surveyors followed the zonal method, obtained the same non-metamorphic succession, and in the course of a few years not only demonstrated the Alpine structure of the region, but proved the existence of some of the grandest and most important phenomena known to the world of geology. It is to be hoped that at no distant date we may see in a Survey Memoir on the Highlands a worthy companion volume to the great Upland Memoir.

Lapworth returned to the Highlands in the following Summer, but the plain living and hard thinking brought on a serious illness which prevented him from writing further on the tectonic side of the subject. But not before he had reached conclusions on dynamic metamorphism somewhat similar to those arrived at on other grounds by Lossen in the Harz and Lehmann in the Erzgebirge. These views were summarized in a short paper published by the Geologists' Association (1885), and more fully developed later on in his edition of Page's "Introduction to Geology" and elsewhere.

When Professor Lapworth went to Birmingham it was thought that the fossiliferous Llandovery rocks of the Lickey Hills were the oldest rocks in the Central Midlands. But in the year 1882, aware that the earlier geologists had paralleled the quartzites of Nuneaton and the Lickey with those of the Wrekin and Caradoc, which had later on been shown by Callaway to be at least older than the Upper Cambrian, he suggested that these rocks were probably the outstanding parts of a buried land surface older than the Silurian. In less than a month actual proofs of this view were discovered at the Lickey by Mr. F. T. S. Houghton and by Lapworth himself.

The same year Lapworth and Mr. Jerome Harrison proved that the rocks of Nuneaton, Hartshill, and Atherstone, instead of being Coal-measures and Millstone Grit as laid down on the published maps, were also parts of this buried land and of Cambrian age. This was established by Lapworth's finding of Cambrian fossils in the shales of Stockingford, above the Quartzite, and volcanic rocks of Uriconian type underneath it. These discoveries, of course, demanded fresh maps of the districts implicated; in 1886 the officers of the Survey came down, satisfied themselves as to their correctness in the Nuneaton district, and brought out new editions of their maps in order to include them. In 1898 the same thing was done for the Lickey Hills, the official surveyor being on this occasion an old student of Lapworth's, trained by him on those very hills. The more crucial parts of both these districts had already been mapped in detail by Professor Lapworth, sometimes in company with his students.

The further discovery of calcareous beds in the upper part of the Nuneaton Quartzite, by Dr. T. Stacey Wilson, led to the searching of the rocks for fossils along this line of country by Professor Lapworth, and the discovery of a bed of limestone bearing *Hyolites* and other fossils characteristic of the lowest fossiliferous Cambrian or Etche-minian horizons of America and elsewhere (1897).

In 1886 work was begun in the Shelve district of Shropshire, and in the course of two or three years the sequence was made out and compared with that of South Scotland, North Wales, and Scandinavia (1887, 1894). In later years the more detailed mapping of the greater part of that area has elucidated its structure, while at the same time the more complicated Caradoc region on the east of the Longmynd has been studied. Failing to find in that district a satisfactory base to the Ordovician System, the Cambrian rocks were next dealt with, the first outcome being the discovery of *Olenellus* and its accompanying fauna at the top of the basal Shropshire Quartzite (1888). This discovery resulted directly in the finding of the equivalent of the *Olenellus* Limestone at Nuneaton, and indirectly in the finding of *Olenellus* in the 'Fucoid Beds' of North Scotland. Thus a definite Lower Cambrian horizon became marked out over a large area, and the base of the Cambrian System was drawn at the bottom of the Quartzite.

It was, however, soon found impossible to complete the study of the Lower Palæozoic sequence of this region without mapping the underlying floor of Dr. Callaway's Uriconian and Longmyndian rocks and working out the sequence and structure of the Harlech anticline, which has been more or less completed by Lapworth and his friend Dr. Stacey Wilson.

This bald enumeration of thirty-three years' field-work naturally leads to a brief consideration of the causes which have contributed to its success. The principal reasons appear to the writer to be the following:—(1) Careful mapping on lines similar to those adopted by the Geological Survey, but usually in greater detail; the difficult areas being done on as large a scale as possible, and the crucial points visited many times over until their structure has become quite clear. To this class of work Lapworth was naturally drawn by his early interest in physical geography, when he was always seeking to explain the causes underlying observed phenomena. His untiring industry, actuated by what has been called 'a genius for stratigraphy' and a good eye for a country, filled even the dullest routine work with interest. (2) The observation of minute lithological changes whether in a vertical or a lateral direction. (3) The zonal collection and identification of fossils from every band which yields them. (4) The capacity to 'see solid' into a map so that a complete picture of the solid structure is constantly present before the mind. (5) The careful thinking out of the bearing of facts observed and entered on the maps in the light of many possible theoretical explanations, until a consistent hypothesis is hit upon by the method of trial and error. (6) But, above all, the power to realize vividly the conditions which might have given rise to the observed phenomena; so that in imagination he sees them at work and studies their results. It has been said more than once that it is of no use to contradict Lapworth when he has made up his mind on a geological question, "because he was there when the rocks were made."

2. *Work in the Laboratory and Study.*

Lapworth's investigations on the graptolites must be regarded as the outcome of his work in the Uplands, for from this region he collected and worked through hosts of these fossils, the difficulty of satisfactorily identifying species causing him to save all specimens which might lead to unmistakeable identification or throw light on the life-history of these extinct hydrozoa. At the time he began the study the classification of the graptolites in general use was in almost as unsatisfactory a state as the grouping of the rocks, and the two studies had to be carried on concurrently. But while this increased the labour it intensified the interest, and directed attention to points which might otherwise have been overlooked. The graptolites, among which excellent work was also being done by Hopkinson and Nicholson, soon began to sort themselves out; the rock-formations resisted much longer. Lapworth's study and comparison of his own collection, with those already made in other parts of the world, gave rise to his paper "On an Improved Classification of the Rhabdophora," which was published in 1873, and has since been either accepted as the standard to which graptolites are referred, or has formed the basis upon which the newer provisional classifications are founded. Having acquired a profound belief in the value of graptolite species for zone work, he took every opportunity for several years to collect specimens not only in Scotland but in Wales and Ireland, and of studying the works and collections of others, thus accumulating a vast amount of material for his invaluable treatise on "The Geological Distribution of the Rhabdophora" (1879–80), in which for the first time not only are graptolite zones established over Britain, but the distribution of the zones and their contents all over the world, so far as was then possible, was analysed, tabulated, and described, and the inference established that the graptolite was as reliable as the ammonite for a working stratigraphical index.

Some years elapsed before these conclusions were accepted in their entirety, except by his friends and fellow-workers in Scandinavia, but gradually his methods were taken up by first one and then another of the younger men in Britain and abroad, until, eventually, students of Palæozoic rocks in all parts were sending Lapworth graptolites for identification, and numerous papers and appendices to papers, containing descriptions of new species and identifications of old ones, were published (1875, 1877, 1881). St. David's, County Down, Central Wales, and many other British districts soon yielded graptolites in sufficient quantity to enable the rock-horizons to be ascertained, and though the results sometimes conflicted with the apparent stratigraphy, that was only so much the worse for appearances and so much the better for facts. From foreign countries and from the Colonies specimens came in for identification and as tests of the mapping. Led insensibly thereto by their own discoveries, palæontologists fell into the habit of similarly classifying their fossils and employing them zonally, so that now the despised graptolite of thirty years ago has become universally accepted as the guide to the zonal order of the older fossiliferous rocks.

The Upland work demonstrated that graptolites had not been standing still while all the Silurian rocks were being deposited, but that there had been continual variation, modification, and evolution. This, with the material subsequently accumulated, bearing on the life-history and habitats of the group and the probable causes to which their evolution was due, enabled Professor Lapworth to contribute to a paper by Walther an important communication on the "Mode of Life of the Graptolites" (1897), in which he advanced the theory that whilst the earliest and dendroid graptolites stood upright in shallow shore water, the later and more typical forms (Rhabdophora) hung suspended from floating sargasso-like seaweeds, so that they were drifted over the sea-waters as 'pseudo-plankton' by currents, and their skeletons thus distributed more or less all over the sea-bed. This gave origin to the wide distribution of graptolite zones, and also, in all probability, was the actuating cause of the morphological evolution of the families and genera of Rhabdophora, as well as the explanation of their abundance in black carbonaceous shales.

Later on Dr. Lapworth undertook the task of describing the British graptolites for the Palæontographical Society, and devoted a large amount of time to the correct drawing and illustrating of the fossils. Numerous experiments in the reproduction of illustrations were tried and are still being tried, and a new form of microscope (the Lapworth-Parkes) was worked out, by which even large specimens can be drawn in great detail, and under such conditions of lighting that no important point of structure is omitted, the main purpose being to present the object as like nature as possible without any interposition of the personality of the artist. The large-scale drawings are afterwards reduced by means of photography to the natural size of the fossil. The monograph is now being written and illustrated jointly by Miss Elles and Miss Wood under Dr. Lapworth's editorship.

A rapid reader, with the faculty of quickly 'tearing the heart out of a book,' of 'spotting' mistakes into which a writer may have fallen, and of seeing the importance of an author's facts even when his interpretation is wrong, Lapworth goes to his work, whether in the field or the study, with a clear view of the problems to be faced and a knowledge of the crucial points for testing hypotheses, of which he has generally plenty on hand ready for immediate use. Thus it often happens that the main points in a research are settled in a few days, but, meanwhile, a host of new problems have arisen, and for their solution it is necessary to work out the district thoroughly. As Professor Marcel Bertrand pertinently puts it, Lapworth's widest results have been often arrived at "à l'aide de ces outils qu'il a forgés lui-même et que d'autres eussent dédaignés." This, coupled with a keen zest for outdoor work, which carries him out into the field on every fine day and most wet ones if they happen to be Saturdays or in holiday-time, accounts for the large amount of single-handed field-work that he has accomplished. His own explanation is, that it is simply the natural outcome of a childhood spent among books in lieu of companions, of a manhood blessed by the constant encouragement and aid of his friends, and of almost a lifetime passed in the sympathy of his pupils.

The keenness in understanding and appreciating the work of others, which led Lapworth to abstract parts of Heim's Alpine treatise in order to show that there was nothing new in the principles employed in his own Highland work except their application to that district, and which is further exemplified in his appreciative memoirs of his early scientific friends Linnarsson, Nicholson, and Crosskey, is accompanied by a vivid imagination which enables him to visualize accurately the subjects on which he reads, a power of recognizing connecting links between severed lines of enquiry, and a faculty for picking out those exceptions to laws which indicate the existence of some greater law including the less.

In his two papers "On the Tripartite Classification of the Older Palæozoic Rocks" (1879) and "The Close of the Highland Controversy" (1885) we see Lapworth in another light. In these tactful endeavours to still controversy, neither of them fruitless, we see such a grip of the subjects dealt with as to indicate complete mastery of the literature, independent thought, extreme care and skill in the presentation of conclusions and suggestions, and just that gentle suspicion of the authority which his own work on the subjects dealt with entitled him to assert. In each case Lapworth brought out the best points in the discoveries of the rival pioneers, and showed that of such points those which were vital were generally the common property of the rivals and their schools; but he indicated most firmly that past history and dead controversy must never be allowed to clog the wheels of progress. In both cases the old men had built a firm platform on which the new men were standing ready for the next rush forward; they should not be too much concerned about the building of that platform when once they are convinced about its soundness, nor must they spend all their time quarrelling as to how its parts were first put together. The great thing for them is to make the next advance and to see that it is unhampered by questions of authority or nomenclature. It is largely due to the moderate tone of these papers that the Highland question is now no more, and that the term 'Ordovician' has been adopted nearly all over the world.

The appointment of Professor Lapworth to the presidency of the Geological Section of the British Association at Edinburgh in 1892 necessitated the preparation of an address, and gave him the opportunity of welding together his researches and theories in geology and geography by dealing with the rock-fold, the 'wedding-ring' of the two sciences. After treating of the physical and geological aspects of the structure he passed on to apply it to the making of mountains and continents, and to connect it with the form and structure of the earth itself. Further developments of this subject in time and space were communicated to the Geologists' Association and the Royal Geographical Society respectively, and have been treated of in college and other lectures on tectonic geology.

As Lapworth's South Scottish work came into contact with and made Barrande's theory of 'Colonies' untenable, so his views on the effects of mountain movement conflicted with Richthofen's beautiful theory of the coral-reef origin of the limestone masses of the Dolomites. A paper on the Dolomite country by Miss Ogilvie (Mrs. Gordon) was read before Baron von Richthofen, who was present at the Edinburgh meeting, and Lapworth, who had long considered the matter, although he had never visited the ground, took the opportunity of stating his belief that the so-called reef structures were the result of crust-deformation and not of original deposition, and that the associated igneous rocks belonged to the period of movement. The work and conclusions of Miss Ogilvie on this Dolomite region are familiar to tectonic geologists.

But although the results of Lapworth's work have conflicted with some of the grandest geological hypotheses of his time, there is probably no other geologist who employs theory as a working tool to a greater extent in his own research, in teaching, and in prompting investigation and discovery in others, or who so instinctively relies upon the scientific use of the imagination. In his favourite 'fold theory,' 'reciprocal' or 'antilogous' theory of deformation, the rock-fold, made up of two homologous and balanced parts, the one positive and the other negative ('antilogues'), is made to do duty as the archetype, and this type, so characteristic of more or less flexible sheets, is traced in the one direction into the wave-shape of fluids, and in the other direction into the fractures and faults of solid bodies. The fold-line or zero line is identified with the elastic curve, and the fold-shape is regarded as recognizable in all three dimensions and in all gradations of size. When we hear the applications of this theory employed by Lapworth to account for the land and water hemispheres of the globe, the shapes and trends of all crust movements, and hosts of other geological phenomena, we are fascinated with the manner in which the countless facts fall into apparent order and relationship, and for the time are almost willing to accept his sanguine view that "this twisted plate unlocks the whole treasure-house of the new geology." But we confess, all the same, to a feeling of profound satisfaction when its employer asserts that it must be regarded in the meantime as a working hypothesis, a symbolical expression of facts, rather as a means of grouping than of explaining phenomena, until such time as its assumptions and illustrations have been more fully identified with the every-day results and conclusions of the physicist.

How interesting and stimulating is Lapworth's habit of employing some striking theory and stringing upon it crowds of associated facts, those who attended the Shropshire excursion in 1894 will remember, who heard him describe the effects of the rolling in of the Caledonian crust-creep from the north-west upon the Ordovician region, already folded to the north and south, and how the location of the laccolites and other igneous injections in particular parts of the wrinkles was thus determined; or those who joined the long excursion to Birmingham in 1898, and heard the physiography of the middle valley of the Severn explained as the result of the enforced irruption of the original upper Dee in early Glacial times, or the relations of the Triassic and Palæozoic rock of the Midlands pictured as those of a rugged mountain region slowly buried under a sea of desert-sand and marl. In the same way his advanced students are led to store up and correlate countless facts in their memory by their natural harmony with some all-embracing theory, such, for example, as the explanation of the tectonics, lithology, and palæontology of the Palæozoic rocks on the theory of the developmental history of an ancient festoon island region like that of Eastern Asia, or the explanation of the phenomena of the Carboniferous rocks by the struggle for supremacy between the Caledonian and the Armorican crust-creeps. But these theories are always regarded as servants and not masters, merely provisional approximations to the truth.

3. *Teaching Work.*

For twenty years Lapworth has been sending into the world a stream of geologists, many of them equipped, not only with knowledge of their subject, but with enthusiasm and capacity for original work in it. He has watched the Mason Science College grow into the Mason University College, and that again into the University of Birmingham, and has taken an active part in each step of the advance. While he does not disdain to drill his students and drum into them by question and answer the points he wishes them to get hold of, he is rarely content in his lectures with the mere imparting of information, but almost invariably he happens upon points which rouse genuine interest. His department not only covers so much of Geology as can be crammed into the limited time allotted to the study, but he has started and maintained large classes in Geography, dwelling particularly on those parts of the study which admit of scientific treatment. Indeed, these classes, the bearing of the Edinburgh address, and the bias of much of his own research, are all symptoms of his attitude towards the sister science, regarding Geology as the Geography of the past, and Geography as the Geology of the present. He has aroused a widespread local interest in Geology by delivering afternoon and evening lectures of a more popular but still systematic character, by holding weekly excursions during the Summer, and by delivering occasional lectures in the neighbouring towns. Amongst the characteristic features of his teaching may be mentioned the classes on structural and field geology, his economic courses, and his research classes. His classes on structural geology learn the principles which guide the field geologist's work, and his practical class spends a term in the actual mapping of a Midland district on the six-inch scale, with the accompanying office-work. One or more workers are generally to be found in the research department engaged upon graptolites, trilobites, brachiopods, rock-specimens, or other material collected in the field. In order that he may have a larger amount of time to devote to investigation and to those portions of his teaching which may be regarded as special to himself, the lovers of science in the city and district have provided him with an assistant-professor to take the rest of his College teaching.

For many years a Geological Section of the Birmingham Natural History and Philosophical Society has met in his rooms in the Mason College. The largest contributor of papers and subjects for discussion has been the Professor himself, but the first drafts of many papers afterwards contributed to the greater learned societies have often been read and discussed by his students in that Section.

By conducting long excursions for the Geologists' Association, the British Association, and other bodies, into districts with which he was especially familiar, by publishing papers and guidebooks descriptive of the regions to be studied, and by his textbooks on geology and physical geography, his teaching has reached a wider circle.

But more far-reaching still has been his influence amongst specialists. The zonal and graptolite work has been taken up by many observers in similar lines of research, not only in Britain, but all over the world, in Scandinavia, Bohemia, France, Canada, and the United States. The value of his advice and assistance has been felt again and again by scientific investigators. His faculty for picking out exceptional facts, the patience which enables him to listen to a long and detailed account of a research, the avidity with which he seizes on those points which fit in with or run counter to his own theories, his delight in each bit of new discovery, and, above all, his encouraging sympathy and the generous manner in which he gives his own ideas and principles in the hope that they may bear fresh fruit in new soil, all make him an ideal confidant; for to him there is nothing that is "common or unclean," each branch of research has its separate value, and he has the faculty of giving those who consult him the impression that their work forms a part of some greater whole; there is nothing more encouraging to a young man than to find that what he had perhaps considered an isolated line of enquiry is really linked up with the advance of science as a whole.

Although it comes rather under the head of administrative than educative work, it may be here mentioned that Lapworth's intense belief in the practical and educational value of geology has led him to advocate the teaching of the economic side of the science, not only to miners, prospectors, and engineers, but to those engaged in building, surveying, brewing, and sanitary business, and of the pure science to those who are never likely to make any practical use of it except as a means of enlarging their knowledge of nature.

Throughout a good deal of friendly antagonism to the Geological Survey he has always retained the personal friendship of its Officers and strenuously maintained the vital importance of that institution to the country; and acting recently on a Departmental Enquiry into the functions and work of the Survey he has taken his share in remodelling its scope and administration.

4. *Applied Geology.*

During his residence in Birmingham Lapworth has been frequently consulted in matters relating to such subjects as sites, water, and minerals. In this way he has had means of acquiring a vast amount of information, otherwise inaccessible, relating to the structure of the Midland coalfields and their surrounding areas. Indeed, it may be said that one of his main inducements to undertake this class of work has been in order to enrich his knowledge of a branch of science which is practically untouched by the learned societies and the textbooks. The complicated geology of the Midlands, a rugged region covered unconformably by Coal-measures and in most places buried up unconformably by New Red Sandstone, gives rise to a series of difficult problems, each of which must be the subject of a special investigation involving scientific methods, the careful mapping of areas, and the disentangling of the involved structure of difficult districts. In the Midland region, at least, it has become abundantly clear that the most complicated questions of stratigraphy, vulcanicity, and palæontology, all have an eventual, if not an immediate, application to the economic side of the subject; and that there is probably no problem in pure geology that will not in the end have its bearing on applied geology.

In conclusion, one would like, were it permitted, to say a word of the man apart from the geologist. But, after all, is it necessary? His personality is so well known, his influence so wide, his geniality and kindliness of heart so patent to his friends, that it is quite needless to refer to them; and his enemies have yet to be discovered.

Opponents and antagonists there have been in plenty, but it is in their ranks that we find many of those who respect Lapworth most, whilst not a few of them have become his warmest friends.

SCIENTIFIC PAPERS BY PROFESSOR C. LAPWORTH.

1870. "On the Lower Silurian Rocks of Galashiels": Geol. Mag., Dec. I, Vol. VII, pp. 204–209, 279–284; Trans. Edinb. Geol. Soc., vol. ii (1874), pp. 46–58.

1872. "On the Graptolites of the Gala Group": Rep. Brit. Assoc., vol. xli, p. 104.

1872. "Note on the Results of some Recent Researches among the Graptolitic Black Shales of the South of Scotland": Geol. Mag., Dec. I, Vol. IX, pp. 533–555.

1873. "On an Improved Classification of the Rhabdophora": Geol. Mag., Dec. I, Vol. X, pp. 500–504.

1874. "Note on the Graptolites discovered by Mr. John Henderson in the Silurian Shales of Habbie's Howe, Pentland Hills": Trans. Edinb. Geol. Soc., vol. ii, pp. 375–377.

1874. "On the Diprionidæ of the Moffat Series": Proc. Geol. Assoc., vol. iii, pp. 165–168.

1874. "On the Silurian Rocks of the South of Scotland" [1872]: Trans. Glasgow Geol. Soc., vol. iv, pp. 164–174.

1875. (With John Hopkinson.) "Descriptions of the Graptolites of the Arenig and Llandeilo Rocks of St. Davids" [1874]: Quart. Journ. Geol. Soc., vol. xxxi, pp. 631–672.

1876. (With Professor Henry Alleyne Nicholson.) "On the Central Group of the Silurian Series of the North of England": Rep. Brit. Assoc., 1875, pp. 78–79.

1876. "On the Scottish Monograptidæ": Geol. Mag., Dec. II, Vol. III, pp. 308–321, 350–360, 499–507, 544–552.

1876. "Llandovery Rocks in the Lake District": Geol. Mag., Dec. II, Vol. III, pp. 477–480.

1876. "Silurian Rocks of the West of Scotland" (with figures of the Graptolites): Western Scottish Fossils Catalogue.

1877. "On the Graptolites of County Down": Proc. Belfast Nat. Field Club, Appendix, 1876–7, pp. 125–144; three plates.

1878. "The Moffat Series" [1877]: Quart. Journ. Geol. Soc., vol. xxxiv, pp. 240–343, 345–346.

1879. "On the Tripartite Classification of the Lower Palæozoic Rocks": Geol. Mag., Dec. II, Vol. VI, pp. 1–15.

1879–80. "On the Geological Distribution of the Rhabdophora": Ann. Mag. Nat. Hist., vol. iii (1879), pp. 245–257, 449–455; vol. iv (1879), pp. 333–341, 423–431; vol. v (1880), pp. 45–62, 273–285, 358–369; vol. vi (1880), pp. 16–29, 185–207.

1880. "On the Genus *Nemagraptus* (*Nematolites*) of Emmons" [1879]: Proc. Edinb. Phys. Soc., vol. v, pp. 106–113.

1880. "On Linnarsson's Recent Discoveries in Swedish Geology": Geol. Mag., Dec. II, Vol. VII, pp. 29–37, 68–71, 240.

1880. "On New British Graptolites": Ann. Mag. Nat. Hist., vol. v, pp. 149–177.

1880. "On the Correlation of the Lower Palæozoic Rocks of Britain and Scandinavia": Geol. Mag., Dec. II, Vol. VIII, pp. 260–266, 317–322.

1880. "On the Cladophora (Hopk.) or Dendroid Graptolites collected by Professor Keeping in the Llandovery Rocks of Mid-Wales" [1880]: Quart. Journ. Geol. Soc., vol. xxxvii, pp. 171–177.

1881. "Introductory Textbook of Physical Geography," by the late David Page. Tenth edition. Revised and enlarged by C. Lapworth.

1882. "Recent Discoveries among the Silurians of South Scotland" [1878]: Trans. Glasgow Geol. Soc., vol. vi, pp. 72–84.

1882. "The Girvan Succession"; Part i, Stratigraphy [1881]: Quart. Journ. Geol. Soc., vol. xxxviii, pp. 537–664.

1882. "The Life and Work of Linnarsson": Geol. Mag., Dec. II, Vol. IX, pp. 1–7, 119–122, 171–176. [Silurian Rocks of Sweden.]

1882. "On Graptolites" [Abstract]: Trans. Geol. Soc. Glasgow, vol. vi, pt. 2, pp. 260–261.

1882. "History of the Discovery of Cambrian Rocks in the Neighbourhood of Birmingham": GEOL. MAG., Dec. II, Vol. IX, pp. 563–566; Proc. Birmingham Phil. Soc., vol. iii (1883), pp. 234–238.
1883. "The Secret of the Highlands": GEOL. MAG., Dec. II, Vol. X, pp. 120–128, 193–199, 337–344.
1883. "Geikie's Textbook of Geology": GEOL. MAG., Dec. II, Vol. X, p. 39.
[1884?] "The Mason College and Technical Education": an address delivered at the Mason Science College, Birmingham, 1884.
1885. "On the Close of the Highland Controversy": GEOL. MAG., Dec. III, Vol. II, pp. 97–106; see also Proc. Geol. Assoc., vol. viii (1884), pp. 438–442.
[1885?] "Books on Historical Geology": Birmingham Reference Library Lectures.
1885. "On the Durness and Eriboll Areas": Proc. Geol. Assoc., vol. ix, No. 2, pp. 56–65.
1886. "On the Sequence and Systematic Position of the Cambrian Rocks of Nuneaton": GEOL. MAG., Dec. III, Vol. III, pp. 319–322.
1886. "On the Palæozoic Rocks of the Birmingham District": Rep. Brit. Assoc. (Sect. C), 1886, pp. 621–622; see also British Association Handbook, 1886, pp. 216–236.
1886. "Preliminary Report on some Graptolites from the Lower Palæozoic Rocks on the South Side of the St. Lawrence from Cape Rosier to Tartigo River, etc.": Trans. Roy. Soc. Canada (Sect. iv), 1886, pp. 167–184.
1887. "The Cambrian Rocks of the Midlands": Rep. Brit. Assoc. (Sect. C), 1886, pp. 622–623.
1887. "The Ordovician Rocks of Shropshire": Rep. Brit. Assoc. (Sect. C), 1886, pp. 661–663.
1887. "The Highland Controversy in British Geology, its Causes, Course, and Consequences": Rep. Brit. Assoc. (Sect. C), 1886, pp. 1025–1026.
1888. "On the Discovery of the *Olenellus* Fauna in the Lower Cambrian Rocks of Britain": GEOL. MAG., Dec. III, Vol. V, pp. 484–487.
1888. "Introductory Textbook of Geology," by David Page; revised and in great part rewritten by C. Lapworth.
1889. "On the Ballantrae Rocks of South Scotland, and their Place in the Upland Sequence": GEOL. MAG., Dec. III, Vol. VI, pp. 20–24, 59–69.
1889. "Note on Graptolites from Dease River, B.C.": GEOL. MAG., Dec. III, Vol. VI, pp. 30–31; see also Canadian Record of Science, vol. iii (1889), pp. 141–142.
1891. "On *Olenellus Callavei* and its Geological Relationships": GEOL. MAG., Dec. III, Vol. VIII, pp. 529–536.
1891. "The Geology of Dudley and the Midlands," an address delivered to the Midland Union of Natural History Societies: Proc. Dudley and Midland Geol. & Sci. Soc. & Field Club, 1891.
1893. Address to the Geological Section of the British Association: Rep. Brit. Assoc., 1892, p. 695. See also "Heights and Hollows of the Earth's Surface": Journ. Roy. Geog. Soc., N.S., vol. xiv (1892), pp. 688–697.
1894. (With W. W. Watts.) "The Geology of South Shropshire": Proc. Geol. Assoc., vol. xiii, pp. 297–355; two plates.
1894. "The Face of the Earth": *Nature*, vol. xlix, pp. 614–617.
1894. "Our Future Coalfields," abstract of Gilchrist Lecture: *Birmingham Daily Post*, 1894.
1895. "Dr. Crosskey and Geology": extracted from "The Life and Work of Henry William Crosskey, LL.D., F.G.S."; Birmingham, 1895.
1897. "Die Lebensweise der Graptolithen"; contributed to "Ueber die Lebensweise fossiler Meeresthiere von Prof. Dr. Johannes Walther": Zeitsch. der Deutsch. Geol. Gesell., vol. xlix, 2, pp. 238–258.
1897. "Note on Cambrian *Hyolithes* Sandstones from Nuneaton": Trans. Edinb. Geol. Soc., vol. vii, pp. 231–232.
1898. "Sketch of the Geology of Birmingham District, etc.": Proc. Geol. Assoc., vol. xv, pp. 313–408.
1899. "The Survey Memoir on the Southern Uplands"; a review: GEOL. MAG., Dec. IV, Vol. VI, pp. 472, 510.
1899. "An Intermediate Textbook of Geology," founded on the "Introductory Textbook of Geology" by the late David Page.

II.—A Systematic Nomenclature for Igneous Rocks.

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I. Introductory.

THE present nomenclature of igneous rocks is generally acknowledged to be unsatisfactory, for not only is it without useful meaning, but it is also so unsystematic that it forms a severe tax upon the memory. The manifest and urgent need of reform, which these circumstances create, must be my excuse for presenting in a short note a suggestion likely to require much elaboration. A systematic nomenclature, I need hardly say, can only rest upon a systematic classification, so that the proposals I shall herewith make would have been fitly accompanied by an attempt at producing a classification of the kind. As I have found, however, that much expenditure of time and labour will be necessary to accomplish this task, I have decided upon publishing at once certain proposals with regard to nomenclature, which could be largely applied to classifications at present in use.

It has long been the custom of many authors to name subdivisions of groups by prefixing to the family-name the name of the mineral which distinguishes the subdivision.[1] Thus we have, for instance, *muscovite-granites*, *biotite-granites*, *hornblende-granites*, and *augite-granites*; also *hornblende-biotite-granites*, *augite-biotite-granites*, etc. This system is undoubtedly a step in the right direction, because the name of a sub-group is thus made to point out the distinguishing feature in its composition. When more than one prefix is required, however, such names become too cumbrous for general use, and the practical result is that in such cases a new name is invented, generally signifying nothing but the locality where the rock was first found, or the name of its discoverer. The method breaks down, in fact, under a severe test.

II. Description of Prefixes.

The system of nomenclature which I propose is based upon that just described, but differs from it in that the prefixes are *contracted.* Several can be used, therefore, before a name tends to exceed a reasonable number of syllables in length. Instead of *hornblende-biotite-granite,* for instance, I should say *hornbi-granite,* pronouncing the *bi*-syllable long, as in 'biotite.'

Other advantages have been secured by the use of conventions as to the arrangement of the prefixes, and as to the exact meaning of the family-names. The order of the prefixes denotes the relative abundance of the minerals, that of the most abundant standing next to the family-name. Thus in a *hornbi-granite* biotite preponderates over hornblende, whilst in a *bihorn-granite* the reverse is the case.

[1] I use the term *family* throughout in the sense in which it is used by Rosenbusch in his "Elemente der Gesteinslehre," that is to say, for groups like the *granites*, *diorites*, etc.

If objection were taken to making the relative abundance of minerals a factor in the nomenclature, I should answer that I believe it will prove a useful step, as too little attention has hitherto been paid to variations in the relative abundance of a rock's constituents, and there exists a very simple method of determining this factor.[1]

Other properties besides mineral composition are occasionally made use of as bases of subdivision, and further prefixes will be required in naming the groups thus formed. When the subdivisions are based upon *structure*, prefixes may be obtained by contracting the names of the various structures. For example, *pilotaxitic* can be contracted to *pitaxo-*, *intersertal* to *inserto-*, and so forth. It is almost exclusively amongst the dyke-rocks and lavas that structure is made the basis of subdivision, and names would be produced such as *mipegmo-rhyolite* for a granophyric or micropegmatitic rhyolite, or *hypidio-basalt* for a basalt with hypidiomorphic-granular structure.

Besides mineral and structure prefixes, others denoting some fact in the chemical composition of the rock as a whole may be required. Thus *bas-* or *basi-* would mean *basic*, *ali-* would signify *alkaline*, and so on. These prefixes should generally come immediately before the family-name, and should be separated from it by a hyphen when they are used to name subdivisions of the principal families. Thus the alkaline-syenite family, a group which may be ranked as of equal importance with the normal or calc-alkaline syenites, would be named *alisyenite*; but the name of the basic subdivision of the diorite family, if such a subdivision were made, would be written *basi-diorite* with a hyphen.

III. Index Minerals.

The use of a family-name must evidently in every case imply the presence in the rock to which it is applied of certain essential minerals, which need not therefore be mentioned in the prefix. These I term the *index* minerals of a family, because, being common to all its members, they serve to point out to which family a new specimen belongs. As an example, I may take the family-name *granite*. Every rock so named, whether there be a prefix or not, must contain the minerals quartz and orthoclase in abundance, and these, therefore, are its index minerals. Granites usually, of course, contain other minerals besides, and some or all of them may be mentioned in the prefix. In the same way the index minerals of *gabbro* are obviously plagioclase and monoclinic pyroxene.

It is very important that accurate definitions of the index minerals of all rock-families should be provided; but I am not in a position to supply them at present. A few such definitions I have been successful in framing, and I therefore feel confident that with sufficient study every family can be properly defined.

In the meantime, before this work is completed, the want of accurate definitions will not seriously affect the application of

[1] See A. Rosiwal: Verhandlungen der k. k. geol. Reichs-Anstalt, 1898, p. 143.

the system of nomenclature here proposed. Petrologists of any experience know more or less accurately from constant use the index minerals of every family, and ambiguity is likely to arise only in the case of rocks falling near the boundary between two families.

IV. The Prefixes *a-* and *mono-*.

The recognition of index minerals and the formation of definitions would be of little use, however, if the fact were not acknowledged that rocks exist which do not contain the index minerals of any family, and so cannot be classified at all if the scheme be rigidly maintained. So far as I know, such aberrant forms are nearly always *schlieren*, products of differentiation in immediate continuity with and passing gradually into the parent mass; and they are therefore generally classed along with the rock of their parent mass, from which they differ only in the absence of one of the index constituents.[1] To indicate the abnormality of their composition in their names, I propose to place in the prefix the name of the absent index mineral, preceded by the privative *a-*. This combined prefix should stand immediately in front of all the other mineral prefixes, separated from them by a hyphen. As examples of names thus produced I may quote *apyr-gabbro* for *anorthosite*, which is essentially a gabbro without the pyroxene, and *apyr-magne-peridotite*, which denotes certain of the *schlieren* which sometimes occur in masses of gabbro and peridotite, and consist of magnetite associated with olivine and only traces of other minerals.

The difficulty of determining whether a mineral is actually present or not, when it is suspected in small quantities, will tend to produce confusion, if an index mineral must necessarily be absolutely wanting before it can be declared absent in the name. For all practical purposes an index mineral has vanished if its proportion be less than 5 per cent. by weight of the whole rock, and I therefore propose this amount as the limit, falling below which the rock either passes into another family or requires the missing index mineral placed in the prefix with the privative *a-*.

There remains yet one more prefix whose use I have found indispensable, namely *mono-* or *mon-*, meaning *only*. It is of use chiefly in the case of sub-groups which are distinguished from others of the same family by the *absence* of minerals, rather than their presence. For instance, a rock which consists of nothing but the index minerals of some family can only be distinguished from other members of the same family by the absence of the minerals which characterise them. This want of additional minerals may be expressed by using *mono-* as the sole prefix in naming a rock. Thus a *mono-gabbro* is a rock consisting solely of an intermediate or basic plagioclase and a monoclinic pyroxene, the index minerals

[1] The word *schliere* is here used in the sense defined by Rosenbusch ("Elemente der Gesteinslehre," 1898, p. 41), Reyer ("Theoretische Geologie," p. 81), and Zirkel ("Petrographie," 1893, i, p. 787). It has been introduced into the English language by Holland ("The Charnockite Series": Mem. Geol. Surv. India, vol. xxviii, p. 217).

of the gabbro family, no account being taken of the usual accessories. Reference to the table (No. IV) on p. 312 will show that this prefix occurs again in the descriptive name for *umptekite*, namely *monamph-alisyenite.* It is used here because, whilst in certain members of the family an amphibole is the most abundant ferromagnesian mineral, in *umptekite* it is the *only* one, and to avoid all risk of confusion it is well to state that fact in the name. The use of this prefix is really simply a means of avoiding the use of the same name in both an extended and restricted sense at once.

V. Order of Prefixes.

The order in which prefixes of different kinds are placed when required in the same name is an important matter. The rule which I propose is that a prefix used to name a major subdivision be always placed nearer to the family name than a prefix used for a minor subdivision. For instance, supposing that the subdivisions of the dolerite family, founded on mineral composition in the ordinary way, were themselves subdivided according to structure, then the structure prefix would always precede the mineral prefix in the name of each of the ultimate subdivisions, producing such names as *ophit-oli-dolerite*, *hypidio-horn-dolerite*, etc. When on the other hand the first subdivision is on the basis of structure, as in the rhyolites, the order must be reversed, producing such names as *diopsi-mipegmo-rhyolite*, *bi-perlo-rhyolite*, etc. This rule is obviously the most convenient, for it leaves the name of a major subdivision intact in the names of the minor subdivisions which it contains, so that a single glance shows to which major subdivision any minor subdivision belongs. It must not be supposed that this double subdivision and the cumbrous names it produces will be frequently employed. It is probable, however, that as the study of igneous rocks progresses, subdivision will be carried further and further; and it is therefore well to be prepared beforehand with a method for naming sub-groups of future origin in any system of nomenclature which we adopt to-day.

It will have been observed that hyphens are always placed between prefixes of different kinds, and between a prefix and the family-name, in order to facilitate reading the compound name. They are not required to separate prefixes of the same kind, as for instance when a series of mineral prefixes follow one another, nor should they be inserted within family- or subfamily-names.

VI. Lists of Contractions.

The various kinds of prefixes have now been fully discussed. For the sake of uniformity, in case others should wish to use this system, I proceed to display in full all the contractions which appear likely to be necessary. The first list, containing the contractions of mineral names, includes, I believe, all that are likely to be required. It will be noticed that different forms are generally needed according to whether the next syllable begins with a vowel or a consonant.

Table I. List of Contractions for the Names of Minerals.

Mineral	Before a Consonant	Before a Vowel	Mineral	Before a Consonant	Before a Vowel
Actinolite	Actino-	Actin-	Hornblende	Horn-	Horn-
Ægyrine	Ægi-	Æg-	Hypersthene	Hyper-	Hyper-
Albite	Albi-	Alb-	Labradorite	Labra-	Lab-
Amphibole	Amphi-	Amph-	Leucite	Leu-	Leuc-
Analcime	Analci-	Anal-	Magnetite	Magne-	Mag-
Andesine	Ande-	Andes-	Melanite	Melano-	Melan-
Anorthite	Anorthi-	Anorthi-	Melilite	Melli-	Mel-
Anorthoclase	Anorthoclase-	Anorthoclas-	Mica	Mica-	Mica-
Anthophyllite	Antho-	Anthy-	Microcline	Microcline- (Ortho-)	Microcline- (Orth-)
Apatite	Apa-	Ap-	Muscovite	Musc-	Musc-
Arfvedsonite	Arfve-	Arfved-	Nepheline	Neph-	Neph-
Augite	Augi-	Aug-	Nosean	Nose-	Nos-
Barkevicite	Barke-	Bark-	Oligoclase	Oligo-	Olig-
Basalt Hornblende	Bashorn-	Bashorn-	Olivine	Oli-	Oliv-
Biotite	Bi-	Bi-	Orthoclase	Ortho-	Orth-
Bronzite	Bronzi-	Bronz-	Pyroxene	Pyro-	Pyr-
Bytownite	Byto-	Byt-	Quartz	Quartz-	Quartz-
Cancrinite	Cancri-	Can-	Riebeckite	Riebe-	Rieb-
Corundum	Corun-	Corund-	Sodalite	Sodali-	Sodal-
Diallage	Dial-	Dial-	Sphene	Spheni-	Sphen-
Diopside	Diopsi-	Diop-	Titanite	Tita-	Titan-
Enstatite	Ensta-	Enst-	Topaz	Topa-	Topaz-
Felspar	Fels-	Fels-	Tourmaline	Tourma-	Tourm-
Garnet	Garnet-	Garnet-	Tremolite	Tremo-	Trem-
Haüyne	Hau-	Hau-	Zircon	Zircon-	Zirc-

The names of structures do not admit of contraction quite so readily as those of minerals, but it is only in very few cases that the name cannot be reduced to three syllables. The list of contractions given below (Table II) is almost complete, but for some words such as *hypocrystalline-porphyritic* and *glomeroporphyritic,* besides *granular, granulitic,* etc., unambiguous contractions do not exist. It may become necessary, in some cases, to adopt new names for such structures, though I hesitate to go so far at present. Suggestions from any quarter will, however, be gratefully received and considered. In the case of names for which contractions cannot be invented, and which are therefore omitted from the following list, it will probably be best for the present to use the whole name without contraction.

The contractions are given in the form which should be used when the next syllable begins with a consonant. When followed by a vowel the final *-o* should in most cases be dropped. The pronunciation remains unaltered in contractions which are formed by the omission of a syllable from the centre of the word. Thus, for instance, the *mi-* in *misphero-* is pronounced long as in 'microscope' or 'microspherulitic,' and *not* short as in 'miss.'

The name *amygdaloidal* is omitted from the list because that structure is merely a secondary derivative of the vesicular structure. As it is generally the rule in naming an igneous rock to imagine it back in its original and unaltered condition, the two structures become for our purpose essentially the same, and the name *vesicular* may be used for both.

Table II. List of Contractions for Names of Structures.

Name	Contraction	Name	Contraction
Allotriomorphic-granular	Allotrio-	Ophitic	Ophito-
Eutaxitic	Eutaxo-	Panidiomorphic-granular	Panidio-
Felsophyric (see Microfelsitic)	Mifelso-	Pilotaxitic	Pitaxo-
Glassy or vitreous	Vitri-	Pœcilitic	Pœcilo-
Hyalopilitic	Hyapilo-	Porphyritic	Porpho-
Hypidiomorphic-granular	Hypidio-	Rhomboidal (Rhombeu-) felspar structure	Rhomfels-
Intersertal	Inserto-	Spherulitic	Sphero-
Miarolitic	Miaro-	Trachytic	Tracho-
Microfelsitic	Mifelso-	Variolitic	Varilo-
Micropegmatitic or Granophyric	Mipegmo-	Vesicular	Vesico-
Microspherulitic	Misphero-	Vitrophyric (see Glassy)	Vitri-
Ocellar	Ocello-		

There remain a few miscellaneous contractions which are occasionally employed, and may be conveniently exhibited in another table. The prefixes for 'rich in soda' and 'rich in potash' are obtained by contracting the German words *natron* and *kali*, rather than the English words *soda* and *potash*, because, owing to their use for symbols in chemistry, the former are more widely understood in England than are the latter in Germany.

Table III. List of Miscellaneous Contractions.

Before a Consonant	Before a Vowel	Meaning
a-	an-	without (privative)
ali-	ali-	rich in alkalies
basi-	bas-	basic
calci-	calc-	rich in lime
kali-	kali-	rich in potash
kalko-	kalk-	rich in lime (German)
medio-	medi-	medium, middle
mono-	mon-	only
multi-	mult-	much, many
natro-	natr-	rich in soda
pauci-	pauc-	little, few

VII. Family-Names.

For the sake of further illustration, I have prepared, and reproduced below, a table showing the classification of the Alkaline Series of plutonic igneous rocks, which gives both the old and the new names (see Table IV, p. 312). The Alkaline Series is troubled with a particular superabundance of names. Probably this is because most of its members have been discovered in recent years, since detailed petrographical research became general, and its families have therefore actually become subdivided to a far greater extent than those of the Calc-alkaline Series, although the latter has been studied very much longer. The table therefore shows that a great number of names will become redundant, if a systematic nomenclature be adopted.

Hitherto nothing has been said respecting the names of families. This is because complete revolution is impossible, and existing names must be accepted to a great extent, however meaningless and awkward they may be. There is, however, one family-name which I have felt the necessity of altering, as reference to the table will show; that is, the name *nepheline-* or *elæolite-syenite.* The name was probably the best which could be given at the time the family was established, pointing out as it did the relation which these rocks were then supposed to hold to a well-known group, the Syenites.[1] In view of what we know at the present time, however, concerning the Alkaline Series, the name is not only useless but misleading. In no essential quality does the so-called nepheline-syenite resemble a normal syenite. The silica percentage, which ranges, roughly speaking, from 50 to 60, is that of the more basic diorites and some acid gabbros, rather than that of the syenites. As regards mineral composition also, the two are absolutely distinct. The normal syenite consists of orthoclase and a ferromagnesian mineral, which are the index minerals of the family, together with a plagioclase felspar not exceeding the orthoclase in amount, and usually a small quantity of quartz. The nepheline-syenite, on the other hand, contains alkali-felspar (either potash or soda predominating) and nepheline as index minerals, with which are associated ferromagnesian minerals in small quantity and mostly of an alkaline type, and frequently sodalite, leucite, nosean, cancrinite, etc., without plagioclase or quartz. Hence it is evident that merely removing the nepheline from a nepheline-syenite would not make it into an ordinary syenite, and the name has therefore no justification. Since the family is a member of the Alkaline Series, and at the same time occupies a middle place in the range of silica percentage, I propose to substitute for *nepheline-syenite* the descriptive name *midalkalite.* This is compounded of 'mid,' the abbreviated form of 'middle,' and 'alkali,' which signifies the series to which the family belongs. The only alternative was the form *medalkalite,* adopting the Latin word *medius* for 'middle.' The word sounds strange and uncouth, however, to English ears, and conveys its meaning much less clearly than *midalkalite*; whilst the latter is probably equally adaptable to French and German.

Possibly the coining of a new name upon a new principle demands some apology. It may be suggested that the better course would have been to select one of the numerous names already given to various members of the nepheline-syenite family, and to extend its meaning to embrace the whole group. Every other family-name has arisen in that way, and a uniform system might have been preserved. I consider, however, that there are very strong objections to any such extension of the meaning of a name; indeed, I hold that an extension of meaning is justifiable *only when the additional species taken in do not surpass, either in the wideness of their difference from one another or in number, the species already associated with the name* —the word *species* being here used merely to designate any small

[1] The name was given by Rosenbusch in 1877. He himself anticipates the objection which I am about to raise (see Mik. Phys., 1877, ii, p. 204), and proposes that, if it be insisted on, the name *foyaite* should be adopted instead.

group possessing well-recognised characteristics. It is inevitable that the meaning of a name should be altered from time to time—sometimes narrowed, though generally extended; but every such alteration must be gradual, taking place step by step. The reason for this lies in human nature. A radical alteration in the meaning of a name involves such a revolution of ideas and habits that most men refuse to accept any such proposal; and its adoption by only a few simply leads to endless confusion. On the other hand, a slight alteration of meaning requires but a trifling readjustment of ideas and habits; and, therefore, so long as the change is clearly justified, it is soon recognised as convenient and gradually comes into use.

Whilst these objections clearly prevent the adoption of such names as *lujaurite, litchfieldite,* etc., to replace *nepheline-syenite,* there is one name, *foyaite,* which would appear at first sight to escape them. It has been suggested, and sometimes used, as a synonym for *nepheline-syenite,* and few authors, if any, now restrict its meaning solely to the type of rock originally described by Blum under that name. A little investigation shows, however, that even this name has not had an application wide enough to allow of its extension over the whole group which I propose to call *midalkalites.* Rosenbusch uses it to include only what might be called the normal types of nepheline-syenite; those which are poor in coloured constituents, and in which the alkali felspars are both abundant, the potash felspar predominating over the soda felspar, rather than the reverse. This use of it excludes such types as Litchfieldite, Laurdalite, Lujaurite, and many others, but includes Brögger's and Derby's Foyaites. At the same time it appears probable that the majority, if not all, of those authors who have used *foyaite* as synonymous with *nepheline-syenite,* have had in their minds only those normal types included by Rosenbusch under that name. The name is therefore applied to a definite group of rocks closely allied to one another, and it would be a contravention of the principle above stated to apply it to such widely differing rocks as *laurdalite, litchfieldite, borolanite, leucite-syenite,* and *sodalite-syenite.* It will, indeed, be found convenient to retain the name *foyaite* with Rosenbusch's meaning as marking a subfamily.

The only course left me was to coin a new name. A descriptive name seemed likely to be most convenient, and I therefore chose *midalkalite.* The fact that all other family-names are of the non-descriptive kind, and that I do not at the same time propose descriptive names to replace them, is no valid objection to the introduction of one such name. If this one prove a success, others can be added from time to time as desired.

Two other family-names require a brief notice. Desiring to reduce the number of existing family-names as far as possible, I have followed Rosenbusch and grouped together the soda and potash rocks, so that the theralites and shonkinites form one family, and the ijolites and missourites another. Instead of retaining the double name for each family, however, as he does, I have selected one of the names in each case to cover both the soda and potash rocks. Guided by the principle above set forth, I have selected the name of the soda rocks in each case, because they are far more important, both in number and variety, than the corresponding potash rocks. The family of *Theralites and Shonkinites* therefore becomes the family of *Theralites*, and the family of *Ijolites and Missourites* becomes the family of *Ijolites*. The name *ijolite* is neither convenient nor euphonious, but I fear there exists no alternative which could be adopted. It is not objectionable enough to warrant the proposal of a new name, and there is no other name in the family which has sufficient extension to allow it to be applied to the whole family in accordance with the above-mentioned rule.

The chief reason for combining the soda and potash rocks in one family as I have done, is that if they were separated here, amongst the plutonic alkaline rocks, the same multiplication of families ought to be allowed throughout the whole igneous series. Instead of about thirty-five families, as we now have, we should then have nearly sixty, each with a name to be remembered. This seems to me too large a number, in the present state of our science. It will be observed, however, that I propose still to keep the potash and soda rocks separated, making them subfamilies instead of families, and naming them accordingly. The theralites and shonkinites, for instance, become respectively *natrotheralites* and *kalitheralites*.

The silica percentages, which are stated for each family in Table IV, are intended for information only. They show roughly the limits of silica variation in each family, so far as its members have been analysed and the results have been accessible to me, but they must not be considered as a part of its definition. The limits are stated in whole numbers for the sake of clearness, but they should be read so that the limit stands 0·5 per cent. on the *outside* of the figure given. A range of 67–57 per cent., for example, must be read as 67·5–56·5 per cent. This convention is necessary because the limiting values fall more frequently on the half unit than the unit.

Table IV. Scheme of Classification of the Plutonic Division of the Alkaline Series of Igneous Rocks.

Family I.—ALIGRANITES. (= Alkaligranites, Ros.)

Two Index Minerals: Quartz; *and an* alkali-felspar.
SiO_2 % 78–68.

1. Bi-aligranite (= Nordmarkite, Brögger, *in part*).
2. Amph-aligranite (*includes* Riebeckite-granite, Sauer).
3. Pyr-aligranite.

Family II.—ALISYENITES. (= Alkalisyenites, Ros.)

One Index Mineral: *An* alkali-felspar.
SiO_2 % 67–57.

1. Pyrobiamph-alisyenite (= Pulaskite).
2. Biamph-alisyenite (= Nordmarkite, *the greater part*).
3. Monamph-alisyenite (= Umptekite).
4. Rhomfels-pyr-alisyenite (= Laurvikite).
5. Ǽg-alisyenite (= Ǽgyrine-syenite).

Family III.—MIDALKALITES. (=Nepheline- *or* Elæolite-syenites.)

TWO INDEX MINERALS: *An* alkali-felspar; *and* nepheline.
SiO_2 % 60–48.

1. Pyr-midalkalite (= Foyaite, BLUM; Pyroxene-foyaite, Ros.).
2. Amphi-midalkalite (= Amphibole-foyaite, Ros.).
3. Bi-midalkalite (= Mica-foyaite, Ros.; *includes* Miascite; *and* Ditroite).
4. Natro-midalkalite (= Litchfieldite).
5. Rhomfels-pyr-midalkalite (= Laurdalite).
6. Eudægi-midalkalite (= Lujaurite).
7. Leuci-midalkalite (*includes* Leucite-syenite *of Magnet Cove, Arkansas*).
8. Cancri-midalkalite (= Cancrinite-syenite).
9. Melano-midalkalite (*includes* Borolanite; *and* nepheline-syenites *of Montreal and Magnet Cove, Ark.* [Cove-type]).
10. Sodali-midalkalite (*includes* Sodalite-syenite *of Julianehaab*).

Family IV.—ESSEXITES.

THREE INDEX MINERALS: Labradorite; augite *or* diopside; *and* biotite (*or an* alkaline amphibole *or* pyroxene).
SiO_2 % 50–43.

1. Multifels-essexite (*includes* Essexites *of Cabo Frio; Jacupiranguinha; Rongstock; and Dignaes*).
2. Mediofels-essexite (*includes* Essexites *of Salem, Mass.; and Sölvsberg*).
3. Paucifels-essexite (*includes* Essexites *of Arkansas; Montreal; Penikkavaara, near Kuusamo; and Brandberg*).

Family V.—THERALITES. (= Theralites *and* Shonkinites.)

THREE INDEX MINERALS: *A* pyroxene; felspar (plagioclase *or* orthoclase); *and* nepheline, *or* sodalite, *or* leucite.
SiO_2 % 50–40.

Subfamily A.—NATROTHERALITES.

1. Augi-natrotheralite[1] (= Theralite, *sen. str.*; *and includes most of the* Teschenites).
2. Ægi-natrotheralite (= Natronsussexite).
3. Barke-natrotheralite (= *certain* Teschenites).

Subfamily B.—KALITHERALITES.

1. Augi-kalitheralite[1] (= Shonkinite).
2. Ægaugi-kalitheralite (= Pyroxene-malignite).
3. Amphi-kalitheralite (= Amphibole-malignite).
4. Melano-kalitheralite (= Garnet-malignite).

[1] The *a* of *natro-* and of *kali-* is pronounced long as in 'state.' The *i* of *kali-* is short as in 'pit,' but it is dropped in the name *kalijolite*, in which the first *i* should be pronounced long as in 'write.'

Family VI.—IJOLITES. (= Ijolites *and* Missourites.)

Two Index Minerals: Pyroxene; *and* nepheline, *or* sodalite, *or* leucite.
SiO_2 % 47–40.

Subfamily A.—NATRIJOLITES.

1. Augi-natrijolite[1] (*includes* Ijolites *of Imandra See, Kola Penin.*; Elæolite-syenite (Ridge-type) *of Magnet Cove*; *and* Jacupirangite).
2. Ægaugi-natrijolite (*includes* Ijolites *of Kuusamo*; *Kaljokthal*; *and Alnö*).
3. Ægi-natrijolite (= Urtite).
4. Aneph-sodali-natrijolite (*includes* Tawite; *and* Sodalite-syenite *of Square Butte, Montana*).

Subfamily B.—KALIJOLITES.[1]

(*Includes at present only* Missourite.)

VIII. Changes in the Subdivision of Families.

The subdivisions of the families contained in the above table are in almost every case those suggested by Rosenbusch in the most recent editions of his works, but I have not adopted them without testing their validity whenever possible.[2] The aligranites he does not subdivide, but as I see no reason why they should not be treated in the same way as the granites, I have subdivided the family on the basis of its coloured minerals. Amongst the midalkalites, the subdivision *melano-midalkalite* is new. Rosenbusch places borolanite in the leuci-midalkalite (leucite-syenite) group; but, considering that Horne and Teall distinctly state that they give that name to a rock consisting essentially of orthoclase and melanite, and that leucite only occurs in parts of the mass which they describe, I think that borolanite and rocks of that composition should be entitled to rank as a distinct sub-group in the great midalkalite family. Garnet plays an important rôle as an original constituent in many basic rocks of the alkaline series; to a much greater extent indeed than is generally recognised.

The two rocks *urtite* and *tawite* are removed from the midalkalite (nepheline-syenite) family, with which they are classed by Rosenbusch, presumably because of their association. They will be found in the family to which their mineral composition assigns them, that is to say, the Ijolites.

The principal difficulty which I experienced in naming subdivisions was the frequent want of definite information as to the relative proportions of the constituents of a rock. Many descriptions even of recent date fail in this respect, and it would be well if all petrologists realized, as a few already do, that a mere statement of the minerals found in a rock is not a complete description of it. On

[1] See footnote on preceding page.
[2] See "Elemente der Gesteinslehre," 1898, and Mikr. Phys., 1896, vol. ii.

the contrary, it is the relative proportions of the constituents which establishes the identity of the rock. For instance, a kalitheralite (e.g. malignite) may contain the same minerals as an alisyenite. The former may contain 25 per cent. orthoclase, 25 per cent. nepheline, and 50 per cent. of ferromagnesian minerals, and the latter 90 per cent. orthoclase, 5 per cent. nepheline, and but 5 per cent. of ferromagnesian minerals. They may be composed of exactly the same minerals, and yet in such different proportions that they belong to widely separated families.

Another example will show how unsatisfactory is this practice of merely giving a qualitative description of a rock. I have, of late, frequently had to read descriptions of rocks in order to determine to which subdivision of a family they should be consigned in cases where the subdivisions are distinguished by the most abundant ferromagnesian mineral. In one description, after two or three pages had been devoted to an amphibole and two pyroxenes which the rock contained, it was just mentioned at the end that the rock contained biotite. The impression given was that the amphibole and pyroxenes were the important ferromagnesian minerals, whilst biotite was quite subordinate in quantity. On examining a slice of the rock, however, I saw at a glance that the biotite was far more abundant than both the amphiboles and pyroxenes taken together, and that it had received so little attention merely because it presented no point of special interest. Now that an easy method of determining the relative proportions of constituents is known, namely, that of Rosiwal already referred to (see footnote, p. 305), it is to be hoped that there will be speedy reform in this matter.

Although I believe that the names given to the rocks in the above table generally represent their composition correctly, I cannot vouch for the fact. Owing to the vagueness of many descriptions in the above-mentioned respect, and because I have not thought it worth while merely for the purpose of illustration in a preliminary notice to spend much time in consulting literature not to be obtained in Cambridge, it may be that a few of my names will bear correction. That cannot, however, affect the value of the system of nomenclature itself; and I trust that authors who are acquainted with any rocks which I may have misnamed will be so kind as to set me right.

IX. The Naming of Newly Discovered Rocks.

In conclusion, I may perhaps offer some suggestions as to how newly discovered rock-species should be named in the future. The first step in identifying a rock is to determine its essential constituents, that is to say, those which make up more than 5 per cent. by weight of the whole rock. According to their nature, whether they are of the alkaline type or not, the rock is first assigned either to the Alkaline or the Calc-alkaline Series. Amongst the essential constituents it will next usually be possible to find two or three which coincide with the index minerals of some particular family, and the rock can then be forthwith placed in that family. Should the essential constituents include the index minerals of more than one family, which will rarely be the case, the rule is to choose those which are most abundant. The family-name being thus obtained, observe next upon what basis the family is subdivided, whether it is by the nature of the ferromagnesian mineral, by the kind or quantity of felspar present, or by some other property. All the constituents of the rock, essential and accessory, being now considered, it will be easy to assign the rock to its right subdivision, supposing one already exists. If, on the other hand, the rock is a new type and no place awaits it, a new subdivision can be created and named in accordance with the general system.

The only rocks which it will be found difficult to name are those which do not contain the index minerals of *any* family. In such cases the association of the rock is the first point to be considered. If any such rock clearly forms part of an igneous mass which can be readily assigned to a family, let the doubtful rock also be assigned to the same family, and give it a name in which the missing index mineral is preceded by the privative *a*-. If, however, besides being entirely new, the rock does not appear to be associated with any known type, it becomes a question whether a new family should be established. This course must be adopted only when there is really no other way of naming the rock, and the family name selected should be, as far as possible, descriptive of the rock's peculiarity in mineral or chemical composition.

I cannot end without expressing my gratitude to Prof. Bonney, my first master, for the interest with which he has followed my work upon classification and nomenclature and for the many suggestions which he has freely offered. To Prof. Rosenbusch also I am deeply indebted for the kindly instruction received at Heidelberg, which has opened my eyes and smoothed my path in many ways, but more especially in this research.

III.—Notes on the Tourmaline of the White Granite of Meldon, Dartmoor.

By Lieutenant-General C. A. McMahon, F.R.S.

THIS "remarkable variety of granite" was briefly described by Mr. J. J. Harris Teall, F.R.S., in his "British Petrography" (1888), p. 316, and an interesting account was given in a footnote of the process by which the author was able to identify the topaz found in the rock.

In a paper on Dartmoor published in 1893 (Q.J.G.S., vol. xlix, p. 385), I described in some detail the mode of occurrence of this intrusive rock and some of its characteristics; and in the following year (Q.J.G.S., vol. L, p. 338) I noted the occurrence of a second outcrop on the flank of South Down.

None of the above references to the white granite of Meldon contain a description of the tourmaline found in it, and as this mineral presents some unusual features a few remarks on it may interest students of petrology.

White tourmaline (achroite) has not yet, so far as I am aware, been found in the British Islands, but the tourmaline of the Meldon granite approximates to colourless tourmaline sufficiently closely to render it probable that if the attention of mineralogists is drawn to the subject true achroite may yet be detected in British rocks.

The following remarks are based on the study of a good suite of thin slices made from hand specimens collected by me, and of numerous fragments of tourmaline separated from these specimens with the aid of a heavy solution. When I was at Meldon the granite was being quarried, and I was able to get unweathered samples.

Fragments of tourmaline examined with a powerful pocket lens are seen to be in part colourless and in part of pale-brown colour.

Under the microscope, when examined with the aid of transmitted light, the tourmaline in thin slices (as thin as those "made in Germany" for instance) is absolutely colourless and devoid of dichroism. It is consequently difficult to distinguish from the topaz with which it is associated. This difficulty is increased by the fact that both minerals, as seen in thin slices of the Meldon rock, closely resemble each other in habit. Both are allotriomorphic and occur in irregular shaped grains. The tourmaline rarely presents itself in prismatic form, whilst the cleavage, usually so characteristic of topaz, is rarely to be seen in the topaz of the Meldon granite. As, moreover, the refraction of both minerals is higher than that of Canada balsam, and of the felspar and quartz with which they come in contact, the difference in the refraction of topaz, as compared with that of tourmaline, does not help one to discriminate between them.

The positive character of the double refraction of topaz could not be made out in any of my slices, as no bisectrix could be seen in converging polarized light. The axial angle in topaz from different localities varies very much, and it is probably large in the variety found in the Meldon granite.

The rock under consideration affords an illustration of the help that may sometimes be afforded by our much abused thick slices of English manufacture. In such slices the Meldon tourmaline presents a somewhat more normal appearance. Even in thickish slices, however, the mineral is sometimes colourless in whole or in part, but more often a reddish or reddish-brown streak or patch is to be seen in the otherwise colourless grains which exhibits the characteristic dichroism of tourmaline.

The appearance of these coloured stripes and patches suggests to me the possibility that the colour may be due to the alteration of an originally colourless tourmaline; namely, to the oxidation of the iron contained in the mineral. Iron is not an essential constituent in this complex silicate, and my previous studies have familiarized me with the idea that iron may be removed, or oxidized, without breaking up the fundamental silicate of which it is more or less a casual unessential member.

The tourmaline in the Meldon granite very rarely exhibits prismatic outlines in thin slices, but in the isolated fragments both this mineral and the topaz show a slightly increased tendency to do so. The tourmaline, however, even in thin slices, is frequently elongated in the direction of the vertical axis (c'); and as the greatest absorption takes place at right angles, and compensation with the quartz wedge occurs parallel to this direction (viz. to c'), a ready and sure means of identifying the mineral exists in such cases.

When this observation can be made one cannot remain in doubt as to which is tourmaline and which is topaz, as the latter is not dichroic in thin slices, and compensation with the quartz wedge, in the case of topaz takes place at right angles to c', and in the case of tourmaline parallel to c'.

When dichroism is apparent in the Meldon tourmaline the change is from colourless (e) to a yellowish or reddish-brown (o).

In cases where the above-mentioned observation cannot be made, namely, when dichroism is absent, I have found the following methods very useful.[1]

I have often, when examining the topaz in my slides, been able to obtain in converging polarized light the interference figure of an optic axis, namely, a single bar, or a bar bisecting the first ring of the interference figure, which remained without change of character during a revolution of the crossed nicols through 360°. When this interference figure is obtained it shows clearly that the mineral is a biaxial one, and consequently that it is topaz and not tourmaline. Axial sections of the latter mineral, on the other hand, may be obtained in my thin slices, which in converging polarized light yield a negative uniaxial cross which does not open out on revolving the nicols. Sometimes when the section has not been cut quite normal to the vertical axis of the crystal, only two of the arms of the cross can be seen, and sometimes their point of junction is outside the field. In such cases, with one of Swift's improved one-sixth objectives, I can generally get the two arms just on or just outside the edge of the field, and can make sure that the arms are those of an uniaxial mineral. In cases of doubt I am able to confirm this observation by inserting the one-fourth undulation mica plate, when the double refraction of tourmaline being negative, *one* dot (only half of the cross being visible) appears in a line with the axis of the mica plate and well within view.

Observation of the strength of the double refraction also affords, in some cases, a method of distinguishing between the two minerals. The birefringence of topaz does not exceed 0·010, whilst that of tourmaline is 0·020. The colour of the former mineral, as seen in thin slices, does not rise above the indigo-blue of the second order of Newton's scale, and very often falls below that. On the other hand, the colour shown by the tourmaline in my sections frequently rises to the indigo-blue of the third order.

Lastly, the character of the metamorphism effected by aqueous agents affords a useful test. Tourmaline alters to steatite, mica,

[1] I confine myself to optical tests and those which can be applied to thin slices.

chlorite, and *cookeite*;[1] whilst topaz changes to steatite, mica, and *kaolin*.

In my Meldon specimens the green tint seen in some of the tourmaline is probably due to the birth of ultra-microscopic particles of chlorite in the originally colourless crystals. The topaz, on the other hand, sometimes exhibits partial kaolinization, and when it does so it is clear that the mineral is topaz and not tourmaline.

On the whole, I think it probable that the somewhat partial and patchy colour seen in the Meldon tourmaline is due to the post-genital alteration of an originally colourless variety of this mineral. I do not think the faint colour now visible is due to the bleaching of an originally dark-coloured tourmaline. An operation of this kind would imply the bleaching of the whole of the white granite itself, which I do not think probable. Moreover, it would involve chemical action to an extent that must have left very powerful marks on the felspars and other susceptible minerals contained in the rock, that could not remain unobserved.

IV.—An Abnormal Section of Chloritic Marl at Mupe Bay, Dorset.

By A. Strahan, M.A., F.G.S.

In "The Geology of the Isle of Purbeck and Weymouth" (p. 152) I referred to some green sand which occurs next below the Chalk in Mupe Bay, Dorset, as somewhat resembling Chloritic Marl, but as being too thick for that bed. As it was followed by the Gault, I concluded that it belonged to the Upper Greensand. The section was subsequently visited by Mr. W. Hill, who collected from the sand in question *Holaster subglobosus*, var. *altus*, and *Echinoconus castanea* among other fossils, and inferred that it was Chloritic Marl. He considered that though it passed up insensibly into the Chalk it was faulted against the Gault, but that there had been also considerable contemporaneous erosion of the Upper Greensand. In April of this year I revisited the section in company with Mr. Hill, and was fully satisfied as to the correctness of his views. The following account has been drawn up from our observations:—

The Lower Chalk becomes extremely impure in its lower part, and contains much glauconite; it thus graduates insensibly downwards into a gritty glauconitic sand. The sand contains a few phosphatic casts, more or less worn or corroded, scattered throughout it, but has a well-marked nodule-bed crowded with these casts at its base; other fossils with the shell preserved and not filled in with phosphate occur also throughout the whole bed.

Below the sand comes a sandy glauconitic clay, forming part of the Gault, but the fact that the separation is sharp, and that the chert-beds of the Upper Greensand and the passage-beds down into the Gault are absent, proves that the two are faulted together, although the fault-plane is parallel to the highly inclined bedding.

[1] See Dana's textbook, last edition.

The thickness of sand between the fault and what may be taken as the base of the Chalk amounts to 15 feet.

The following list of fossils includes those collected in April, 1901, and those obtained previously by Mr. Hill. They prove that the whole of the sand should be referred to the Chloritic Marl. The identifications are by Mr. E. T. Newton.

CHLORITIC MARL, MUPE BAY.

SCATTERED THROUGH THE BED.

Terebratula squamosa, Mant.
Cidaris Bowerbanki, Forbes.
Echinoconus castanea, Brongn.
Holaster subglobosa, Leske.
Holaster subglobosa, var. *altus*, Ag.
Holaster suborbicularis? Defr.
Plocoscyphia?

FROM NODULE-BED AT BASE.

Helicoceras, sp.
Columbellina?
Turritella, sp.
Cucullæa carinata? Sow.
Cucullæa mailleana? D'Orb.
Isocardia, sp.
Trigonia, sp.
Cardium, sp.
Cardita, sp. (? *tenuicosta*).
Pleuromya (*Panopæa*).
Cytherea plana, Sow.
Plicatula, sp.
Exogyra, sp.
Polyzoon on Lamellibranch.
Rhynchonella (near to *grasiana*).

A section at the top of the cliff (referred to on p. 151 of the Memoir on the Isle of Purbeck) shows that the Chloritic Marl maintains an abnormal thickness for 200 yards at least west of the section on the beach. It is there succeeded downwards by a considerable thickness of Upper Greensand, in which, however, no representative of the Chert Beds could be found, and which presumably belongs to the lower part of the formation. Two explanations for this sequence may be offered: firstly, that the fault which throws Chloritic Marl against Gault on the beach does not follow the bedding precisely, but cuts obliquely through the Upper Greensand, so as to throw Chloritic Marl against that formation westwards; secondly, that the upper part of the Upper Greensand suffered erosion before the deposition of the Chloritic Marl.

The first explanation is supported by the fact that the section on the beach places the existence of a fault beyond doubt, and shows also that the fault is approximately parallel to the highly inclined beds. In favour of the second explanation it may be urged that the abnormal thickness and character of the Chloritic Marl point to the Upper Greensand having undergone erosion. The phosphatic casts of fossils, though but little water-worn, are fragmentary. While, therefore, they have neither travelled far nor been rolled upon a beach, they are not in their original matrix. The absence of any fragments of chert among the nodules in the Chloritic Marl appeared to me to point to the erosion of the Upper Greensand having been but slight, but in explanation of this Mr. Hill suggests that the chert-nodules were formed at a later date, and that the beds were all soft when the erosion took place. For myself I am inclined to think that the segregation of nodules followed as a rule closely upon the deposition of the sediments in which they occur.

The fossils, generally speaking, have too wide a range to determine exact horizons in the Upper Greensand, but Mr. Jukes-Browne points out to me that *Cytherea plana*, which occurs as a phosphatic cast in the nodule-bed, favours the idea of erosion to below the Chert Beds, for he has not observed it from any higher horizon.

In the Memoir on the Isle of Purbeck (pp. 161, 162) I referred to the general consensus of opinion that there had been some slight erosion of the Upper Greensand before the deposition of the Chloritic Marl, and gave some instances, but I know of no other case in which the evidence is so strong or where the erosion appears to have been so great as at Mupe Bay. That it was strictly local is proved by the fact that in Lulworth Cove to the west, and in Warbarrow Bay to the east, the sequence is normal, and the Chloritic Marl resumes its normal thickness of 3 to 4 feet. It is unfortunate that the existence of a fault introduces a doubt how far the incompleteness of the sequence should be attributed to contemporaneous erosion and how far to subsequent movement. While accepting the evidence that there was erosion, perhaps considerable, of the Upper Greensand, I am disposed to call in the aid of the fault at the top as well as at the bottom of the cliff, to account for some of the missing beds.

My thanks are due to Mr. Hill for giving me the opportunity of making this correction, and for supplying much of the material on which it is founded.

NOTICES OF MEMOIRS.

I.—Origin of the Ancient Crystalline Rocks.—Dr. Frank Dawson Adams gives an account of the excursion to the Pyrenees in connection with the Eighth International Geological Congress (Journ. Geol., 1901, ix, pp. 28–46). The object of the excursionists was to examine, under the leadership of Professor Lacroix, certain intrusive granite masses, which have not only intensely altered the strata through which they pierce but which have produced a wholesale transformation of the sedimentary rocks in question into granite, the granite now occupying the space formerly occupied by the sediments. The districts examined were Aix-les-thermes, L'Etang de l'Estagnet, L'Etang de Baxouillade, Cirque de Camp Ras, Foix, Arignac, Cabre, Vicdessos, Sem, Massat, Bagnères-de-Bigorre, Pouzac, Payole, Cirque d'Arbisson, and Barèges. While recognizing that the excursion was merely a rapid traverse of a district which has received detailed attention from the French petrographers, Dr. Adams sums up as follows: "While the transfusion of a certain amount of material into the limestones along the immediate contact of the intrusions and also a solution of the limestone to a limited extent in certain cases seems highly probable; the wholesale transformation of limestone into diorite, or of shale into gneiss and granite, which has been described in the case of these contact zones of the Pyrenees, is as yet very far indeed from being proved."

II.—Nodular Granite from Pine Lake, Ontario. By Frank Dawson Adams, Ph.D. (Bulletin of the Geological Society of America, 1897, vol. ix, pp. 163–172, pl. xi; February 10, 1898.)—Professor Adams, while carrying out some work for the Geological Survey of Canada in the eastern part of the Province of Ontario, has discovered a remarkable occurrence of orbicular or nodular granite in the township of Cardiff, in the county of Peterborough. In this part of the country the fundamental rocks are Crystalline Limestones, associated with Gneisses and Amphibolites, broken through by great intrusions of Granite. The nodule-bearing Granite occurs on the north and south sides of Pine Lake. It is rather fine-grained and usually gneissic in places, but often massive. The nodules are confined to a portion only of the Granite, and are not in proximity to the Amphibolite; and therefore the nodular structure is not a contact phenomenon. The nodules are spherical or ellipsoidal, and occur either scattered through the rock or, more rarely, in lines. When the nodules occur in rows they gradually get closer together until they seem to fuse or coalesce into a continuous band or vein. The centres of the nodules exhibit little segregation bunches of schorl. Professor Adams concludes that these nodules are due to a primary differentiation of the magma, for the reason that they do not include certain minerals such as Microcline, which have evidently crystallized from the magma latest, and which are abundant in the surrounding Granite; while on the other hand Sillimanite occurs in the nodules, being one of the first to separate from the magma, but does not occur in the surrounding Granite.—F. C.

III.—An Experimental Investigation into the Flow of Marble. (Philosophical Transactions of the Royal Society of London, 1901, vol. cxcv, pp. 363–401.)—These experiments have been carried out by Messrs. Frank Dawson Adams and John Thomas Nicolson; pure Carrara marble being the rock selected. The paper deals with the methods employed, deformation of the dry rock at ordinary temperature, at 300 C., and at 400 C., and at 300 C. in the presence of water. Comparison is made of the structures produced in Carrara marble by artificial deformation with those produced by deformation in the case of metals, and comparison of the structures produced with those observed in the limestones and marbles of highly contorted portions of the earth's crust. The following is the summary of results:—(1) By submitting limestone or marble to differential pressures exceeding the elastic limit of the rock and under the conditions described by the authors, permanent deformation can be produced. (2) This deformation, when carried out at ordinary temperatures, is due in part to a cataclastic structure and in part to twinning and gliding movements in the individual crystals composing the rock. (3) Both of these structures are seen in contorted limestones and marbles in nature. (4) When the deformation is carried out at 300 C. or, better, at 400 C., the cataclastic structure is not developed, and the whole movement is due to changes in the shape of the component calcite crystals, by twinning and gliding. (5) This latter movement is identical with that produced in metals by squeezing or hammering, a movement which in metals as a general rule, as in marble, is facilitated by increase of temperature. (6) There is therefore a flow of marble just as there is a flow of metals under suitable conditions of pressure. (7) The movement is also identical with that seen in glacial ice, although in the latter case the movement may not be entirely of this character. (8) In these experiments the presence of water was not observed to exert any influence. (9) It is believed, from the results of other experiments now being carried out but not yet completed, that similar movements can, to a certain extent at least, be induced in granite and other harder crystalline rocks, and that several structures developed in these rocks in nature in highly contorted regions can thus be reproduced. Photo-micrographs of the marble are given.

IV.—Geology of West Cornwall.—Mr. J. B. Hill, who has been studying the geological structures of Western Cornwall for some years, has been talking to the Royal Geological Society of Cornwall about them. His paper has appeared in the Transactions (1901, vol. xii, pt. 6), and his conclusions, given in his own words, are as follows:—"The structures of the stratified formations in West Cornwall are identical with the structures of crystalline schists. In the Falmouth district, so far as yet examined, true slates have not been met with. The strata have been thrown into a series of isoclinal folds, accompanied by small faults. With these folds and faults minor structures have been set up until the whole rock has often become a mass of minute folds and thrusts, with their accompanying strain-slip cleavages. These processes have been carried so far that 'crush-conglomerates' have been produced on a large scale. It is evident, from a study of this district, that had the rocks been subjected to those stresses at a greater depth and below the zone of fracture, where they would not have been so free to move, they would have been converted into true schists. They possess now every structure of schists, but the mineralization has been wanting."

"The visible dip of the rocks is of no value, except as registering the inclination of the limbs of folds. As an illustration of this fact, it may be pointed out that although the strata have a general dip to the south-east, between Falmouth and Truro, we are apparently crossing the strike from the coast to the heart of the county, yet, instead of getting deeper in the stratigraphical series, we are on precisely the same geological horizon as at Falmouth, the intervening ground being made up of a succession of isoclinal folds."

This last paragraph is, we believe, confirmatory of De la Beche's view, and does not support the view sometimes expressed, that in this district we have a great thickness of sedimentary deposits.

V.—Argonaut from the Tertiary of Japan.—Mr. Yoshiwara has just published in *Annotationes Zoologicæ Japanenses* (1901, vol. iii, pp. 174–176) a description of a supposed new Argonaut from the Neogene tuff of Agenokimura, near Matsue, Iugori, province Izumo, Japan. This was found by Mr. J. Asāi, and mentioned by Professor

Jimbo as long ago as 1896 in the *Journal of the Tōkyō Geographical Society*, vol. viii. The specimens, of which there are two, can only be distinguished from '*A. tuberculosa*, Linn.' (said by Yoshiwara to be identical with *A. nodosa*, Sol., and *A. oryzata*, Mensh.), by the general outline of the shell, the size of the whorls near the centre, and the rows and numbers of the ribs. It is of considerable interest to find that this tuberculate form of the genus, which has never been found living in Japan, existed there in Tertiary times.

VI.—The Grand Canyon of the Colorado.—Professor W. M. Davis has published in the Bulletin of the Museum of Comparative Zoology at Harvard College (Geol. Series, v, No. 4, May, 1901) an account of an excursion to the Grand Canyon of the Colorado. His results may be summarized as follows:—"There is some probability that the San Rafael swell, like the Waterpocket flexure, is of pre-Tertiary origin. The other deformations of the region, both flexures and faults, are almost exclusively of much earlier date than the canyon cycle, and they may have been formed relatively early in the erosional history of the district. The total denudation of the region thus far accomplished may be considered in two parts, of which the first—the great denudation—was far advanced before the general uplift by which the second—the erosion of the canyon and the stripping of weak strata from the plateaus—was introduced."

"But the great denudation was complicated by repeated movements, after each of which the processes of erosion may have reached an advanced stage before the occurrence of the next series of disturbances. It is only by an analysis of these repeated movements and revived erosions that the origin of the drainage system can be determined. As far as this analysis can be attempted at present for the Grand Canyon district, the side streams seem to be of various origins, except that none of them appear to be antecedent. The Colorado itself may be in part antecedent to some of the many dislocations that the district has suffered, but it seems to be for the most part consequent on the displacements caused by faulting in the later part of the great denudation, and on the form that the surface had assumed at that time."

"The floor of the Toroweap valley is higher than the neighbouring valley floors, because it is sheeted with heavy lava flows which have effectively withstood the intermittent erosive effects of wet-weather floods. The past climate of the region cannot be safely determined; a change from a humid to an arid climate at the close of the Miocene does not appear to be demanded by the facts that have been appealed to in its support."

Professor Davis gives a bibliography and some illustrations, many of which are new, and one of which, a general photographic view of the Grand Canyon, is especially good. T. R. J.

VII.—Shorter Geological Notes.—Elkanah Billings, for twenty years palæontologist to the Geological Survey of Canada, and the founder of the *Canadian Naturalist and Geologist*, formed the subject of Dr. Ami's address as president of the Ottawa Field

Naturalists' Club, last December. The material has now been extended, a bibliography added, and the whole published in the *American Geologist* for May.

Professor E. W. Hilgard's "Historical Outline of the Geological and Agricultural Survey of the State of Mississippi," which appeared in the publications of the Mississippi Historical Society, has been reprinted in the *American Geologist* for May. It gives an interesting picture of the origin, rise, and progress of one of the United States Surveys, and provides an official account of the publications, always of value.

Mr. J. A. Cunningham has published a contribution to the Theory of the Order of Crystallization of Minerals in Igneous Rocks, in the Scientific Proceedings of the Royal Dublin Society (1901, vol. ix, pt. 4). The paper should be read in connection with Dr. Joly's paper, "Theory of the Order of Formation of Silicates in Igneous Rocks," published by the same Society in 1900.

REVIEWS.

I.—The Mineralogy of Scotland. By the late M. Forster Heddle, M.D., F.R.S.E. Edited by J. G. Goodchild, F.G.S. 2 vols.: 360 pp., 30 figures in text, 117 plates. (Edinburgh: David Douglas, 1901. Price 36*s*. nett.)

During the greater part of a long life the late Professor Heddle, for many years Professor of Chemistry in the University of St. Andrews, spent his holidays in the mineralogical exploration of his native country, and scarcely a single locality from which there was a likelihood of obtaining good specimens can have been left unvisited by him; he was thus able to bring together a collection of Scottish minerals remarkable for its completeness and for the excellence of its material; to its examination, chiefly chemical, he devoted all his available time. Some years ago the collection was purchased for the nation and deposited in the Museum of Science and Art at Edinburgh; there it was arranged and labelled, for public exhibition, by Dr. Heddle during the latter years of his life.

Of the topographical and chemical mineralogy of Scotland, Professor Heddle had thus an unsurpassed knowledge, and he made voluminous notes with a view to the eventual publication of a treatise by means of which the information so laboriously acquired might be preserved to posterity. Unfortunately, like too many other investigators, he was called to his rest when his work was still far from complete; there was thus a great danger that his notes might never be printed and made available for general use. His family has done what was possible to avert the threatened catastrophe, and have obtained help for the completion and editing of the work; the notes have been prepared for press and the treatise has been edited by Mr. J. G. Goodchild, who is now closely associated with the custody of the collection itself.

To complete the work, Mr. Alexander Thoms, son-in-law of

Professor Heddle, has compiled a list of the mineral species which have been found in each of the counties of Scotland; Mr. James Currie has prepared a list of Scottish Pseudomorphs, and an index of Scottish palæosomatic minerals; Mr. J. G. Goodchild has added an alphabetical list of minerals, indicating by means of asterisks those which occur in Scotland, and has further prepared a series of beautiful gnomograms and stereograms of the crystallographic forms of the more common mineral species.

The result is the issue of the two fine volumes now before us; the book is well printed, and illustrated regardless of expense; an excellent portrait of the author is given as frontispiece, and is followed by a short memoir. No more impressive memorial of Dr. Heddle could have been devised by his family.

The work is of course of the dictionary type, and designed, not for continuous reading, but for the purposes of reference; its usefulness depends, to a large extent, on the completeness and accuracy of the specification of the localities. No pains have been spared over this part of the book; all the places mentioned in Dr. Heddle's notes have been identified as far as possible, a tedious task, involving much difficulty and enquiry when the localities are remote from railways, are not recorded on the best maps, and are represented by names of which there is much diversity of spelling. Fortunately, Dr. Heddle had left a set of Ordnance Survey Maps, on which his annual wanderings had been traced; with the help of these, and much aided by the wide information of Mr. James Currie, Mr. Goodchild has prepared a Synonymic Index (33 pages) to the Scottish Mineral localities, specifying for each locality the position on the Ordnance Map and the names of the mineral species to be found there.

The numerous plates illustrating the forms of crystals have been prepared at great cost, and they add to the beauty of the volume; but Dr. Heddle left behind him no information as to whether the figures were original or not. Some, at least, were doubtless taken from works illustrating the minerals of other countries, though probably they at the same time illustrate Scottish minerals preserved in his own collection.

It should be mentioned that in the text there are numerous illustrations of agates, to the mode of origin of which Dr. Heddle had given much study.

It would add to the usefulness of the work if in a subsequent edition an alphabetical index to the mineral species and varieties, with page-references, were placed at the end of it.

II.—Homœomorphy among Jurassic Brachiopoda. By S. S. Buckman. Proc. Cotteswold Naturalists' Field Club, 1901, vol. xii, pt. 4, pp. 231–290, pls. xiii–xiv.

In this paper Mr. Buckman performs a welcome service by drawing attention to the occurrence of what he terms 'homœomorphy' in Jurassic Brachiopoda. The part played by parallelism in producing striking similarities between members of separate stocks has hitherto been sadly neglected, and the failure to recognize this independent acquirement of similar general features has doubtless repeatedly led to confusion. Two of the most striking examples of this phenomenon, described by the author, are furnished by *Terebratula imitator* and *Zeilleria subcornuta*, and by *Terebratula subomalogaster* and *Zeilleria anisoclines*.

Some of the descriptions of new forms in this paper are unfortunately too brief, and might with great advantage have been amplified. The value of generic separations among the Jurassic Terebratuloids is, to some extent, admittedly a matter of personal opinion. But it may seriously be doubted whether any useful purpose is to be attained by the adoption of such a 'genus' as *Pseudoglossothyris*, proposed in this paper. It appears, at least, to be hardly justified by the somewhat slender distinctive characters embodied in the definition provided. Abuses of the word 'genus' are now unfortunately common, and there is a widespread and regrettable tendency to burden an already involved nomenclature by such additions.

The expression 'date of existence' scarcely commends itself when employed in relation to fossil shells. Doubt may be entertained whether the elaborate 'time-table' provided by the author can ever have more than a local value, and perhaps this is all that is claimed for it. For his useful and suggestive contribution to our knowledge of homœomorphy, Mr. Buckman is to be congratulated.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 8th, 1901.—J. J. H. Teall, Esq., M.A., V.P.R.S., President, in the Chair. The following communication was read :—

"The Influence of the Winds upon Climate during the Pleistocene Epoch: a Palæo-Meteorological Explanation of some Geological Problems." By F. W. Harmer, Esq., F.G.S.

Winds are an important factor in determining the distribution of climatic zones. Deviations of the isotherms from the normal are generally connected with the direction of the prevalent winds. The influence of marine currents is indirect rather than direct. Changes of wind cause marked and sudden changes in the weather, though the general direction of ocean-currents remains the same. Permanent alterations in climate during past epochs would have equally resulted from permanent changes in the wind. Anomalous weather is due to some unusual arrangement of high and low-pressure areas. Former cases of anomalous climate can only have occurred when the meteorological conditions were favourable.

Continental areas tend to be cyclonic in Summer and anticyclonic in Winter, while the reverse is broadly true of the oceans. During the Glacial Period ice-covered areas would have remained more or less anticyclonic throughout the year, while low-pressure areas must have prevailed in regions to the south of them and over the adjoining oceans. This would have altered the prevalent direction of the winds and the distribution of rainfall; thus the anticyclone of the European ice-sheet may have caused cyclonic storms to pass farther south than at present, bringing oceanic winds over the Sahara, which formerly enjoyed a humid climate. Dead shells are rarely found now on the eastern shores of Norfolk and Suffolk, though they are driven on to the Dutch coast by westerly gales. Shell-débris in the Upper Crag-beds of East Anglia shows that easterly gales were common at that period. This may have been due to the altered path of cyclones, caused by the glacial conditions which were becoming established in regions to the north of Great Britain. The abundance of mammoth-remains along the shores of the Polar Sea and the alternate humidity and desiccation of the basin of Nevada may have resulted from allied causes.

It is difficult, however, to restore hypothetically the meteorological conditions of the Pleistocene epoch on the theory that the maximum glaciation of the eastern and western continents was contemporaneous. In that case an enormous anticyclone would have extended from the pole southward over both continents at the same time, causing cyclonic conditions in the Atlantic both in Summer and Winter. Such a condition of things would have flooded Western Europe with warm southerly winds. No such meteorological difficulties arise if the hypothesis that the more important glacial and interglacial periods alternated in the western and eastern continents be adopted. Thus persistent and excessive cold in North America during the Winter of 1898–99 was coincident with abnormal warmth in Europe; the winds were northerly and polar in America, southerly and strictly complementary in Europe.

On the other hand, the effect of an ice-sheet anticyclone extending from Greenland to Central Europe might have been to force the storm-tracks of the North Atlantic to the south-west, producing warm south-easterly winds in Labrador, which would have tended, moreover, to divert the surface-currents of the North Atlantic from the European to the American coast. The glaciation of Great Britain could only have happened at a time when the Icelando-British Channel was closed. No permanent ice-sheet could have existed in Britain and Scandinavia while the influence of the Gulf Stream was as it is at present.

It is possible that the shifting of glacial conditions from one side of the Atlantic to the other may have been due to differential earth-movements.

The views taken in this paper afford a simpler explanation of geological facts than those usually adopted. Instead of supposing that the climatic changes of the Great Ice Age, several times recurrent at intervals of a few thousand years, were due to astronomical or physical causes, it is suggested that the climate of the Northern Hemisphere being, from some unexplained cause, colder than that of our era, conditions of comparative warmth or cold may have been more or less local, affecting the great continental areas at different periods.

II.—May 22nd, 1901.—J. J. H. Teall, Esq., M.A., V.P.R.S., President, in the Chair.

Mr. George Abbott, in exhibiting some specimens of Cellular Limestone from the Permian beds at Fulwell, Sunderland, which he proposed to present to the British Museum (Natural History), remarked that their interest depended upon the assumption that they were entirely inorganic. Although showing a remarkable resemblance to corals, yet no zoologist or geologist had yet claimed them as organic. If this surmise were correct, the carbonate-of-lime-molecules—probably when amorphous—must have had some inherent molecular directive force which produced the numerous distinct patterns in their structure. These fall into four distinct classes—honeycomb (two kinds), coralloid, and pseudo-organic, the last-named being remarkable for having a constant discoidal shape, and therefore those of this class must have had their external form also controlled by the hypothecated force. Each class appears to have passed through four stages of 'growth' and to have undergone some marvellous rearrangements of the particles while in the solid condition. So far as he knew, no one had previously attempted to classify the different patterns, nor had anyone, except Mr. William King, in his work on "Permian Fossils," offered any theory as to the formation of this cellular structure in the Magnesian Limestone. (See Prof. G. A. J. Cole's letter, Geol. Mag., April, p. 187.)

The following communications were read:—

1. "On the Skull of a Chiru-like Antelope from the Ossiferous Deposits of Hundes (Tibet)." By Richard Lydekker, Esq.

Twenty years ago the author proposed the provisional name of *Pantholops Hundesiensis* for an extinct species of antelope typified by an imperfect skull figured in Royle's "Botany, etc., of the Himalaya Mountains," pl. iii, fig. 1. The specimen is in the Museum of the Geological Society, and an examination has confirmed the original determination. The skull, although of rather smaller dimensions, comes very close to that of the existing chiru (*Pantholops Hodgsoni*) of Tibet in general form of brain-case, in the strong ridges marking the upper limits of the temporal fossæ, and in the contour of the occipital surface. The horn-cores have the same highly elliptical cross-section, and the same general setting-on and upright direction. The fossil apparently came from the horizontal deposits of Hundes, and its age is probably not greater than Upper Pliocene.

2. "On the Occurrence of Silurian (?) Rocks in Forfarshire and Kincardineshire along the Eastern Border of the Highlands." By George Barrow, Esq., F.G.S. (Communicated by permission of the Director of H.M. Geological Survey.)

These rocks occur in three lenticular strips between the schistose rocks of the Highlands and the boundary-fault next the Old Red Sandstone. The largest is about 20 miles long, and extends almost from Cortachy to beyond the Clattering Bridge; it is about ¾ mile wide at its widest. The rocks are divided into two groups: the Jasper and Green Rock Series below and the younger Margie Series above. A section along the North Esk River is described in detail, and other sections referred to it. The lower division consists of fine-grained sandstones (bearing microcline), grey slaty shales, jaspers (sometimes containing circular bodies resembling radiolaria), and a variable series of basic igneous rocks ('green rock') of coarse texture and probably intrusive origin. The upper division consists of conglomerates, pebbly grits, dark and white shales, pebbly limestone, and grey shale. The age of the series cannot be definitely ascertained, but the lower division is compared with the Arenig cherts, etc., of the Southern Uplands, while the Margie Series is newer than this, but older than the Old Red Sandstone. Both groups have been much deformed, but the sediments contain clastic micas and have undergone practically no recrystallization, and the igneous rocks are never changed into hornblende-schists. The deformation is greatest near the junction with the Highland Schists, giving rise to a deceptive appearance of an upward succession and an apparent transition in crystalline character, but the crushing never extends more than a few yards into the Highland Series. A major thrust separates the Highland Schists from the Jasper and Green Rock Series, and a minor thrust generally separates the latter from the Margie Series. The position of the major thrust and that of the later great boundary fault skirting the Old Red Sandstone have been determined by the outer limit of the aureole of crystallization of which the South-Eastern Highlands form a part. The harder crystalline schists to the north-west have snapped off from the softer portions, now covered by newer rocks to the south-east.

3. "On the Crush-Conglomerates of Argyllshire." By J. B. Hill, Esq., R.N. (Communicated by R. S. Herries, Esq., M.A., Sec.G.S., with the permission of the Director of H.M. Geological Survey.)

While the sedimentary origin of the Highland Boulder-bed is proved by the foreign boulders contained in it, there occur in the Loch Awe region certain conglomerates, often along definite horizons, which may have been confused with it, but which the author is able to prove have originated by crushing. The sedimentary rocks of the area include all the members of the Loch Awe Series, consisting of grits, slates, and limestones, the latter being mostly gritty in character. Associated with these is an enormous amount of igneous material of Dalradian age, ranging from intermediate to basic in composition, together with porphyrite-dykes probably of Old Red Sandstone age and a plexus of Tertiary dykes. The sediments are everywhere folded, the folds being of isoclinal type. The Dalradian igneous material consists of epidiorites; and evidence is brought forward to prove that these rocks are intrusive, while their great apparent bulk is probably to be accounted for by repetition due to folding. A petrographical description is given of the various types of rocks represented among the epidiorites, the minerals of which include hornblende and felspar, with chlorite, epidote, calcite, quartz, and iron-ores. There is every gradation in texture from a coarse gabbro-like type to the finest schists, and some of the rocks are vesicular. The rocks are frequently foliated.

The crush-conglomerates have been observed in the limestones, quartzites, and epidiorites; but they are most conspicuously developed at the junction of rocks of dissimilar character, and especially when the limestone and epidiorite are in juxtaposition. The junction of the two rocks is intricately folded: folded knobs of epidiorite measuring from a few inches to a foot or more being packed together in a limestone matrix. In the sections big blocks may be seen in process of division by shearing movements, which have succeeded the folding. The limestone seems generally to have played the part of a plastic body, and has accommodated itself as a matrix to the folded and isolated fragments of epidiorite, between which it has been squeezed. Thus the origin of the conglomerate is satisfactorily proved by the fact that it contains fragments of rocks newer than the sediments in which the crush-conglomerates are embedded. The author considers that it would be safer to regard such conglomerates in this area as have a calcareous matrix as having been formed by crushing.

CORRESPONDENCE.

THE *MAMMILLATUS*-ZONE IN EAST SURREY.

Sir,—In a short communication to this Magazine for May, 1899 (pp. 234–5), evidence was brought forward of the persistence of the zone of *Hoplites interruptus* along the Gault outcrop through Kent and Surrey. Since then Mr. Jukes-Browne's valuable memoir on the English Gault and Upper Greensand has appeared, and in this certain beds at the extreme base of the Gault in West Kent and East Surrey are considered as probably belonging to the lower zone of *Acanthoceras mammillatum*, though palæontological evidence of this is wanting. This evidence can now fortunately be supplied. About a mile and a half south-south-east of Merstham, at a point marked on the new 1-inch sheet 286 as "Stocklands Farm," there is a small brickfield where the extreme base of the Gault is dug. The junction with the Folkestone sands is not actually seen, but these sands are dug within a few yards of the section. In the lowest part of the clay there are abundant large and irregular phosphatic nodules, full of glauconite grains and with many quartz-grains also. In these nodules fossils occur, including two species of Ammonites, *Acanthoceras mammillatum* and *Desmoceras Beudanti*, the latter being particularly abundant. (These determinations have been kindly verified by Mr. Crick, of the Natural History Museum.) Other fossils occur, but not abundantly, and I cannot give a list, as most of them were dispersed among a party of my students before the special interest of the section was discovered. Coniferous wood occurs abundantly, beautifully preserved.

The section is closely similar in appearance to one at Reigate, described in Proc. Geol. Assoc., vol. xvi, p. 162, and there said to be unfossiliferous. On a recent visit, however, I found a piece of coniferous wood there just like that at Stocklands, but no Ammonites. I would suggest to local geologists the advisability of a persistent search for the latter. A. M. Davies.

25, Mortimer Street, W.

NAMES FOR BRITISH ICE-SHEETS.

Sir,—To discuss fully the wide questions raised by Mr. Lamplugh's reply to my letter of last April would require far too much space, so I content myself with repeating that to propose a name for that which has not been proved to exist is, to say the least, premature. It is also objectionable, because so many persons cannot become familiar with a name without assuming that it implies the existence of a reality. As man is naturally prone to idolatry, which in the present age commonly takes the form of phrase-worship, I am sure that if the North Sea Ice-sheet passed without protest it would quickly materialize into a geological fact. I had no objection to using the term 'Scandinavian Ice-sheet,' because something of the kind must have existed in that country, yet I was careful to speak only of 'Caledonian ice.' So I cannot allow Mr. Lamplugh to smuggle in an East British Ice-sheet under the cover of any phrase in my letter. As for the late Glacial age of the Dogger Bank, that of course is possible; but I think whoever makes use of it as an argument should indicate under what circumstances such a long shoal-like mass of morainic matter was deposited in that position. Also, I should like to have an explanation of the causes which would lead to an exceptional precipitation of snow on any particular part of a comparatively level plain which had considerable land masses on three sides. My complaint against the school of glacialists to which Mr. Lamplugh belongs is, that they insist on those facts which seem to favour their ideas and ignore all which have the contrary effect. Thus, like the defenders of the Ptolemaic system of Astronomy, they support hypothesis by hypothesis, and invent epicycles to escape from difficulties. It is, however, a gain to have it admitted that boulders did not take an inside or outside passage on an ice-sheet the whole way from Scandinavia to Eastern England. This encourages me to hope that a course of sea-bathing early in the Glacial Epoch may embolden some geologists to repeat the process later in the same, and to extend southward the submergence which must have occurred then (Geol. Mag., 1877, p. 72, and 1900, p. 289) in a more northern region. T. G. Bonney.

CURIOUS BRECCIAS IN THE HIGHLANDS.

Sir,—There are in the Scottish Highlands between Loch Katrine and the upper part of Loch Lomond several bosses of diorite surrounded by brecciated schist. These are very curious, for each boss of diorite is surrounded by a narrow fringe of breccia consisting entirely of schist without any admixture of igneous matter. It seems to me that the diorite must have been forced up in a solid state through the schist, which in consequence got broken up; for had the diorite been in a molten state when it came up, some of it would surely have flowed among the fragments of schist.

Yours
very truly
G. Lindström

Further north, in Glenfalloch, there is a more extensive area of similar brecciated schist, where, however, as far as I remember, no igneous rocks are to be seen.

The researches of Lapworth, Peach, and Horne in the Highlands, of Lamplugh in the Isle of Man, and of others elsewhere, have taught us that solid rocks have been broken up or ground into powder by mechanical violence on a far larger and more extended scale than had been previously dreamed of.

If I am right in my conjecture as to the origin of the breccias mentioned above, they are instances of the same sort of thing.

June 4, 1901. J. R. Dakyns.

P.S.—I am reminded by my friend, Mr. C. T. Clough, that the breccias may be due to explosions. They are mentioned by Sir Archibald Geikie in his work on "Ancient British Volcanoes," but I have not the book at hand to refer to.—J. R. D.

OBITUARY.

GUSTAF LINDSTRÖM.

(WITH A PORTRAIT, PLATE XIII.)

Born at Wisby, Aug. 27, 1829. Died at Stockholm, May 16, 1901.

How vividly comes to one's mind that little room looking into the courtyard of the Riksmuseum at Stockholm, with its plain deal floor, deal tables and writing-desk, and the rough deal shelves for books covering three of its walls, the only decoration a few portraits (as of Angelin and Darwin), the only sign of comfort an old horse-hair sofa. Here for twenty-five years, day after day, Gustaf Lindström pursued his quiet labours on that wonderful collection stored in the adjoining room, a collection rich chiefly in the fossils of Silurian Gotland amassed by the successive exertions of Hisinger, Angelin, and Lindström himself. At one of the windows in that room, overmuch darkened though it was by the tall houses opposite, one would see G. Liljevall developing some rare fossil or making those exquisite drawings that illustrated Lindström's papers; at another window the attendant boy, usually a Gustaf too, made cardboard trays or sorted out new accessions; while a third window was generally occupied by some foreign palæontologist who had journeyed far to study the famous collection. Many are there of these who to-day mourn Lindström, not merely as a leader gone from among them, but as an ever attentive host, and as a dear friend.

Born among the mediæval ruins of Wisby, in whose cliffs and on whose strand fossils are to be had for the mere taking, the meditative and retiring youth could not fail to have his interest aroused by the relics of the past. He might have been a great archæologist, in fact his academic thesis was on the history of his native island in Queen Christina's reign, and in after years he published two thick volumes on the Middle Ages in Gotland; but the direct incentive to palæontological studies was early furnished. "In 1845," he once wrote, "when I was quite a boy, much wondering at the marvellous things I saw enclosed in the limestone rocks of my native island of Gotland, Sir Roderick, accompanied by M. de Verneuil, visited the island and ranged its strata, along with the other old 'transition rocks' of Sweden, in his newly-founded realm 'Siluria.' This fact acted upon me as a fresh revelation, and indicated the path upon which to proceed." It was no doubt also Murchison's visit which suggested his enquiry into the elevation of Gotland, the subject of his first paper (1852).

But Lindström, though he continued to the last to study the geological relations of the Gotland rocks, did not become a mere stratigraphical palæontologist. In 1848 he commenced student at Upsala University and took the opportunity of attending a course of lectures delivered by Lovén in Stockholm. Thus was impressed on him the need to the palæontologist of a thorough understanding of living animals, and so, after taking his doctor's degree in 1854, he served for a time as extraordinary amanuensis at the zoological museum of the University, and published purely zoological papers—on the invertebrate fauna of the Baltic, on the larva of *Peltogaster*, and on the development of *Sertularia*. In 1856 he accepted a post as school-teacher in Wisby, and in 1858 a mastership at the Grammar School in that town. During these years he translated a textbook of zoology by H. Masius, and produced his "Geologiens Grunder," which was an adaptation of the works of Lyell to Swedish students, and contained numerous original illustrations from the geology of Sweden; it speedily ran through two editions, and did much to increase the study of geology in that country.

Now settled in Wisby, Lindström, without dropping his zoological researches, as proved by a paper on the fish of Gotland (1867), devoted more attention to the fossils of the island. He began with the Brachiopoda (1860), but soon turned to the Cœlentera, and in 1865 published the first of that valuable series of papers on the rugose corals which led up to his memoir on the operculate corals of the Palæozoic formations (1883). These papers, while disclosing hitherto unsuspected facts of coral structure, finally solved the problem of the systematic position of the peculiar *Calceola*, previously regarded as an aberrant brachiopod. A remarkable type of madreporarian was fully described by him in 1868 under the name *Calostylis*, and again discussed in his memoir on the Anthozoa perforata of Gotland (1870). He wrote also on the tabulate corals, and was at the same time investigating the deep-sea corals of the Atlantic. To complete the account of his work on the corals, we may mention his papers on Silurian corals from Russia (1882), on *Rhizophyllum* (1884), on *Prisciturben* (1889), on the 'Corallia baltica' of Linnæus (1895), a description of some Silurian corals from Gotland, including the new genera *Nodulipora*, *Holophragma*, and *Dinophyllum*, with re-descriptions of his *Helminthidium*, *Pachypora*, *Polyorophe*, *Actinocystis*, and others (1896), on a *Tetradium* from Beeren Eiland (1899), on the Neocomian *Thecocyathus Nathorsti* from King Charles Land (1900), and his great memoir on the Heliolitidæ (1899).

But before these last-mentioned papers were written occurred the death of the Keeper of the fossil Invertebrata in the State Museum at Stockholm, N. P. Angelin, and the Academy of Sciences appointed

Lindström to the post (1876). One of his first tasks in this new and more favourable position was the completion and publication of the "Fragmenta Silurica" (1880), for which some plates had been prepared by Angelin. There also fell on him the difficult and ungrateful labour, shared with Lovén, of editing Angelin's "Iconographia Crinoideorum." These tasks accomplished, Lindström found time to attack other groups of Gotland fossils. Thus, in 1884 we have from him a beautifully illustrated memoir "On the Silurian Gastropoda and Pteropoda," of importance as indicating the varying nature of the fauna in correspondence with the varying conditions in different parts of the Gotland sea. In 1885 he issued a revision of the trilobites and Merostomata, containing descriptions of many new species, while in the same year he was associated with T. Thorell in a publication that awoke profound interest, namely, the description of a scorpion, *Palæophonus nuncius*, from a bed of Lower Ludlow age at Wisby.[1] This was the oldest air-breathing animal then known, but there have since been described *Proscorpius*, Whitfield, from the Waterlime group of New York, *Palæoblattina*, Brongniart, from the Middle Silurian of Calvados, and *Protocimex*, Moberg, from the Upper Ordovician of Sweden. He then turned his attention to the remains of Cephalopoda preserved in a hard, splintery limestone of Southern Gotland, and requiring the utmost patience for their extraction and elucidation. The result of this was the important memoir on "The Ascoceratidæ and the Lituitidæ," in which he lucidly explained the complicated structure of that extraordinary nautiloid, *Ascoceras*. The year 1895 produced another discovery of the greatest interest, namely, a *Cyathaspis* from beds of Lower Wenlock age at Lau in Gotland; the minute structure of the plates was very fully described by Lindström.

These important memoirs by no means exhausted the activities of Professor Lindström. He visited Gotland every summer and pursued his enquiries into its geology, as many minor papers bear witness. On these wanderings through the island he also collected the materials for his archæological studies. He published a list of the fossils of Gotland, followed by lists of the Cambrian, Ordovician, and Silurian faunas of Sweden. He took an active part in the affairs of the Academy, and occasionally gave popular lectures on subjects of general geological interest. Of recent years, as the burden of age began to press more heavily, he rejuvenated himself (as he expressed it) by visits to Italy, in which both as naturalist and archæologist he took the greatest possible delight. But this did not cure the gradual failure of eyesight that was his greatest trouble, and rather more than two years ago he finally lost the use of one eye. When I saw him last, in 1899, he was dreading the loss of the other, but was still hard at work, and greatly excited over an important discovery just made in the trilobites. Oddly enough, this concerned certain maculæ, believed by him to be vestigial eye-spots, occurring on the hypostome of many genera. This gave rise to the last paper he ever wrote, a wonderfully detailed study of these maculæ and of the

[1] Another Silurian scorpion, referred to Lindström's genus *Palæophonus*, has been discovered by B. N. Peach at Lesmahagow, Lanarkshire.

visual organs of the trilobites in general, with important bearings on the zoological position of those animals (February, 1901).

The scientific work of Gustaf Lindström, though not greatly affecting the more theoretical and philosophical questions of zoology and geology, was marked, as we have seen, by many discoveries of great interest and importance. But the discovery of to-day is the stale news of to-morrow, and it is not by any sensational features of his work that his fame will continue. It will continue and it will increase by reason of the immense care he bestowed on all details, the accurate descriptions, and the exquisite illustrations. He recognized the futility not merely of the ordinary semi-diagrammatic figures but also of the more pretentious photographs, when there was question of such perplexing detail and variation as is presented by the corals. It is only just to say, and Lindström himself always insisted, that in his attempts he received the greatest help from the remarkable artistic talents of Mr. G. Liljevall. His work will live because of the absence of unwarranted speculation, because of its thoroughness, because of its honesty. He had always, in the rich collection at his elbow, and in the appeals of his contemporaries, the temptation to publish much more than he did, but future generations will rejoice that he understood how it was better to do one thing conscientiously than many things superficially.

Lindström indeed was thorough and true-hearted in all relations of life. Though retiring and careless of popular applause, he was more sensitive of the opinion of others than he might have been had he mixed more with the world. It were far from the truth, however, to regard him as a narrow-minded recluse. He interested himself in many subjects outside those of pure science, and one soon perceived the sly and kindly humour that twinkled behind his spectacles. He was ever ready to discuss English literature or politics. Those of other countries too, perhaps; but he had a great affection for England, which he visited last in 1874, and he was always full of reminiscences of Murchison and our ancient heroes of geology. Huxley also he met and was much impressed by, and hoped that a day would yet come when a "Life" would be written that would do justice to "that great and good man." Most of his important works were written in English, while of some he published translations in the Geological Magazine. To the workers from all countries who made pilgrimage to Gotland or to Stockholm he was attentive and hospitable, but I have thought that the particular kindness he showed to me at all times, and specially when I first came to Sweden an unknown student, must have been due to my nationality. He was member of the Russian and Prussian Academies of Science, of the Belgian Geological Society and many others, but few honours pleased him more than those received from the Geological Society of London, of which he was elected Foreign Correspondent in 1885, Foreign Member in 1892, and whose Murchison Medal he received in 1895. There are many in this country who now sorrow for his loss, and while all will ever honour him as a great palæontologist, there are not a few who will long remember him with affection as a personal friend.

F. A. Bather.

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ORIGINAL ARTICLES.

I.—The Earliest Traces of Man.[1]

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

THE origin of Man remains an unsolved problem. In spite of very keen and anxious researches, extending over many years, we are still without a real clue to the difficulty. Whence and how and when he came we do not know, and we had better say so.

In the valley of the Nile, where the earliest knowledge of writing has been traced, our written records take us back perhaps 7,000 years. At that period the various races and varieties into which the human race is divided by the naturalist were apparently completely differentiated. The different families of language which the philologer has discriminated were sharply defined, while his thought and the products of his thought (of which language is an index), of comparative archæology, mythology, etc., etc., show that these races were as trenchantly distinguished as they are now.

Whatever else this means it must mean (if the history of mankind has been continuous) that the origin of man is a long way off, a much longer way off than people were once willing to admit. The differences and distinctions here pointed out must have taken a very long time to mature, and if man originated in one stock, which has overspread and conquered the earth, as some of us think, it must have taken a vast time for the many languages, religions, customs, and thoughts, which characterize his many and varied clans and tribes and nations, to diverge so much from each other.

It may be that presently with the assistance of comparative methods applied scientifically to language, religion, and art, we may be able to disentangle the crooked threads into which the web of human progress has been woven; but this must take a long time. It will involve a wide and searching analysis of difficult details,

[1] "Palæolithic Man in Africa," by Sir John Evans, K.C.B., F.R.S.: Proc. Roy. Soc., 1900, vol. lxvi.

"Eolithic Implements," by Rev. R. Ashington Bullen, B.A., F.L.S., F.G.S.: Trans. Vict. Inst., 1900.

"A Collection of Stone Implements in the Mayer Museum," by H. O. Forbes, LL.D.: Bull. Liverpool Mus., 1900, ii.

"The Age of the Surface Flint Implements of Egypt and Somaliland," by H. O. Forbes, LL.D.: Bull. Liverpool Mus., 1901, iii.

and will probably depend a good deal more on the ethnographer and the linguist than on the archæologist.

With that great problem we have not at present to do, however. If we are to make any progress at all we must limit it very considerably, and detach ourselves completely from such ambitious issues as the origin of Man, etc., etc., as we must from all attempts at surveying the universe from China to Peru. Our geographical as well as our archæological frontiers must be sharply limited.

Let us for a few paragraphs, therefore, limit ourselves to a smaller area and narrower conditions, and try to realize what we have been able to learn of the oldest inhabitants of the European area. It will readily be seen that the problem means that we must summon the geologist to our help. The problem is, in fact, as much a geological as it is an archæological one. It depends for its solution quite as much upon clearly distinguishing the geological horizon where the test object is found as upon the character and appearance of the object itself. If an object is found in an undisturbed bed of sand, gravel, or clay, it must if thus *in sitû* be as old as the laying down of the bed in question, and that is a geological problem.

The first step taken in answering the question we are discussing was a long time ago. In 1713 an implement made of black flint and of the type now known as Palæolithic was discovered with the tooth of an elephant in digging gravel in Grays Inn Lane. This implement was distinctly recognized as of human workmanship, and was presented to the British Museum, in which collection it has since remained.

In the catalogue of the Sloane Collection we find the following entry in regard to this very famous relic:—"*No.* 246, *a British weapon found, with elephant's teeth, opposite to black St. Mary's near Grayes Inn Lane* (*Conyers*). *It is a large black flint shaped into the figure of a spear point* (*K.*)." It appears, says Sir John Evans, to have been found at the close of the seventeenth century, and a rude engraving of it illustrates a letter on the antiquities of London, by Mr. Bagford, in 1715, and printed in Hearne's edition of Leland's "Collectanea," I, lxiv. From his account it would seem that the skeleton of an elephant was found not far from Battlebridge by Mr. Conyers, and that near the place where it was found "a British weapon made of a flint lance, like unto the head of a spear, was dug out" (Evans, "Stone Implements," 2nd ed., pp. 582–3). Sir J. Evans gives a full-sized illustration of this very interesting implement. The importance of this discovery was not recognized. Neither the geological position of the gravels in the Thames Valley nor the fact of the elephant in question having been an extinct animal could then be known or appreciated, and the discovery was doubtless treated as in no sense an extraordinary one from the archæological side.

The next recorded step taken in this inquiry was also made in Britain, namely, the discovery by John Frere in 1797 of three flint implements of the same type in the beds at Hoxne in Suffolk, which have since become so famous, and in company with bones of great size. The objects in question were found twelve feet deep in the ground, and Frere, who clearly discriminated them as of human workmanship, says of them, "I think they are evidently weapons of war, fabricated and used by a people who had not the use of the metals" (*Archæologia*, xiii, 103). This statement was the first one in which the position was maintained by a scientific person that man had passed through a stage of culture in which he used stone only for his tools and weapons, and when he was still ignorant of the use of metals. Beyond this Frere could not of course go. The key to the whole position was not yet available. What it is very important to remember is, that long before the question was sophisticated by discussions about the antiquity or origin of man, and when it was a mere question of discriminating early specimens of human workmanship, these flint objects from the gravels of the Thames and the so-called diluvial beds of Suffolk were distinctly recognized as having been made by human hands.

The key necessary to unlock the next difficulty in the progress of discovery was produced by Cuvier in 1813, when he showed that the remains of elephants and other great beasts found in the superficial beds belong to species no longer living.

This conclusion ought to have been followed by its natural corollary, namely, its application to the discoveries already mentioned, and the admission that man was contemporaneous with the extinct animals; but the geology of the surface beds (since known as Post-Tertiary and Pleistocene) was still an unexplored province of that science; the discoveries in question were buried and forgotten, and Cuvier, whose researches had been almost entirely confined to the Tertiary beds, where he had chiefly to do with a fauna all of which had passed away, not unnaturally adopted a sceptical attitude in regard to man having lived with animals now extinct. He had met with no examples of the kind himself, and naturally appealed to other explanations when evidence to the contrary which seemed ambiguous was produced.

Such evidence was, in fact, forthcoming in 1823, when Ami Boué brought before the same great anatomist the discovery of some human bones found in the widespread loamy deposit of the Rhine Valley known as loess or lehm. This discovery was made near Lahr. (See *Annales des Sciences Naturelles*, 1829–50.)

When this discovery was brought before Cuvier he refused to accept its testimony. Discussing it in 1831 ("Discours sur les révolutions du globe," p. 29), he says, "Toute porte a croire, que l'espèce humaine n'existait point dans les pays où se découvrent les ossemens fossiles, à l'époque des révolutions qui ont enfoui ces os." It can well be believed that such a pronouncement from such a source largely dominated European opinion on the subject, for Cuvier's authority was naturally paramount.

Tournal, in a communication addressed to the *Annales des Sciences Naturelles* in October, 1828, says of the caverns at Bize, near Narbonne, "human bones occur in the same beds as the bones of extinct animals, and both exhibit the same chemical and organic characters," and he urges that the existence of actually fossil human remains must be treated as a question in suspense. Inasmuch, however, as Tournal tells us that with the human bones were found pottery and modern marine shells, it would seem that the remains must in part, if not altogether, have belonged to so-called Neolithic times. (See *Annales des Sciences*, vol. xv, pp. 348–350.)

In 1829 M. Tournal communicated to this publication further remarks on the same subject. In this letter he refers to the researches of M. Christol, and says they were both agreed that the existence of man was not separated from that of the extinct animals, but they had been contemporaries. He says that M. Christol had shown him the human bones which he had found in the department of the Gard, i.e. in the caves of Sauvignargues, Poudres, etc., and that it was impossible to distinguish their condition from that of the bones of tigers, lions, and hyænas found with them. Their physical and chemical condition was the same, and they were found in the same beds; while in regard to the bones of some of the extinct animals he had himself found in the caverns of Bize, they bore the character of having been cut by human weapons. (Id., vol. xviii, pp. 142 seq.)

These remarks fell upon deaf ears, and the long and dreary process of sapping and undermining the prejudices of the dominant school of geologists had to be pressed for many a long year before the position was stormed. The two most effective workers in this field both died without their conclusions being accepted. One of them, who spent his life and his fortune in exploring the caves of Belgium and died broken-hearted, was Schmerling. The other, a Roman Catholic clergyman called McEnery, did corresponding work at Kents Hole. In each case the explorer claimed to have shown from evidence that was irreproachable that man had lived contemporaneously with the extinct beasts, and had left his remains mingled with theirs in the red earth beneath the stalagmite floors of the caverns.

It must not be forgotten that the person who persistently in England refused to accept the conclusion of the contemporaneity of man and the extinct beasts, and who caused McEnery's now famous memoir to be locked up at the Royal Society for years after his death, was Huxley, while Owen's views on the matter were much more enlightened.

Meanwhile, M. Boucher de Perthes, an antiquary at Abbeville, became convinced, after years of patient search, that implements of human workmanship occurred in the undisturbed gravels of the Somme Valley, and must date from the time when those gravels were deposited. He had preached for years in vain, when fortunately a great English palæontologist, the late Dr. Falconer, passed that way and was persuaded by the evidence he saw that M. Boucher de Perthes was right, and he eventually persuaded Professor Prestwich, Sir John Evans, and Sir John Lubbock to visit Abbeville and Amiens and to explore and report upon the facts. The result of their labours was embodied in a famous memoir in the *Philosophical*

Transactions. This made the position so clear and patent that the pendulum, which had been obstinately pointed to the recency of man, swayed right over, and the great mass of scientific men accepted what they had previously refused to credit.

It must be remembered by all those who turn to this famous memoir that its authors proved nothing whatever new. Their conclusions were those which had been arrived at by Tournal and Christol, by Schmerling and McEnery, long before. They merely stamped with a kind of official sanction what ought to have been generally received before.

The memoir in question, however, gave a great impetus to the inquiry about early man in Europe, and the credit of the next step in the enquiry is due to Lord Avebury (then Sir John Lubbock) and Professor Dawkins. It was Professor Dawkins, I believe, who first definitely showed that there was a gap in the history of early man, which was indexed and measured by a very important palæontological fact, namely, that of the separate coexistence of man with extinct animals and his coexistence with domesticated animals, the remains of the two sets of beasts never overlapping so far as we know. This remains the real touchstone separating the earliest known men in Europe from their successors.

Sir John Lubbock completed Professor Dawkins' distinction by giving a special name to each section of early man. The men who lived with the extinct beasts and used roughly chipped tools and weapons he styled Palæolithic, while those who used finely chipped or polished weapons and tools and had domesticated animals he called Neolithic.

After this mapping of the general problem a vast deal of work was done in many countries defining the geographical area where Palæolithic man lived, and describing his mode of life and surroundings, and among those who worked most assiduously in this behalf none have earned our gratitude more than Messrs. Christy and Lartet.

A great problem still remained to be solved, which involves a polemic, though one in which the strugglers on the old platform are becoming fewer and fewer. This is the question whether Palæolithic man lived before or after the distribution of the Drift; on this question I have myself written a good deal, and in a large work to be shortly published have tried to condense a vast mass of evidence justifying those geologists, and I believe they are now the large majority, who hold that Palæolithic man lived before the distribution of the Drift, and that the great gap, which is recognized by everyone, between Palæolithic and Neolithic man is coincident with that distribution and in all probability connected with it.

In quite recent years a further step has been taken which I believe will be eventually justified. The period before the Drift, which is specially marked by the presence of two elephants — *E. antiquus* and *primigenius* — was, I believe, perfectly continuous with that known as the Forest Bed, and marked by the presence of a special fossil elephant known as *E. meridionalis*. The two were, I believe, simply phases of one continuous period. It would not, therefore, be *prima facie* improbable if the remains of Palæolithic man should be found in the Forest Bed.

Such remains are claimed to have been found at that horizon in Norfolk by Mr. Abbott and Mr. Savin, in Dorsetshire by Dr. Blackmore, and they have been also reported from the same horizon at St. Prest in France and in the Val d'Arno, north of Italy, in each case the remains of human workmanship being accompanied by those of *E. meridionalis.* I believe these finds are quite genuine. They are what we should *prima facie* have expected, and so far as we know they are the earliest remains of man hitherto found.

So far there is a fairly general agreement among geologists and archæologists in regard to the evidence about primitive man. At this point, however, a clear divergence must be recognized. A small and pertinacious body of inquirers, including especially Mr. B. Harrison, Mr. W. J. Lewis, and the Rev. R. A. Bullen, have in season and out of season insisted that traces of human workmanship have been discovered at a much earlier horizon in the form of very rude flint implements which have been found in the so-called plateau gravels of Southern England. To these implements the name of eoliths has been given, and the champions of their age and authenticity number among them no less important persons than Professor Prestwich and Professor Rupert Jones. They have failed, however, to secure the countenance of a large number of sceptical critics, among whom I confess I find myself. I have seen many hundreds of these eoliths, but I have seen very few which seem to me to have any purpose or motive of any kind in their shape or construction. This was fully admitted by Prestwich, who confessed that the number of these stones which showed any rational purpose in their shape was a very small percentage indeed, and surely this ought to be the first and prime necessity in attributing them to human handiwork. It was this special feature in the palæoliths of the river gravels and the caves which made men first assign them to human handiwork. How can this same conclusion be applied to thousands of shapeless stones, whose irregular outlines defy all classification? The champions of the stones fall back upon a class of tools whose shape need not be very precise, and to read their lucubrations one would suppose that the men and women who used these eoliths were engaged from January to December in nothing else but scraping skins. Some have, in fact, suggested that they did nothing else than scrape their own skins, and that the eoliths performed the double function of strygils and vermin-killers! There are no arrow-heads amongst these stones, no lances, no tools such as we are accustomed to find among recognized palæoliths.

What we do find, and what needs explanation, is a large number of once angular flints whose angles have been rubbed down by trituration, probably in a stream, and whose edges have been snipped all round their sinuous outlines. This snipping seems to be the only reasonable ground for attributing them to human hands. I am bound to say it appears to me a very crude and remote reason upon which to base such a stupendous hypothesis.

Apart from the characters of the stones themselves, there is the difficulty of their geological age. In the book already referred to which I am about to publish, the age of the southern gravels will, among other things, be discussed. I have ventured to argue in it once again that these plateau gravels, as now distributed, were not the result of diurnal causes, fluviatile or otherwise, but of the same general cause which laid down the great mass of the drift and which acted independently of the contour of the country. I cannot, therefore, see in these gravels any traces of that vast lapse of time postulated by the champions of the human origin of the eoliths, and on the supposition that they were of vastly greater age than palæoliths.

We must remember another fact, namely, that the types we style Palæolithic, which are well marked, can now, as we have seen, be traced back to the horizon of the Forest Bed. It is very strange that some of them should not occur with these eoliths in the plateau gravels, that in many places they should not overlap and be found mixed together, and *that nowhere,* so far as we know, should these same eoliths be found with the remains of extinct animals by which their real age could be tested. How is it they do not occur in the caverns or in the brickearths and gravels of the valleys, and how is it there is no continuity of shape and contour with their successors? It is these questions which stiffen our obstinacy and increase our scepticism about these so-called eoliths.

A few words about another matter. As we have seen, the real and logical distinction in Europe between the so-called Palæolithic and the so-called Neolithic age is the existence of a gap hitherto unbridged. On the one side we find articles of human workmanship associated with extinct beasts, and on the other with domesticated animals, the two never having been found mixed together. This is the real and supreme distinction; for in regard to the shapes of the implements, their mode of tooling, etc., intermediate forms occur—perhaps I ought to say *necessarily* occur. The significance of this gap is a polemical subject. To me it has always meant a great catastrophe, and I have urged it in many ways and produced the evidence for it in many quarters, and was never more convinced of its occurrence than at this moment. I have never, however, argued that this catastrophe, whatever it was, overwhelmed the greater part of Africa. That continent seems to have a very long history as a continuous subaerial surface. Its black races represent very primitive forms of man, many of them hardly changed for thousands of years, and living apparently very much in the same way and with the same surroundings as Palæolithic man had in Europe.

Palæolithic man may therefore be said to still survive in Africa. It is consequently not wonderful that in several places on that continent, notably in South Africa, in Somaliland, and in the Sahara, implements called Palæolithic have occurred in large numbers, not buried in gravel beds containing the bones of extinct animals, but lying about on the surface, their age being therefore quite indefinite. To call them palæoliths seems a misnomer, for that term has an archæological sense in Europe and defines a geological horizon which it is impossible to equate with anything in Africa, where traces of the catastrophe we have mentioned and of the gap which it caused are not available. And if we are to justify the use of the term, it must be apart altogether from its defining a geological period or a particular archæological horizon, and merely as marking a stage of culture. Hence we have had recently a mighty fight, which has been largely upon the connotation of a name. This fight has occupied the pens of Sir John Evans and Dr. Forbes, both of whom have written with the skill and knowledge that might have been expected of them. The issue has been complicated by the fact that Africa north of the Atlas Mountains is zoologically and archæologically a part of Europe. In Algiers evidence is ample that the same destruction of Pleistocene animals, marked by their rapid entombment in gravel and brickearth, took place as occurred in Europe; and there, as in Europe, the traces of Palæolithic man, properly so called, have been found in the gravels and drift-beds associated with the extinct beasts, a fact to which Sir John Evans has called especial attention. In the valley of the Nile similar remains of man were found long ago by General Pitt-Rivers in the breccias and coarse gravels of the great valley, and here also may claim to be truly Palæolithic. But in the case of the surface implements from Somaliland and the country of the bushmen, we must, if we are to be precise, be careful that in applying the term Palæolithic we do not in some way imply great age, for all it may mean is a mere survival, just like the survival of the stone lamps of the Esquimaux and the stone pots and pans of the Hebridean cottiers.

II.—The Circulation of Salt and Geological Time.

By Professor J. Joly, M.A., D.Sc., F.R.S.

FROM time to time I have received from correspondents suggestions that the method of determining the geological age of the Earth by the rate of solvent denudation of sodium might be open to considerable error if the allowance made in my paper (Trans. R.D.S., ser. II, vol. vii), for sodium chloride carried from the sea by winds and washed from the atmosphere by rain, was seriously at fault. These suggestions arise from incomplete study of the quantities involved. Had more space been given in my paper to this question, the hasty criticisms I have had to contend with, doubtless, would be less often advanced. The whole matter is capable of the simplest arithmetical statement, and the limit of error arising from this source easily defined. Recently one gentleman has written at considerable length on the matter in the pages of the *Chemical News*. I have replied to Mr. Ackroyd in that journal. But the definition of the limit of error referred to, and the consideration of some other points raised in the discussion, are more in place in a geological than in a chemical journal. I would therefore seek for space in the GEOLOGICAL MAGAZINE wherein to repeat in part what I have said in the *Chemical News*, adding some matters more especially suited to geological readers.

If all the chlorine in rivers were combined with sodium present in the river-water, much the larger part of the sodium would remain over. The quantity of sodium in river-water which finds its equivalent of chlorine in the water requires special consideration. It obviously may in part be derived from the ocean by the agency of winds and rains. That this part *only* can be considered as derived from such a source a simple proof is given later on. The question then arises as to what amount of sodium chloride is observed to fall in rain, or what amount of chlorine falls with rain; the assumption being made, not quite accurately, that the sodium carried by rain is measured by the chlorine present.

Very full information relating to the chlorine content of rain-water falling in various parts of England and Scotland, and some other coastal parts of the world, is on record. What is wanted is fuller knowledge of the chemical character of rains falling in inland areas, more especially as to their content of sodium. The broad fact at our disposal is, that as we proceed inland a rapid diminution of the percentage of chlorine appears. In inhabited parts of Europe but 200 miles from the sea, the proportion observed appears to be one-twelfth, normally, of what is observed 30 or 40 miles from the sea. In India, about 300 miles from the sea it was found to be 0·04 per 100,000.

In a country like ours where no point is more than a few score miles from the sea, coastal conditions prevail over its entire area. Even within the small British area, however, there appears to be a rapid diminution in the proportion of chlorine carried by the wind to more inland parts. This is observed even in the more inhabited parts, notwithstanding the fact pointed out by Dr. Angus Smith that where coal is being consumed on a considerable scale this proportion must be expected to rise. Although this is so, I do not think it can be doubted that a large part of the chlorine of British rivers, and of well waters also, must be sea-derived. A simple comparison of the chlorine content of British surface waters and of rain, bearing in mind the inevitable concentration of the latter by evaporation, sufficiently demonstrates this fact. This is pointed out in my paper "An Estimate of the Geological Age of the Earth" (p. 35).

In inland countries on the other hand it is extremely doubtful, according to our present knowledge, if *any* of the chlorine observed in rain is derived from the sea, for the circulation of salt from the earth to the air or from inland salt deposits, along with other mineral dust, may be accepted as *inevitable*. Raised with every wind, again washed down with rains, evaporated to dryness, and again raised mingled with the light dust of soils, an amount of saline matter comparable with so minute a quantity of chlorine as was observed in India might well circulate from the earth to the air, and be returned by the rains to the rivers. Such chlorine is, of course, derived by solvent denudation from the soils.

Mr. Ackroyd (*Chemical News*, June 7th, 1901) goes so far as to assume that the inland salt lakes must owe their salts mainly to wind-borne chlorine. That some of the salt lakes of the earth situated near the ocean, or in the track of storms, or even of prevailing winds from the sea, derive contributions of salts from the ocean, is probable. Calculations have been made by Pierre in France and others showing how considerable in amount the salts carried from the sea in immediate coastal regions may be. It is, however, only necessary to refer to the chemical composition of the salt lakes themselves to see that any such origin for the greater mass of the salts present is totally inadmissible. The Dead Sea, for instance, shows a very large excess of magnesium salts over sodium salts, their chlorides constituting 15·9 per cent. and 3·6 per cent. respectively of the total solids. There is even a large excess of calcium over sodium in its waters. In the Great Salt Lake the proportions are just the other way; the percentages are nearly marine, 11·9 of sodium chloride and very little magnesium chloride, but 1·1 per cent. There is relatively very little calcium. Now this is the more embarrassing for Mr. Ackroyd's hypothesis, in that the first lake is close to the sea, the latter very remote from it. Thus the lake which is most favourably situated for the rain supply of sea-salts is just that one which most completely departs in its chemical composition from that of the ocean. Again, we find a lake such as the Elton Lake of the Kirghis Steppe, 200 miles from the Caspian, possessing a chemical composition approximating to that of the Dead Sea: 19·7 per cent. of Mg Cl, 5·3 per cent. of $Mg\,S\,O_4$, and 3·8 per cent. Na Cl. Calcium is, however, in its case absent or inappreciable. Now while the observed wide differences in chemical composition are entirely at variance with a pluvial origin, the rain being supposed to derive its burden from the common reservoir of the ocean (almost homogeneous in composition), they are quite in accord with an origin by solvent denudation, as a glance at the considerable differences of river analyses will show, and as indeed would be *a priori* inferred from the wide range of solubility and chemical composition of the surface materials of the earth.

But all indirect arguments as to the magnitude of the error which might arise from the circulation of sea-salt must be used in subordination to a simple demonstration, on the known facts, of the magnitude of the *maximum* error possible from this source. The estimation of the maximum error is easily arrived at.

Professor Dittmar in his report on the chemical composition of the ocean shows that the amount of chlorine present is *in excess* of the sodium, so that attaching chlorine ions to sodium ions there remains over a large excess of chlorine, appearing in the statement of total solids as 10·8 per cent. of Mg Cl. We have, in fact, 77·7 per cent. of Na Cl and 10·8 per cent. of Mg Cl. A simple calculation will show that it results that 18 per cent. of the Cl must be otherwise allocated than to the sodium, or is, in short, in excess of the Cl equivalent of the sodium present.

Now it is certainly a fair assumption that if rain receives its salts from sea spray a similar excess of Cl ions over Na ions will obtain in rain-water. We must at least conclude (in deference to the current belief that the proportions of salts in rain-water and sea-water are not generally quite in accord) that the sodium equivalent of the chlorine found in rain-water constitutes an excessive estimate of the former. Pierre's results, to which I have already referred, fully confirm this statement. He finds, in kilogrammes received per hectare per annum, quantities of sodium chloride and other chlorides, as well as of sodium sulphate, which afford 29·7 kilos of chlorine and 17·72 kilos of sodium. Ascribing to this amount of sodium its equivalent of chlorine, we have still a balance of over 8 per cent. of the chlorine.[1]

We now turn to what we know of the chemical constitution of river salts. I take Sir J. Murray's mean analyses of nineteen chief rivers of the world. Here we find the striking fact that there is *a large excess of sodium over chlorine*: or the conditions of the sea are reversed. We find, in fact, 157×10^6 tons of sodium and 84×10^6 tons of chlorine carried to the ocean per annum, and as the combining weights of these elements are to one another as 23 : 35 it will appear that considerably the larger part of the sodium of rivers must exist otherwise combined than with chlorine, were the ionizing conditions removed. Let us now go so far as to assume that *all* the chlorine in rivers is derived from rain, and that this brings into the rivers its *full equivalent* of sodium, and we can obviously calculate the maximum possible effect upon the age of the Earth arising from the circulation of salt. (This can fall short of the maximum only on the assumption of a selective retention of chlorine in soils, for which I know of no evidence.) In this method of treating the quantities at our disposal we leave, in short, the whole of the sodium equivalent of the chlorine of rivers out of account in deducing the age of the Earth. The result of the new calculation is that the previous estimate of 96 millions of years rises to under 148 millions of years. This result is, however, over the maximum deducible even from the foregoing assumptions, for as we diminish our estimate of the chlorine derived by solvent denudation during geological time we increase the estimate we necessarily make for original sodium in the ocean derived by a primeval acid denudation effected by free HCl (for we must

[1] Pierre's figures for the several salts in the units mentioned above are—

$NaCl$	37·5
KCl	8·2
$MgCl_2$	2·5
$CaCl_2$	1·8
Na_2SO_4	8·4
K_2SO_4	8·0
$CaSO_4$	6·2
$MgSO_4$	5·9

A rainfall of 60 cm. per annum is assumed.

assume so much more chlorine to have been free in the original atmosphere), and thus we are bound to diminish our numerator as well as our denominator. The final result would be 141×10^6 years. In obtaining this figure we simply assume that no part of the chlorine now in the ocean was at any time contained in the rocks, and that in a period of primeval acid denudation it acted as H Cl to bring chlorides into the original ocean. In other words, that the $28,316 \times 10^{12}$ tons of Cl now in the ocean took part in the primeval denudation, 6·7 per cent. of it uniting with sodium, and thus bringing $1,250 \times 10^{12}$ tons of sodium into the primeval ocean, the calculation being made on the basis defined in my paper. Deducting this from the $15,627 \times 10^{12}$ tons of Na now in the ocean, we have $14,377 \times 10^{12}$ tons to be accounted for by the annual river supply. On our present assumptions the annual supply is not to be taken at its full value of 157×10^6 tons, but this reduced by the sodium equivalent of the whole of the chlorine in rivers (that is, the equivalent of 84×10^6 tons), i.e. 55×10^6 tons. The geological age is therefore the quotient of $14,377 \times 10^{12}$ by 102×10^6, which is rather less than 141 million years.

The assumptions made in obtaining this upper limit are, I need scarcely point out, unjustifiable. We are not at liberty to ascribe all the chlorine of the rivers to rain. Whether derived directly from the rocks and soils, extravasated deposits (as when contained in ore deposits), or from accumulations due to past or present inland denudation in 'rainless' areas, this element, so far as it is a carrier of sodium, must enter our denominator. Nor can we assume the chlorine of rain-water a fair measure of sodium transported from the sea, seeing that such chlorine, if directly sea-derived, should, to the extent of 18 per cent., exist combined with magnesium or other element, and according to observation does so exist to the extent of over 8 per cent. And again, what chloride of sodium is found in rain-water is very surely in part derived from the land. Finally, what we know of the percentage of chlorides in inland rains points to a supply inadequate to furnish the quantities appearing in Sir J. Murray's analysis of mean river-water, for of coastal rains by far the greater part finds its way back quickly and directly to the sea by the small rivers and streams, and does not enter into the composition of the larger rivers, the catchment areas of which are either far inland or rise on the land side of the great mountain ranges. The amount of chlorine appearing in the mean river-water is a little over 0·30 part per 100,000. Contrast this with the estimate 0·04 obtained 300 miles from the sea in India, or the Darmstadt estimate 0·09 part per 100,000, both localities being still relatively close to the sea. On all these grounds I have restricted my allowance for rain-borne chloride of sodium to 10 per cent. of what appears in rivers.

We might base an allowance on the scanty knowledge we possess as to the chlorine content of rains falling some 300 miles from the sea. Let us accept 0·10 per 100,000 as the average amount of Cl carried by rains to the rivers after evaporation, and assume that all this was of marine origin and brought with it its full equivalent of sodium. We thus assume that one-third of the chlorine in rivers is derived from the ocean. We will now calculate what correction on the 96 millions of years this allowance will involve.

The total chlorine discharged by rivers annually into the ocean is 84×10^6 tons, and 33 per cent. of this is 28×10^6 tons; this is, we assume, derived from the ocean. Of the total Cl discharged by rivers we see that 56×10^6 tons (the part derived from the rocks) are not cyclical.

The 33 per cent. of chlorine which is wind-carried, as we assume, has a sodium equivalent of $18{\cdot}4 \times 10^6$ tons. Deducting this from the total annual river supply of sodium, i.e. from $157{\cdot}3 \times 10^6$ tons, we have $138{\cdot}9 \times 10^6$ tons derived from the rocks.

Let now N = the sodium now in the ocean $= 15{,}627 \times 10^{12}$.

n = the quantity of sodium derived from solvent denudation and discharged annually by rivers $= 138{\cdot}9 \times 10^6$.

C = quantity of chlorine now in the ocean $= 28{,}316 \times 10^{12}$.

c = quantity of chlorine derived by solvent denudation and annually discharged by rivers $= 56 \times 10^6$.

(All in tons.)

If now X = Geological Time, we see first that the quantity of chlorine cX was derived from the rocks during the time X, and therefore the amount $C - cX$ must have originally been free in the primeval atmosphere. I have shown in my paper on the Age of the Earth that there is reason to believe that 6·7 per cent. by weight of such free chlorine would take up sodium from the earth-crust. Consequently, the weight of sodium brought in, expressed as a fraction of the free chlorine, is $\frac{6{\cdot}7}{100} \times \frac{23}{35}$, the last fraction being the ratio of the combining weights. This factor becomes 0·044 when reduced. In other words, the mass of sodium brought into the primeval ocean was $0{\cdot}044\ (C - cX)$.

Hence the equation for Geological Time will be—

$$X = \frac{N - 0{\cdot}044\ (C - cX)}{n}$$

and from this we have—

$$X = \frac{N - 0{\cdot}044\ C}{n - 0{\cdot}044\ c}$$

Inserting the numbers given above, we get $X = 105 \times 10^6$.

Allowing, as I have done in my first paper, a deductive correction for direct coastal denudation, we may state our final result as just about one hundred millions of years. We are not justified in stating our result more definitely. We keep in mind that our knowledge of river analysis and of ocean mass are certainly not final.

So far, then, as error from rain-borne chloride of sodium can affect our result, surely the limits are fixed with sufficient straitness! We have, without any further deductions, 96 millions of years if we accept the correction of 10 per cent. on the chloride of sodium of rivers; we have 105 millions of years if the correction should be 33 per cent. I do not believe an unbiassed consideration of the knowledge at our disposal will permit of an allowance *larger* than the latter.

I have given the foregoing estimation in its algebraic form in consequence of the remark of a writer in *Nature* (in a review of my paper) that it was a pity that the age of the Earth has to be *assumed* in making allowance for the primeval acid denudation. Such assumption of the duration we seek to determine is not, however, necessary, as the foregoing algebraic statement shows.

The teaching of the calculation which I gave in my original paper, that the missing sodium of the rocks is equal to or in excess of that added to the ocean during geological time, has been taken by some as by no means opposed to the view that the ocean may have primevally contained the greater part of its present sodium, or to a rapid convergence in the rate of solvent denudation.

The greater part of these sediments, we are assured, were laid down under conditions not even inimical to life, or, as Sir Archibald Geikie has contended for the very ancient Torridonian rocks, under physical conditions much as obtain to-day. But this is not all. The oldest sediments are just those which are chemically the least impoverished and the least washed out of the whole series, and, indeed, might almost be identified by their higher alkali percentages. This fact is obviously quite opposed to the view that they were exposed to more intense solvent actions than obtain to-day. In a word, the internal evidence, chemical, physical, and organic, afforded by the successive strata, controverts the convergence of denudative activity which some have casually assumed, and in the light of this fact the calculation in question *does* oppose the theory of a sodium-charged primeval ocean. We are assured, in fact, that the introduction of sodium age by age had to wait upon the denudation of the rocks, and was thus regulated by a rate to which we know of no disturbance.

III.—On the Enon Conglomerate of the Cape of Good Hope, and its Fossil *Estheriæ*.

By Professor T. Rupert Jones, F.R.S., F.G.S., etc.

In the "Annual Report of the Geological Commission" published at Cape Town in 1895, Dr. Corstorphine refers at pp. 16–19 to the extent and features of the Enon Conglomerate, and to the occurrence of fossil *Estheriæ* in some of its strata. His two assistant geologists, Messrs. A. W. Rogers and E. H. L. Schwartz, in their "Reports on the Southern Districts between Breede River and George" and "On Oudtshoorn," at pp. 73, 76–79, describe in detail the position and characters of the Enon Conglomerate and its '*Estheria* shale.'

This Conglomerate (with its sandstones and shaly beds) occurs in the Breede River valley, Worcester Division of the Western Province, and extends to Ashton and the Swellendam Division, just south of the Langebergen; it covers also a large area eastwards as far as Mossel Bay, and along the valley of the Olifant's River in the Oudtshoorn District, just south of the Great Zwarteberg range. This formation consists of a quartzose conglomerate with a ferruginous cement, and with intercalated, variable, lenticular sandstones. In general it is less than 50 feet thick, but in some places the conglomerate hills rise 400 feet above the valleys (pp. 16 and 17).

At about 30 miles east of Swellendam, and 20 miles from the sea, there is an outlier of Enon Conglomerate, on which are the two towns of Heidelberg and Riversdale. In the vicinity of the former rises the Duivanhocks River, which runs down to the sea at St. Sebastian Bay. Near Heidelberg occur the shaly arenaceous strata, with multitudes of flattened *Estheriæ* on the bed-planes.

The name 'Enon Conglomerate' was first used by Dr. W. Guybon Atherstone (*Eastern Province Monthly Magazine*, vol. i, No. 10, June, 1857, p. 528), for the quartzose conglomerate which he noticed at Enon, in the Alexandria Division of the Eastern Province, among the upper waters of the Sunday's River, on the flank of the Zuurberg. The name has been adopted by others, and used particularly in Mr. E. J. Dunn's Geological Map of South Africa.

Mr. A. G. Bain's section and remarks at p. 58, vol. vii, Trans. Geol. Soc., ser. II, 1845, indicate this conglomerate and some overlying portions of the Wood-bed series of the Uitenhage Jurassic formation, in Lower Albany, north of the Bushman River. Mr. Bain also noticed (op. cit., p. 184) the occurrence of the Enon Conglomerate, with ferruginous cement, "at Lange Kloof and other parts of the district of George," as well as "on the flank of the Zuurberg" and "at Grobbelar's Kloof near Graham's Town."

In the *Mining Journal* for July 3rd, 1886, the following arrangement was given by me for this conglomerate and associated strata :—

Jurassic: Uitenhage Formation[1]	*Trigonia* Beds	400 ? feet.
	Wood Bed	
	Saliferous Bed	
	Zwartkop Sandstone ...	
	Enon Conglomerate ...	300 feet.

(Unconformable or Devonian and other old rocks in Albany.)

At pp. 76–78 of the Rep. Geol. Comm. for 1898 it is stated that "The Enon Conglomerate extends from the Paardeberg eastwards, as a huge sheet covering up the Bokkeveld Beds on the south and the Malmesburg Beds on the north. It lies in the middle of the valley between the Zwartebergen and Langebergen. Typically it consists of pebbles of quartz and quartzite, imbedded in a dark red matrix, but varieties occur which are very similar to those in the conglomerate south of the Langebergen. Along the Gamka Flats there are white gravels with large boulders similar to those in Honig Klip's Kloof, and along the Olifant's River on the west there are green sandstones and white claystones [?], the same as

[1] See also Quart. Journ. Geol. Soc., 1867, vol. xxiii, pp. 149 and 167.

one finds north-west of Heidelberg. The Enon Conglomerate of the Oudtshoorn District closely resembles, in its lithological character and relation to the older rocks, the similar deposits in the country to the south of the Langebergen. Although determinable plant-remains, with the possible exception of lignite, in which the minute structure has been preserved, have not yet been found in the rock, there are indefinite casts of fragments of wood in the sandstone near Oudtshoorn, which are very like the casts in the sandstone of Cape St. Blaize and Heidelberg."

At p. 19 Dr. Corstorphine remarks:—"The character of the Enon Series—thick banks of conglomerate, passing in most localities within a short distance, vertically and horizontally, into coarse, lenticular beds of sandstone, the latter containing stems and other plant-remains, with fresh-water *Estheria*, and in one instance a coleopterous wing-cover—points to a fluviatile origin for the whole. It is, with the exception of the recent sand-dune limestones and other superficial deposits, the youngest formation in the area so far surveyed."

At p. 18 he states:—"Shales and claystone [?] also occur, sometimes gray, sometimes black and almost coaly in appearance. Near Herbertsdale and Heidelberg the shales are common, and at the former locality they contain numerous plant-remains. At Heidelberg a white shale [shaley arenaceous bed] occurs with abundant *Estheria* casts."

In March, 1899, I received from Mr. A. W. Rogers, one of the Geological Surveyors of Cape Colony, three specimens of Enon Conglomerate collected at Heidelberg, Swellendam District. Two of the specimens (300 *a* and 302 *a*) consist of hard, white, laminated, fine-grained sandstone (not argillaceous nor calcareous), showing bed-planes, covered with flattened valves of *Estheria*. The other is an irregular and slickensided fragment of similar siliceous rock (296 *a*). A large part of it is not laminated, and the matrix seems to have been crushed after consolidation; it contains some imperfect and indeterminable casts and fragments of valves, modified by pressure. These relics are distinguishable by their being stained with yellow ochre. The rest of the piece is laminated, and the bed-planes show many valves crowded together, flattened and modified in their outlines. Their surfaces mostly present the appearance as if the outer layer or film of shell had been dissolved or melted, as it were, into a very thin, sometimes brownish varnish or glaze; and no reticulate or other ornament between the concentric ridges can be discovered in these valves.

Looking at the striking general similarity of the numerous variable, sub-oblong, and sub-oval shapes in the crowds of extremely flattened valves on these bed-planes, we evidently see the result of shoals of probably one kind, or local tribe, of *Estheria* having been suddenly enveloped in heavy deposits of mud; and it is difficult to distinguish any specific difference among the individuals.

Venturing, however, to place them all under one quasi-specific title, I group them as Estheria anomala, sp. nov. (Figs. 1–4).

On specimen 302 *a* there is one individual (Fig. 1) which has retained in great part the shape of the bivalved carapace, but is rather narrowed vertically. The left valve remains exposed, and a portion of the dorsal region of the other valve protrudes beyond it. This left valve has the oblong-ovate shape common in the genus, and bears indications of numerous concentric close-set lines or ridges. It measures 5 mm. in length and 3 mm. in height.

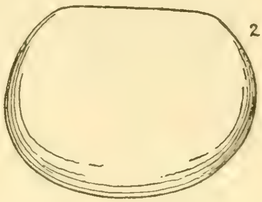


FIG. 1.—*Estheria anomala*, sp. nov. Carapace showing the left valve, somewhat narrowed by crush. Magnified 8 diam.
FIG. 2.—A right valve, crushed quite flat. Magnified 8 diam.

A modified right valve (Fig. 2), on the same specimen, quite smooth, and widened out by pressure until it is almost suborbicular, measures 5·75 mm. in length and 4·5 mm. in height, and yet may be of the same species as the foregoing, there being many intermediate shapes on the bed-planes of this rock.

On specimen 300 *a* are other flattened valves, often nearly suborbicular. Fig. 3, which has a short and broad ovate form, with an apparently short but distinct dorsal border or hinge-line, measures 6·25 by 4·25 mm., and may be taken as belonging to the specific type. The spaces between the concentric ridges (Fig. 4) exhibit no ornament.

FIG. 3.—*Estheria anomala*, sp. nov. A right valve, somewhat misshapen by pressure. Magnified 8 diam.
FIG. 4.—Part of the surface of Fig. 3. Magnified 75 diam.

None of the *Estheriæ* above mentioned from the Enon Conglomerate of Heidelberg correspond with the three known South African species:—

Estheria Greyii, Jones: GEOL. MAG., 1878, p. 100, Pl. III, Fig. 1. This differs altogether in the general shape. It was from the Lower Karoo beds, near Cradock, Cape Colony.

Estheria Draperi, Jones: Geol. Mag., 1894, p. 289, Pl. IX, Figs. 1 *a, b, c*. This sub-oblong form is much larger, and has ornamented interspaces, but is the nearest in general form. It was from the Uppermost Karoo beds, in the Drakensberg, Natal.

Estheria Stowiana, Jones: Geol. Mag., 1894, p. 290, Pl. IX, Figs. 2 *a, b*. This little valve differs from the others especially in its sub-elliptical outline. Having its full complement of numerous concentric ridges, it is not a young form, as suggested in 1894. From the Uppermost Karoo beds, in the Drakensberg, Natal.

IV.—On the Reported Occurrence of the Camel and the Nilghai in the Upper Miocene of Samos.

By C. I. Forsyth Major, M.D., F.Z.S.

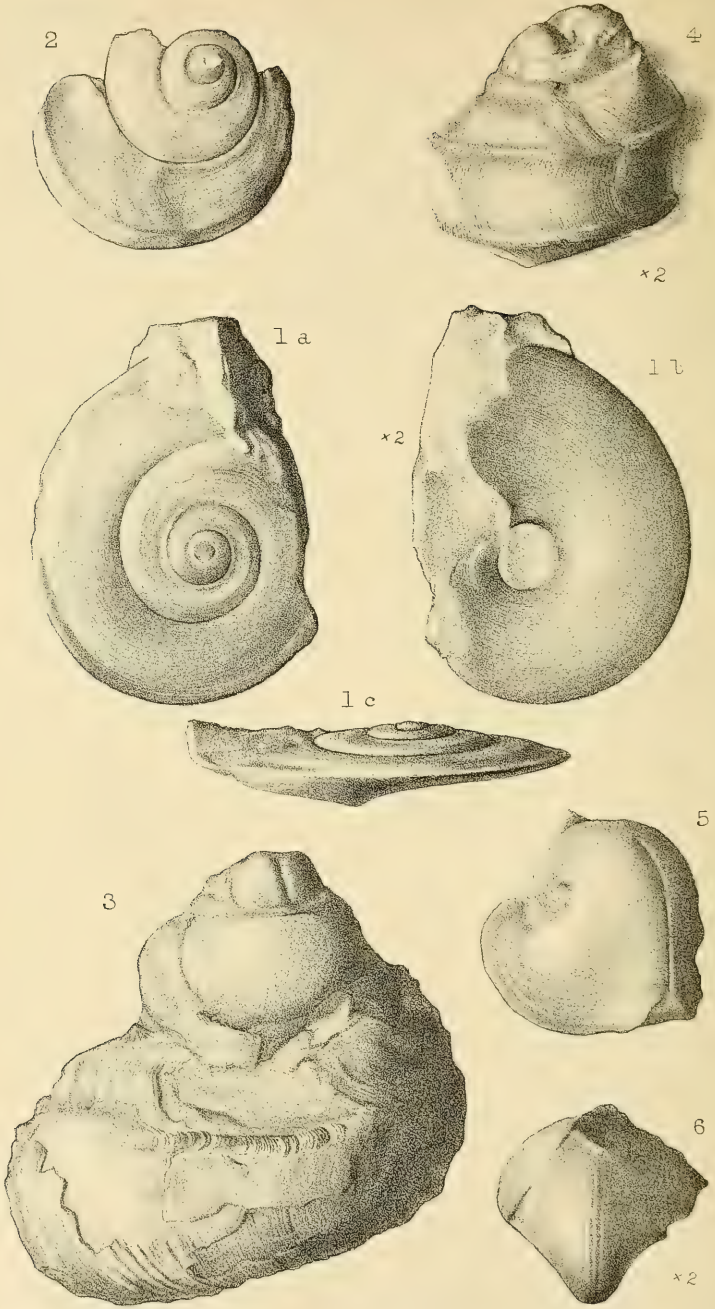
In a notice on "Fossil Camels in Europe," inserted in the periodical *Natur und Haus* (1901, ix, 5, p. 179), it is stated that amongst the fossils from Samos in the Stuttgart Museum there occurs, under a wrong name, the well-preserved skull of a Camel, and likewise "a near relative of the Indian Nylgau, *Portax pictus*."

On a visit to the Stuttgart Museum a few weeks ago, I was kindly allowed to examine the above-named specimens, with the result that the skull supposed to be a Camel is found to be that of a hornless member of the Giraffidæ, agreeing almost exactly in form with hornless skulls of *Samotherium Boissieri*, Maj., but considerably smaller. It is doubtless the female skull of *Palæotragus Rouenii*, Gaud.

Breadth of frontals behind the orbits in a *Samotherium Boissieri* ♀ ...	240·5 mm.
Breadth of frontals behind the orbits in the Stuttgart skull	187 „
Breadth of frontals across the orbits in the Stuttgart skull	161 „
Breadth of frontals across the orbits in *Palæotragus Rouenii*, according to Gaudry	160 „

The hornless *Camelopardalis parva*, Weith., from Pikermi, is the same species as *Palæotragus Rouenii*. The difference in the shape of the molars is only apparent, the examination of the type-specimen of the latter in the Paris Museum showing that the teeth are not correctly drawn in fig. 2, pl. xlv of the "Animaux fossiles et Géologie de l'Attique."

The fossil claimed to be a near relative of the *Portax* is likewise a Giraffoid, intermediate in size between *Samotherium Boissieri* and *Palæotragus Rouenii*; the incorrectly repaired supraorbital horn of the left side is preserved. In size and shape the molars correspond with (1) some isolated teeth doubtfully assigned by Gaudry to his *Camelopardalis Attica*; (2) an "isolated upper tooth series" from Maragha (Persia), described by Rodler & Weithofer; (3) isolated teeth, also from Maragha, in the British Museum (M. 3,867 and 3,869); (4) the teeth of the type-specimen of *Giraffa vetusta* (Wagn.), from Pikermi, if due account is taken of the latter's rather worn condition. The Stuttgart skull shows the characters of *Palæotragus*



G. M. Woodward del. et lith.

West, Newman imp.

Silurian Gasteropoda.

and *Samotherium* (the unfortunate former name will presumably, as previously stated by me, supersede the latter); it is therefore probable that its anterior and posterior limbs were of approximately the same relative length as in *Samotherium Boissieri*, and not giraffe-like as in *Camelopardalis Attica*. If this suggestion proves to be correct, the proper name for this intermediate-sized member of the Giraffidæ will be *Palæotragus vetustus* (Wagn.).

The hornless skull and the teeth described under the name of *Alcicephalus Neumayri* in Rodler & Weithofer's paper on the Ruminants of Maragha (1890) belong to *Samotherium Boissieri* (1888); not so the limb-bones ascribed to *A. Neumayri*, which agree better with the size of *Palæotragus Rouenii*.

It is but fair to state that there are labels in the Stuttgart Museum to show that the Giraffoid affinity of the two fossils in question had been duly recognized.

V.—Woodwardian Museum Notes: Salter's Undescribed Species. V.

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

(PLATE XV.)

Pleurotomaria striatissima (Salter). (Pl. XV, Figs. 1 and 2.)

1873. *Pleurotomaria striatissima*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 171 (*a* 987, *a* 991).

1891. *Pleurotomaria striatissima*, Woods: Cat. Type Foss. Woodw. Mus., p. 113.

There are two specimens of this species in the Woodwardian Museum, both of which were named and labelled by Salter. The smaller and more perfect one, *a* 987 (Fletcher Collection), is first mentioned, and is stated to have come from the Lower Ludlow of Dudley. The larger specimen is from the same horizon of Green Quarry, Leintwardine, and shows only a portion of the upper surface.

Diagnosis. — Shell much flattened, discoidal; very low, short spire; whorls five or six in number, much flattened, coiled into a nearly flat spiral; outer whorl with acute margin furnished with small, narrow projecting band, marked off by groove from rest of whorl, and bordered by a raised thread-like line above and below (shown in Leintwardine specimen). On the inner whorls this band lies on the suture-line and is almost hidden. Apical surface of whorls ornamented with regular, equidistant, longitudinal, revolving striæ, 30–40 in number. At about one-third the distance from the outer margin is a raised thread-like line or keel, parallel to the striæ and more conspicuous on the inner whorls. Umbilical surface of shell flattened or very weakly convex, swelling slightly towards the mouth (which is not preserved). This surface is ornamented with revolving striæ, similar to the apical surface, but there is no raised thread-like line or keel amongst them. Umbilicus deep, circular, and about one-fifth the width of the base.

MEASUREMENTS.

	mm.
Diameter of larger specimen	35
Diameter of smaller specimen	22

PLEUROTOMARIA UNIFORMIS, Salter. (Pl. XV, Fig. 3.)

1873. *Pleurotomaria uniformis*, Salter, n.sp.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 155 (*a* 879).

Salter (*loc. cit. supra*) described this species as "large, quite without ridges except band." His original specimen (*a* 879), from the Fletcher Collection, is the only one which we possess, and it is poor material on which to base a new species, as it is distorted and the shell mostly missing. It was found in the Wenlock Limestone of Dudley, and measures approximately 65 mm. in length and 60 mm. in width across the body-whorl.

DIAGNOSIS.—Shell large, broadly conical, of few whorls (the three upper ones are alone preserved). Whorls convex, with apical face oblique to axis and having its surface slightly raised in the middle between the suture-line and slit-band. Slit-band of moderate width, marginal, separating apical face from convex portion of whorl below, and situated above the middle line of the whorl; with rounded prominent borders, and with a convex surface crossed by transverse crescentic striæ and occasionally by thicker lamellæ. Suture-line shallow. Body-whorl large, apparently nearly half the length of shell. Ornamentation of apical face of whorls consisting of transverse sigmoidal lines; rest of whorls crossed by transverse non-sigmoidal striæ, with a few thicker striæ interspersed at irregular intervals.

PLEUROTOMARIA ? HELICOIDES, Salter.

1873. *Platyschisma helicoides*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 186 (*b* 140, *c* 26).
1891. *Platyschisma helicoides*, Woods: Cat. Type Foss. Woodw. Mus., p. 111.

The two specimens on which Salter founded this species are both from the Upper Ludlow of Lesmahagow. Neither is at all well preserved, and but very few characters are visible. Salter says of this species: "A shell very like the *Trochus helicites* of the British Ludlows, but flatter and having a marked subangular band."

DIAGNOSIS.—Shell small, coiled into a low spiral of five or six whorls. Whorls angulated; apical surface narrow, flat, horizontal, with elevated keel round edge; sides steeply sloping. Margin of last whorl appears to be expanded into horizontal lamellar band. No slit-band visible. Surface ornamentation unknown.

MEASUREMENTS.

	mm.
Height	2·5
Width	7·0

REMARKS.—As Salter remarks, this species is quite distinct from Sowerby's *Trochus* [*Platyschisma*] *helicites*,[1] but it is unfortunate

[1] Sil. Syst., pp. 603, 706, t. iii, figs. 1*e*, 5. Siluria, 4th ed., p. 162, Foss. 26, fig. 9; t. xxxiv, fig. 12.

that the material is so badly preserved that even the genus is doubtful. It is quite possible that it is a *Horiostoma*, but the apparently alate margin reminds one of *Pleurotomaria alata* (His.),[1] and the shape of the whorls is also similar, especially in the variety *subcarinata*.

TROCHONEMA BIJUGOSA, Salter. (Pl. XV, Fig. 4.)

1873. *Trochonema bijugosa*, Salter, n.sp.: Cat. Camb. Sil. Foss. Woodw. Mus., p. 156 (*a* 875).

1891. *Trochonema bijugosa*, Woods: Cat. Type Foss. Woodw. Mus., p. 115.

There are only two specimens of this species in the Woodwardian Museum, and they are the original ones determined by Salter. The larger one shows a portion of the body-whorl and succeeding whorl with the shell well preserved; the smaller one is merely an imperfect internal cast of the two basal whorls, and it is doubtful if it is rightly attributed to the same species. Both are from the Wenlock Limestone of Dudley and belong to the Fletcher Collection. Salter describes the species as "much resembling *T.* (*Turbo*) *trochleatus* of McCoy and Hall," and the figure in the margin appears to be a rough restoration of it.

DIAGNOSIS.—Shell conical, turbinate; of six (?) whorls; apical angle 60°. Whorls angulated by two parallel longitudinal keels, between which their surface is flattened and vertical. Apical surface of whorls sloping down steeply from suture-line to upper keel, but swollen into a low, revolving ridge close below suture-line, defined below by distinct groove. Lateral surface flattened vertical, about one-third height of whorl, bounded above by upper keel and below by lower keel; lateral surface meets apical surface at angle of 45°, and in basal whorl meets umbilical surface at same angle. Umbilical surface sloping, faintly convex. Keels forming rounded, projecting, parallel bands, marked off above and below by faint narrow grooves. The lower keel is rather the larger of the two. Surface of valves ornamented by regular, continuous, strong, equal striæ. On apical surface the striæ are oblique, and close to the upper keel bend sharply back and cross it in a series of sharp crescents resembling those on the slit-band of *Pleurotomaria*. Between the keels on the lateral surface the striæ are nearly straight and vertical, and cross the lower keel directly without bending back, and continue thence on to the umbilical surface, where they become sigmoidal.

MEASUREMENTS.

	mm.
Width of larger specimen	20·0
Estimated height of ditto	20·0

REMARKS.—It is unfortunate that the material on which this species is based is not more complete, and accordingly the species does not admit of very satisfactory definition. At any rate, it seems to be distinct from any previously described.

[1] Lindström: Sil. Gastrop. Pterop. Gotl., p. 118, pl. x, figs. 33–37.

BELLEROPHON RUTHVENI, Salter. (Pl. XV, Figs. 5 and 6.)

1873. *Bellerophon Ruthveni*, n.sp., Salter: Cat. Camb. Sil. Foss. Woodw. Mus. (*b* 61).

1891. *Bellerophon Ruthveni*, Woods: Cat. Type Foss. Woodw. Mus., p. 96.

It is to be regretted that the four specimens on which Salter founded this species are so poorly preserved and distorted. They are all from the Kirkby Moor Flags of Benson Knot, near Kendal, and were labelled by McCoy *B. expansus* (Sow.). Salter describes *B. Ruthveni* as "Smaller than *B. dilatatus* and with the band angular, and the whorls angular where the band becomes so. Very common, $1\frac{1}{4}$ inch wide." The shape of the shell resembles *B. expansus* with large expanded aperture, with inner lip bent down considerably and outer lip possessing a wide acuminate V-shaped sinus. The slit-band is comparatively narrow, and lies sunk between faintly elevated margins. Near the aperture the whorl seems to be slightly carinated and compressed, though this appearance may be due to crushing in the rock. In one of the smaller specimens there are traces of one or two longitudinal thread-like lines running parallel to the slit-band on the surface of the shell, slightly diverging towards the mouth, but no other ornamentation or surface-markings are visible. The specimens are so poor that it is impossible to give any satisfactory definition of the species, and it is extremely doubtful in my mind whether Salter's species can stand.

EXPLANATION OF PLATE XV.

FIG. 1*a*.—*Pleurotomaria striatissima*, Salter, viewed from above, enlarged twice natural size.

FIG. 1*b*.—The same, viewed from beneath, enlarged twice natural size.

FIG. 1*c*.—Side-view of same, enlarged twice natural size.
From the Lower Ludlow of Dudley.

FIG. 2.—*Pleurotomaria striatissima*, Salter, natural size; from the Lower Ludlow, Leintwardine.

FIG. 3.—*Pleurotomaria reniformis*, Salter, natural size; Wenlock Limestone, Dudley.

FIG. 4.—*Trochonema bijugosa*, Salter, enlarged twice natural size; Wenlock Limestone, Dudley.

FIG. 5.—*Bellerophon Ruthveni*, Salter (side-view), natural size; Kirkby Moor Flags, Benson Knot, Kendal.

FIG. 6.—The same (carinal aspect), enlarged twice natural size; same locality.

VI.—ON THE BRITISH EARTHQUAKES OF 1900.

By CHARLES DAVISON, D.Sc., M.A., F.G.S.

(WITH A MAP.)

DURING the past year there were only two undoubted earthquakes in this country. Some may have occurred in Glen Garry, one of our most sensitive regions; but the construction of a new railway through the valley renders it difficult to identify true earthquakes with certainty. The total number of British earthquakes during the last twelve years thus amounts to 116, of which 46 had epicentres in England and Wales and 70 in Scotland, 42 of the latter number being confined, or almost confined, to Glen Garry.

Ochil Earthquakes of Sept. 17 and 22, 1900.

The two undoubted earthquakes occurred on Sept. 17 at 10.15 p.m. and Sept. 22 at 4.30 p.m. There were also four other reported shocks, whose seismic character is not established, at the following times:—

(*a*) Sept. 17, 3.30 p.m., Menstrie.
(*b*) Sept. 17, 10.5 p.m., Alva.
(*c*) Sept. 18, 2 a.m., Alva.
(*d*) Sept. 18, about 2.55 a.m., Bridge of Allan.

The first two were noticed by several persons at each of the places mentioned, but I have no record of them except the statement that slight shocks were felt.

Earthquake of Sept. 17, *at* 10.15 *p.m.*—I have received 56 accounts of this earthquake from 26 places, in addition to negative records from 11 other places.[1] The epicentre is situated among the Ochil Hills, and consequently the intensity of the shock in the central region is unknown. At places near the boundary, in the valleys of the Forth and Allan, the intensity was 4, and it can hardly have exceeded this degree in any part of the disturbed area.

The boundary of the disturbed area, which corresponds to an isoseismal line of intensity slightly less than 4, is roughly elliptical in form, 15 miles long and 9½ miles broad, and includes 117 square miles. Its longer axis is directed E. 13° N. and W. 13° S., and the centre of the area is 3 miles N. 32° W. of Alva. In spite of the absence of observations from the neighbourhood of Glendevon, it is probable that the curve is drawn with a fair approach to accuracy.

The shock seems to have been nearly uniform in its character all over the disturbed area, a single prominent vibration succeeded by a tremor such as would be caused by a heavy weight falling on the floor and making the building shake, and lasting altogether not more than three seconds.

Of the 55 observers who provide detailed accounts of the earthquake, 48 distinctly heard the sound, 4 are doubtful or fail to answer the question, while 3 state that they heard no sound at all. Thus, the percentage of those who heard the sound is not less than 87. A few observers describe the sound as a loud sharp crash or a low rumbling sound, while as many as 41 refer it to one of the ordinary types. Of these, 29 per cent. compared it to the noise of heavy waggons or traction-engines passing, 10 per cent. to thunder, 5 per cent. to wind, 12 per cent. to the tipping of a load of coal or bricks, 17 per cent. to the fall of a heavy body or the banging of a door, 12 per cent. to blasting or explosions, and 15 per cent. to miscellaneous sounds, such as the trampling of horses, a distant waterfall, a large flock of pheasants flying over the house, or the rush of heavy rain against the window. On the whole the frequency of comparison to sounds of short duration is unusual, and this no doubt is due mainly to the prominence of the heavy thud that

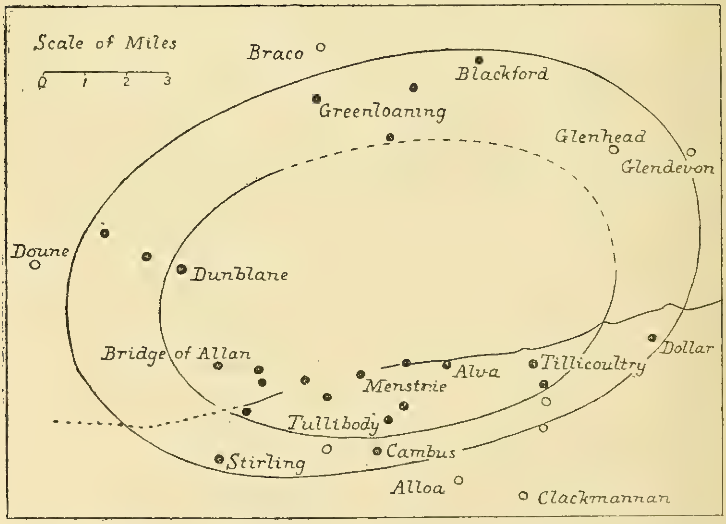
[1] The outer curve on the map and all places marked refer to this earthquake.

accompanied the principal shaking, while the rumble which died away with the tremor was unnoticed or undescribed.

The beginning of the sound preceded that of the shock in 10 cases and coincided with it in 19; while the end of the sound preceded that of the shock in 2 cases, coincided with it in 17, and followed it in 3 cases. The time-relations of both initial and final epochs are given by 22 observers, and these show that the sound was of greater duration than the shock in 8 cases, and of equal duration in 12, while in 2 others the relative duration is doubtful.

Earthquake of Sept. 22, at 4.30 p.m.—This shock was weaker and less widely observed than the preceding, and I have not more than 20 accounts from 13 places, together with negative records from 15 places. The intensity of the shock was 4, and probably was not much greater even near the epicentre.

The boundary of the disturbed area is an isoseismal of the same intensity as that of the earlier shock, that is, slightly less than 4. In the north-east quarter, the boundary is indicated by a broken line, being doubtful owing to the absence of observations in this part of the disturbed area. It is 11 miles long and 7 miles wide, and contains an area of 60 square miles. The longer axis is parallel to that of the other shock, and its centre is 2½ miles N. 37° W. of Alva.



Though slighter, the shock closely resembled that of the 17th inst., one observer (at Bridge of Allan) describing it as a sudden abrupt loud shock, as if some extremely heavy body had fallen outside the house, followed immediately by a tremor.

The earthquake-sound was recorded by 13 out of 15 observers who enter into details, that is, the audibility-percentage, as in the first earthquake, was 87. Of the few observers who describe the sound, 9 per cent. compare it to passing waggons, 27 per cent. to thunder, 9 per cent to wind, 36 per cent. to a cart of coals or bricks being emptied, 9 per cent. to the fall of a heavy body, and 9 per cent. to the distant firing of cannon. Thus, the reference to sounds of brief duration is even more marked than in the earlier shock. The beginning of the sound preceded that of the shock in 2 cases and coincided with it in 5; while the end of the sound coincided with that of the shock in 4 cases.

Origin of the Earthquakes.—From the seismic evidence, we can determine only the direction of the originating fault, which must be about E. 13° N. and W. 13° S. If it hades to the north, the fault-line must lie to the south of the centres of the disturbed areas, and if to the south on the north side.

On the map of the earthquakes is shown that part of the great Ochil fault which traverses the disturbed areas of the earthquakes. Its general direction is E. 11° N. and W. 11° S., and, if the fault haded to the north, it would thus satisfy the seismic conditions; but this, I am informed through the kindness of Sir A. Geikie, is not the case. "It is known to hade to the south both by direct observation and by the effects of denudation upon the intrusive sill of dolerite in the Carboniferous rocks, where it is thrown against the andesites and agglomerates of Lower Old Red age." As the shock would be less strongly felt on the hard compact rocks of the Ochil Hills than on the softer rocks to the south, it follows that the earthquakes cannot be attributed to slips along the Ochil fault.

There is no other parallel fault of any consequence marked on the Survey map (Sheet 39), though several faults cross the Ochil Hills in a nearly perpendicular direction. The only conclusion we can come to, therefore, is that the earthquakes are connected with some fault or faults, whose existence has not yet been ascertained by geological evidence.

Doubtful Earthquake.

Pendleton (*near Manchester*), *April* 7, 1900.—An earth-shake, somewhat similar to that of Feb. 27, 1899, occurred at 1.17 a.m. on April 7. Mr. Mark Stirrup has again kindly sent me records of this shock, from which it appears that the disturbed area, as before, is not more than 4 or 5 miles in diameter, and that the centre is close to the Irwell Valley fault, but a mile or two further to the south or south-south-east of that shaken in 1899. At Pendleton the vibration resembled that felt in a house when a heavy traction-engine passes; and the sound appeared as though the mortar and walls were being crushed. In the collieries, at a depth of about 3,000 feet, the noise was also considerable; and the shock is said to have caused dust to rise. As the intensity of the shock was 4 or 5, and the disturbed area very small, the depth of the centre of disturbance must have been slight. The evidence is less complete than in the former case, but, so far as it goes, it supports the view of the origin of these earth-shakes in mining districts which I suggested in my last paper on British earthquakes.

Spurious Earthquakes.

Shortly after 10 p.m. on July 18, a series of disturbances was observed at different places along the south coast of England, between Torquay and Brighton. At first they were supposed to be earthquakes, but they were afterwards traced to the gun-firing during a sham fight which took place at Cherbourg at the hour mentioned in honour of the French President's visit to that town. The evidence for this conclusion is as follows:—(1) The area within which the sounds were heard was a narrow band hardly more than a mile or two wide, following all the windings of the coast, and interrupted in that part of Hampshire shielded from Cherbourg by the higher ground of the Isle of Wight. (2) The disturbances occurred in groups, each of which lasted several minutes. (3) The waves were obviously propagated through the air, for they caused a drumming in the ears, and windows were shaken while floors were still. (4) Lastly, the sounds were recognized as those of heavy guns, and were ascribed to this origin with a confidence which increased with the observer's neighbourhood to Cherbourg.

VII.—Geological Notes from Tanganyika Northwards.

By Malcolm Fergusson, Esq.

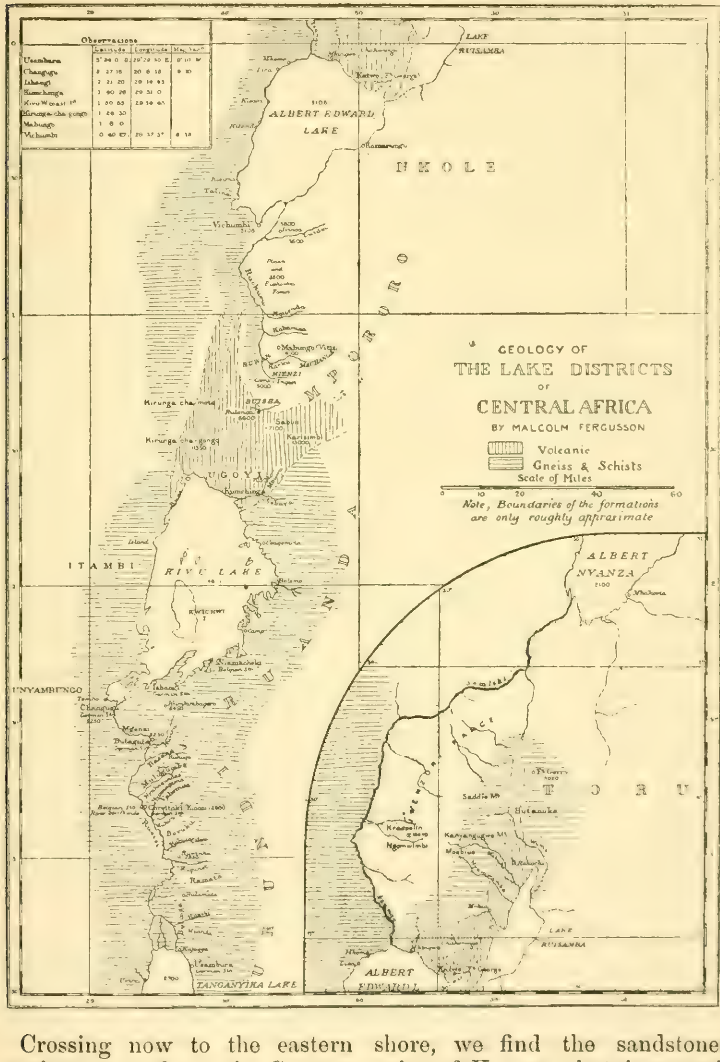
(WITH TWO MAPS.)

THE southern shore of Lake Tanganyika and the country for a distance of 40 miles south of the lake consist of sandstones and conglomerates, dipping north about 10°. These sandstones stretch some little way up the eastern and western shores, and appear to continue away to the south-west. Proceeding further north along the lake shore they get harder, being in places metamorphosed into a pink quartzite.

In colour the sandstones are reddish or grey, generally very coarse. At the lake they are of enormous thickness, being quite 3,000 feet at Kituta, and they surround the southern shore in a precipitous horse-shoe which descends to the water's edge. On the west coast they come to a sudden stop at the Lufu Valley, where there is a break in the range, the plateau descending to the level of the lake into which the Lufu River flows. Here the geology changes, and an intrusive dyke of quartz-felsite comes in, followed by a lava-flow which has every appearance of stratification, and which I mistook for a sedimentary deposit at a distance. It is a rhyolite which has poured down the Sumbu Valley into Cameron Bay, the present appearance being a bank of rhyolite rising from the beach.

["Under the microscope the rock has a brecciated appearance, owing to the intermingling of lenticular pink (or in one specimen dark) spherulitic patches with colourless, finer-grained, microfelsitic material showing well-marked flow-structure. A few small phenocrysts of quartz and altered felspar (mainly oligoclase) are present."]

Immediately north of this rhyolite the country begins to rise again, splitting up into small detached hills at first and gradually rising to mountains of quartz-felsite at Moliro's. [" This rock contains fairly large phenocrysts of quartz and orthoclase in a microfelsitic base showing flow structure and in parts also spherulitic structure."]



Crossing now to the eastern shore, we find the sandstones continue up as far as the German station of Kasanga, but just north of this they terminate and felsitic rocks again intrude and predominate, granite sometimes showing up through the mass. As we proceed further north the felsite disappears, and at Mpimbwi occur granite, gneiss, and schists. ["A specimen of gneiss or crushed granite from this locality presents under the microscope a good example of cataclastic structure with long irregular patches of quartz (showing marked undulose extinction), some microperthite, and bands of sericite in a mosaic of crushed quartz and felspar."]

While at Kilando we experienced three earthquake shocks, only a small interval of time elapsing between them. The missionaries say they are of frequent occurrence, especially during the months of September, October, and November. Here the plateau is broken up, and the country descends in altitude to hills of 400 feet or 500 feet in height, with sometimes extensive plains and valleys.

The occurrence of felsitic rocks on both sides of the lake suggests that the rift had occurred through the middle of a large mass of this rock which originally had been continuous, and that the lake was formed subsequently.

Recrossing to the western shore at Tembwi we find granite, gneiss and schists with a large quantity of white quartz veins running through them. Going north and approaching the Lukuga Valley these gradually descend, breaking up into low ridges and hills, and give place to deep red sandstones, which, however, are only of limited extent and appear to be quite recent, as I found what I took to be crab markings on the surfaces, and they were probably deposited along a river valley. The river was evidently of much larger size at one time, and even now is of considerable size during the time of floods, as evidenced by the great width of the bed and the position of native dwellings, which are all situated high up and back from the banks.

The only known deposit of limestone in the Tanganyika district occurs at the French mission station Mpala, a few miles south of Tembwi. It is a white crystalline limestone, containing no fossils, and supplies the whole district with lime.

North of the Lukuga the country is almost flat for a distance of 10 miles or so and for some way inland. About one mile north of the outlet there is a small stream, the Lubui, flowing *into* the lake.

Ten miles from the Lukuga the country rises sharply again at Kahangwa, where I landed to look at the formation which strikes out into the lake in a sharp bluff composed of dark-grey contorted phyllite. At Mtowa the formation seems to be principally schists.

Again crossing the lake, I found soft grey sandstones which continue north to Ujiji, but in many places here is open plain land and the rock is covered with soil and vegetation.

Immediately north of Ujiji the country rises again precipitously from the lake shore, showing sandstone formation containing thick beds of conglomerate, dipping generally east about 20°. These sandstone beds rest on granite, which can be seen above the water line at Viuwko and Lumungi.

North of Lumungi the sandstones give place to granites, gneiss, and schists, which form the main constituents of the mountain range running north along the shore and up past Usambura, where they bend east a little and form a large open fertile plain, enclosed by these mountains on the one side and by the Western Congo Range on the other.

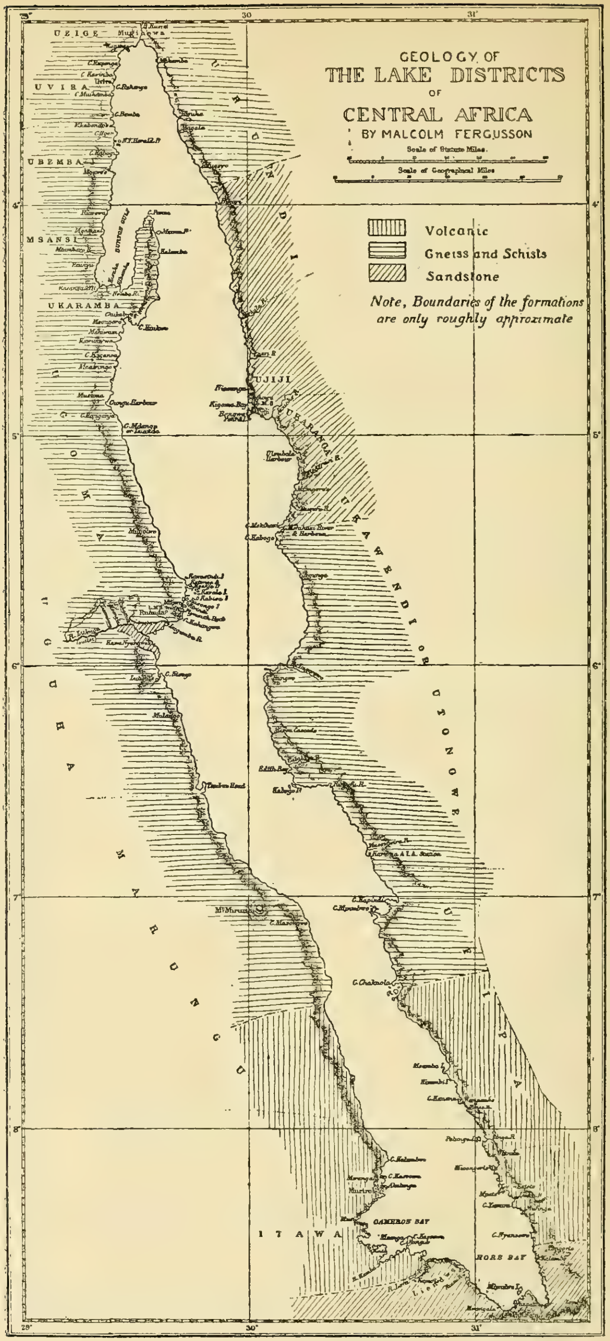
Referring to the question of Tanganyika having been once connected with the sea, it is impossible to state definitely any ideas on the subject from the limited observations I was able to make, but the enormous thickness and extent of the sandstones on the southern shore, extending southwards forty miles and then bending round and continuing west, give one the idea that this might have been an old arm of the sea connecting Tanganyika westward by way of the Congo. If the sandstones could be traced towards the Congo the problem might be solved. Connection northwards at any time seems to me impossible. The mountain range at Kivu forms a dividing barrier, in fact is a north and south watershed, from which the waters flow south to Tanganyika and north to the Nile.

North of Tanganyika is a broad fertile alluvial plain covered with grass, euphorbias, and scrub, extending north for about 25 miles. Then spurs come down from the main ranges east and west, and from here the country is hilly.

Just south of Butagata, the German station on the Rusisi, occur some hot springs. From here the country rises again sharply for about 2,300 feet, with rounded hills covered with deep red soil showing no outcrop of rock. This continues round the south-eastern shore of Lake Kivu. Then gneiss and schists come in which continue northwards as far as the volcanic area. In one place, on the north-eastern shore at which we landed, I found a white fissile rock. [" This rock is very similar to rocks from Abyssinia, which have been referred to sölvsbergite (see Min. Mag., 1900, xii, p. 265), the fissile character being due to the platy arrangement of the felspars. Under the microscope it shows a trachytic felt of small felspar laths with interstitial, minute, ragged patches of a pale-green augite. From its poorness in coloured minerals the rock is best referred to the bostonites."]

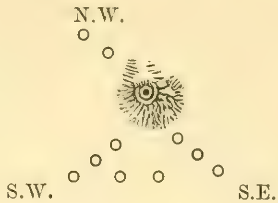
The main eastern range comes down to the lake and extends along the east and north shores as far as Kumchengi, then continuing north; the western range also follows the lake shore and strikes north, forming a valley similar to the Rusisi Valley north of Tanganyika; but this valley of Kivu is filled with lava which has been poured out from several volcanoes, of which two are still active, emitting steam and sulphurous fumes. The larger of these, Kirunga-cha-gongo, is 11,350 feet in height, and the crater is about one and a half miles in diameter at the top. It has been recently eruptive, as can be seen by the streams of lava cutting through the forest.

The lava seems to be extremely scoriaceous everywhere, and has poured down southwards into the lake and northwards almost as far as the Albert Edward. The line of volcanic action seems to be proceeding from east to west, as there are six or seven large extinct cones almost in a line east of this, and the two active ones are at the western extremity.



MAP OF LAKE TANGANYIKA.

Around the large cone, Kirunga-cha-gongo, there are many smaller cones which appear to radiate off along definite lines of weakness. Thus :—



The great Western or Congo Range here consists of granite, gneiss and schists, the schists increasing in proportion as it gets further north, till at the Albert Edward the whole range appears to be composed of mica-schist.

Lake Kivu, whose only outlet is the Rusisi, does not seem to have fallen in level at any time, as there are no signs of old terraces round the shores, and there are many old trees growing close down to the shore, cemented in by a sort of concrete wall formed by spray dashing up on the boulders and pebbles, evaporating and leaving a deposit of carbonate of magnesium. The floor of the lake is in places paved with this deposit.

Generally the lake is deep right up to the shore. It has every appearance of having been formerly simply a river running down the valley northwards into the Albert Edward. The volcanic eruptions then took place in the valley, filling it up with lava and damming up the water, which gradually rose and flooded the banks till it found an outlet south by way of the Rusisi into Tanganyika. The natives call it 'The River.'

A curious point about the water of Kivu is that, unlike ordinary water, which contains a solution of calcium carbonate, it contains a solution of magnesium carbonate. The floor of the lake is paved with what appears to be a precipitate of this substance, and the pebbles and boulders around the shore are cemented with it. There are no dolomites or other magnesium rocks, as far as I could see in the district; therefore the inference is that springs containing magnesium carbonate in solution must be feeding the lake and keeping up a constant supply.

["The quantity of water received and the state of preservation were not such that reliance could be placed on quantitative results, but from analyses made by Mr. J. Hart Smith, A.R.C.S., it is evident that magnesium replaces calcium in the water, the analytical and spectroscopic evidence showing that traces only of calcium salts are present. Fragments obtained from the lake floor, consisting of a calcareous tufa evidently deposited round vegetable *débris*, were analyzed by Mr. W. Robertson, A.R.C.S., and were found to contain CaO 28·65, MgO 12·66 per cent. as the mean of two closely agreeing analyses."—W. E. W.]

Lake Albert Edward is a shallow lake throughout, with a sandy bottom. The natives can pole their canoes nearly everywhere, only occasionally having to resort to paddles. The lake is not in a 'rift' like Tanganyika, but has more the appearance of an overflow.

Immediately north of Albert Edward, at Katwe Fort George, a white volcanic tuff occurs. ["It is on the occurrence of these tuffs round 'crater-lakes' that the idea of considerable recent volcanic activity at the foot of Ruwenzori mainly depends.[1] The present tuff shows signs of stratification, with parallel flakes of biotite and muscovite, so that it has been probably rearranged by water. Microscopic examination shows that it consists by no means wholly of volcanic material. It contains small angular fragments of a biotite-granite or gneiss, oligoclase, quartz, biotite, brown hornblende, pink garnet, and colourless augite. Any doubts, however, which might have been entertained as to the volcanic origin of these 'tuffs' were set at rest by an examination of the tuff collected by Mr. Scott-Elliot, and referred to as No. 96 in the paper already cited. Under the microscope this tuff is seen to be made up mainly of round lapilli, of which the larger ones consist of a mere shell of glassy volcanic material surrounding fragments either of biotite or of a granitic or gneissic rock, which must have been torn from the walls of the vent during the eruption."] Tuffs with crater lakes, hot springs, and cones continue up to Ruwenzori and around the eastern foothills to beyond Fort Gerry. There are salt lakes around Katwe. The foothills of Ruwenzori are composed of gneiss; beyond and above this mica-schists occur, dipping steeply; and still higher, nearer the centre of the mountain, epidiorite[2] is the predominating rock.

The accompanying Figure shows a section of the mountain as approached from the east.

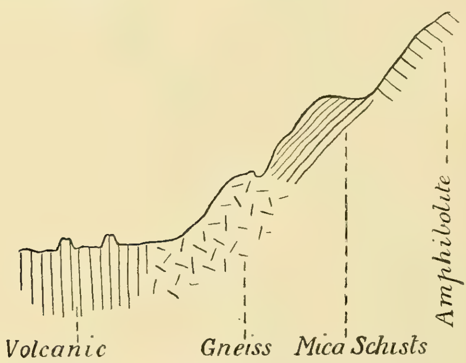


Diagram-Section on the East side of Ruwenzori.

Proceeding eastwards from Toro, the prevailing rock is gneiss as far as Uganda, with occasional dolerite dykes. ["A specimen of these dolerites consists of large ophitic plates of a nearly colourless augite, felspar laths, and large plates of ilmenite; in parts in the interstices

[1] Scott-Elliot & Gregory: Quart. Journ. Geol. Soc., 1895, li, p. 674.
[2] Scott-Elliot & Gregory, l.c.

of the felspars were ophitic plates of quartz. In its quartz contents and general character the rock is strikingly similar to quartz-dolerites (diabases) of the Transvaal (e.g. rock from near Potchefstroom).”] To the west of Lake Victoria sandstones overlie the gneiss and continue round the lake shore for some distance. This gneiss formation is again in evidence on the eastern shore, and continues up the Nandi plateau till the volcanic disturbances from the eastern rift valley occur at Mau.

[“The rocks collected in this volcanic region consist mainly of phonolites and phonolitic trachytes. Most of them contain phenocrysts of anorthoclase and ægirine-augite in a trachytic groundmass of felspar-laths, through which are distributed irregular grains and feathery patches of augite, and of soda-hornblendes closely related to, if not identical with, *Cossyrite* and the *Catophorite* of Brögger. Some of them contain olivine in small amount, and in this respect as well as in their more glassy character approach closely to the pantellerite-like rocks or *Kenytes* of Mt. Kenya described by Gregory.[1] An anorthoclase phonolite from Mau differs from the phonolites on the east side of the rift valley in containing large crystals of a remarkably pleochroic (colourless to deep rose-red) sphene, which appears to have crystallized about the same time as the augite phenocrysts, since in some cases it includes augite and in others is included by that mineral. Besides the phonolites there is also a specimen of andesitic hornblende-enstatite-basalt, somewhat similar in character to the so-called enstatite-porphyrite from Schneidemüllerskopf, Thuringia.”]

North of Lake Naivasha I found a deposit of very pure diatomaceous earth containing fragments of obsidian, and on account of this I imagined it to be a volcanic tuff till Mr. J. J. H. Teall examined it and found it to be full of diatoms. [“The obsidian chips appear to be worked implements similar to those from the same neighbourhood described and figured by Gregory (‘The Great Rift Valley,’ p. 324).”]

The diatomaceous earth has been examined by Mr. Thomas Comber, who finds that it consists of fresh-water species, of which he has identified the following:—

1. *Neidium affine*, Cl., forma major, V. H.
2. *Anomœoneis sphærophora*, Cl.
3. *Diploneis ovalis*, Cl.
4. *Pinnularia acrosphæria*, Rbh.
5. *P. legumen*, Ehr.
6. *Navicula bacilliformis*, V. H.
7. *N. pseudobacillum*, Grun.
8. *N. pupula*, Kutz.
9. *N. Tuscula*, Grun.
10. *N. slesvicensis*, Grun.
11. *N. radiosa*, Kutz.
12. —— var. *tenella*, Breb.
13. *N. mutica*, Kutz.
14. *Cymbella lanceolata*, V. H.
15. *C. cistula*, V. H., var. *maculata*, Kutz.
16. *C. cymbiformis*, V. H.
17. *C. parva*, Cl.
18. *C. leptoceras*, Kutz.
19. *C. turgida*, Greg.
20. *C. amphicephala*, Naeg.
21. *Gomphonema gracile*, Ehr.
22. —— var. *aurita*, Breb.
23. *G. intricatum*, Kutz.
24. *G. subclavatum*, Grun.
25. *G. montanum*, Schum.
26. *Amphora ovalis*, Kutz.

[1] Quart. Journ. Geol. Soc., 1900, lvi, p. 205.

27. *Cucconeis placentula*, Ehr.
28. —— var. *lineata*, Grun.
29. *Achuanthidium lanceolatum*, Breb., var. *dubia*, V. H.
30. *Epithemia gibba*, Kutz.
31. *Epithemia gibba*, var. *parallela*, V. H.
32. —— var. *clavata* (= *E. clavata*, J. L. B., MS. in Coll. R. M. S.).
33. —— var. *ventricosa*, Kutz.
34. *E. zebra*, Kutz.
35. —— var. *proboscidea*, Kutz.
36. *E. sorex*, Kutz.
37. *E. gibberula*, Kutz.
38. *Ennotia incisa*, Greg.
39. *Fragilaria mutabilis*, Grun.
40. —— var. *intermedia*, Grun.
41. *F. construens*, Grun.
42. —— var. *venter*, Grun.
43. *F. virescens*, Ralfs.
44. *Synedra splendens*, Kutz.
45. *S. ulna*, Ehr.
46. *S. oxyrhynchus*, Smith.
47. —— var. *nova*, var. *mesolepta*.
48. *Odontidium mesodon*, Kutz.
49. *Surirella linearis*, Smith.
50. *S. Smithii*, Ralfs (a large form of it).
51. *Nitzschia tenuis*, Smith.
52. *N. amphibia*, Grun.
53. *Stephanodiscus astræa*, Grun.
54. —— var. *spinulosa*, Grun.
55. *Cyclotella Kutzingiana*, Thwaites.
56. *C. operculata*, Kutz.
57. *Melosira granulata*, Ralfs.
58. *M. crenulata*, Kutz.
59. *M. tenuis*, Kutz.

(57–59: These three run into each other.)

60. *M. distans*, Kutz.

My deepest thanks are due to Mr. G. T. Prior, of the British Museum (Natural History), to Dr. Wynne, of the Royal College of Science, and to Mr. Thomas Comber,—to Mr. Prior for his kindness in examining and naming the rock specimens, and in supplying the petrographical descriptions; to Dr. Wynne for chemical analyses of water and rocks, and for the deep interest he has shown in the matter; and to Mr. Comber for his exhaustive examination of the diatomaceous earth.

NOTICES OF MEMOIRS.

I.—THE GEOLOGICAL HISTORY OF THE RIVERS OF EAST YORKSHIRE, being the Sedgwick Prize Essay for the year 1900. By F. R. Cowper Reed. 8vo. London (Clay), 1901, 4*s*. nett.—The selection of the dependence of the watercourses of a country upon its geological structure as the subject of the Sedgwick Essay for 1900, gave Mr. Reed an opportunity of turning out a piece of work on a subject which has not received that attention in this country it has deserved. The district chosen by the author for his investigations has been carefully surveyed and mapped, and due acknowledgment has been made of the work of the Officers of the Geological Survey, and particularly of that of Mr. Fox-Strangways.

Mr. Reed divides his essay into five parts:—(1) General characters of East Yorkshire; (2) Geological structure; (3) Physical history; (4) The present rivers and their relations to the geological structure; (5) The history of the relations of the rivers to the geological structure. His observations are illustrated by maps.

Mr. Reed draws the following conclusions:—"By the preceding examination of the geological and physical evidence we have traced the general outlines of the evolution of the present drainage-system of East Yorkshire through several successive stages, and we find that its history is intimately bound up with that of the whole of Eastern England since Palæozoic times. There are local details still waiting to be filled in and branches of the subject still to be investigated, but it is believed that they will produce no evidence which will contradict the main results here worked out. The division of the physical history of the region since Cretaceous times into six stages or cycles is based on geological evidence which is practically incontrovertible; the assumptions as to the original slope of the surface and the deformation of the peneplain are supported by orographical measurements and geotectonic considerations of great weight, as well as by being in harmony with evidence from other parts of England; and, finally, the theory of consequent and subsequent streams has been established on a firm foundation by Davis and many other workers in the same field. The hypothesis of the secondary origin of the Moorland anticlinal as a watershed more or less parallel to the original consequent streams has been found to afford a natural and satisfactory explanation of the behaviour and characters of the watercourses which it concerns; and the modifications effected by the Glacial Period have been interpreted in most cases from direct field-evidence."

II.—Rocky Mountain Region of Canada.—One of the last labours of the lamented geologist, George Mercer Dawson, was his presidential address, delivered before the Geological Society of America on December 29th, 1900. It appeared in the Bulletin for February. Dr. Dawson took as his text "The Geological Record of the Rocky Mountain Region of Canada." The address was an enumeration of the several formations now known to be represented, a brief description of each, and a review of the main outlines of the geological evolution of the area in so far as it has been made apparent. Dr. Dawson began by giving a sketch of the physiographical features, then he took the various formations in review, and finally gave an excellent account of the physical history of the area.

III.—Age of the Earth.—Professor Joly's paper on the Age of the Earth, discussed by Osmond Fisher in the Geological Magazine for March, 1900, recalled to the memory of M. P. Rudzki a method of estimation which he had published in Petermann's Mittheilungen in 1895. Rudzki has now published his further researches and results in Bull. Ac. Sci. Cracovie (February, 1901). The paper is printed in French.

IV.—A Fossil Crab and other Trails.—*Cancer proavitus*, a new crab from the Miocene greensand of Martha's Vineyard, is described by Packard in Proc. Amer. Ac. Sci., 1900. It resembles the living *irroratus*, and provides material for some general remarks on the phylogeny of the genus *Cancer*. In another paper in the same Proceedings Mr. Packard describes supposed Merostomatous and other Palæozoic arthropod trails, with some notes on those of *Limulus*. He shows that there is a marked difference between the trails of limuloids and isopods, and that while the trail of *Merostomichnites Beecheri* is limuloid, that of *Merostomichnites Narragansettensis* is isopodal.

V.—Shorter Geological Notes.—In his report of progress of the Lausanne Museum for 1900, Professor Renevier calls attention to a fine collection of fossils received by the Museum from M. Rittener, of Sainte-Croix. The collection contains 2,000 specimens, all of which are properly located and zoned.

A skin and two skulls of the new and remarkable mammal, lately discovered by Sir Harry Johnston in the forest on the borders of the Congo Free State, were exhibited before the Zoological Society at their meeting on the 18th June. Sir Harry Johnston's original idea that the animal belonged to the giraffes was endorsed, it having relations with the extinct Helladotheres. It was named *Okapia Johnstoni.*

Gustav Keller has drawn and Dr. Andreae has described six large wall-diagrams of extinct animals. They are—*Rhytina gigas, Elephas primigenius, Triceratops* and *Agathaumas, Megaceros giganteus,* an Ichthyosaur, and a Plesiosaur. They are published by Th. G. Fischer, of Cassel, and can be bought separately at six marks apiece.

In Symons' Meteorological Magazine for June, 1901, are several matters of geological interest. There is a report of the Second Conference for the International Investigation of the Sea and the Air; there is the programme drawn up by the Leeds Committee for proposed Observations on Dew-ponds; and there is a note on the Norwegian Rainfall Service, in which service snow and rain are measured in separate gauges.

The School of Mines and Industries of Bendigo, Victoria, issues an Annual Report for the year ending June, 1900, of 96 pages. The Macgillivray Museum attached to the School pays special attention to mining matters, and the curator asks for donations of books and specimens connected with the subject. The syllabus of examinations is a full one. The Mining Science Society seems to have had a successful year of work.

REVIEWS.

I.—The Caucasus.

Aus den Hochregionen des Kaukasus. Wanderungen, Erlebnisse, Beobachtungen von Gottfried Merzbacher. 2 vols.: pp. xxxviii, 958 and 964, with 246 illustrations and a map. (Leipzig: Duncker & Humblot.)

HERR MERZBACHER has observed the Horatian rule of keeping a book in the desk for nine years, because the journey of which this is the fruit was undertaken in the Summer and Autumn of 1891. He was accompanied by the well-known Alpine climber, Herr L. Purtscheller, who, however, returned rather before his friend, and by two guides from Kals. Though the weather at times was unpropitious they succeeded in ascending several important peaks, such as Elbruz, Tetnuld, Dongus-orun-Jusengi-Baschi, a mountain as difficult as its name, its companion Sulukol-Baschi, Dschanga-tau, Kasbek, Gimarai-Choch, and others, besides an unsuccessful attempt on Uschba, the Matterhorn of the Caucasus—sixteen peaks in all, ranging in height from 13,000 to over 18,000 feet—together with other excursions during a journey along the greater part of the chain from west to east. After giving some account of his expeditions in the publications of the German-Austrian Alpine Club for 1892, Herr Merzbacher has worked up the material into two bulky volumes. His book must be the outcome of great and assiduous labour, for he has apparently made himself master of the literature of the Caucasus, or at any rate of all that is accessible. He describes the physical characters, geology, glaciers and glaciation, the meteorology, and the ethnology of this great mountain chain, which, unlike the Alps, is more of a bridge than a barrier between the east and the west. He might apply to the Caucasus the well-known epigram "what there is to know I know it," and he places this at the disposal of his reader. The present work differs mainly from the two handsome volumes published by Mr. Douglas Freshfield in 1896 in that it is written more definitely from the scientific point of view, and thus is practically a monograph on the Caucasus. Both works contain good maps and are enriched with numerous illustrations, but those in the one before us, though in many cases excellent, hardly succeed in reaching the level of the best in Mr. Freshfield's book.

To do justice to Herr Merzbacher's work would require an essay, so that it must suffice to notice a few points of special interest to geologists. In the main the author accepts the conclusions in regard to the structure, orography, and geology of the Caucasian chain which I expressed in an appendix contributed to Mr. Freshfield's book. As a mountain system the Caucasus is more elevated, but less complex in structure than the Alps. The author has drawn up a list of the principal peaks in each, which demonstrates that those in the Caucasus tower above their bases (like Mont Blanc above Chamonix) fully a thousand feet, and sometimes considerably more, than those in the Alps; the crest of the chain also is more elevated, and conspicuous gaps, at any rate in the western half, are fewer. The average height of the snow-line in the Caucasus is 7,690 feet on the north side, and 7,950 feet on the south, though on the former a glacier comes down to 5,791 feet and on the latter to 5,325 feet, but on taking an average of nearly twenty in each case, those on the north side, as might be expected, descend lower by about 240 feet. On two points Herr Merzbacher inclines to differ from me. The mention of some important conglomerates in beds of Miocene age led me to infer that the Caucasus, like the Alps, had been produced by two sets of earth-movements, the mountain chain being due mainly to the former, the eruptions to the latter. He refers the whole to a single set of movements corresponding with the later or Pliocene age. Again, I thought it more probable that the mountain-making thrusts had come from the north; he gives them an opposite direction. Much may be said on both sides, but so far as I can see, instead of bringing forward any new evidence he contents himself with calling my opinion "rein theoretisch," forgetting to remark that I carefully stated this to be an hypothesis which, with one or two more, was advanced as being, in my opinion, "the most probable interpretation of such facts as have been ascertained."

Herr Merzbacher collected a fair number of geological specimens, which are minutely described by Dr. L. von Ammon in an appendix. The latter separates them into four groups: (I) the Archæan rocks of the Central *Massif*; (II) diabases and contact rocks from Gimarai-Choch to Kasbek; (III) black shales or slates,[1] and sandstones; (IV) younger eruptive rocks. He also has given a note on some sinter from the hot springs of Saniwa. (I) Additions have been made to the detailed knowledge of the Central *Massif* even since the publication of Mr. Freshfield's volumes, and now Dr. von Ammon describes specimens collected from some of its important summits. Among them is a gneiss, with two species of mica, from Dongus-orun; the rocks on the upper part of this mountain are mostly granitic, and Dr. von Ammon thinks the gneissic character of this specimen may be due to pressure. Next come a white granite, containing, however, some scales of biotite (passing into a chloritic mineral) from Uschba: a biotite granite from Sulu-kol-Baschi; granite with two micas from Tetnuld: green-speckled white granite from Dschanga-tau (these three being the highest rocks on the peaks) with a chlorite epidote schist and a quartzose epidote rock from the last-named mountain, a rather fine-grained green-speckled granite from the peak of Sugan-Tau, and a diabasic rock from that of Tepli. The localities rather than their petrographical character give an interest to all these. So it was with the few which I examined for the late Mr. Donkin in 1887. (II) Gimarai-Choch, 15,676 feet high, lies rather more than five miles to the west of Kasbek. The rock of the actual peak is a diabase, which has been minutely examined, but seems not to be specially interesting, except that a little quartz is present; varieties of the same rock were brought from a rather lower level, on one of which were some glass splashes, doubtless due to lightning; a schalstein or diabase tuff was obtained rather more than 300 feet below the peak, and specimens of sedimentary rocks (*hornschiefer* and *schieferiger hornfels*), probably members of the next group, were also obtained on this mountain. (III) Dr. von Ammon separates these (sedimentary rocks) into three groups: (*a*) the first, dark *schiefer*, he assigns, for reasons presently to be given, to the Jurassic system; (*b*) the second, also black *schiefer*, from the Pirikitelisch range in the Eastern Caucasus and from Daghestan; (*c*) those from Laila. They have been carefully studied, for doubt has been expressed as to their geological age. Favre claimed to have identified *Bythotrephis* in some, and assigned these to the Palæozoic era. This identification, however, has been disputed, so that further evidence is desirable. Most of Herr

[1] The ambiguous word *schiefer* is used. Perhaps some day Continental geologists will put an end to a long-standing confusion by using one term for a cleaved, another for an uncleaved rock. Here, I expect, the rocks are commonly slates.

Merzbacher's specimens are unfossiliferous, while some of the dark *schiefer* contain numerous rutile needles; this, however, is not conclusive, and on the whole Dr. von Ammon is disposed to refer them to the Jurassic period, to which one sandstone, from its fragments of echinoderms, almost certainly belongs. But Herr Merzbacher speaks in his narrative of *schiefer* which he regarded as more ancient, so it is very possible (as I pointed out in 1896) that these dark rocks may be, some of Mesozoic, some of an earlier date. (*c*) The rocks of Laila come next, with which we may consider (*a*) already mentioned. Laila (13,400 feet) is a peak to the S.S.E. of Elbruz, but on the opposite side of the watershed. On it Signor Sella in 1889 found some fragments of crinoids. These, as was explained in the appendix to Mr. Freshfield's book, were considered by Mr. Bather and Dr. Gregory to resemble most nearly *Balanocrinus*, a subgenus of *Pentacrinus*, of late Cretaceous or Tertiary age, while Herr Merzbacher, both then and now, placed them very near *Extracrinus subangularis*, a Liassic species. Dr. von Ammon, after examining some other specimens collected by his friend, agrees with him in the identification and in referring the rocks to the Lias. Fossils were also obtained at a spot in the heart of Daghestan between Tindi and Akuada. Among them are joints of a pentacrinus, which Dr. von Ammon figures, assigning it to a new species, *P. Merzbacheri*, which is near to *P. pentagonalis* (Goldf.), and very probably belongs, like it, to the Callovien, or, at any rate, the Middle Jura. A pecten was also found, which closely resembles *P. personatus* (Goldf.), also a Jurassic form. Hence the upper part of Laila is more probably composed of Jurassic than of Cretaceo-Eocene rocks. (IV) With the younger eruptive rocks comes a specimen from the western summit of Elbruz, obtained possibly at a slightly greater elevation than that which I examined.[1] Dr. von Ammon seems to think my description too brief, but I believe that I omitted nothing of importance, and doubt the utility of enlarging on trivial details. His specimen, however, contains a little hypersthene[2] and quartz, both of which are absent from mine. The rock of which he gives an analysis contains 63·80 of SiO_2, with a rather high percentage of alkalies, viz. $Na_2O = 5{\cdot}47$ and $K_2O = 3{\cdot}26$, but is not otherwise remarkable; very probably the two specimens represent slightly different ejections. He expresses a doubt whether this peak is a broken crater, but the descriptions of earlier visitors (a violent gale gave Herr Merzbacher little opportunity of making observations) seem favourable to the idea. In any case he regards the volcano as comparatively modern, thinking it may have continued its eruptions even into the Glacial Epoch. The remaining specimens, three in number, come from Kum-tube, a mountain rising from the Tschegem-thal on the northern side of the watershed, some thirty miles east of Elbruz. The volcanic rocks, which have been already

[1] Proc. Roy. Soc., 1887, vol. xlii, p. 318.

[2] I have again examined my slice, but though a pyroxene is certainly (I said possibly before) present in grains of rather variable size, most at any rate give an oblique extinction. But I think it may also contain about two flakelets of biotite.

noticed by Abich, break through and alter Jurassic sediments. Some of them are hypersthene-augite andesites (the former mineral dominating markedly in two specimens)—that on the summit distinguished by the epithet *vitrophyrischer*—and another is a hornblende-biotite-dacite. These accordingly seem to be nearly related to the volcanic rocks of Elbruz and Kasbek, and to belong to the same group as those of Ararat.

We have dwelt chiefly on the petrology, because that has received such close attention, but valuable geological information is introduced into the narrative throughout the book. Herr Merzbacher, however, does not forget to notice the physical geography, the natural history, the inhabitants of the various districts, their dress, accoutrements, architecture, and habits of life. All these are abundantly illustrated by reproductions of photographs, which are valuable to the ethnologist, and will be more so in the future, as the distinctive characteristics of tribes once isolated by the obstacles of a mountain region disappear before the advance of European civilization. The book, in fact, is a monument of laborious research and a perfect mine of information, which will be useful alike to the mountaineer, the traveller, and the scientific student.

T. G. Bonney.

II.—Silurian Crinoids of Chicago.

The Paleontology of the Niagaran Limestone in the Chicago Area. The Crinoidea. By Stuart Weller. Bull. Nat. Hist. Survey Chicago, IV, part 1, 153 pp., xv pls., and text-figures; 27 June, 1900.

THE Crinoids of the Niagara Limestone of the Chicago region, including south-eastern Wisconsin, have been the subject of publications by Winchell & Marcy, James Hall, and S. A. Miller. Nevertheless the amount written was by no means proportional to the size of the fauna, and a large number of species escaped notice even in Wachsmuth & Springer's great Monograph of the North American Camerata. This has not been due to want of material, for the collections of these fossils are many and rich, but to their unattractive appearance as, for the most part, internal casts of the theca alone in a coarse dolomite. Gratitude and praise are therefore due to the energetic instructor in palæontology at the University of Chicago, Dr. Stuart Weller, for the trouble that he has taken in deciphering this unpromising material and for presenting the results in this clearly written and clearly illustrated memoir.

The results are of wider interest than might have been anticipated. It was hardly to be expected that Dr. Weller should discover new facts of morphology, nor has he done so. But the Crinoidea, perhaps to a larger extent than the other elements of the fauna, shed much light on the problems of distribution. They are represented by no less than 69 species (Dr. Weller says 68), classified as follows:—Monocyclica, Inadunata, *Stephanocrinus* 1 sp., *Myelodactylus* 1 sp., *Zophocrinus* 1 sp.; Adunata, *Platycrinus?* [probably one of the

Coccocrininæ] 1 n.sp., *Marsipocrinus* 1 n.sp.; Camerata, *Melocrinus* or *Mariacrinus* (the evidence of the fixed brachials suggests the former genus to Dr. Weller, but to me the latter) 1 sp., *Macrostylocrinus* 4 spp. of which two are new, *Corymbocrinus* (i.e. *Clonocrinus*) 2 n.spp., *Eucalyptocrinus* 13 spp. of which three are new, *Callicrinus* 9 spp. of which four are new, the allied *Chicagocrinus* n.g. with 2 n.spp., *Periechocrinus* 7 spp. of which one is new; Dicyclica, Inadunata, *Amplheristocrinus* 1 n.sp., *Cyathocrinus* 3 spp. of which one is new, *Crotalocrinus* 1 n.sp., *Botryocrinus* 1 sp.; Flexibilia, *Pycnosaccus* 1 n.sp., *Lecanocrinus* 2 spp., *Ichthyocrinus* 1 sp., and the doubtful *Gazacrinus* 2 n.spp.; Camerata, *Thysanocrinus* (i.e. *Dimerocrinus*) 4 spp., *Cyphocrinus* 1 n.sp., *Lampterocrinus* 4 spp. of which three are new, *Siphonocrinus* 3 spp., *Archæocrinus* 1 n.sp., *Lyriocrinus* 1 sp. Thus this region "contains, next to the Island of Gotland . . . a larger number of species of crinoids of this horizon than any similar region in the world, so far as is known at the present time." Dr. Weller credits Gotland with 172 species; but, as he rightly says, "these are not all associated in the same stratum." There are probably more than 69 species in bed *f* of Gotland, but fewer in bed *d*, which latter alone corresponds to the Niagaran. Failure to recognize this vitiates the contrast of "only six species of inadunate crinoids in the Chicago fauna against 40 in Gotland," for bed *d* has yielded only two Inadunate species, whereas I, with the classification given above, find nine in the Chicago fauna. In this connection it is interesting to note that bed *d* in Gotland is characterized by abundant Eucalyptocrinidæ, Dimerocrinidæ, and Periechocrinidæ, and that these are the families most largely represented in the Chicago area. The really interesting point, however, is that the crinoid fauna of this area, and indeed the Silurian fauna of the Mississippi valley generally, is related to the contemporaneous fauna of north-western Europe more closely than to the neighbouring New York fauna. The present memoir describes species of *Crotalocrinus*, *Pycnosaccus*, and *Corymbocrinus* (i.e. *Clonocrinus*), genera hitherto known only from England and Scandinavia, if we except a few *Crotalocrinus* stems from Arctic America. Dr. Weller, from the consideration of this and other evidence, concludes that the connection was by way of a "North Polar sea with a great tongue stretching southward through Hudson Bay to about latitude 33°. . . . At the latitude of New York there was a bay reaching to the eastward, in which the Silurian sediments of the New York system were deposited." Labrador, Greenland, and Scandinavia formed a more or less continuous land mass, around which another tongue of the northern sea extended south into Europe. In this connection Dr. Weller raises an imaginary difficulty by saying that "in western Russia the Silurian strata are not exposed"; they are indeed not so fully developed as the Cambrian and Ordovician, but they do occur, and are also found on the mainland of Sweden and Norway and in Belgium, countries in which Dr. Weller's map does not indicate them. These corrections of course do but strengthen Dr. Weller's suggestion; but it remains no more than a suggestion, to be confirmed or rejected when our knowledge of Silurian faunas is far greater than it now is. A remembrance of the numerous local variations in the character of the Silurian faunas, and of the sporadic distribution of many genera, especially among crinoids, should make us exceedingly cautious. It is well, however, to keep these broad questions before our minds, since they emphasize the need for the most detailed systematic description and the most exact collecting.

In view of the importance of correctness and exhaustiveness in work of this nature, it may be as well to remedy a few slips and omissions that have very naturally crept in, as well as to make a few minor suggestions. Dr. Weller gives a Bibliography of Silurian Crinoidea, believed to be nearly complete so far as American literature is concerned. It does not, however, contain the names of F. de Castelnau, E. J. Chapman, T. A. Conrad, B. F. Shumard, R. P. Whitfield, or L. P. Yandell; nor is there reference to J. Hall's paper in *Trans. Albany Institute*, x, p. 57, or to Beachler's notes in the *American Geologist*, vii, p. 178, and ix, p. 408. Reference to J. W. Salter's appendix to Sutherland's "Journal," 1852, might give Dr. Weller more information about Arctic American crinoids, while he might be interested in a note of my own on *Brachiocrinus* (*Amer. Geol.*, xvi, p. 213). Neither that genus nor its unique species is mentioned in his very useful list of Silurian Crinoids, which also lacks my *Botryocrinus decadactylus* and *B. ramosus*. A stranger omission is that of *Hapalocrinus retiarius* (Phillips, as *Actinocrinus*). *Hapalocrinus*, which is due to Jaekel, is, as one anticipated, confused with *Haplocrinus*, Steininger. Dr. Weller does not, of course, intend his list as authoritative on nomenclature; but it is as well to point out that *Cyathocrinus capillaris*, Phillips, is a *Gissocrinus*, that *Poteriocrinus dudleyensis*, Austin, is at all events not a *Cyathocrinus*, that *Pisocrinus milligani*, Mill. & Gurl., is synonymous with *P. quinquelobus*, Bather, and that *Pycnosaccus ornatus*, Weller, is apparently a *lapsus calami* for *P. americanus*, Weller. I may further take this opportunity of stating that *Arachnocrinus, Callicrinus, Calpiocrinus, Cordylocrinus, Desmidocrinus, Hapalocrinus, Lyriocrinus, Mariacrinus, Patelliocrinus, Pycnosaccus, Stephanocrinus*, and perhaps other genera, are represented in the Wenlock Limestone or Wenlock Shale of England, although not so indicated in Dr. Weller's list of genera (in some cases through inadvertence). This substantiates the criticism that Dr. Weller's comparative census is, through no fault of his, a little too "previous."

The memoir contains a general account of crinoid structure which should be useful to those for whom it is intended. But is it quite safe to say that the food-supply of a crinoid is increased by its stationary position? The assertion seems to ignore the locomotive power of those crinoids that are not attached as well as the action of ciliary currents. At any rate it is misleading to describe *Carabocrinus* as "a very simple crinoid whose dorsal cup consists entirely of three circles of plates." The definition of the terms 'proximal' and 'distal' applies only to the dorsal elements; for ventral elements the centre of reference is the oral pole. Figure 13 is labelled *Pisocrinus flagellifer*, a name that is a synonym of *P. pilula*. Fig. 14 is labelled *Cyathocrinus ramosus*, just as all text-book writers persist in labelling it, although in 1893 I proved that the specimen belonged to *C. longimanus*.

The descriptions of the species are clear, but comparison would have been facilitated had the author been at the pains to construct diagnoses; while the labours of his successors might have been lightened had he fixed on type-specimens for his new species and told us in what collections such specimens were preserved. A few minor points also need elucidation. Thus, the description of the arms in *Cyathocrinus cora* does not seem to me to agree with Figs. 8 and 9; since this is the most striking feature of the species, enlarged drawings should have been given. The diagram of *Amphcristocrinus* on p. 67 seems to agree with the new species *A. dubius* rather than with *A. typus*; but this is misleading. The arms of the new species *Lampterocrinus dubius* are said to differ from those of typical species "in having no brachial plates of higher order than the costals," or primibrachs; but since the arms are not preserved, it is hard to see how this can be proved. *Archæocrinus* has hitherto been recognized only in the Trenton Limestone, but a species *A. depressus* is here described, although the elevated median series of anals is not characteristic of the genus. The new species described as *Platycrinus* (?) *dubius* shows no sign of the large interradials usual in that Carboniferous genus, and is more likely to be a *Coccocrinus* or *Cordylocrinus*. Dr. Weller says that for most of his generic descriptions he is largely indebted to the publications of others. It is therefore not clear how much weight is to be attached to his accounts of *Gazacrinus*, *Stephanocrinus*, and *Zophocrinus*, all genera about which fresh information was badly wanted. Dr. Weller's own palæontological work has been quite enough to justify him in publishing his own opinions and descriptions, and such a course would more advance science and would fix the responsibility for certain doubtful statements.

Dr. Weller's further studies in the palæontology of the Niagaran Limestone of Chicago will be awaited with interest. They are likely to fulfil the promise of this first one, and perhaps if the author will take a friendly hint or two they will meet with an even more favourable reception. F. A. Bather.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—June 5th, 1901.—J. J. H. Teall, Esq., M.A., V.P.R.S., President, in the Chair. The following communications were read:—

1. "On the Passage of a Seam of Coal into a Seam of Dolomite." By Aubrey Strahan, Esq., M.A., F.G.S.

The author was informed by Mr. N. R. Griffith in 1900 that the Seven-Feet Seam of the Wirral Colliery had been found to pass into stone of an unusual character. For a distance of 1,600 yards from the shaft this seam was good, and about 4 feet thick. A little farther in, bands of stone from 1 to 10 inches thick made their appearance in it, and, gradually increasing in thickness, these bands eventually constituted the whole seam, the last traces of workable coal disappearing at 250 yards from the point where the change first began. The boundary of the barren area has been found for a distance of 1,480 yards, and it runs north and south. The stone is at first black, but after weathering it becomes grey, and displays curious structures, among which are pisolitic or mammillated structures, the intervening spaces being filled with coaly matter. One specimen displays woody tissue filled with dolomite. Analyses by Dr. W. Pollard yield from 18·5 to 13 per cent. of magnesia. The phenomena are not those of a 'wash-out,' as there is no sign of erosion, but there is proof that the dolomite was formed in almost motionless water, and the conditions appear to have been those under which a tufa would form. It appears to have been formed on a spot to which clastic material scarcely gained access, and which was reached even by vegetable matter in scant quantity and in a finely divided condition.

2. "On some Landslips in Boulder-clay near Scarborough." By Horace W. Monckton, Esq., F.L.S., V.P.G.S.

In 1893 Mr. Clement Reid drew attention to a foliated structure developed in Drift at Beeston, near Cromer (Proc. Geol. Assoc., vol. xiii, p. 66), and soon afterwards the present author noticed examples of a very similar character in Boulder-clay on the Yorkshire coast. The Clay forms much of the cliffs, and slips, large and small, are very frequent. When the Clay is dry, vertical cracks forming a sort of columnar structure occur, and the Clay breaks away in lumps, while a moister condition causes flow, producing more or less horizontal flow-structure which, as in the Cromer case, has the appearance of irregular bedding. The author illustrated his remarks by photographs of the cliffs taken by himself.

II.—June 19th, 1901.—J. J. H. Teall, Esq., M.A., V.P.R.S., President, in the Chair. The following communications were read:—

1. "On the Use of a Geological Datum." By Beeby Thompson, Esq., F.G.S., F.C.S.

A proper interpretation of geological phenomena frequently requires that allowance shall be made for differential earth-movements that have taken place since the period under consideration. Present differences of level in rocks of the same age may be due to actual differences in depth of the sea-floor on which they were deposited; but they may also be the result of subsequent differential earth-movements. The rock selected as a datum should combine as far as possible the following characteristics:—It should be thin, of considerable horizontal extension, having similarity in physical characters and palæontological contents over a large area, and situated as near as possible, in vertical sequence, to the reference deposit. In Northamptonshire three formations meet these requirements—the Rhætic beds, the Marlstone Rock-bed, and the Cornbrash. The author applies the Marlstone rock-bed as a datum to the study of the five chief deep explorations in Northamptonshire, with the following results :—While the old land-surface (below the Trias) now varies in height by more than 250 feet, the variation in thickness of the rocks between it and the Middle Lias only reaches 56½ feet; and although the old land-surface is actually lowest where the Rhætic rocks have not been detected, when compared with the position of the Marlstone it is found to be the highest. The further application of the same method enables the author to recognize Rhætic rocks at Northampton, to correct the record of the Kingsthorpe shaft, and to explain the presence of Triassic saline water in the Marlstone. A revised section of the Kingsthorpe shaft is given. Another point proved is that a general levelling-up process was going on just before the beginning of the Lower Liassic Period, and another at the close of the Middle Liassic Period.

2. "On Intrusive, Tuff-like, Igneous Rocks and Breccias in Ireland." By James R. Kilroe, Esq., and Alexander McHenry, Esq., M.R.I.A. (Communicated by R. S. Herries, Esq., M.A., Sec. G.S., with the permission of the Director of H.M. Geological Survey.)

Many fragmental igneous rocks, although resembling tuffs, cannot be regarded as ejectamenta on account of their character and mode of occurrence in the field. Rocks of this type occur to the east of Lough Eake in Donegal, in the district of Forkhill in Armagh, at Blackball Head in Cork, in Waterford, near Arklow, in Wexford, and elsewhere. Sometimes they consist of partly fused and broken-up felspathic mica-schist merging into felsite-dykes, at other times of brecciated slate, granite, and felsite embedded in a scanty andesitic matrix. At Blackball Head the rocks cross the bedding of the associated sedimentary rocks of the region. The authors agree with Professor Lapworth in considering it possible that "igneous matter making its way between the moving masses may consolidate as sills when the pressure is great. . . . As movement progressed intermittently, we should have the formation of subterranean agglomerates, tuffs, and breccias, which would be forced sometimes between bedding-planes, sometimes into dyke-like fissures." A series of sections is exhibited to illustrate how tuff-like masses invade black slate of Llandeilo age in the south-east of Ireland, generally adhering to the direction of bedding, but frequently cutting across it and detaching numerous pieces from the slate, which are more abundant near the margins of the intrusion than elsewhere. The masses frequently assume a tuff-like appearance. At Arklow Rock tongues of tuff-like rock penetrating black slate of Llandeilo age contain pieces of limestone of Bala age, as well as pieces of the slate. The development of vesicular texture in lapilli-like, contained, fragments may be due to the simple release of pressure.

CORRESPONDENCE.

SUARDALAN, GLENELG.

Sir,—At a recent meeting of the Geological Society, after the reading of Mr. G. Barrow's communication on the supposed Silurian Rocks of Forfarshire, Sir A. Geikie alluded to similar rocks which have been found elsewhere along the Highland Border, and (as reported) he gives to me the credit of having found these rocks in the district lying between Loch Lomond and Callander.

The credit of this discovery does not belong to me, but to my friend and former colleague, Mr. J. R. Dakyns. I merely completed the mapping of the rocks alluded to after Mr. Dakyns left Scotland.

Glenelg, *June* 19, 1901. C. T. Clough.

OBITUARY.

RICHARD HOWSE, M.A.

Born 1821. Died 1901.

All visitors to Newcastle-upon-Tyne on the occasion of the last meeting of the British Association there, in 1889, remember the large and, in some respects, unique collections displayed in the fine and spacious new building known as the "Hancock Museum." Older visitors will also remember the same collections housed, or rather hidden away, in the cramped and crowded old Natural History Museum at the other end of the city. All must have carried away a pleasing recollection of the handsome, dignified and, latterly, venerable naturalist who was the loving and somewhat jealous guardian of the scientific treasures in both places. Mr. Richard Howse had for so many years been identified with these collections, had for so long watched over, exhibited, and described their rarities, that he had come to be regarded, as it were, as the one living being amongst the multitudinous dead things around him, and it is difficult to think of them bereft of his animating presence. Mr. Howse was no ordinary Curator. Born in Oxfordshire in 1821, much of his boyhood was spent in collecting the land and fresh-water shells, the birds and eggs, and especially the fossils which abound round Thame, his native place. At a very early age he came and established himself as a schoolmaster at South Shields, and from that time—for some sixty years—his residence in the North of England was unbroken. From the moment of his arrival on Tyneside he made the study of the natural objects of the land and sea about him the main purpose of his life. To his extraordinary activity as an observer and collector all the scientific publications of the North bear witness. His name is to be found repeatedly quoted in—I think I may say—*every* one of the many lists of plants, animals, or fossils which make the Transactions of the Newcastle and Berwickshire Societies so valuable as sources of accurate reference. He was fortunate in coming at a time when

Dr. Johnston of Berwick, Albany Hancock, and Joshua Alder were working out the Invertebrates of the North-East coast, when the materials for Baker's "Flora" were being accumulated by Watson, Bowman, Wailes, and Oliver, when George Tate of Alnwick was classifying the Lower Carboniferous rocks of North Northumberland, and William Hutton, with Lindley and Witham, was bringing out his Fossil Flora, when King was beginning his Permian work, when Bold was cataloguing the insects of the district, and when John Hancock and Hewitson were studying its birds and their eggs. Mr. Howse was a fellow-worker with all these men and, later, with Atthey, Norman, Hodge, Embleton, Kirkby, Duff, Dinning, the two Bradys, and others of whom some are still with us. He botanized, geologized, dredged, collected fossils, and all things—in a universal way almost appalling to a modern specialist. Moreover, in geology he was by no means a mere collector, for he did a considerable amount of original mapping—as in Weardale and in Redesdale—long before the Geological Survey had entered upon the ground. Chiefly in order to be nearer the Museum and the Library of the Literary and Philosophical Society he after a few years removed from Shields to Newcastle, where he opened another private school, in which many of the present leading men of the North were educated—including, I believe, the actual senior Member for the city. When Dr. King left Newcastle Mr. Howse succeeded to the Curatorship of the Museum, still keeping school, however, and devoting only what time he could spare to the collections. But this was for a short period only, and in the seventies he was able to relinquish teaching and give his whole time to the Museum. The removal of the specimens, many of which had scarcely been unpacked before for lack of room, and their entire rearrangement in the Hancock Museum (largely due to the liberality of the late Lord Armstrong, and opened by the Prince of Wales in 1884), were carried out by him with the assistance of his well-known and capable lieutenant, Mr. Joseph Wright. Curating was not his only work: he was *ex-officio* editor of the joint Transactions of the Natural History Society and Field Club, and also for many years one of the Honorary Secretaries of the latter.

Mr. Howse's publications were far too numerous to be fully detailed here. Amongst the most important must be mentioned an admirable Synopsis of the Geology of Northumberland and Durham, written jointly with Mr. Kirkby for the use of the British Association in 1863; a Catalogue of Permian Fossils, with a later Supplement, which gave rise to a lively priority dispute with Dr. King, whose own "Catalogue" appeared almost on the same day as Mr. Howse's; a Catalogue of the Hutton Collection of Fossil Plants; one of the local Carboniferous Fossils in the Museum; another of the Fishes, etc.; and some joint palæontological papers with Albany Hancock and others. Of purely geological memoirs two—one on the Boundary between the Millstone Grit and the Carboniferous Limestone Series and the other on the Divisions of the Drift in the North of England—were of special value.

Mr. Howse's writings on geology and palæontology, however, do not represent a tithe of the results of his labours. He overflowed with information, but was slow to publish. Much of his knowledge has died with him, since he does not appear to have left any manuscript notes of consequence. Many undescribed specimens remain in safe keeping which it had been his intention to describe, and which are still, of course, available for study.

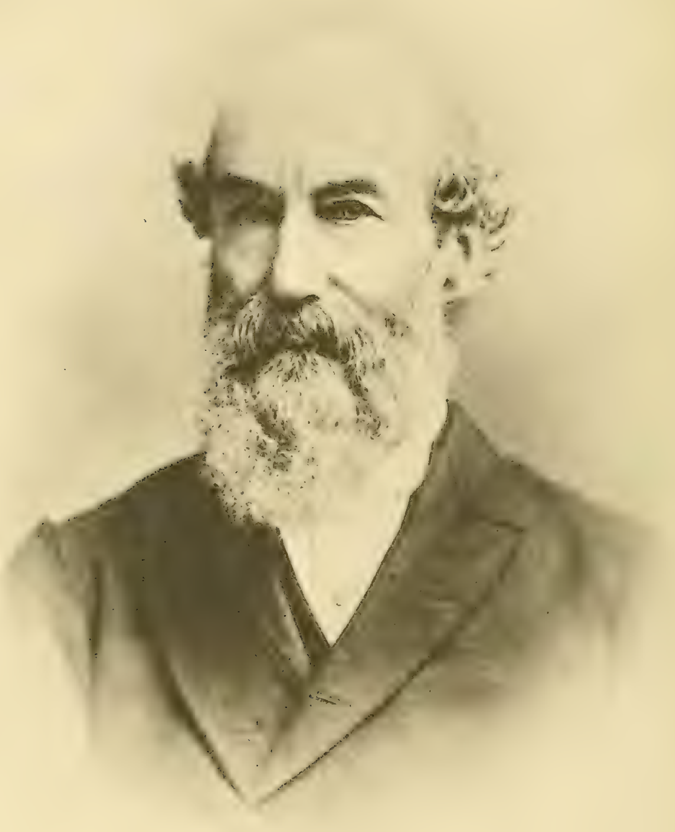
Mr. Howse was essentially a practical and original worker, and a willing helper to other workers. His kindness to all in whom he saw even the slightest trace of the great love of Nature which was his own most striking characteristic was unfailing. Coupled with this was a sensitiveness which sometimes led him into controversies such as that with Professor King already referred to, and a constitutional shyness which prevented him from taking any prominent part on public occasions. It is pleasant to think that notwithstanding this he was gratified towards the close of his active and useful life by the award of an honorary degree by the University of Durham.

G. A. Lebour.

JOSEPH LE CONTE.

Born Feb. 26, 1823. Died 1901.

Joseph Le Conte was born in Liberty Co., Georgia, Feb. 26th, 1823. He was a descendant of a French Huguenot who towards the end of the seventeenth century emigrated to New Rochelle, New York. His grandfather removed to Georgia before the revolution. His father, Louis Le Conte, was a graduate of Columbia College. Joseph graduated at Franklin College, Georgia, in 1841, and at the New York College of Physicians and Surgeons in 1845. After practising for a short time at Macon, Georgia, he went to Cambridge, Mass., where he studied under the elder Agassiz, whom he accompanied in 1851 on an exploring expedition to Florida. After graduating at the Lawrence Scientific School in Cambridge he was for a few years Professor of Natural History and Geology in Franklin College, and from 1856 to 1869 Professor of Chemistry and Geology in South Carolina College. In 1869 he was appointed Professor of Geology and Natural History in the University of California, a post that he held from that time until his death. In 1892 he was President of the American Association for the Advancement of Science, the meeting being held that year at Rochester, New York. He wrote a series of papers on Monocular and Binocular Vision, but his more important works deal with Natural History and Geology. In 1874 he issued his book on "Religion and Science; a series of Sunday lectures on the relation of natural and revealed religion," and in 1888 his work on "Evolution: its history, its evidences, and its relations to Religious thought." He published several papers on Physical Geology; of these his essay entitled "A theory of the formation of the great features of the earth's surface" deserves to be specially mentioned. His "Elements of Geology" appeared in 1878, and a revised and enlarged edition in 1882.



Yours very truly.
T. G. Bonney

THE

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ORIGINAL ARTICLES.

I.—Eminent Living Geologists: The Rev. Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S., F.S.A.

(WITH A PORTRAIT, PLATE XIV.)

THOMAS GEORGE BONNEY was born July 27th, 1833, at Rugeley, Staffordshire. His family is of Huguenot origin, and thus affords yet another instance of the remarkable intellectual enrichment of our country which resulted from the religious persecutions in France. His father, the Rev. Thomas Bonney, son of the Rev. George Bonney, vicar of Sandon, and sometime Fellow of Jesus College, Cambridge, was a man of wide and varied interests, and a hard worker, in spite of feeble health; he was master of the Grammar School, Rugeley, and for many years 'perpetual curate' of Pipe Ridware, a very small parish about five miles from Rugeley. The church was rebuilt through his efforts, and he took great interest in primary education, acting for some time informally as Inspector of Schools in the Diocese. He married a daughter of Edward Smith, a Staffordshire man of independent means, and died in 1853, leaving a widow and ten children, of whom Professor Bonney, then just entering upon his second year at Cambridge, was the eldest. The family inherited some property, but the income it afforded was small for the education of so many.

Professor Bonney's inclination towards natural science was to a great extent inherited; both father and mother were keen botanists and had a general love for natural history, which was shared by all their children. The boys were great collectors of eggs, butterflies, moths, and beetles; but in Professor Bonney's case a special inclination towards geology was first aroused by the gift of some fossils from a relative, a lady who was herself a good geologist, a friend of Buckland, Sedgwick, and others of that generation. Some four years later — he would then be a boy of about 14 — he visited Filey with his father and mother, and collected fossils there, so that when, soon after, he went to school at Uppingham he was already bitten.

Of course, no Natural Science was taught at school in those days, but in compensation football and cricket were then regarded merely as recreations and had not attained to their present tyranny, so that the boys were free to take country walks, and were even rather encouraged to do so. Here, then, was an opportunity for fossil-collecting, and though none of the other boys were geologically-minded, several of them were egg-collectors, and as Bonney was that too, his occasional search for fossils was excused as an amiable weakness. Before he left, Bonney was head of the school, and in 1852, having obtained a School Exhibition, he went to Cambridge, entering at St. John's College, where he was fortunate enough to obtain a scholarship at once.

His school-teaching had been chiefly classical (of the Oxford stamp), but he owed to two of the masters a real liking for mathematics, and the Headmaster had given him a taste for literature. While at Cambridge the famous 'Coprolite' pits of the Cambridge Greensand began to be opened, and Bonney was amongst the earliest to collect from the rich and remarkable fauna they revealed. As he was reading for both the Mathematical and Classical Tripos there was naturally no time for attending lectures on science, yet the fame of Sedgwick drew him now and then within the walls of the geological lecture-room, and he had the privilege of hearing the 'old man eloquent'; but a regular course of geological or other science lectures he never attended, and hence to some extent no doubt the individuality and independence of his systematic views. Professor Bonney took his degree in 1856; he was 12th Wrangler, and 16th in the second class of the Classical Tripos. He had proposed to read for the Theological Tripos, but his health failing, he left Cambridge and spent part of the summer at Weymouth and Freshwater, when he made his first acquaintance with the Tertiary fossils of the Isle of Wight; the rest of the Long Vacation was spent in Switzerland. The complete change restored his health, and while abroad he accepted an offer of the Mathematical Mastership at Westminster School. The laborious task of teaching now had the chief claim on his attention, but still left opportunities of leisure, especially during vacation, which Bonney made the most of as he continued the study of geology. He had now also to prepare for the Church, and was ordained deacon in 1857 and priest in 1858. In 1859 he was elected to a Fellowship at St. John's, and returned to that College in 1861 as Junior Dean. Natural Science was then beginning to secure a due recognition from the University. Up till 1861 the Natural Science Tripos, which had been in existence for something like sixteen years, was open only to Bachelors of Arts; but in that year it acquired equal rights, and a candidate could then obtain the degree of B.A. without previously passing through the Mathematical or Classical School. Of late years the candidates for this Tripos have considerably exceeded in number those for either of the ancient schools. The study of Natural Science received, however, but slight encouragement from the Colleges, and Bonney, as soon as he was well settled down at Cambridge, joined in the movement which was being made to press its claims; an open exhibition in Natural Science was offered by St. John's, partly as a consequence of his efforts. Professor Bonney, in what perhaps may be regarded as an excess of grateful recognition, has been known to say that he owes whatever success he has had in life to the Fellowship he obtained at St. John's; with equal, if not more truth, many who are now engaged in the advancement of scientific learning might say the same of the opportunities which this college exhibition has afforded them.

In the summer of 1858 Bonney paid his second visit to Switzerland, crossing the Strahleck and the Weissthor; his love of the Alps dates from this journey; since then he has returned to them something like two out of every three years of his life. In 1860, 1862, 1863, and 1864 he was chiefly engaged in exploring the French and Italian Alps, then rather imperfectly known. At the end of the last journey he went on to the South of France, and while there fell a victim to malaria, from the effects of which he has never since been entirely free. These, though they prevented him from 'roughing' it as much as he would have liked, did not put a stop to his climbing, which he continued in a steady but not too adventurous way till about ten years ago, and even still he sometimes undertakes an ordinary ascent of 5,000 feet or so. Hence his intimate knowledge of the Alps, which from the Visp to the Salzkammergut is well-nigh unrivalled.

By the year 1868 Bonney's knowledge of geology had ceased to be that of an amateur; the stage of preparation had passed, and having in that year been appointed Tutor he commenced to give College lectures on the subject; in the next year he was formally appointed Lecturer on Geology by the College. He had not enjoyed the advantages which are now open to every geological student, but he had fully availed himself of that strenuous training which we are beginning regretfully to look back upon as the good old-fashioned education. Mathematics had impressed upon his mind the real necessities which are demanded by a proof. Classics had assisted him to cultivate a literary gift, and travel had taught him facts at first-hand. Freshness and reality as a natural consequence were the distinctive marks of his Cambridge teaching. Soon after he commenced to lecture, his great contemporary Sedgwick, yielding to failing health and the increasing infirmities of old age, gradually retired from the active work of his Chair, and thus it fell upon Bonney to keep alive the traditions of the Cambridge School of Geology. How thoroughly alive they were kept his numerous pupils may testify. To his pupils he might be said to have given all he had: he helped them to the utmost of his powers, by lectures, private tuition, friendly advice, and informal teaching in the field; the last took place during Term in the district around Cambridge, and in Vacation in various remote parts of the British Isles. Nor must the social gatherings be forgotten, when his students made from time to time the acquaintance of the leading geologists of the day. In this self-devotion Bonney was perhaps too careless of advancing his own reputation; the Long Vacations were spent in investigation and research, but Term left little or no time to prepare the results for publication, and hence his fame fell behind his merits. This was unfortunate; it injuriously affected his claims when he stood for election to Sedgwick's Chair, and he was defeated by 6 votes. The range of his teaching was very wide; even in those early days he had recognized the 'one in the many' of earth-knowledge, and while on one occasion he would describe in detail the structure of a single mountain, on another he would treat undauntedly of the earth as a whole. Physical Geography was taught in a way to convince students that, if they wished to become geologists, they must also be meteorologists, hydrographers, and geographers as well; but Cosmogony was by no means banned, and some knowledge of Astronomy was essential, so that unless they exercised great care his students might find themselves unexpectedly knocking their heads against the problem of the 'three bodies.' Palæontology was the subject of a course, and in 1873 one on Petrography, practically illustrated by the microscope, was added. This was among the first courses of systematic teaching in modern Petrography given in the British Isles, probably the very first. From it Teall and Sollas (not to mention others) gained their first insight into this branch of Geology. A list of those who attended the general course on Geology would be interesting reading, but without it the names of J. E. Marr, A. Strahan, Jukes-Browne, Clough, W. W. Watts, R. D. Roberts, Milnes-Marshall, P. H. Carpenter, and F. M. Balfour may be recalled, as well as those first mentioned. F. M. Balfour will be best known as the bright particular star of the Biological School, but his interest in Geology at that time is shown by a clever paper written in conjunction with his cousin, Gerald Balfour (late Chief Secretary of State for Ireland), to explain the downward dip of the beds surrounding a volcanic neck.

The thoughts of an old student often wander fondly to those early days spent under Professor Bonney's paternal care. Let us set out on one of those reminiscent journeys. Here is the bold portal of St. John's; we turn in, cross the first quad, and enter that beautiful second court, so justly praised by John Ruskin; in the middle of the left-hand side is an entrance which leads to a narrow staircase, and on the first landing we read over a door, in white letters on a black ground, Rev. T. G. Bonney. We knock and pass into the outer room, furnished in the austere beauty of ancient oak; a massive lecture-table stands in the middle, and at the nearer end is a bookcase full of white-vellum covered volumes containing presentation copies of scientific pamphlets. This is the lecture-room, and somehow it impresses us; there is a feeling as of an ancient University in the air, and when the tall spare figure of the Tutor approaches to welcome us we seem to realize an idea already formed in the mind as an expression of the *genius loci.* He leads us through a door at the other end into his private sanctum, a bright and cheerful chamber, the walls lined with books, except above the fireplace, whither our eyes are drawn by the vigorous yet delicate outlines of Alpine ranges, displayed in long panorama, the fruits of the Professor's pencil in Long Vacation rambles. The Tutor takes his seat at the table, and perhaps spends a good half-hour in a running commentary on the answers we have given to his preparatory examination papers, or, it may be, discusses with stimulus and advice some budding idea which by an artful kindness he leaves us to imagine is as interesting to him as to ourselves. Out of this room a door leads into another, larger, and by its light and elegant furniture proclaimed the drawing-room; on the walls are many beautiful glimpses of mountain scenery in the dream-like colouring of Elijah Walton. This is the place of many a social gathering, especially after Chapel on Sunday evenings: there you, an undergraduate, just out of your teens, may meet Adams of Neptunian fame, and recognize, to your surprise, that he is really a fellow man; Miller, the most exact of mineralogists, will probably be there; and sometimes there are ladies, and the gracious presence of Miss Bonney, the Tutor's sister. This time it is the last meeting in the May Term, and we discuss the coming Vacation ramble; a few weeks, and the scene has shifted to the Lizard, where the class, nearly a full score strong, is hammering out the mysteries of gabbro and serpentine, and hornblende-schist. There is Teall, he is very busy over a supposed Troctolite at Coverack, and by his side Jukes-Browne, adherent with argument; Milnes-Marshall is on the beach sketching a queer dyke over which Sollas is climbing with cat-like agility; R. D. Roberts is busy with a notebook, and Strahan is discussing with the Professor a question of intersection, whether the gabbro cuts the elvan or the elvan cuts the gabbro. It is a long sunny day; at its close the Professor presides at a frugal meal, and we come home to quarters by boat; Edmund Kelly, with his clean-cut Greek profile, wearing a Phrygian red cap, takes the helm and steers with the courage of an ancient Viking. Such were those days when life was young and tobacco was sweet, and our revered Professor was a great boy like the rest of us, only infinitely more wise.

In 1877 Bonney was elected Professor of Geology in University College, London, but still continued to lecture at St. John's; in 1881, on being appointed Secretary of the British Association, he finally quitted Cambridge and took up his residence in London, on the borders of Hampstead Heath.

On an endowment accruing to the Chair in University College in 1885, he resigned the Secretaryship of the Association in order the better to devote himself to the professorship. This, however, was very uphill work; single-handed, and unprovided with modern appliances, he found himself set to make bricks without straw. To add to his difficulties the effects of the agricultural depression now began to make themselves felt, and he found it necessary to supplement his income by literary work; thus commenced his connection with one of the leading London journals, for which he still continues to write. In 1901 he resigned the professorship and was succeeded by Mr. Garwood. One alleviation in his London work cannot here be overlooked, the voluntary assistance rendered by Miss Raisin, who was for several years a zealous pupil and co-worker. She wrote several petrological papers in conjunction with Professor Bonney.

A few years before his retirement, in 1895, the feelings of his old students, both Cambridge and London, found spontaneous expression in the gift of his portrait painted by Mr. Trevor Haddon. The presentation took place in University College before a large and distinguished assembly, and few who were present will forget how on that dull December afternoon a warm glow of feeling seemed to expand and grow luminous as speaker after speaker rose to express his gratitude "to the Tutor whom they had feared, the Master whom they reverenced, and the Friend they loved."

Amidst his engrossing labours as a teacher and investigator in geology, Professor Bonney has found time for work as a literary author. "Outline Sketches of the High Alps in Dauphiné" was published in 1865, "The Alpine Regions of Switzerland and the Neighbouring Countries" in 1868, "The Coast of Norway" (1870), "Vignettes, Alpine and Eastern" (1873), "The Bernese Oberland" (1874), "Lakes and Mountain Scenery of the Swiss Alps" (1874), "Welsh Scenery" (1875–76), "English Lake Scenery" (1876), the letter-press in Walton's "Peaks and Valleys of the Alps" (1867), and in the same artist's "Flowers from the Upper Alps," and much of the descriptive text in such well-known works as "Picturesque Europe," "Our Own Country," "English Cathedrals" is from his pen. Of more particularly scientific works may be mentioned "The Story of our Planet" (1893), "Charles Lyell and Modern Geology" (1895), "Ice Work, Past and Present" (1896), "Lewis; on the Genesis of the Diamond" (1897), and "Volcanos" (1899).

The life of a geologist, the life of an author, have not, however, been sufficient to satisfy Professor Bonney's insatiable industry; he has lived, too, the life of a clergyman. He was one of the Cambridge Preachers at the Chapel Royal, Whitehall, in 1876 to 1878, and has five times been a Special Preacher before the University of Cambridge, on the last occasion being Hulsean Lecturer. These lectures were published in 1885 under the title of "The Influence of Science on Theology." He has also published "The Holy Places of Jerusalem" (1864), "Old Truths in Modern Lights" (Boyle Lectures, 1890, 1891), and "Doctrine and Modern Thought" (Boyle Lectures, 1891, 1892).

He is an Examining Chaplain to the Bishop of Manchester and an Honorary Canon of that Cathedral. He frequently preaches in London, and those who listen to him will recognize the same independence of thought and variety of mood which distinguish his scientific lecturing; at one time the hearer will be charmed with a rare eloquence, at another he will enjoy that keen satire which once led to the remark "Professor Bonney has a tongue like a sword!"

Professor Bonney became Fellow of the Geological Society in 1860; he was one of the Secretaries from 1878 to 1883, and

President in 1884 and 1885. In 1889 he received the award of the Wollaston Medal. He was elected a Fellow of the Royal Society in 1878. In 1886 he was President of the Geological Section of the British Association; in 1888 he delivered one of its Evening Discourses. He has also been President of the Mineralogical Society, is a member of the Alpine Club and has been its President. He is a Doctor of Science, Cambridge, he has received the honorary degree of LL.D. from the University of Montreal, and of D.Sc. from the University of Dublin, which was conferred on the occasion of the celebration of the Tercentenary of Trinity College.

The subject which earliest engaged the attention of Professor Bonney was glaciers and their action; this was at the time when Ramsay's fascinating theory of the origin of lake-basins, developed by that genial and brilliant investigator with his accustomed skill, and urged with all his infectious enthusiasm, had captivated the minds of nearly all the young English geologists. Possibly the more readily, owing to the besetting sin of the so-called Uniformitarian School, which in its neglect of quantitative reasoning was content for the most part to discover tendencies, without proceeding to inquire whether these were sufficient or continued far enough to produce the effect they were supposed to explain. Thus it was urged that since a glacier can be shown to have produced a number of mountain tarns, there is no reason why in sufficient time it should not accomplish the incavation of a lake or an inland sea, such as Lake Geneva, or Superior, or the Caspian.

Bonney's mathematical training had freed him from this fallacious tendency, and his intimate knowledge of the Alps and their glaciers led him to take very different views as to the origin of the Swiss lakes; and thus amongst his earliest papers we find a careful analysis of the problem as illustrated by particular instances, with observations and arguments which led to complete disproof of the erosion theory and a return to views which are more suggestive of the spirit of De la Beche than of Lyell. Glacial problems have from that time to this always maintained their interest for him, and the popular theories of to-day are at present as little accepted by him as were those which first engaged his attention. Whether the present theories will be longer lived than those of the past, time alone will show. From glaciers Bonney next turned his attention to rocks, and here again was led into conflict with prevailing views, which seem to have been inspired by the same pursuit of suggestive tendencies. The remarkable changes produced on sedimentary rocks by what is vaguely termed metamorphic action had led the Lyellian school to assign a metamorphic origin to granite. If a shale may become converted into a slate, or even a mica-schist, why should not the process continue and mica-schist pass into gneiss, and gneiss find its final term in granite? A study of contact phenomena will frequently afford evidence of the continuity of granite with gneiss. and thus but one link remains to be discovered by the connection of gneiss with mica-schist. The imagination sometimes supplied this, and thus a cycle was completed; for, commencing with granite, this, suffering first disintegration and then deposition, is known to give rise to sedimentary rocks, while these under the magic of metamorphism were supposed to be converted into granite again. Thus a beginning or ending to which Lyellians were always averse was evaded. To insist on the significance of the missing link, and to restore to the igneous rocks their true place in the constitution of our planet, was one of the tasks which Bonney set himself and successfully accomplished. But if where geologists had traced a gradual passage a sharp line of demarcation could be shown to exist, dividing the igneous from the sedimentary rocks, what of the alleged transitions between the various schists themselves? Had imagination played its useful part in their case also? "Metamorphic action is of all ages" had been translated into the statement that "any kind of metamorphic rock may be of any age." This is a formula that Bonney has never been able to accept: the Archæan rocks are for him marked as such not only by their infraposition to the Eozoic systems but also by their intimate structure; and he professes to be able to distinguish them not only in the field but also under the microscope. Whether in this important matter he be in the right or no, again time alone can decide, but whatever its verdict on this point the immense additions to our knowledge which have resulted from his researches into the difficult and obscure subject of the most ancient rocks will always retain a permanent value. The difficulties are sufficient to render it repulsive to most minds, but the less known about a thing the greater are its attractions for Bonney. Charnwood was a true *terra incognita* up to 1877, when Bonney first made known the fragmental igneous character of much of its rock, and afterwards assigned it to a Pre-Cambrian horizon. How thorough his work was in this region will appear from the subsequent investigations and detailed mapping of Professor Watts, who has been known to grumble that Professor Bonney was always right, and has left very little for his successors to discover in this region. From Charnwood attention was next directed to Anglesey, which was found to offer so many perplexities that it was abandoned for a while, and the Alps were again resorted to in the hope that there might be found some suggestive clue to their interpretation. But in the Alps Professor Bonney found himself in *mediis rebus*; he had left the outskirts for the very centre of the arcanum, and ever since has been engaged in trying to decipher the history of the crystalline schists and gneisses in that chain, as well as in other lands. A summary of his views is given in his Presidential Address to the Geological Society in 1885; a more recent account appears in "An Outline of the Petrology and Physical History of the Alps," read before the Geologists' Association in 1897. Of course, while working on such subjects as this, when the facts are often obscure and opinion still fermenting, the chances of controversy are great, scarcely indeed to be avoided, even were it well to avoid them; for it is still true that strife in the domain of things intellectual, as elsewhere, is lord over the ways of evolution, the great eliminator of error, and thus also the revealer of the truth. Professor Bonney has never shrunk from controversy, and has but little reason to regret it. The exposure of the mistake which had been made over the nature of the "Belemnite-bearing garnetiferous Calc-schist" was well worth a fight; but that the mistake should have been made at all diminishes any surprise that might have been felt at the easy way in which one limb of the great Glarus double-fold yielded at the first serious assault, and was sheared off into the limbo of defunct hypotheses.

The English Trias is perhaps one of the most interesting of our systems, for, in spite of its scarcity in fossil remains, it offers many fascinating problems to the explorer of the unknown; the mystery of the pebble beds in particular appeals to the imagination. Professor Bonney's explanation of these as fluviatile deposits has now become generally accepted, and Continental geologists, like Penck, have extended his views to other cases; nor, indeed, have all the results which are likely to follow from this promising theory yet been harvested.

The history of coral atolls, one of the most important problems now pressing for solution, has for long been a subject of interest to Professor Bonney; the summary of the arguments, for and against Darwin's explanation, which he has given in an appendix to the last edition of Darwin's "Coral Reefs" may be taken as a model of judicial fairness. Subsequently, as Chairman of the Coral Reefs Committee appointed by the Royal Society, he worked hard in the interests of the various expeditions which were sent out from this country and Australia to investigate the atoll of Funafuti, and from which such valuable results have followed.

Professor Bonney's petrographical work is too multifarious for a short epitome; its commencement belongs to the early period of Zirkel and Rosenbusch, and is anterior to the publication of the great classic, "Mineralogie Micrographique," of Fouqué & Levy. Among his earliest essays were explanations of the origin of Serpentine and Luxullianite; later he found an almost unexplored field awaiting the microscope among the older igneous rocks of North Wales; from then onwards till the present we owe to him a continuous succession of studies on igneous rocks from various parts of the world, and among his most recent discoveries is that by which the diamond has at length been traced to its true birthplace and shown to be an original constituent of what is itself a somewhat rare igneous rock, namely, eclogite.

Needless to add that Professor Bonney has been a somewhat extensive traveller: besides the Alps, his most familiar ground, he has travelled in the Pyrenees, Auvergne, Normandy, Brittany, over many parts of Germany and Italy, Norway, Sweden, Denmark, and Canada, which he visited on the occasion of the meeting of the British Association in 1884. Every journey has had a definite geological purpose, usually an attempt to solve some special problem; and the observations which were made were always recorded on the spot, usually with illustrative sketches; the notebooks in which these are accumulated would make a small library. Professor Bonney possesses considerable artistic power, and at one time sketched a good deal, but of late years he has ceased to do so, except for geological purposes.

When we contemplate the monumental results of Prof. Bonney's prodigious activity we shall surely conjecture that here was a man especially blessed with bodily robustness, and with leisure, the fruit of private means; yet he has always suffered from imperfect health, to which sedentary work was obnoxious, and has all his life been compelled by circumstances to labour for an income. What, then, is the secret of his success? Possibly, mainly method, the habit of doing a thing at once, and doing it only once; the time which most people lose in hesitation, procrastination, and repetition has thus been secured for useful work: but such method is the privilege of those only who are possessed of an indomitable will and of a mind logical to an unusual degree.

In spite of years Professor Bonney is still young: he has accomplished much; much more remains for him to do. With unabated ardour he still presses forwards in the pursuit of truth. That he may attain it, and in no small degree, is the earnest wish of his sincere friends and admirers. We bid him God speed!

LIST OF SCIENTIFIC PAPERS BY PROFESSOR T. G. BONNEY.

"On some Flint Implements from Amiens": Rep. Brit. Assoc., 1862, pt. ii, p. 70.

"On the Historical Evidence of Volcanic Eruptions in Central France in the Fifth Century": Geol. Mag., 1865, Dec. I, Vol. II, pp. 241–244.

"On Traces of Glaciers in the English Lakes": Geol. Mag., 1866, Dec. I, Vol. III, pp. 291–293.

"Note on a case of Prismatic Structure in Ice": Proc. Cambridge Phil. Soc., 1866–67, vol. i, pp. 57–59.

"Kitchen-Middens on the Great Ormeshead": Geol. Mag., 1867, Dec. I, Vol. IV, pp. 343–344.

"On Traces of Glacial Action near Llandudno": Geol. Mag., 1867, Dec. I, Vol. IV, pp. 289–293.

"On the supposed occurrence of Pholas Burrows in the upper parts of the Great and Little Ormesheads": Geol. Mag., 1869, Dec. I, Vol. VI, pp. 483–489.

"On supposed Pholas-Burrows in Derbyshire": Geol. Mag., 1870, Dec. I, Vol. VII, pp. 267–270.

"Notes on the Geology of the Lofoten Islands": Quart. Journ. Geol. Soc., 1870, vol. xxvi, p. 623; Phil. Mag., 1871, vol. xli, p. 76.

"Prismatic Structure in Ice": *Nature*, 1870, vol. i, p. 481; 1871, vol. iii, p. 288.

"On a Cirque in the Syenite Hills of Skye": Geol. Mag., 1871, Dec. I, Vol. VIII, pp. 535–540.

"On the Formation of 'Cirques,' and their bearing upon theories attributing the Excavation of Alpine Valleys mainly to the action of Glaciers": Quart. Journ. Geol. Soc., 1871, vol. xxvii, pp. 312–324; Phil. Mag., 1871, vol. xlii, pp. 317–318.

"Ice Scratches in Derbyshire": Geol. Mag., 1872, Dec. I, Vol. IX, pp. 269–270.

"On certain Lithodomous Perforations in Derbyshire": Geol. Mag., 1872, Dec. I, Vol. IX, pp. 315–318.

"Notes on the Roslyn Hill Clay Pit": Geol. Mag., 1872, Dec. I, Vol. IX, pp. 403–408.

"Lakes of the North-Eastern Alps, and their bearing on the Glacier-Erosion Theory": Quart. Journ. Geol. Soc., 1873, vol. xxix, pp. 382–395.

"On the occurrence of a Quartzite Boulder in a Coal Seam in South Staffordshire": Geol. Mag., 1873, Dec. I, Vol. X, pp. 289–291.

"On the Upper Greensand or Chloritic Marl of Cambridgeshire" [1872]: Proc. Geol. Assoc., 1874, vol. iii, pp. 1–20.

"Notes on the Upper Engadine and the Italian Valleys of Monte Rosa, and their Relation to the Glacier-Erosion Theory of Lake-Basins": Quart. Journ. Geol. Soc., 1874, vol. xxx, pp. 479–489.

"On some supposed Pholas Burrows in Carboniferous Limestone Rocks" [1869]: Proc. Cambridge Phil. Soc., 1876, vol. ii, pp. 150–152.

"Note on supposed Mollusc Borings in the Carboniferous Limestone of Derbyshire" [1870]: Proc. Cambridge Phil. Soc., 1876, vol. ii, pp. 182–183, 266–267.

"On a Cirque in the Syenite Hills in the Isle of Skye" [1871]: Proc. Cambridge Phil. Soc., 1876, vol. ii, pp. 238–239.

"On the Section exposed at the Roslyn Hill Pit, Ely" [1872]: Proc. Cambridge Phil. Soc., 1876, vol. ii, pp. 268–269.

"On a Boulder in a Coal Seam, South Staffordshire" [1873]: Proc. Cambridge Phil. Soc., 1876, vol. ii, p. 301.

"Some Notes on Glaciers": Geol. Mag., 1876, Dec. II, Vol. III, pp. 197–199.

"On Columnar, Fissile, and Spheroidal Structure": Quart. Journ. Geol. Soc., 1876, vol. xxxii, pp. 140–154; Phil. Mag., 1876, vol. i, p. 328.

"The Lherzolite of Ariége": Geol. Mag., 1877, Dec. II, Vol. IV, pp. 59–64.

"On Mr. Helland's Theory of the Formation of Cirques": Geol. Mag., 1877, Dec. II, Vol. IV, pp. 273–277.

"On certain Rock-structures, as illustrated by Pitchstones and Felsites in Arran": Geol. Mag., 1877, Dec. II, Vol. IV, pp. 499–511.

"On the Serpentine and Associated Rocks of the Lizard District": Quart. Journ. Geol. Soc., 1877, vol. xxxiii, pp. 884–924; Phil. Mag., 1877, vol. iv, pp. 74–75.

"On the Microscopic Structure of Luxullianite": Min. Mag., 1877, vol. i, pp. 215–221.

"Notes on the Relations of the Igneous Rocks of Arthur's Seat": Proc. Geol. Assoc., 1878, vol. v, pp. 500–511.

"Note on the Felsite of Bittadon, North Devon": Geol. Mag., 1878, Dec. II, Vol. V, pp. 207–209.

"Note on the Microscopic Structure of some Welsh Rocks" [1877]: Quart. Journ. Geol. Soc., 1878, vol. xxxiv, pp. 144–146.

"On the Serpentine and Associated Igneous Rocks of the Ayrshire Coast": Quart. Journ. Geol. Soc., 1878, vol. xxxiv, pp. 769–784.

"The Pre-Cambrian Rocks of Great Britain": Proc. Birmingham Phil. Soc., 1879, vol. i, pt. 3, pp. 140–159.

"On Professor Dana's Classification of Rocks": Geol. Mag., 1879, Dec. II, Vol. VI, pp. 199–203.

"Notes on some Ligurian and Tuscan Serpentines": Geol. Mag., 1879, Dec. II, Vol. VI, pp. 362–371; Italia Com. Geol. Boll., 1879, vol. x, pp. 461–474.

"Notes on the Microscopic Structure of some Rocks from Caernarvonshire and Anglesey": Quart. Journ. Geol. Soc., 1879, vol. xxxv, pp. 305–308.

"On the Quartz-Felsite and Associated Rocks at the Base of the Cambrian Series in North-Western Caernarvonshire": Quart. Journ. Geol. Soc., 1879, vol. xxxv, pp. 309–320.

"Note on some Rocks from South America": Quart. Journ. Geol. Soc., 1879, vol. xxxv, pp. 588–590.

"Notes on the Microscopic Structure of some Shropshire Rocks": Quart. Journ. Geol. Soc., 1879, vol. xxxv, pp. 662–669.

"On some Specimens of Gabbro from the Pennine Alps" [1878]: Min. Mag., 1879, vol. ii, pp. 5–8.

"On the Rocks of the Lizard District (Cornwall)" [1877]: Proc. Cambridge Phil. Soc., 1880, vol. iii, p. 85.

"Note on the Microscopic Structure of some Pre-Cambrian Rocks": Geol. Mag., 1880, Dec. II, Vol. VII, pp. 125–127.

"On some Recent Classifications of Welsh Pre-Cambrian Rocks": Geol. Mag., 1880, Dec. II, Vol. VII, pp. 298–303.

"Note on the Pebbles in the Bunter Beds of Staffordshire": Geol. Mag., 1880, Dec. II, Vol. VII, pp. 404–407.

"On some Serpentines from the Rhætian Alps": Geol. Mag., 1880, Dec. II, Vol. VII, pp. 538–542.

"Petrological Notes in the vicinity of the upper part of Loch Maree" [1879]: Quart. Journ. Geol. Soc., 1880, vol. xxxvi, pp. 93–107.

"On the Serpentine and Associated Rocks of Anglesey, with a Note on the so-called Serpentine of Porthdinlleyn (Caernarvonshire)" [1880]: Quart. Journ. Geol. Soc., 1881, vol. xxxvii, pp. 40–50.
"On a Boulder of Hornblende Picrite near Pen-y-Carnisiog, Anglesey": Quart. Journ. Geol. Soc., 1881, vol. xxxvii, pp. 137–140.
"Notes on the Microscopic Structure of some Anglesey Rocks": Quart. Journ. Geol. Soc., 1881, vol. xxxvii. pp. 232–237.
"On the Twt Hill Conglomerate": Geol. Mag., 1882, Dec. II, Vol. IX, pp. 18–22.
"Notes upon some Specimens of Shropshire Rocks" [1881]: Quart. Journ. Geol. Soc., 1882, vol. xxxviii, pp. 124–125.
"On some Nodular Felsites in the Bala Group of North Wales": Quart. Journ. Geol. Soc., 1882, vol. xxxviii, pp. 289–296.
"Report on three Specimens of Rocks trawled in the English Channel": Trans. Devon. Assoc., 1883, vol. xv, p. 367.
"Remarks on a Proposed Classification of Rocks" [1881]: Proc. Geol. Assoc., 1883, vol. vii, pp. 96–104.
"On a New Theory of the Formation of Basalt" [1881]: Proc. Geol. Assoc., 1883, vol. vii, pp. 104–111.
"Second Note on the Pebbles of the Bunter Beds of Staffordshire": Geol. Mag., 1883, Dec. II, Vol. X, pp. 199–205.
"On some Breccias and Crushed Rocks": Geol. Mag., 1883, Dec. II, Vol. X, pp. 435–438.
"On a supposed case of Metamorphism in an Alpine Rock of Carboniferous Age": Geol. Mag., 1883, Dec. II, Vol. X, pp. 507–511.
"Note on the Nagelflue of the Rigi and Rossberg": Geol. Mag., 1883, Dec. II, Vol. X, pp. 511–514.
"The Hornblendic and other Schists of the Lizard District, with some additional Notes on the Serpentine" [1882]: Quart. Journ. Geol. Soc., 1883, vol. xxxix, pp. 1–24.
"The Microscopic Structure of a Boulder from the Cambridge Greensand, etc.": Proc. Camb. Phil. Soc., 1883, vol. v, pp. 65–67.
"Note on the Lithological Characters of a Series of Scotch Rocks collected by Dr. H. Hicks": Quart. Journ. Geol. Soc., 1883, vol. xxxix, pp. 159–166.
"Additional Notes on Boulders of Hornblende Picrite near the Western Coast of Anglesey": Quart. Journ. Geol. Soc., 1883, vol. xxxix, pp. 254–260.
"Notes on a Series of Rocks from the North-West Highlands collected by C. Callaway": Quart. Journ. Geol. Soc., 1883, vol. xxxix, pp. 414–420.
"On a Section recently exposed in Baron Hill Park, near Beaumaris": Quart. Journ. Geol. Soc., 1883, vol. xxxix, pp. 470–477.
"On the Rocks between the Quartz-Felsite and the Cambrian Series in the Neighbourhood of Bangor": Quart. Journ. Geol. Soc., 1883, vol. xxxix, pp. 478–485.
"On a Collection of Rock Specimens from Socotra" [1882]: Proc. Roy. Soc., 1883, vol. xxxiv, pp. 145–148; Phil. Trans., 1883, pp. 273–294.
"The Building of the Alps": Royal Institution, April 4, 1884.
"Microscopic Structure of Rocks from the Andes of Ecuador" (E. Whymper): Proc. Roy. Soc., 1884, vol. xxxvi, pp. 241–248, 426–434; 1884, vol. xxxvii, pp. 114–137, 394–410.
"The Microscopic Structure of Trowlesworthite": Trans. Roy. Geol. Soc. Corneo, 1884, vol. x.
"On the Archæan Rocks of Great Britain": Rep. Brit. Assoc., 1884, pp. 529–551.
"On the Geology of the South Devon Coast from Torcross to Hope Cove": Quart. Journ. Geol. Soc., 1884, vol. xl, pp. 1–27.
"On some Rock Specimens collected by Dr. Hicks in Anglesey and North-West Caernarvonshire": Quart. Journ. Geol. Soc., 1884, vol. xl, pp. 200–208.
"Notes on the Microscopic Structure of Rocks from Guernsey": Quart. Journ. Geol. Soc., 1884, vol. xl, pp. 420–430.
"Note on some Rock Specimens collected by Dr. C. Callaway in Anglesey": Quart. Journ. Geol. Soc., 1884, vol. xl, pp. 583–589.
"Remarks on Serpentine": Geol. Mag., 1884, Dec. III, Vol. I, pp. 406–412.
"On the so-called Diorite of Little Knott (Cumberland), with further remarks on the occurrence of Picrites in Wales": Quart. Journ. Geol. Soc., 1885, vol. xli, pp. 511–522.

"Address on Geological Progress in Britain during the year 1884, especially with regard to the Western Highlands, with a Discussion of the Principles of Petrological Nomenclature": Quart. Journ. Geol. Soc. (Proc.), 1885, vol. xli, pp. 46–96.

"On the occurrence of a Mineral allied to Enstatite in the Ancient Lavas of Eycott Hill, Cumberland": Geol. Mag., 1885, Dec. III, Vol. II, pp. 76–80.

"Report on the Rocks collected by H. H. Johnston, Esq., from the upper part of the Kilima-njaro Massif": Rep. Brit. Assoc., 1885, pp. 682–685.

"On Bastite-Serpentine and Trokolite in Aberdeenshire, with a Note on the Rock of the Black Dog": Rep. Brit. Assoc., 1885, p. 1016; Geol. Mag., 1885, Dec. III, Vol. II, pp, 439–448.

"Preliminary Note on some Traverses of the Crystalline District of the Central Alps": Rep. Brit. Assoc., 1885, pp. 1027–1029.

"Remarks on the Stratified and Igneous Rocks of the Valley of the Meuse in the French Ardennes": Proc. Geol. Assoc., 1885, vol. ix, pp. 247–260.

"On some Rock-specimens collected by Dr. Hicks in North-West Pembrokeshire": Quart. Journ. Geol. Soc., 1886, vol. xlii, pp. 357–363.

"On Lava from Old Providence Island": Min. Mag., 1886, vol. vi, pp. 39–45.

"On Picrite from Gipps Land and Serpentine from Tasmania": Min. Mag., 1886, vol. vi, pp. 54–58.

"Presidential Addresses": Min. Mag., 1886, vol. vi, pp. 111–119 and 195–201.

"Address on the Work done by the Society and on other matters connected with the Progress of Geology in this Country, and on the so-called Metamorphic Rocks": Quart. Journ. Geol. Soc. (Proc.), 1886, vol. xlii, pp. 49–115.

"Note on the Microscopic Structure of some Rocks from the Neighbourhood of Assouan collected by Sir J. W. Dawson": Geol. Mag., 1886, Dec. III, Vol. III, pp. 103–107.

"Address to Geological Section": Rep. Brit. Assoc., 1886, pp. 601–621.

"Notes on the Structures and Relations of some of the older Rocks of Brittany": Quart. Journ. Geol. Soc., 1887, vol. xliii, pp. 301–321.

"Microscopic Structure of three Rocks from the Caucasus": Proc. Roy. Soc., 1887, vol. xlii, pp. 318–325.

"On a Glaucophane Ecloglite from the Val d'Aoste": Min. Mag., 1887, vol. vii, pp. 1–7.

"On a Variety of Glaucophane from the Val Chisone": Min. Mag., 1887, vol. vii, pp. 191–193.

"Note on some Specimens of Glaucophane Rock from the Ile de Groix": Min. Mag., 1887, vol. vii, pp. 150–155.

"Note on Specimens of the Rauenthal Serpentine": Geol. Mag., 1887, Dec. III, Vol. IV, pp. 65–70.

"Preliminary Note on Traverses of the Western end of the Eastern Alps during the Summer of 1887": Rep. Brit. Assoc., 1887, pp. 705–706.

"On some results of Pressure and of the Intrusion of Granite in Stratified Palæozoic Rocks near Morlaix, in Brittany": Quart. Journ. Geol. Soc., 1888, vol. xliv, pp. 11–19.

"On the Obermittweida Conglomerate, its Composition and Alteration": Quart. Journ. Geol. Soc., 1888, vol. xliv, pp. 25–31.

"Notes on a part of the Huronian Series in the Neighbourhood of Sudbury (Canada)": Quart. Journ. Geol. Soc., 1888, vol. xliv, pp. 32–45.

"Note on Specimens from Mysore collected by G. Attwood, Esq.": Quart. Journ. Geol. Soc., 1888, vol. xliv, pp. 651–653.

"Observations on the Rounding of Pebbles by Alpine Rivers, with a Note on their bearing upon the Origin of the Bunter Conglomerate": Geol. Mag., 1888, Dec. III, Vol. V, pp. 54–61; Rep. Brit. Assoc., 1888, pp. 721–722.

"Note on the Structure of Ightham Stone": Geol. Mag., 1888, Dec. III, Vol. V, pp. 297–300.

"The Sculpture of Alpine Passes and Peaks": Geol. Mag., 1888, Dec. III, Vol. V, pp. 540–548.

"On a Peculiar Variety of Hornblende from Mynydd Mawr": Min. Mag., 1889, vol. viii, pp. 103–107.

"On a Picrite from the Liskeard District": Min. Mag., 1889, vol. viii, pp. 108–111.

"Notes on two Traverses of the Crystalline Rocks of the Alps": Quart. Journ. Geol. Soc., 1889, vol. xlv, pp. 67–111.
"On the Crystalline Schists and their Relation to the Mesozoic Rocks in the Lepontine Alps": Quart. Journ. Geol. Soc., 1890, vol. xlvi, pp. 187–240.
"On the occurrence of a variety of Picrite (Scyelite) in Sark": Geol. Mag., 1889, Dec. III, Vol. VI, pp. 109–112.
"Note on some Pebbles in the Basal Conglomerate of the Cambrian at St. Davids": Geol. Mag., 1889, Dec. III, Vol. VI, pp. 315–318.
"The Effects of Pressure on Crystalline Limestones": Geol. Mag., 1889, Dec. III, Vol. VI, pp. 483–486; Rep. Brit. Assoc., 1889, pp. 571–572.
"Preliminary Note on the alleged occurrence of Fossils in the Crystalline Schists of the Lepontine Alps": Rep. Brit. Assoc., 1889, p. 571.
"Mr. Mellard Reade's Interpretation of the Lower Trias Physiography": Geol. Mag., 1890, Dec. III, Vol. VII, pp. 52–55.
"Note on the Effect of Pressure upon Serpentine in the Pennine Alps": Geol. Mag., 1890, Dec. III, Vol. VII, pp. 533–542.
"Note on a Contact Structure in the Syenite of Bradgate Park": Quart. Journ. Geol. Soc., 1891, xlvii, pp. 101–108.
"Petrological Notes on the Euphotide of the Saas-thal": Phil. Mag., 1892, ser. iii, vol. xxxiii, pp. 237–250.
"Growth and Sculpture of the Alps": Alpine Journal, 1892, vol. xiv, pp. 38–50, 105–118, 221–235.
"Notes on some Specimens of Rocks which have been exposed to High Temperature": Proc. Roy. Soc., 1892, vol. l, pp. 395–403.
"Specimen from the Permian Breccia of Leicestershire": Midland Naturalist, 1892, vol. xv, pp. 25 and 49.
"On the so-called 'Gneiss' of Carboniferous Age at Guttannen (Canton Berne, Switzerland)": Quart. Journ. Geol. Soc., 1892, vol. xlviii, pp. 390–400.
"On the Relation of the Bunter Pebbles of the English Midlands to those in the Old Red Sandstone Conglomerates of Scotland": Rep. Brit. Assoc., 1892, p. 719.
"Do Glaciers Excavate?": Geographical Journal, 1893, vol. i, pp. 481–499.
"Note on the Nufenenstock (Lepontine Alps)": Quart. Journ. Geol. Soc., 1893, vol. xlix, pp. 89–93.
"On some Schistose 'Greenstones' and allied Hornblendic Schists from the Pennine Alps, as illustrative of the effects of Pressure-Metamorphism": Quart. Journ. Geol. Soc., 1893, vol. xlix, pp. 94–103.
"On a Secondary Development of Biotite and of Hornblende in Crystalline Schists from the Binnenthal": Quart. Journ. Geol. Soc., 1893, vol. xlix, pp. 104–113.
"On some Quartz-Schists from the Alps": Geol. Mag., 1893, Dec. III, Vol. X, pp. 204–210.
"On some Assumptions in Glacial Geology": Rep. Brit. Assoc., 1893, pp. 775–776.
"On some cases of the Conversion of Compact 'Greenstones' into Schists": Quart. Journ. Geol. Soc., 1894, vol. l, pp. 279–284.
"Mesozoic Rocks and Crystalline Schists in the Lepontine Alps": Quart. Journ. Geol. Soc., 1894, vol. l, p. 285.
"Some Notes on Gneiss": Geol. Mag., 1894, Dec. IV, Vol. I, pp. 114–121.
"On the Probable Temperature of the Glacial Epoch": Rep. Brit. Assoc., 1894, p. 660.
"A Note on Cone-in-cone Structure": Min. Mag., 1895, vol. xi, pp. 24–27.
"A Comparison of the Pebbles in the Trias of Budleigh Salterton and of Cannock Chase": Rep. Brit. Assoc., 1894, p. 655; Geol. Mag., 1895, Dec. IV, Vol. II, pp. 75–78.
"Supplementary Note on the Narborough District (Leicestershire)": Quart. Journ. Geol. Soc., 1895, vol. li, pp. 24–34.
"On the Mode of Occurrence of *Eozoon Canadense* at Côte St. Pierre": Geol. Mag., 1895, Dec. IV, Vol. II, pp. 292–299.
"The Serpentine, Gneissoid, and Hornblende Rocks of the Lizard District": Quart. Journ. Geol. Soc., 1896, vol. lii, pp. 17–51.
"On a Pebbly Quartz-Schist from the Val d'Anniviers (Pennine Alps)": Geol. Mag., 1896, Dec. IV, Vol. III, pp. 400–405.
"The Kirchet and its Critics": Alpine Journal, 1897, vol. xix, pp. 29–40.
"Additional Note on the Sections near the Summit of the Furka Pass (Switzerland)": Quart. Journ. Geol. Soc., 1897, vol. liii, pp. 16–21.

"Note on an 'Ovenstone' (Talcose-schist) from near Zinal, Canton Valais". GEOL. MAG., 1897, Dec. IV, Vol. IV, pp. 110–116.
"On some Rock-specimens from Kimberley, South Africa": GEOL. MAG., 1897, Dec. IV, Vol. IV, pp. 448–453, 497–502.
"An Outline of the Petrology and Physical History of the Alps": Proc. Geol. Assoc., 1897–98, vol. xv, pp. 1–18.
"The Garnet-Actinolite Schists on the Southern Side of the St. Gothard Pass": Quart. Journ. Geol. Soc., 1898, vol. liv, pp. 357–373.
"Notes on some small Lake-basins in the Lepontine Alps": GEOL. MAG., 1898, Dec. IV, Vol. V, pp. 15–21.
"Fulgurites from Tupungato and the Summit of Aconcagua": GEOL. MAG., 1899, Dec. IV, Vol. VI, pp. 1–4.
"On the Bunter Pebble-beds of the Midlands and the Source of their Materials": Quart. Journ. Geol. Soc., 1900, vol. lvi, pp. 287–306.
"Plant-stems in the Guttannen Gneiss": GEOL. MAG., 1900, Dec. IV, Vol. VII, pp. 215–220.
"Parent Rock of the Diamond in South Africa": Proc. Roy. Soc., 1900, vol. lxv, pp. 223–236.
"Additional Notes on Boulders, etc., from Newland's Diamond Mines": Proc. Roy. Soc., 1900, vol. lxvii, pp. 475–484.
"The Parent-rock of the Diamond": GEOL. MAG., 1900, Dec. IV, Vol. VII, pp. 246–248.
"Colonel Feilden's Contributions to Glacial Geology": GEOL. MAG., 1900, Dec. IV, Vol. VII, pp. 289–294.
"Schists in the Lepontine Alps": GEOL. MAG., 1901, Dec. IV, Vol. VIII, pp. 161–166.

BY PROFESSOR T. G. BONNEY AND S. ALLPORT.

"Report on the Effects of Contact-Metamorphism near New Galloway": Proc. Roy. Soc., vol. xlvi, pp. 193–204.

BY PROFESSOR T. G. BONNEY AND MISS E. ASTON.

"On an Alpine Nickel-bearing Serpentine with Fulgurites": Quart. Journ. Geol. Soc., 1896, vol. lii, pp. 452–459.

BY PROFESSOR T. G. BONNEY AND REV. E. HILL.

"The Pre-Carboniferous Rocks of Charnwood Forest": Quart. Journ. Geol. Soc., 1877, vol. xxxiii, pp. 754–789; 1878, vol. xxxiv, pp. 199–238; 1880, vol. xxxvi, pp. 337–350; Phil. Mag., 1877, vol. iv, pp. 76–77.
"The Hornblende-schists, Gneisses, etc., of Sark": Quart. Journ. Geol. Soc., 1892, vol. xlviii, pp. 122–146.
"Relations of the Chalk and Drift in Möen and Rügen": Quart. Journ. Geol. Soc., 1899, vol. lv, pp. 305–326.
"On the Drifts of the Baltic Coasts of Germany": Quart. Journ. Geol. Soc., 1901, vol. lvii, pp. 1–19.

BY PROFESSOR T. G. BONNEY AND F. T. S. HOUGHTON.

"On some Mica-Traps from the Kendal and Sedbergh Districts" [1878]: Quart. Journ. Geol. Soc., 1879, vol. xxxv, pp. 165–179.
"On the Metamorphic Series between Twt Hill (Carnarvon) and Port Dinorwig": Quart. Journ. Geol. Soc., 1879, vol. xxxv, pp. 321–325.

BY PROF. T. G. BONNEY AND MAJOR-GENERAL C. A. McMAHON.

"Results of an Examination of the Crystalline Rocks of the Lizard District": Quart. Journ. Geol. Soc, 1891, vol. xlvii, pp. 464–499.

BY PROFESSOR T. G. BONNEY AND MISS C. A. RAISIN.

"Report on some Rock-Specimens from the Kimberley Diamond Mines," with Note by Professor T. R. Jones: GEOL. MAG., 1891, Dec. III, Vol. VIII, pp. 412–415.
"On the so-called Spilites of Jersey": GEOL. MAG., 1893, Dec. III, Vol. X, pp. 59–64.

"On the Relation of some of the Older Fragmental Rocks in North-Western Caernarvonshire": Quart. Journ. Geol. Soc., 1894, vol. L, pp. 578–602.
"On Varieties of Serpentine and Associated Rocks in Anglesey": Quart. Journ. Geol. Soc., 1899, vol. lv, pp. 276–304.
"Rocks and Minerals from Karakoram Himalayas": Proc. Roy. Soc., vol. lv, pp. 468–487.

BY PROFESSOR T. G. BONNEY, MISS C. A. RAISIN, AND SIR J. B. STONE.

"Notes on the Diamond-bearing Rock of Kimberley, South Africa": Geol. Mag., 1895, Dec. IV, Vol. II, p. 492.

CONTRIBUTIONS (GEOLOGICAL) TO BOOKS PUBLISHED BY OTHERS.

E. Whymper, "Travels among the Great Andes of Ecuador," 1891: Appendix, pp. 140–143.
E. Fitzgerald, "Climbs in the New Zealand Alps," 1896: pp. 337–339.
Freshfield & Sella, "The Exploration of the Caucasus," 1896: vol. ii, pp. 223–232.
C. E. Mathews, "The Annals of Mont Blanc," 1898: pp. 286–294.
E. Fitzgerald, "The Highest Andes," 1899: pp. 311–332.
H. J. Pearson, "Beyond Petsora Eastward," 1899: pp. 234–239, 258–263, and (with H. S. Jevons) 277–287.

II.—Preliminary Note on some Recently Discovered Extinct Vertebrates from Egypt. (Part I.)

By Chas. W. Andrews, D.Sc., F.G.S., British Museum (Nat. Hist.).

DURING a recent visit to Egypt, through the kindness of Captain H. G. Lyons, Director-General of the Egyptian Survey, I have on several occasions had opportunities of accompanying members of the Staff of the Geological Survey on collecting expeditions into the Western Desert.

On one of these journeys I accompanied Mr. H. J. L. Beadnell, F.G.S., to the Fayûm, and we took the opportunity of examining the escarpments of Upper Eocene and Oligocene age in a locality from which Mr. Beadnell had previously obtained some remains of Zeuglodonts and Sirenians. On our first visit it was not until we were about to return to Cairo that any finds of importance were made, but on the last day of our stay a number of interesting specimens were found, including portions of the skeletons of a Sirenian (probably *Eotherium ægyptiacum*, Owen),[1] of *Zeuglodon* (? *Z. Osiris*, Dames),[2] and of a small ungulate, as well as remains of reptiles (*Crocodilia, Chelonia,* and *Ophidia*). On our return to Cairo it was arranged to go back to this rich locality and make as extensive collections as possible. The results of this second visit were very satisfactory, and a number of interesting specimens were obtained.

The beds from which the remains were collected are, in Mr. Beadnell's opinion, probably of Upper Eocene and Lower Oligocene

[1] Owen, "On Fossil Evidences of a Sirenian Mammal (*Eotherium ægyptiacum*, Owen) from the Nummulitic Eocene of the Mokattam Cliffs, near Cairo": Quart. Journ. Geol. Soc., vol. xxxi (1875), p. 100, pl. iii.

[2] Dames, "Ueber Zeuglodonten aus Aegypten und die Beziehungen der Archaeoceten zu den Uebrigen Cetaceen": Palaeont. Abhand., neue Folge, Bd. i (1894), p. 189.

age. In the present paper, merely very brief notices of some of the more important new forms are given, but subsequently it is intended by Captain Lyons to publish as complete an account as possible of the geology and physical geography of the district, prepared by Mr. Beadnell, with detailed descriptions of the fossil vertebrata by the present writer.

MAMMALIA.

The mammalian remains obtained include a Sirenian probably identical with *Eotherium ægyptiacum* from the Mokattam Hills, described by Owen on the evidence of a brain-cast only; *Zeuglodon*, including apparently Dames' *Z. Osiris*, and perhaps a second species; and, lastly, several ungulates which are new to science, and are the subjects of the following notices.

Palæomastodon Beadnelli,[1] Andrews. (Fig. 1.)

One of the most important specimens found in the higher beds (probably Lower Oligocene) is the nearly complete left ramus of the mandible of a Proboscidean, which is in many respects similar to that of *Mastodon angustidens*, but belonged to a much smaller and in

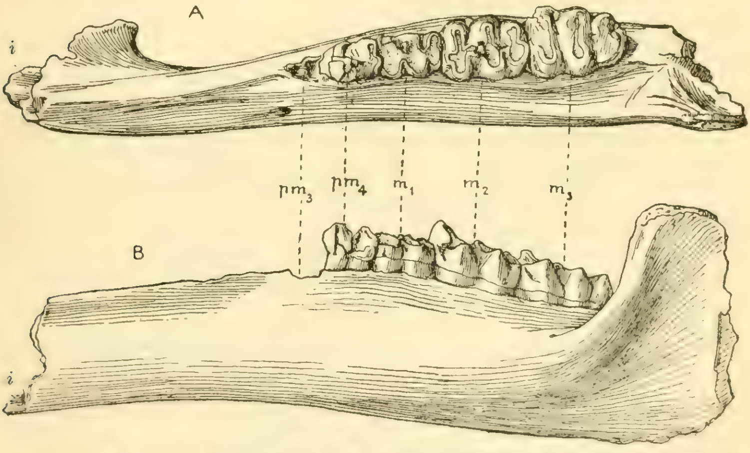


FIG. 1.—Left ramus of mandible of *Palæomastodon Beadnelli*. One-sixth natural size. (A) From above; (B) outer surface.

several respects more generalized form. Remains of *M. angustidens* (or a very closely allied form)[2] were found by Mr. T. Barron and

[1] "Tageblatt des V Internationalen Zoologen-Congresses," Berlin, No. 6, August 16th, 1901, p. 4.

[2] Remains of a small Mastodon from the Lower Miocene (Cartennien) near Isserville (Kabylie), Algiers, have been described by Depéret (Bull. Soc. Géol. France, sér. III, tom. XXV, 1897, p. 518) under the name *Mastodon angustidens*, var. *pygmæus*. The teeth from Moghara, though slightly smaller than specimens from Sansan, are not sufficiently so to justify their reference to this small variety. Moreover, there seems to have been little or no cement in the valleys of these teeth, while in Depéret's specimen it was abundant.

myself in Lower Miocene at Moghara, to the north-west of the present locality, and it seems probable that this mandible may have belonged to an ancestor of that well-known Miocene species.

The mandibular ramus (Fig. 1) is long and relatively narrow from above downwards, and is very slightly decurved anteriorly. It is chiefly remarkable for the elongation of the edentulous region in front of the cheek-teeth; in this region the alveolar border forms a sharp edge without trace of tooth sockets. The symphysis commences about 12 cm. in front of the anterior premolar, but its length cannot be determined, as the anterior portion of the jaw is broken away. Judging, however, by the large size of the central canal at the broken end, it seems probable that the symphysis was considerably elongated, though possibly not to the same extent as in *M. angustidens*. The base of an alveolus for a tusk (Fig. 1, *i*) is preserved on the broken end.

The coronoid process rises from the outer surface opposite the posterior third of the last molar; but its upper part is broken away, as also are the condyle and the angle. The cheek-teeth are distinctly proboscidian, and the molars are very similar to the anterior molars of some Mastodons. There were originally five teeth *in sitû*, but the anterior one (pm. 3) has fallen out of its socket, the form of which indicates that this tooth had two roots, a smaller anterior and a larger posterior; probably the crown was triangular in outline. The next tooth (pm. 4) is much broken; it seems to have consisted of a high anterior ridge, a median transverse crest, only traces of which remain, and a small posterior ridge now much worn. The next tooth (m. 1) is likewise trilophodont, the hinder crest being much the smallest. It is much worn and considerably broken on the inner side. The succeeding molars are in an excellent state of preservation. Both are trilophodont, but in the last the hinder ridge (talon) is considerably larger than in m. 2. Each transverse ridge is evidently composed of two tubercles, and is connected with the ridge behind by a very slightly developed longitudinal prominence. Small tubercles occur at the inner ends of the transverse valleys in m. 3. The outer ends of the ridges are far more worn than the inner, which stand up considerably above the rest of the tooth-crown. There is a regular increase in the degree of wear from m. 3 to m. 1. It seemed just possible that the tooth here described as m. 1 might be the last milk-molar, but its state of wear compared with that of the other teeth, and the absence of any trace of a premolar germ in the jaw beneath it or of a molar behind those now described, prove that the interpretation here adopted is the correct one.

It will be seen that this genus differs from *Mastodon* in the greater simplicity of m. 3, and in the fact that two premolars and three molars are in use at once. I propose the generic name *Palæomastodon* for this form, the name of the species being *P. Beadnelli* after Mr. H. J. L. Beadnell, of the Egyptian Geological Survey, to whom the discovery of these fossils is mainly due and by whom the survey of the Fayûm area has been carried out.

The dimensions of the specimen figured are as follows:—

				mm.
Total length of specimen			...	610
Depth of ramus in middle of diastema			...	96
,,	,,	immediately in front of p.m. 3	...	105
,,	,,	immediately beneath p.m. 4	...	120
,,	,,	at symphysis	...	97

Dimensions of Teeth (in millimetres).

	Length.	Width.
p.m. 3	41 (of alveolus)	—
p.m. 4	48	33 (approx.)
m. 1	48	37 (approx.)
m. 2	65	51
m. 3	78	53

Approximate length of molar and premolar series ... 285 mm.

Other specimens probably referable to this form are a maxilla with two molars, a nearly perfect specimen of m. 2, a scapula, a humerus, a femur, a tibia, an imperfect os innominatum, an atlas, and an axis.

Mœritherium Lyonsi,[1] Andrews. (Fig. 2.)

In the lower beds of probably Upper Eocene age a great quantity of remains of an ungulate about the size of a large tapir was obtained. These include numerous portions of the skull and mandible, some with the teeth in good preservation, associated sets of vertebræ more or less complete, ossa innominata, femora, humeri, etc. From these it will eventually be possible to obtain a very good idea of the skeletal structure of this animal. Here it will only be possible to refer briefly to the skull and teeth.

The skull is very massively built. The cranial region is depressed, and the stout zygomatic process arises far back and projects strongly outward. The external auditory opening is on the upper surface of the base of this process, and is bordered posteriorly by an outgrowth of the squamosal which grows round it as in the elephants. The brain-case is relatively large. The orbit is small, and the nasals seem to have been rather short, leaving a large narial aperture.

The teeth are remarkable. In the upper jaw the median pair of incisors are small, the second pair greatly enlarged, triangular in section, and form a strong pair of downwardly directed tusks

[1] "Tageblatt des V Internationalen Zoologen-Congresses," Berlin, No. 6, August 16th, 1901, p. 4. The generic name refers to the fact that the remains of the animal were found near the bed of the ancient Lake Mœris. The species is named after Captain Lyons, Director-General of the Egyptian Geological Survey.

Schweinfurth, in his account of the Fayum (Zeitschrift der Gesellschaft fur Erdkunde zu Berlin, 1886, Bd. xxi, p. 139), states that in a hill about 12½ miles west from the temple discovered by him he collected a jaw of *Zeuglodon* and two mandibular rami of a creature resembling a pig or tapir and corresponding in many respects to *Chœropotamus*. These specimens were afterwards described by Dames, who (*loc. cit. supra*) states that the so-called *Chœropotamus* jaws are in fact the anterior ends of mandibles of *Zeuglodon*. It seems not improbable, however, that Schweinfurth was more nearly right, and that the specimens actually belonged to the present species. A further examination of these specimens is desirable.

(Fig. 2B). Immediately behind the large incisor are two small teeth (represented only by alveoli), the anterior one probably being the third incisor, the posterior the canine; behind this is a diastema of some length (about 27 mm.). (Fig. 2A.)

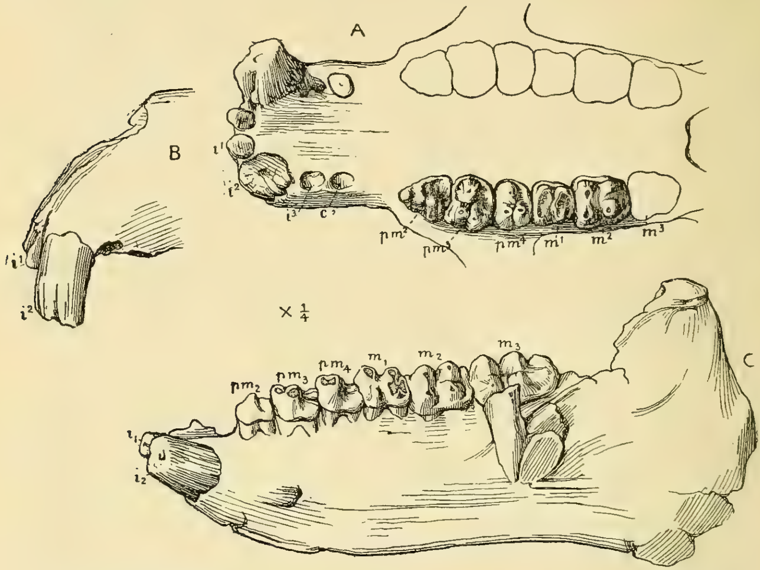


FIG. 2.—Dentition of *Mœritherium Lyonsi*. One-fourth natural size. (A) Upper teeth; (B) front of snout, showing the tusk-like second incisors; (C) left ramus of mandible from outer side.

The cheek-teeth are six in number. The anterior premolar (pm. 2) consists of an outer wall composed of four blunt tubercles, of which the middle two (protocone and tritocone of Scott's nomenclature) are largest and subequal. The anterior (? parastyle) and posterior (? metastyle) are smaller. The inner side of the tooth forms a broad triangular shelf-like edge, worn into a concavity by the tooth below. The next tooth (pm. 3) has two external tubercles (proto- and tritocone) and a large inner tubercle (deuterocone). The cingulum is well developed, and forms a shelf-like hollow on the posterior border. The next tooth (pm. 4) is similar. The first molar is bilophodont, but the crests, which are completely separated by the transverse valley, are distinctly composed of two tubercles, those forming the anterior one being the paracone and protocone, those in the posterior the metacone and hypocone. The cingulum is well developed on the inner and anterior border of the tooth, less distinct on the posterior, and absent on the exterior border. The next tooth (m. 2) is similar, the last is wanting in the specimen described.

The mandible is very solidly constructed, the rami being thickened and very convex from above downward on the outer surface. The symphysial region is massive and spout-like. The dental foramen is beneath pm. 3. The coronoid process arises from the outer surface of the ramus beneath the anterior end of m. 3, and has a thickened anterior border which often remains when the rest is broken away (see Fig. 2c). The condyle is transversely extended, and is convex in that direction as well as from before backward.

There are two pairs of lower incisors, the first being comparatively small teeth crowded between the second pair, which are modified to form large tusks and are triangular in section. The incisors are procumbent.

The first of the cheek-teeth (pm. 2) consists of a high, blunt anterior cusp, and a low, broad shelf-like talon. The next (pm. 3) has a high anterior crest which seems to be composed of at least two united cusps, and in front of the ridge thus formed there is a small antero-internal cusp. Behind there is a talon with a slight median prominence. The next tooth (pm. 4) is similar, and is, therefore, simpler than the succeeding first molar, which is bilophodont, each ridge being evidently composed of two tubercles. On the outer side there is a distinct cingulum, which on the hinder border of the tooth broadens out into a narrow talon with a median tubercle forming a small third lobe to the tooth. The next tooth (m. 2) is similar, but the talon is larger. In the last molar the talon is large and bears a transversely elongated cusp on its postero-internal border.

The molars show a strong tendency to assume a trilophodont form; in fact, the two last may almost be regarded as having already done so. This circumstance, together with the fact that in both jaws the second incisors are enormously enlarged, while at the same time there is a tendency to suppress the others (the third lower having already disappeared), incline me to believe that in this animal we have a generalized forerunner of the Mastodon type of Proboscidean. This conclusion is likewise supported by some points in the structure of the skull and skeleton. As to the group of primitive mammals to which *Mœritherium* is most nearly related, it is not possible to arrive at any definite conclusion till all the available parts of the skeleton have been examined, but perhaps it will be found to have arisen from some, at present, unknown subdivision of the Amblypoda.

Dimensions of Upper Dentition. (Figs. 2a and b.)

Approximate length of upper pm. and m. series ...	147 mm.
Approximate diameter of tusk	30 ,,
Length of diastema	27 ,,

Dimensions of Upper Cheek Teeth.

	Length.	Width.
pm. 2	27 mm. ...	23 mm. (approx.)
pm. 3	26·5 ,, ...	29·5 ,,
pm. 4	23 ,, ...	27·5 ,,
m. 1	29 ,, ...	27 ,,
m. 2	26 ,, ...	23·5 ,,
m. 3		

DIMENSIONS OF THE MANDIBLE AND LOWER DENTITION SHOWN IN FIG. 2C.

Total length	320 mm.	
Height of condyle above inferior border	153 ,,	
Length of premolar and molar	172 ,,	

	Length.	Width.
pm. 2	22 mm. ...	16 mm.
pm. 3	23 ,, ...	21 ,,
pm. 4	25 ,, ...	23 ,,
m. 1	26·5 ,, ...	24·5 ,,
m. 2	35 ,, ...	30 ,,
m. 3	42 ,, ...	30 ,,

A large part of the skeleton of this animal is known, and will be described in the detailed account of these specimens. Here we may

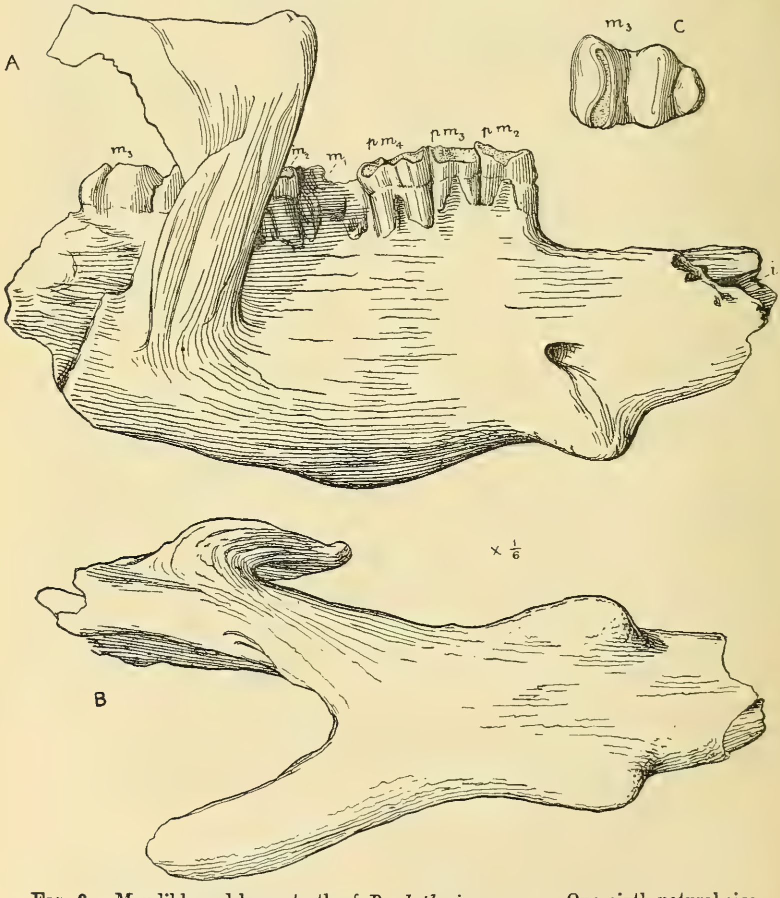


FIG. 3.—Mandible and lower teeth of *Bradytherium grave*. One-sixth natural size. (A) Right ramus of mandible from outer side; (B) mandible from below; (C) third left lower molar.

merely mention that the femur is without third trochanter, and the humerus has no entipicondylar foramen.

Bradytherium grave,[1] Andrews. (Figs. 3 and 4.)

Another very remarkable animal from the lower beds is an enormously heavily built ungulate, which in many respects resembles *Dinotherium,* but in others reminds one of some of the gigantic Amblypoda of North America.

The mandible is shown in Fig. 3A and B. It will be seen that it is a very massive structure. Its inferior border beneath the molar series is convex, and immediately beneath the front of the anterior premolar it bears a stout tuberosity which is directed outward, downward, and forward, and is somewhat similar to the protuberances occurring in the same place in some Dinocerata. In front of this process the lower border of the jaw slopes upward, and forms the floor of the socket for the large tusk-like procumbent incisors. The dental foramen is situated beneath the anterior premolar, and there seem to be two smaller foramina farther back. The coronoid process rises from the middle of the ramus at the level of m. 2. Its greatly thickened border slopes somewhat forward, and rises some 11 cm. above the crowns of the teeth. It then turns back at right angles, but is broken away posteriorly, as also are both the condylar and angular regions. The symphysis is very long (Fig. 3B), commencing beneath m. 1; its upper surface is spout-like and narrows rapidly anteriorly, so that the anterior premolars are only about 5 or 6 cm. apart. In front the pair of large tusk-like incisors are almost in contact in the middle line.

As just mentioned, there was a pair of large tusks, procumbent in position, and close together in the middle line. In this specimen the broken base of the tooth is *in situ* on the left side, while on the right the alveolus is empty. It is possible that there may have been a second pair of small incisors above the large ones, but the evidence of this is not clear. Behind the incisors is a diastema of about 13 cm. The portion of the alveolar border bearing the cheek-teeth is raised considerably above the diastema. There were three premolars, of which the anterior one (p.m. 2) has a triangular crown; it appears to have three roots, of which one is anterior, the other two arranged transversely posteriorly. The next two (pm. 3 and pm. 4) have quadrate crowns, apparently bilophodont, and four roots. The first molar is greatly broken; it had four roots. The second is bilophodont, and the crown is somewhat longer than broad; there are four roots. The last (Fig. 3C) consists of two transverse crests and a large talon: in this also there seem to have been only four roots, the postero-external one being enlarged to support the talon. All these teeth are greatly worn, especially on the outer side. They are also greatly damaged by exposure to drifting sand. The upper cheek-teeth are also much damaged: those of the left side are shown in Fig. 4. The anterior premolar (pm. 2) is broken on its inner side: it seems to have had three roots, and its crown narrowed considerably in front. pm. 3 and pm. 4 are both four-rooted, and their

[1] "Tageblatt des V Internationalen Zoologen-Congresses," Berlin, No. 6, August 16th, 1901, p. 4.

rectangular crowns are wider transversely than from before backward. Their surface is greatly worn, so that no trace of cusps or ridges remains. The greatly worn m. 1 is similar. m. 2 and m. 3 have quadrate crowns, each composed of a pair of transverse ridges, which are much more worn on the inner than on the outer sides.

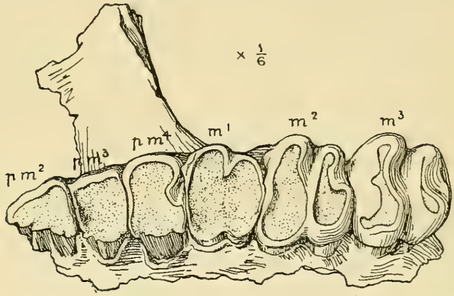


Fig. 4.—Left upper cheek-teeth of *Bradytherium grave*, Andrews. One-sixth natural size.

Besides the mandible and upper teeth here described the collection includes the scapula, humerus, ulna, and some other portions of the skeleton.

The humerus is enormously stout, and its distal end greatly expanded.

This remarkable animal, for which the name *Bradytherium grave* is proposed, in many respects resembles *Dinotherium*, at least as far as its dentition goes, but differs in several points, e.g. in the presence of three premolars and in the existence of a talon on the third lower molar. In some ways, as in the presence of the tuberosity on the lower border of the mandible and in the form of the humerus, it shows some similarity to certain of the Dinocerata. Its actual position remains for the present doubtful. Portions of three individuals were found, so that there is every reason to hope that further search may yield more material for settling this question.

The dimensions of the specimens described and figured are (in millimetres) :—

		Length.	Width.
Upper Teeth.—	pm. 2	57	57
	pm. 3	39	65
	pm. 4	50	80
	m. 1	59	84
	m. 2	75	86
	m. 3	83	87
Lower Teeth.—	pm. 2	51	35 (approx.)
	pm. 3	43	47
	pm. 4	57	55
	m. 1	57	—
	m. 2	86	64
	m. 3	105	70

	mm.
Total length of upper molar and premolar series ...	365
Total length of lower molar and premolar series (approx.)	385
Total length of mandible as figured	660
Depth of ramus beneath pm. 4, about	256

The discovery of these Lower Tertiary mammals is of considerable importance, not merely on account of the interest of the specimens hitherto collected, but as showing that much may be expected from further investigation of the Tertiary deposits of the Libyan Desert. At present I am acquainted with (probably) Upper Eocene, Lower Oligocene, Lower Miocene, and Lower Pliocene mammal-bearing beds; and in several localities, during journeys across the desert, fragments of teeth and bones were observed when it was impossible to stay to make any search after more complete specimens, which must no doubt be obtainable. Another point of importance is that the fauna now described differs entirely from that found in deposits of the same age in Europe, and points to the existence of a large land area to the south which had long been isolated. The few species so far obtained can only represent a very small fraction of those which existed, and when found will throw great light on many obscure questions of geographical distribution. One long-standing problem, viz. the place of origin of the Proboscidea, may perhaps be regarded as solved already.

III.—Note on the Discovery of a very fine Example of *Pleurotoma prisca*, Solander, sp. (1766), at Barton, Hants.

By Henry Woodward, LL.D., F.R.S., V.P.Z.S., F.G.S.

In one of his recent visits to the Natural History Museum, Major C. E. Beadnell kindly showed me a fine example of the well-known shell *Pleurotoma prisca*, which had been obtained some years ago by his son, Mr. Hugh J. L. Beadnell, F.G.S. (now of the Geological Survey of Egypt), when collecting specimens from the Barton Clay (Middle Eocene) in the historical cliffs at Barton, Hampshire, whence, prior to 1766, Gustavus Brander, F.R.S., made his famous collection, some of the specimens of which are still preserved in the British Museum (Natural History).[1]

On comparing this shell with the figures in F. E. Edwards' & S. V. Wood's "Eocene Mollusca" (Pal. Soc. Mon.), tab. xxxiii, figs. 1*a–e*, I was surprised to find Mr. Beadnell's specimen greatly exceeded the figured examples in altitude of the spire, as well as in diameter. I therefore requested Major Beadnell to allow me to figure it, to which he at once most obligingly consented.

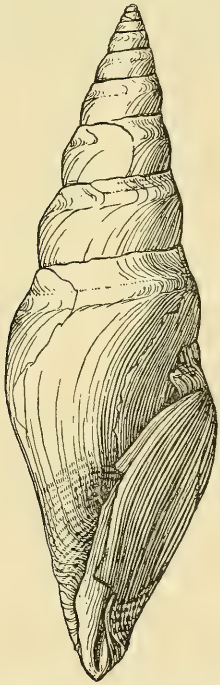
The following is a transcript of Edwards' & Searles Wood's description of *Pleurotoma prisca*,[2] Solander, sp. (1766).

"Shell elongated, fusiform, nearly smooth; the spire almost conical, pointed and moderately elevated, being of equal length with the aperture. The whorls are slightly ventricose; when young, the whole surface is covered with moderately distant, concentric, raised lines, in which state it resembles *Pl. filosa*, Lamk.; these lines, however, are lost on the fourth or fifth volution, and the whorls afterwards become smooth and shining, except at the base and over

[1] Figured and described by Dr. Solander in a work entitled "Fossilia Hantoniensia Collecta, et in Musco Britannico deposita, a Gustavo Brander, 1766."

[2] *Murex prisca*, Brander's Foss. Hant., 1766, p. 16, pl. i, fig. 25; pl. iii, fig. 44.

the posterior margins, round the sutural edges of which last run three or four fine, threadlike, raised lines, occasionally replaced by two or three shallow, obscure furrows; the last whorl is nearly conical, obscurely sulcated at the base and deeply notched at the extremity; the anterior canal is wide, very short, and indistinct. The aperture is narrow and of an oblong-oval form; the outer lip wing-shaped, projecting towards the front, thin and sharp on the edge, and smooth within; the sinus, which is in the very front of the margin, is wide, moderately deep, somewhat triangular in form, and widely rounded at the extremity; the inner lip is much thickened, and is produced and bent outwards in front, giving an umbilicated appearance to the columella, which is slightly twisted and prominently crested towards the base."



Pleurotoma prisca, Solander, sp. Middle Eocene: Barton, Hants.
(Drawn of the natural size.)

There are five specimens figured in Edwards' & Wood's monograph, on tab. xxxiii, figs. 1*a*–*e*; the largest, *a* and *d*, being from Barton, and measuring 70 and 74 mm. respectively in length, by 25 and 22 mm. in breadth.

Mr. Beadnell's specimen measures 90 mm. in length and 28 mm. in breadth, and is therefore considerably larger than either of the above examples. When, however, we turn to other Eocene species of *Pleurotoma,* we find *Pl. cochlis* attaining to a length of 80 mm., *Pl. symmetrica* to 95 mm., *Pl. attenuata* to 98 mm., and *Pl. rostrata* from 80 to 100 mm.

Amongst recent *Pleurotomæ* there are more than a dozen species which exceed *Pl. prisca* in length of shell, up to *Pl. grandis* from the India and China seas, which attains to a length of 135 mm.

Although Mr. Hugh Beadnell's *Pleurotoma prisca* does not "break the record" for size amongst Eocene species, he may at least claim to have unearthed one of the largest specimens of this genus ever found at Barton.

IV.—On the Limburgite from near Sasbach.

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

So much confusion has existed on the subject of limburgite, that, although it has now been partly dissipated, a record of my own investigations may be of use, at any rate to English petrologists. The rock has been classed by some with the peridotites. From these it is separated by Rosenbusch,[1] who in his latest work places it in a subgroup with the augitites in proximity to the basalts. Zirkel uses limburgite as a synonym for magma-basalt. F. Graeff[2] implies relationship with the nepheline-basalts. Harker's[3] remarks suggest similar conclusions, as do those of Cole,[4] though his opening words are perhaps slightly misleading. All, however, lay so much stress upon the absence of felspar, by giving such definitions as "Limburgite und Augitite sind die felspathfreien Entglieder der Gesteinreihe Trachydolerit, Tephrit," etc.,[5] or "Frei von Feldspar und Felspathoiden ist der Limburgit,"[6] and in some cases by reference to the peridotites, that students may readily overlook the fact that this rock is only free from felspar in the same sense as tachylite or many pitchstones and obsidians.

A little consideration of the original analysis should have shown that the rock could not possibly be placed in the same group as the peridotites. This (to which I add a more recent one) gives :—

	(1)[7]	(2)[8]
SiO_2	42·78	44·38
TiO_2	0·28	0·29
Al_2O_3	8·66	9·04
Fe_2O_3	— }	12·82
FeO	17·96 }	
MnO	0·95	0·99
MgO	10·06	10·48
CaO	12·29	12·82
Na_2O	2·31	2·41
K_2O	0·62	0·99
H_2O	3·96	(not given)
	99·87[9]	94·22

1 "Elemente der Gesteinelehre," p. 361. See also "Mikroscop. Physiogr. der massigen Gesteine," p. 811.

2 "Mitt. der Grossher. Badischen Geol. Landesanstalt," ii, p. 405.

3 "Petrology for Students," 1895, p. 179.

4 "Aids to Geology," 1898, p. 262.

5 Rosenbusch: "Elemente," p. 361.

6 Graeff: loc. cit.

7 "Elemente," p. 363.

8 From a pamphlet by Professor Steinmann.

9 Traces also of Cu and Ni.

In eight other analyses quoted by Rosenbusch as representing limburgites we find that

The percentage of	SiO_2	ranges from	40·20	to	44·54
,,	Al_2O_3	,,	8·66	,,	14·89
,,	MgO	,,	6·80	,,	13·34
,,	alkalies	,,	3·50	,,	8·88[1]

But the analysis of a very typical peridotite (dunite) is:[2] SiO_2, 39·61; Al_2O_3, 1·68; FeO, 8·42; MgO, 42·29; Na_2O, 0·01; K_2O, 0·02; H_2O, 5·89. Total, 97·92 (trace of CaO). Among the other analyses of peridotites,[3] we find that the percentage of SiO_2 is often a little higher and that of MgO rather lower, the former rising to about 45, the latter falling even as low as about 20, when, however, the CaO and FeO usually increase, so as to bring the total of the three protoxide bases above 40. The chemical composition of a rock consisting mainly of olivine (i.e. a peridotite) obviously cannot differ materially from that of an olivine; a slight rise in the silica percentage will indicate the incoming of enstatite, or, with addition of CaO, of a monoclinic pyroxene; when the percentage of Al_2O_3 is very low, that is probably present in a spinellid, but with a higher rise (say above 4 per cent.) biotite[4] or white chlorite[5] or anorthite may be expected. Thus, as I pointed out several years ago,[6] limburgite must be much more closely related to the picrites than to the peridotites, and I suggested that it should be regarded as a glassy form of that group.[7]

None, however, of these authors name felspar or a felspathoid as a constituent of limburgite, though some hint at the possibility of their being present, so that it may be worth while to put on record a demonstration of the fact which I obtained in the Summer of 1895. I then collected two varieties of limburgite from a large heap by the roadside, approaching the village of Sasbach, rather more than a mile from the southern quarry at Limburg.[8] One was much less vesicular (or amygdaloidal) than the other, and looked less likely to have a vitreous groundmass, so that on my return to England I had it sliced. Microscopic examination proved it to contain a considerable quantity of felspar, and I should have published a description of it at once had I obtained it from the quarry.[9] So I waited in the hope

[1] Generally under 5·5.

[2] Wadsworth: "Lithological Studies," p. xxiv.

[3] These remarks do not apply to the list given by Professor Rosenbusch, *ut supra*, p. 165, but from personal knowledge I must refuse to admit either the Schriesheim picrite or kimberlite into the peridotites.

[4] As in the mica-peridotite of Kentucky.

[5] As in the Rauenthal serpentines. Here the alumina only amounts to 1·35: see C. A. Raisin, Q.J.G.S., 1897, pp. 251, 257.

[6] Pres. Add. Geol. Soc.: Q.J.G.S., 1885, p. 69.

[7] This is virtually admitted by Rosenbusch ("Elemente," p. 361, and "Mikro. Phys.," p. 813). Zirkel (iii, 76) will not allow even this, and uses limburgite as a synonym for magma-basalt.

[8] Professor Steinmann writes 'Limberg' for the place.

[9] It is not my custom to be satisfied with specimens thus collected. But I had been unable to get a carriage at Riegel (as I had been led to expect), and thus had been obliged to go on foot. It was a hot afternoon, a long and fatiguing walk, and my time was limited by trains, so that I had to turn back without reaching the hill.

that I might either go there myself (it is now more easy of access) or get a friend to ascertain the actual relation of this to the more familiar variety of limburgite. Last Spring, Mr. P. Haas, B.Sc., one of my former students at University College, informed me that he proposed attending lectures at the University of Freiburg, so I asked him to visit Limburg. Early in the Summer he forwarded to me a small box of specimens and a rough sketch of the quarry, on which the position of each was marked, and of which I annex a copy. This quarry, Mr. Haas informs me, is on the south side of the hill marked by the ruined castle of Limburg, near the south-eastern angle; the one from which Professor Rosenbusch obtained and described specimens being on the north-west side, near the ruin and overlooking the Rhine.

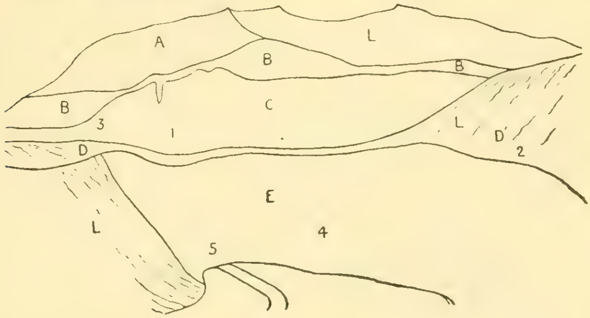


FIG. 1.

A. Upper flow, limburgite (inaccessible).
B. Upper tuff.
C. Middle flow, limburgite.
D. Lower tuff, much foreshortened, with path on cliff edge. All this is covered by slipped-down loess, but Mr. Haas saw the tuff at D and in two places near D′, where also limburgite was exposed in two places (2 marking one of them), and the relations of the lava and tuff appeared to be irregular here.
E. Lower flow, limburgite.
L. Loess, often slipped.

The numerals indicate the positions of the specimens described in the text, 5 being the dark rock.

It will save time to arrange the specimens for description according to their structure rather than their situation in the mass. The first (1) has a general resemblance to a specimen (purchased) which has been in my collection for some five and twenty years, except that its vesicles are a little smaller and more thinly lined with (white) secondary minerals.[1] There is a slight but unimportant difference in the tint of the groundmass, and the visible crystals of augite are a little smaller. Microscopic examination proves the larger crystals to be imbedded in a matrix consisting of small elongated prisms of brownish augite, with a few rods of iron oxide,

[1] I have a couple of slices of limburgite, bought nearly as long ago. They show the usual minerals, imbedded in a rich brown glass, in which also are scattered a few microliths, apparently a pyroxene.

and of an interstitial material, which sometimes is a brown glass, sometimes a clear substance, more or less crowded with brown granules. The latter not unfrequently acts on polarized light, and in its clearer parts the outlines of a prismatic mineral, apparently a felspar, may be detected.

(2) Base of the middle mass, right-hand side. The hand specimen exhibits many crystals of black augite about the same size as in the first specimen, and small light-rust-brown spots, indicating partly decomposed olivine, in a chocolate-brown compact matrix. Vesicles are far from numerous, generally not larger than a mustard-seed, and usually filled with secondary white minerals. As the larger minerals—augite, olivine, and iron oxide—as well as the secondary minerals, zeolites and carbonates, in the vesicles, have been so fully described by Rosenbusch in his classic memoir on this rock,[1] I shall content myself with referring the reader to its pages, for they are practically identical. The olivines (hyalosiderite), I may remark, are frequently, though not universally, idiomorphic, and the augites generally show a slight pleochroism. This is more marked in longitudinal sections, giving a distinctly yellowish tint with vibrations parallel to the vertical axis, and puce-brown with those perpendicular to it. As in the normal limburgite, the larger minerals, augite, olivine, and iron oxide, are rather thickly scattered in a groundmass composed of felted minute prisms of puce-brown augite, with specks of opacite, flakelets of ferrite, and some colourless belonites,[2] and a clear interstitial material, which in parts is doubly refracting, but mostly behaves as a glass. This sometimes (though less frequently) is of a rusty-brown colour, and recalls the base of the typical limburgite. These augite prisms do not exceed ·005″ in length, and are commonly four or five times longer than broad. The ferrite flakelets act on polarized light, as do some little prisms of the same colour, but I suspect this material to be little more than a staining. The groundmass, I may add, is not unlike one figured by Boricky.[3]

(3) "From the left-hand side of the middle mass of limburgite," and (4) "From the central part of the pit, a few feet above the floor." Both these specimens hardly differ megascopically from No. 2, except perhaps in being a shade less vesicular; but this is not true of their groundmass, which, however, is so similar in both, that one description may serve. No. 3 contains numerous transparent lath-shaped microliths, up to about ·015″ long, though in one case double of this, and the clear material between these and other microliths (augite, etc.) is doubly refracting, affording low polarization tints, and resembling an indefinitely crystalline mass of felspar. The microliths show the characteristic twinning of plagioclase, and measurements of extinction angles incline me to refer them to labradorite. The small prisms of augite are much less numerous than in No. 2, but generally a little larger. The opacite and ferrite are more or less inclined to cluster in rod-like patterns, and the

[1] Neues Jahrbuch, 1872, p. 33.

[2] I defer the description of these.

[3] "Petr. Stud. an den Gesteinen Böhmens," pl. ii, fig. 8, and pl. iii, fig. 3.

groundmass is rather variable, being in some parts fairly clear, in others a sort of micro-ophite or micropegmatite, composed of ferrite (or some rust-brown mineral) and felspar. The colourless belonites, mentioned already, are rather abundant. Evidently they consolidated at a very early stage, for they are often numerous in the felspar; they have a higher refractive index than the felspar, and the general aspect of fibrolite, but rather low polarization tints and oblique extinction. This prevents me from referring them to that mineral, which otherwise they resemble.

(5) Comes from the bottom of the pit (about the middle), representing the lowest rock exposed. This apparently differs much from the others. Its colour is greenish-black, slightly mottled in places with a paler green, so that the augite crystals are less conspicuous. Cavities are very few, small, and filled with a pale grey-green mineral. Had I been asked to name the specimen without knowing whence it had come, I should have replied, "probably a picrite." But the microscope shows the differences to be only varietal, the colour being due to the absence of the rust-brown iron oxides so common in the others, and the substitution of a green alteration product in the olivines,[1] as is commonly seen in dark-green serpentines. The groundmass of this specimen is also a little variable, some parts exhibiting the intercrystallization of a basic material and felspar described above, while the latter mineral more commonly forms a clear groundmass of fair-sized crystals, in which the others are scattered; it is, in fact, still more nearly a normal holocrystalline rock than any of the preceding specimens.

The specimen which I collected in 1895 is megascopically very like Nos. 2, 3, and 4, but under the microscope presents a close resemblance to Nos. 3 and 4, as well as (allowing for the absence of the green mineral) to No. 5, with one or two varietal differences. The elongated little prisms of brown augite are more numerous than in the latter three; the micropegmatitic structure is much rarer, for it occurs only as an outgrowth from two or three of the large augites; the minerals, large and small (including numerous colourless belonites), being imbedded in a clear material, which (as in parts of those specimens) is a mass of crystallized felspar (without any separate microliths of the same) often showing the characteristic twinning of plagioclase.

When engaged in putting together these notes I learnt from Miss Raisin that she had visited the north-west quarry at Limburg. She has kindly allowed me to examine her specimens, and slices from three of them. The resemblance between these rocks from the original locality and those described above is so close, that a very brief description will suffice. The minerals occurring porphyritically are the same in all. As regards the groundmass: that of a moderately vesicular specimen from about the middle part of the crag is much darkened with opacite and augite microliths, but the clear interstitial material (not abundant) appears to be a glass. Here and there dark belonites (? a pyroxene encrusted with a brownish iron-oxide) occur, arranged

[1] It affects only the exterior, or penetrates into some of the cracks.

in a sort of 'fern-leaf' pattern. The groundmass of a second specimen (almost free from vesicles) taken not far from the bottom of the cliff, very closely resembles those I obtained in 1895. The smaller augite microliths are not numerous, and all the other constituents are embedded in a clear crystalline groundmass of plagioclase felspar. In a third specimen, generally similar in structure, taken from the base of the cliff, aggregated granules of augite occur locally in a similar groundmass, in which I think a little nepheline is also present. Thus, felspar is abundant in much of the rock at both ends of the hill, of which the original limburgite, with the base of brown glass, is only a local condition.[1]

According to a section of the Limburg Hill from north-west to south-east, published by Professor Steinmann in a pamphlet (for

Fig. 2.

1. Upper flow, limburgite (spheroidal).
2. Upper tuff.
3. Middle flow, nepheline-basalt.
4. Lower tuff (with wood, etc.).
5. Lower flow, black limburgite.
6. Upper flow, limburgite (without olivine).
7. Upper tuff.
8. Middle flow, limburgite (with phillipsite, etc.).
9. Lower tuff.
10. Lower flow, ? limburgite or nepheline-basalt.
11. Loess.

From the top of the hill to the bottom of the southern quarry is about 200 feet.

a copy of which I am indebted to Mr. Haas), three flows, parted by tuffs, are exposed in each quarry. He speaks of the top one in the northern quarry as limburgite, the middle as nepheline-basalt, the lower as black limburgite.[2] In the southern quarry, from which the specimens described in this paper are taken, the upper is limburgite without olivine, the middle limburgite, the lower limburgite or nepheline-basalt. Of the specimens here described, Nos. 1, 2, and 3 are from the 'middle limburgite,' Nos. 4 and 5 from the 'lower stream.' I may say that during my examination of these rocks (before I read Professor Steinmann's notes) I was on the look-out for nepheline. Most of the groundmass is indubitably felspar, but one or two small crystals included in that, and a little interstitial mineral (neither very well preserved), are very suggestive of that mineral, which the analysis would lead us to expect.

These notes, I hope, will make it clear to English readers that the typical limburgite (like tachylite) is only a local glassy condition

[1] Miss Raisin informs me that the specific gravity of a compact specimen is 3·058.

[2] Herr F. Graeff (loc. cit.) also gives a section, naming the top and bottom flows in each limburgite and the middle one nepheline-basalt. He notices the different colour of the mass at the bottom of the southern quarry, and says this has a different habit from typical limburgite.

of a rock which elsewhere contains a considerable quantity of felspar, the one passing into the other in the same quarry, and almost certainly in the same mass. In a classification it must be completely separated from the peridotites, for it is related by composition, on the one hand to the picrites, on the other to the olivine-dolerites, and so occupies, whether in its glassy or holocrystalline condition, a transitional position. Thus, if limburgite be restricted to the vitreous type, a new name must be coined for the other one. It is, however, I think, worth considering whether it would not suffice to speak in future of Limburg-tachylite, Limburg-basalt, etc.

V.—Another Section of Keuper Marls at Great Crosby, Lancashire.

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

In 1884 I described in the Geological Magazine a section of Keuper Marls exposed by the excavation of the Boulder-clay at Moorhey, Great Crosby.[1] This was our first knowledge of their existence in the neighbourhood, the whole area being covered with a thick mantle of Boulder-clay excepting where the Lower Keuper Sandstone comes to the surface in the villages of Great and Little Crosby.

The Great Crosby Machine Brickworks Company in extending their operations in Cooks Lane have sunk a well at the bottom of their brick-pit, proving the Boulder-clay to be 35 feet thick from the surface at this point. It is of a remarkably homogeneous constitution and plastic character throughout down to the very base, there being only a vein of sand 1 foot thick at about 3 feet from the bottom. The most interesting result of the sinking is, however, the discovery that it rests upon the Keuper Marls. These Marls are of a bright blue colour and micaceous. From a personal examination of the well I found that here the Boulder-clay rested upon a well-defined surface of the marls which do not appear to be worked up and mixed with the clay. The well had penetrated 5 feet of the Marls, which fail to show very regular bedding, but appear to have a general dip to the south-east. A bed of more gritty material was to be seen on one side of the well, which is 5 feet in diameter, but it became pinched out on the other side.

At a distance of about 440 yards, in a direction 32° south-east, the Lower Keuper Sandstone crops out near the Police Station, so that there must exist between the two places a considerable fault to which may be due the disturbed appearance of the Marls.

It is the intention of Mr. Peters, the managing director of the Company, to ultimately clear out the whole of the Boulder-clay to the full depth over most of the area. It was in this Boulder-clay that the celebrated "Gypsum Boulder of Great Crosby," weighing 18 tons, now erected in the village, was discovered at a depth of about 20 feet from the surface.[2]

[1] Dec. III, Vol. I, pp. 445–7. See also Q.J.G.S., 1885, vol. xli, p. 454.

[2] See "The Gypsum Boulder of Great Crosby": Proc. Liverpool Geol. Soc., Sess. 1898–99, pp. 347–356.

Moorhey, the only other locality where the Keuper Marls have been proved, is about 7 furlongs to the south-east of the Crosby Brickworks, and the Lower Keuper Sandstone of the village intervenes. The Marls at Moorhey, I should say, are somewhat lower down in the series than those just described. If the whole area of the pit is bottomed many interesting facts may come to light.

NOTICES OF MEMOIRS.

I.—Le Dossier Hydrologique du régime aquifère en terrains calcaires, et le rôle de la Géologie dans les recherches et études des travaux d'eaux alimentaires. (Bull. Soc. Belge géol., 1901, x, pt. 5.)—In a paper of some 180 pages Mr. Van den Broeck replies to the note of Mr. Thomas Verstraeten entitled "Hydrologie des roches, necessité de préciser les situations et les termes." The bulk of the paper is of a controversial nature, but Mr. Van den Broeck has brought together a great deal of valuable matter relative to the subject. With a courteous consideration for his readers the author has provided a detailed table of contents, which occupies 12 pages, and from this we gather that the paper deals with the following items:—Hydrology of the Carboniferous rocks; Hydrology of the Chalk; of the district round Han-Rochefort, of Bocq and Hoyoux, and of Remouchamps; the rôle of geology in the search for water and in the application of hydrology, especially in the study of the aquiferous resources of the Carboniferous System; Hydrology of Condroz, and of the horizontal beds of Tournai. The author concludes his paper by saying that it is thanks to the progress of Geology and Spelæology that these practical questions of applied hydrology can be easily solved to the great benefit of human populations.

II.—Maryland Geological Survey: Eocene. (Baltimore, 1901, pp. 332, 64 plates, map.)—The Eocene deposits of the State of Maryland are described in this volume by William Bullock Clark and George Curtis Martin. The description is prefaced with an excellent map and a bibliography. The deposits are divided into two formations, the Nanjemoy above and the Aquia below. Both are rich in fossils, full lists of which are given. The systematic palæontology begins on p. 93, and is treated of by various specialists. The Vertebrata are few in number and consist of four crocodiles and two tortoises, beside the usual tertiary rays and sharks; there are also remains of *Xiphias* and *Phyllodus*. The Crustacea include some interesting Ostracods described by Ulrich. The Foraminifera, of the usual Eocene types, are described by R. M. Bagg, who is doing careful work on these Protozoa, in an area where they have been for some reason much neglected. The Mollusca by Clark and Martin, the Cœlenterata by Vaughan, and the Bryozoa by Ulrich are all well illustrated, and will be of great use for comparison. Two small *Carpolithi* are described and figured by Arthur Hollick.

III.—The Hunterian Oration, February 14, 1901. By N. C. Macnamara, F.R.C.S. 8vo. London, 1901.—This Oration, to which no title is given, seems to deal with the labours of Hunter and others on the subject of craniology and the light which it is capable of throwing on the prehistoric inhabitants of Western Europe, and of the evolution of the race of men to which we belong. Mr. Macnamara points out that the inhabitants of Western Europe in the later Tertiary and early Quaternary period, as regards the ossification and form, especially of the frontal region, of their skulls, more closely resembled that of the chimpanzee than the race of men now inhabiting Europe. Our search for knowledge is still hampered by the limited supply of the remains of man, but a good deal of general evidence has been obtained from the stone implements so common when properly searched for. Mr. Macnamara believes that the evidence collected proves the existence of man in Tertiary times. With regard to the skull of *Pithecanthropus*, he concurs with the conclusion arrived at by Professor Schwalbe, that taking both its form and capacity into consideration, "it is on the border line between that of man and anthropoid apes"; it is more nearly allied to the skulls of the Neanderthal group of men than it is to the crania of the higher apes; but it is much nearer in anatomical characters to the skull of the chimpanzee than it is to the cranium of the average adult European of the present day. The fact that the inferior gyri of the frontal lobes of the brain are well marked, and that the superficies of this convolution of the brain is double that possessed by the largest known anthropoid ape, suggests that the Java man had in some slight degree the faculty of speech, and that his intellectual capacity was higher than that of any anthropoid ape we are acquainted with.

Mr. Macnamara also points out that it should be clearly understood that up to the present no *bona fide* human remains belonging to the early Palæolitic period have been discovered in Western Europe which are not of the same type as those of the Neanderthal group of men, whose fore and hind limbs indicate that they were a short ape-like and powerful race of beings whose average stature did not exceed five feet. The skulls of men found in geological formations of the Post-Glacial period have the same physical type as those of the strictly early Palæolithic epoch of Western Europe, but with increased brain capacity. These skulls, in the opinion of the author, indicate a gradual transition in form from the ape-like characters of the previous period to a higher standard, and certainly to a much greater skull capacity, especially in the frontal region. Mr. Macnamara remarks on the fact that in the recent elections held in this country, when the question at issue was one in which the whole of the people of Great Britain were deeply interested, a large proportion of the inhabitants of England and Scotland, mainly of Anglo-Saxon origin, voted together on the subject; whereas a contrary opinion regarding the same question was held by the greater proportion of the people of Ireland, and to a large extent by the Welsh, most of whom are derived from Ibero-Mongolian ancestors. It is difficult, he says, to account for this diversity in the sentiments of the people, unless we consider it due to their racial mental qualities.

The Oration is illustrated with an excellent chart of skulls belonging to the Palæolithic, Neolithic, Bronze, and existing races of men.

IV. — Geological Literature added to the Geological Society's Library during the Year ended December 31, 1900. (London, Geological Society, price 2*s.*)—This, the seventh annual record of publications received by the Society, contains 12 pages of titles of serials and academies, of which parts have been added to the library during the past year; 109 pages of titles of papers published in those parts and other separate publications received; and 80 pages of treble-entry, double-column index, analytic of the titles recorded. The work, which is compiled by the librarian, Mr. Rupert Jones, and edited by the Secretary, Mr. Belinfante, deserves to be more widely known than to the Fellows themselves, especially as it is published at so cheap a rate. It provides the best general annual list of geological literature, the index being of especial value, and might be made a really first-class record, if the Society would spend a little more money upon it and include all publications of a geological nature whether received by the Society or not. This system of recording—an alphabetical list, properly indexed—is far and away the most convenient form, and its handy size can be favourably contrasted with those clumsy quartos which are the bugbear of the ordinary man's library.

V.—Buliminæ and Cassidulinæ.—No more useful work is done than that of monographing particular groups. Carlo Fornasini, most active of the students of the Foraminifera, has just published a paper on the Italian forms of these genera (Boll. Soc. Geol. Ital., xx), which he divides into 75 species. He has also published a paper on the Adriatic forms of the genus *Bulimina* (Mem. Ac. Sci. Ist. Bologna, ix). Taking the two papers together they form a valuable contribution to the subject, one of the most interesting points being the publication of some of d'Orbigny's original drawings of the species founded by him in 1826, and which have since remained difficult of absolute identification. Fornasini has put a note in the Riv. Ital. Paleont., vii, on the dates of O. G. Costa's works on the Foraminifera, dates unknown to Sherborn when he published his Bibliography in 1888.

VI.—Other Foraminiferal Publications to which the attention of the student may be profitably directed are: Brown's list and digest of the papers published during 1899 (Zool. Record); Chapman's Foraminifera from the Lagoon at Funafuti (J. Linn. Soc. Zool., xxviii), which gives us for the first time a correct account of the distribution of these organisms across a lagoon, from side to side of the reef; Adalbert Liebus' Foraminiferenfauna des Bryozoenhorizontes von Priabona (N. Jahrb., i, 1901); and Silvestri's Nodosarine del Neogene Italiano (Atti Ac. Pont. N. Lincei, liv).

VII.—Distribution of Vertebrate Animals in India, Ceylon, and Burmah.—Dr. Blanford, writing in the Proc. Roy. Soc., lxvii, considers that whilst it is quite possible that other explanations may be found, it is evident that the peculiarities of the Indian fauna may have been due to the Glacial epoch. During the coldest portion of the Glacial epoch a large part of the higher mountains must have been covered by snow and ice, and the tropical Oriental fauna which occupied the Himalayas, and which may have resembled that of the Indian Peninsula more than is the case at present, must have been driven to the base of the mountains or exterminated. When the country became warmer, the Transgangetic fauna appears to have poured into the Himalayas from the eastward. Dr. Blanford, after discussing the whole matter, says the theory is only put forward as a possible explanation of some remarkable features in the distribution of Indian vertebrates. At the same time it does not serve to account for several anomalies of which some solution is necessary. If thus accepted, it will add to the evidence, now considerable, in favour of the Glacial epoch having affected the whole world, and not having been a partial phenomenon induced by special conditions, such as local elevation.

VIII.—Sphærical Concretions of Graphite.—The sphærical concretions of graphite in the Granite of the Ilmenj were first noticed by Auerbach in 1856, and afterwards described by Rose in 1872. Messrs. Vernadsky and Schklarevsky now show (Bull. Soc. Imp. Nat. Moscou, 1900, No. 3) that the inclusions in these concretions consist of crystals of the minerals characteristic of the Granite—orthoclase, muscovite, biotite, and quartz. The result of their investigations also show that this form of graphite cannot have had a pseudomorphic origin, as considered by Rose, but ought to be considered as a concretion in a granitic magma, analogous to other cases of large sphæroidal inclusions in granite.

IX.—Geology of Scotland.—The Geological Society of Glasgow has recently distributed vol. xi, pt. 2, of their Transactions for 1897–99, but has dated it 1900. We had hoped that this reprehensible practice had been discontinued in this country, and hope that on the next occasion the Society issues publications it will date them accurately. There is a great deal of interesting matter, of which the following is the chief. The late Dr. Heddle's paper on the structure of Agates occupies twenty pages, and is well illustrated ; it may be termed a systematic treatment of the subject. Each form is described in detail, and the whole are grouped in a convenient arrangement according to structure. William Gunn gives a detailed description of the old volcanic rocks of Arran, with notes on the sedimentary rocks associated with them, and an account of the faunæ of those beds. Robert Craig writes of the Greenhill quarries, Kilmaurs, Ayrshire, now closed, and gives an historical sketch of the various discoveries made in them. Peter Macnair treats of the physical geology and palæontology of the Giffnock sandstones, and their bearings on the origin of sandstone rock generally. This is illustrated. He refutes the view that they were of fresh-water origin, and supposes that the contained organic remains have been destroyed, with the exception of the annelid burrows, which he points out are invariably the last things to disappear from percolated sandstones. John Smith has a paper on the Barite veins of south-west Scotland, which mineral he regards as probably an exfiltration product, leached out of the rocks by water, and afterwards re-deposited by the same agent in the veins, but he cannot yet say which of the rocks it was originally derived from. The same writer has a note on the 'China-clay' mine and the Water-of-Ayr stone bed at Troon, and gives some details of localities for radiolarian cherts in Scotland. Two other papers from his pen are "The Permian outlier of the Snar Valley, Lanarkshire" and "Spango Granite," the boulders of which latter he considers were weathered into shape and ready for transport long before the Glacial Epoch. The other original papers, which are all in abstract only, are: Goodchild, the Dolerite of Aberdour; Macnair, the problem of the marginal Highlands; Smith, detached microliths from the Pitchstone Sill at Corriegills (in full, with a plate); Ballantyne, a Bute post-Glacial shell-bed; Cowie, Glacial phenomena of Loch Ranza Glen, Arran; and Horne, the Silurian Volcanic rocks of the southern uplands of Scotland.

X.—Geology in Norfolk.—There are only two papers on Norfolk Geology in the Transactions of the Norfolk and Norwich Naturalists' Society, vol. vii, pt. 2, 1901. The first, by F. D. Longe, is on the formation of flints in chalk. The second, by Professor Newton, records the occurrence of bones of the common Crane, from peat, obtained so long ago as 1867–69, while excavating the Alexandra Dock at Kings Lynn. These bones show a remarkable variation in size of the tibiæ. In the course of his examination of the Woodwardian Museum collections for purposes of comparison, Professor Newton found a right tarso-metatarsus of the Pelican, which further confirms his own and Dr. C. W. Andrews' statement that the Pelican was once a native of the Fens in this country.

XI.—The Geological Distribution of Extinct British Non-Marine Mollusca.—R. Bullen Newton contributes a valuable paper on this subject to the Journal of Conchology. He shows at a glance the geological range of every recorded species of terrestrial and fluviatile shells, excluding only those with manuscript names, or any forms insufficiently described, from the strata of the British Islands. In his list, as no synonymy is attempted, he has introduced the original generic name under which the shell was described, and gives a bibliography of the subject. From a note appended to his paper, we learn that this list was lent to another person for incorporation in a recent publication, but on reference to that publication we find that Mr. Newton's generosity has been studiously ignored by the author in his preface, though the list has apparently been extensively used.

XII.—Geology of Austro-Hungary. — Part iii of the new geological map of the Austro-Hungarian monarchy has just appeared. It contains two maps, those of the Oberdrauberg-Mauthen and the Kistanje-Dernis districts, with their accompanying descriptive pamphlets by Geyer and v. Kerner. In these pamphlets a full bibliography precedes the descriptive text.

XIII.—Laccoliths of Montana.—Messrs. Weed and Pirsson deal with the geology of the Shonkin Sag and Palisade Butte Laccoliths in the Highwood Mountains of Montana in the American Journal of Science for July, 1901. These laccoliths occur in Cretaceous beds, and show a central mass of syenite, surrounded by transition rock, which is in its turn surrounded by shonkinite, the whole having a rind of leucite basalt porphyry. The authors say that these three laccoliths form a transitional group; the Shonkin Sag is the flattest, and also the lowest, and therefore the one most protected from erosion. Its top, in fact, is just beginning to emerge, and from its laccolitic character would not be so evident if it were not for the trenching in it by the former river action which has given such good cross sections. Square Butte stands much higher and has been exposed to much greater denudation; its cover, save in small areas around the base, has been stripped off, and a considerable part of the igneous rock removed. Palisade Butte, standing at the same level as Square Butte, has suffered from the same amount of erosive agencies, but being smaller in size the relative effect has been greater and the cover has entirely disappeared, as well as a large part of the laccolith, so that around it the floor is exposed and only the central portion of the mass remains. From their observations the authors have been enabled to provide us with an excellent account of these interesting structures, which they have illustrated in a clear and exact manner.

XIV.—Bitumen in Cuba.—S. F. Peckham shows in the same Journal that extensive deposits of solid asphaltum exist near the north coast of Cuba, while springs and wells give indications of the existence of liquid bitumens of varying density beneath the surface, over an area of some 4,500 square miles. He is, however, doubtful if, in view of the enormous production which recent developments in Texas and Indiana promise, that there is at present any encouragement for even experimental drilling in Cuba.

XV.—Geology of London.—As President of the Geologists' Association of London, Mr. Whitaker in his annual address to that energetic body dealt with a subject which he has made peculiarly his own. The result is a valuable summary of the papers which have been written on London Geology (to the base of the Drift) since 1888. No less than fifty-nine papers are summarized, and thus rendered easily accessible to general readers. Mr. Whitaker regrets that tendency to over-division of the beds of the Drift so bewildering, as he says, to "simple-minded people like himself." He has also some pertinent remarks on gravels and their ages.

XVI.—Shorter Notices.—A Geological Map and Report on the Tarcoola District, by H. Y. L. Brown, has just reached us. It is part of the Records of the Mines of South Australia, and deals mainly with gold supply.

The Carnegie Museum at Pittsburgh, which was opened in 1895, is described in the Popular Science Monthly for May, 1901, by Dr. J. W. Holland, the Director. Professor Hatcher is making full use of Mr. Carnegie's special fund for research in palæontology, and it is interesting to read that the most perfect specimen of *Diplodocus longus,* six imperfect skeletons of *Brontosaurus,* and the largest known *Mastodon* are in the Museum.

Mr. J. C. Mansel-Pleydell has published in the Proceedings of the Dorset Field Club for 1900 a paper on the Influence of Climatic and Geological Changes upon the British Flora. His annual address for 1900 dealt with the geological history of Pisces. That for 1901, still to be published, dealt with the geological history of the Amphibia and Reptilia.

CORRESPONDENCE.

A SUGGESTED LINK IN THE 'BREAK' BETWEEN PALÆOLITHIC AND NEOLITHIC MAN.

Sir,—In the very interesting paper by Sir Henry Howorth in the August number of your Magazine, we find that to him the great gap between Palæolithic and Neolithic Man means a great catastrophe. In the present attitude of geological opinion, such a statement appears somewhat startling. But if we restrict the meaning of the word 'catastrophe,' as used by Sir Henry, to the occurrence in ancient times of climatic and physical changes of similar nature to those taking place around us at the present day, though of very much greater intensity, probably no geologist is now so rigidly uniformitarian in his views as to refuse to accept it.

The facts before us are these:—During some portion of the Pleistocene Period, probably owing to the co-operation of astronomical and geographical causes, climatic and physical changes, of an intensity which it is difficult for us to realize, were brought about. One of the results of these changes was the distribution of the Drift. There can be little doubt that when this took place man had already made his appearance upon earth. Indeed, Sir Henry is satisfied with such evidence as we possess that his existence dates back even into the previous Pliocene Period. However that may be, and whether we hold that earliest man was Eolithic or Palæolithic, all physical traces of him disappear, with the exception of his imperishable flint implements and a few doubtful bones; and when he next appears on the scene, he has undergone the very considerable advance in development indicated by his entrance on the Neolithic stage. Sir Henry holds that the great gap between Palæolithic and Neolithic man is coincident and in all probability connected with the distribution of the Drift.

However catastrophic in its occurrence the distribution of the Drift may have been, it is obvious that the progress made by man in his passage from the Palæothic to the Neolithic stage was not characterized by that suddenness which is ordinarily associated with the term. Of the history of that progress, of the place of man's abode during it, we know nothing. There is a true 'gap' or 'break.'

In geology and archæology these two words simply imply that our knowledge as to the periods of time concerned is imperfect, and we always expect to find certain of the missing links of the chain of evidence come to light, which they sometimes do in unexpected places.

Is there any link to be found, however remote, to help to bridge over that extraordinary gap between Palæolithic man and his Neolithic successors? I believe there is one, and that it is to be found in the almost universal tradition of a 'deluge'—a tradition which appears to me to have been handed down from our Palæolithic ancestors through the Neolithic, Bronze, and Iron ages of their successors, and to have reached us as a dim and misty conception of their ideas of the—let us call it very bad weather—of the Pleistocene Period. That the story as conveyed to us from Asiatic sources is very different from that written on the page of the rocks in Northern Europe, is not surprising. All tradition undergoes a process of corruption as it is handed down from age to age, and the particular form in which the deluge tradition has reached us is obviously no exception to the rule. Unfortunately, when such a theory is advanced, it is usually seized upon as a confirmation of the miraculous inspiration of Scripture. It is no such thing.

I cannot claim originality for the theory, because I find in Mr. Tiddeman's "Work and Problems of the Victoria Cave Exploration," 1875, the following passage:—"As similar evidences of a submergence late in the glacial period have been observed over large areas in the Old and the New World, and in both hemispheres, in mean latitudes, it may be that the traditions so common to many races and religions of a great deluge are but lingering memories of this great event. It matters not that these myths all differ in their surroundings. The central core still has the solid ring of truth, albeit masked and disfigured by the rust of time."

I venture to suggest that the theory that the deluge tradition is the one and only link which bridges over the gap between Palæolithic man and ourselves, his descendants, is one which is worthy of more attention than it has hitherto received.

J. Adam Watson.

"Hay Tor," Dennington Park Road, Hampstead.
August 18, 1901.

EOLITHIC MAN.

Sir,—It is remarkable that in a quasi-geological paper by a well-known writer should have been allowed to pass current such a statement as that at p. 340 (Geol. Mag., August issue), to the effect that "Huxley caused McEnery's now famous memoir to be locked up at the Royal Society for years after his death." The Rev. McEnery's reports on Kents Cavern were finished about 1826, and Professor Huxley having been born in 1825 must have been always under age and without influence in the Royal Society whilst McEnery's paper was supposed to be "lost," but really kept in the background by influence of the Rev. Dean Buckland, who ascribed the occurrence of anything like human implements to burials of late date, as I myself have heard him affirm at a meeting of the Geological Society.

The reference to Professor Huxley in the paper alluded to above is probably only one of the evidences of the hasty character of the paper; but at first sight it appears, not only uncalled for, but unkind.

Some of his friends, like the writer of this critique, will regret Sir H. Howorth's inability to recognize the actual classification of eoliths as practically established by Prestwich, and illustrated in his own and B. Harrison's collections, as well as in the Museum of the Geological Survey, Royal College of Science, the British Museum (Natural History Branch), and elsewhere. Also, it is lamentable that he cannot appreciate Prestwich's lucid explanation of the geological history and settlement of the eolithic gravel of the Chalk Downs, as reproduced in Mr. Bullen's pamphlet, to which he alludes as having read.

To other shortcomings we need not refer; it is a pity that there should be any, for the author is doubtless an industrious gatherer of facts and notions, evidently so when he seems to have searched one set of about twenty volumes, "1829–50" (!), for the history of Ami Boué's discovery of bones near the Lahr (p. 339).

T. Rupert Jones.

EOLITHIC IMPLEMENTS.

Sir,—Sir H. H. Howorth, F.R.S., has done me the honour of mentioning in the Geological Magazine for August my little paper on the above subject.

Like Balaam, having set himself to curse Israel, he has instead blessed them altogether. On p. 342 he says (assuming their identity with palæoliths), "Such remains are claimed to have been found at that horizon [the Forest Bed] in Norfolk by Mr. Abbott and Mr. Savin, in Dorsetshire by Dr. Blackmore, and they have been also reported from the same horizon at St. Prest in France and in the Val d'Arno, north of Italy, in each case the remains of human workmanship being accompanied by those of *E. meridionalis. I believe these finds are quite genuine.*" (Italics mine.) The implements referred to as Dr. Blackmore's, pl. iii in my paper, have, as a matter of fact, an eolithic facies, and Sir H. H. Howorth's admission concedes all that for which Sir Joseph Prestwich's followers contend. "I thank thee, Roderick, for that word!"

Sir Henry mentions five men as upholding eoliths, including their original discoverer, Mr. Benjamin Harrison, and that paladin of geologists, Sir Joseph Prestwich, who first employed his vast geological learning in their defence; but the list may be largely extended, especially among the rising generation of geologists and anthropologists, not omitting, of course, Professor Rupert Jones and the late acute and careful observer Dr. H. Hicks.

Let the following extract from M. A. Rutot's letter serve as a sample of the encouraging letters received since my paper has been issued. He says: "En Belgique, il n'y a pas beaucoup à combattre pour faire admettre les eolithes comme industrie humaine. Depuis plus de 15 ans, nous sommes habitués à l'industrie Mesvinienne, et la connaissance de cette industrie nous a facilité la comprehension des industries plus primitives, eutel-mesvinienne et Reutelienne, et aussi celle des eolithes d'Angleterre et des silex tertiaires. . . . . Dans la question des eolithes vous pouvez être certain d'être vigoureusement soutenu en Belgique."

["In Belguim, there is not much opposition to overcome in causing eoliths to be accepted as of human workmanship. For more than 15 years we have been used to the work of the Mesvinian period [l'iudustrie Mesvinienne], and our acquaintance with this has rendered easier the understanding of more primitive types of workmanship, e.g., Reutel-mesvinian and Reutelian, as well as that of the English eoliths and of flints of the Tertiary period [des silex tertiares] . . . . With regard to the question of the eoliths you can be sure of vigorous support in Belgium."]

The time is approaching when there will be few or no sceptics on the authenticity of eoliths, and I thank Sir Henry for having, though unconsciously, ranged himself on their side. By the way, "W. J. Lewis," Geol. Mag., p. 342, must be a slip for W. J. Lewis Abbott, F.G.S. The late ardent collector of palæoliths was *Henry* Lewis. R. Ashington Bullen.

"THE EARLIEST TRACES OF MAN."

Sir,—In this article the author (Sir Henry Howorth, K.C.I.E., F.R.S., F.G.S.) taxes the upholders of Eolithic man with an insistence on their views both "in season and out of season." This charge comes rather strangely from the author of the "Glacial Nightmare," etc., and one is at a loss to see either the force or even the meaning of it. All true workers in any science should gladly welcome from others any fresh views, even if they do conflict with previously accepted ones; and had these tended to strengthen those of Sir Henry, they no doubt would have been eagerly accepted by him, and would always have been in season even if forced.

Sir Henry admits to an obstinacy which he says has been stiffened and his scepticism increased by those so-called Eoliths. Now we all welcome honest scepticism, but surely obstinacy is out of place, or should be, in the truly scientific mind. Obstinacy, too, is generally the outcome of prejudice, and this seems to be the case in this Eolithic question.

He speaks as if the uses of all the Palæolithic implements were well *known*—we can only *guess* at most of them—and expects to find in the Eoliths forms parallel with them, and hence by inference a race of men of similar habits and modes of life, and because such is not the case dismisses them with a sarcasm. All hairy animals do scratch a great deal, and even Job scraped himself, and so we may infer that scraping with a kind of 'scraper' was common in his by no means very early period. He expects man to have sprung at one bound over the vast period that separates him from the mere animal to that of the comparatively highly specialized being he was in the Palæolithic period. He thus ignores the *fact* that the rudest *existing savage,* who lives mostly on roots, and so needs very few tools of any kind, was far surpassed by Palæolithic man, the hunter of the Mammoth, etc.

In reference to the implements from the Forest Bed we regard them as Eoliths, and even Sir John Evans would hardly class them as Palæoliths. Also Eoliths *do occur* with the Palæoliths both on the plateau and in the valley gravels. Again, as to M. Boucher de Perthes, an exact parallelism exists between his case and that of Mr. Harrison, and one has only to substitute the one name for the other in Sir Henry's account; yet Sir Henry evidently cannot see the identity of position; one wonders much if he would have been on the side of M. Boucher de Perthes. We maintain, too, that Mr. Harrison's case is the stronger, as he has had all the past experience of others to aid him, coupled with the extensive knowledge he has gained since. Sir Henry speaks of thousands of shapeless stones with no classification; let him call and see Mr. Harrison's collection with an open mind. Is it likely that the men who find and bring these stones to those who collect them—and they do *not* bring them by cartloads—*could* do so unless they perceived that these objects had a distinctive type of their own.

But I must now leave Sir Henry to those whom he has directly attacked by name; they will no doubt answer him in greater detail and more conclusively. F. D. Bennett.

West Malling.

THE LATE REV. J. McENERY.

Sir,—Referring to Sir Henry Howorth's suggestion that Professor Huxley was instrumental in suppressing McEnery's Kents Cavern evidence,[1] it is important to bear in mind that McEnery died in 1841, when Huxley was 16 years of age; that McEnery's MSS. were left in an incomplete state; that they are in the possession of the Torquay Natural History Society; and that they were never in the custody of the Royal Society. The suppression of the Kents Cavern and Brixham Cave evidence is a very long story, and one long subsequent to McEnery's death. The late Edward Vivian, in 1859, in his "Cavern Researches" published the pith of McEnery's investigations, and subsequently Pengelly published McEnery's MSS. in their entirety, so far as they have been preserved, *verbatim et literatim.* A. R. Hunt.

Southwood, Torquay.
August 10, 1901.

[1] Geol. Mag., August, 1901, p. 340.

RECENT DENUDATION IN NANT FFRANCON.

Sir,—When examining the scene of the flood described in this Magazine last February I could not satisfy myself as to whether any channels had previously existed at the same place. My friend Mr. Dakyns informed me, however, that destruction of culverts is mentioned in a description of the damage done to the road. It is clear, therefore, that former channels did exist, and that the whole of the excavation cannot be ascribed to the flood of last August. I think, though, that the old channels must have been small, for if deposition be a measure of denudation, the recent excavating work done must have been very great.

I should like to take this opportunity to again suggest how valuable some regular record would be of denudation observed at the present time. Edward Greenley.

OBITUARY.

BARON NILS ADOLF ERIK NORDENSKIÖLD,

Ph.D., For. Memb. Geol. Soc. Lond., Naturalist and Arctic Explorer.

Born November 18, 1832. Died August 13, 1901.

With deep regret, we have to record the sudden death near Stockholm of Professor Baron Nordenskiöld, the eminent Naturalist and Arctic Explorer. Of a Swedish family long settled in Finland, Nordenskiöld was born in Helsingfors, the capital of that country, his father, Dr. Nils Gustaf Nordenskiöld, the eminent mineralogist, who died in 1866,[1] being at that time Director of Mines for Finland. Naturally, therefore, his ardent sympathies were always enlisted in favour of the land of his birth.

His family had long been eminent in science, and his inherent tastes were fostered and developed by the surroundings of his home at Frugård, which contained extensive collections of minerals and natural history specimens, and by his journeys with his father. On entering the University of Helsingfors in 1849 he devoted himself almost entirely to scientific studies, spending his vacations in excursions to the rich mineral localities of Finland. In 1855 he took his degree as licentiate, and was immediately appointed a mining official of the Government. From this post, however, he was dismissed in the same year for having indulged in pleasantries at the expense of the Russian Government at a private students' feast. A temporary absence being deemed advisable, he continued his studies at Berlin, but in 1857 returned to take his doctor's degree at Helsingfors. As ill-luck would have it, however, a deputation from the Swedish Universities was then entertained at Helsingfors, and the young doctor in an after-dinner speech again showed his sympathies

[1] See Geol. Mag., 1866, Vol. III, p. 288.

too plainly. The affair might have been smoothed over, but Nordenskiöld refused to apologise, and was banished the country.

As may be supposed, the viking philosopher was received with open arms by the Swedes, and after little more than a year was appointed Professor and Keeper of the Mineralogical collections at the Vetenskaps-Akademi in succession to Mosander. Earlier in the same year (1858) he had entered on his Arctic travels by accompanying Torell to Spitzbergen, and in 1861 the two geologists undertook a more complete exploration of the island. Three years later Nordenskiöld headed an expedition, which mapped the southern part of Spitzbergen, and started the great work of measuring an arc of the meridian in those regions. The explorers met with some shipwrecked walrus hunters, however, and were obliged to return, their provisions being inadequate to maintain so large an addition to the party. Nordenskiöld now had higher ambitions, but money was lacking, and turning for help to the rich merchants of Gothenburg he initiated the long alliance with Oskar Dickson, productive of so much good to Arctic exploration. The steamer *Sofia*, which carried the winter post to Gotland, was obtained, and in 1868 Nordenskiöld, with the present cabinet minister, Baron F. W. von Otter, as navigating officer, managed to attain the high latitude of 81 deg. 42 min.—a latitude previously exceeded only by Parry, who in 1827, going with sledges from the *Hecla* in the same direction, reached 82° 45′ N. Subsequently this attainment has been surpassed more than once, as by Charles Hall, who in 1871 reached 82° 16′, Payer in 1874 (82° 5′), A. Markham in 1875–6 (83° 20′), Lockwood of the Greely Expedition in 1884 (83° 24′), while the exploits of Nansen (86° 14′) and the Duke of Abruzzi, 22 miles further north, will be fresh in the memory of our readers.

In 1870 Nordenskiöld set out on a short visit to Greenland to ascertain if possible whether Esquimaux dogs would be suitable for sledge-journeys to the pole. During his stay in Greenland he made an expedition into the interior over the inland ice-sheet and examined the Tertiary plant deposits at Atanekerdluk, where he discovered erect bituminized tree-trunks of Tertiary age *in sitû*, proving that they had grown upon the spot (some were 2 feet in diameter), associated with beds of lignite and layers of dicotyledonous leaves. He also made important observations upon the inland ice-sheet and the glaciers on the coast, and discovered the great blocks of so-called meteoric iron at Ovifak, the largest of which weighed about 19 tons, the next 8 tons, and the third 6 tons. (See Prof. Nordenskiöld's account of his voyage, Geol. Mag., 1872, Vol. IX, pp. 289, 355, 409, 449, 516, and 88.) These masses are now shown to be of telluric origin and to have been ejected probably in Miocene Tertiary times, with the deep-seated basaltic flows through which metallic iron, of a similar character, is found to be disseminated. His belief in their cosmic origin, however, was fortunate in so far as it led Nordenskiöld to the further study of meteorites, while his observations on the surface of the Arctic ice-fields led to the well-known speculations on the falling of cosmic dust.

Nordenskiöld felt convinced that he could reach a much higher latitude by wintering in Spitzbergen and utilizing sledges. Accordingly he sailed thither in 1872 in the *Polhem*, accompanied by two tenders. Unfavourable conditions of the ice rendered the geographical results less important than he hoped; but he discovered fossil plants of great importance to the history of climatology during former geological epochs. Moreover, with Lieutenant Palander, now the Swedish Minister of Marine, he successfully surveyed part of North-East Land, and in the following July the vessels were extricated from their winter quarters at Mossel Bay, on the north coast of Spitzbergen, and returned home richly laden with important scientific collections.

Nordenskiöld now turned his attention to the exploration of Siberian waters, and in 1875, following the pioneers Carlsen (1869) and Wiggins (1874), he sailed through the Kara Sea to the Yenissei, and ascended the river in a small boat, returning home overland. In the following year, after a flying visit to the Philadelphia Exhibition, he introduced merchandise by sea to Siberia, returning in the autumn with his steamer by way of the Kara Sea and Matotschkim Sound. These experiences gave Nordenskiöld a reasonable hope of accomplishing the North-East Passage, and the King of Sweden, Mr. Oskar Dickson, and Mr. Sibiriakoff at once lent their aid to the project.

In July, 1878, Nordenskiöld, with Palander as navigator, started in the *Vega*, accompanied by two smaller ships. She was the first vessel to double the most northern point of the Old World—Cape Tchelyuskin. She wintered near Behring's Straits, and once more free in July, 1879, reached Japan on September 2. After a triumphal passage home around Asia and Europe, Nordenskiöld was enthusiastically welcomed at Stockholm on April 24, 1880, and laden with honours, being created Baron and appointed a Commander of the "Nordstjerne Orden" (Order of the North Star). In 1883 Nordenskiöld made his second voyage to Greenland, where he investigated the inland ice, and succeeded in penetrating with a ship through the dangerous ice-barrier along the east coast of that country south of the Polar circle, a feat in vain attempted during three hundred years by different Arctic expeditions.

Thus, at the age of 51, he brought to a close a career of exploration comparable in the magnitude of its results with that of a Vasco di Gama or a Maghelhaëns. But his intellectual activity was by no means ended. His own explorations furnished material for numerous books and memoirs, such as the account of his first visit to Greenland in 1870 (see Geol. Mag., loc. cit.), "The Voyage of the *Vega* round Asia" (1881), and the "Second Swedish Expedition to Greenland" (1885). His professional work as Keeper of the Mineralogical Division of the State Museum in Stockholm led him to contribute many valuable papers to the publications of the Academy of Science and various technical journals, as those in which he described the new minerals Crookesite, Laxmannite, Thaumasite, and Cleveite. Combined with his love of active exploration was a deep interest in the history of past geographical discovery and the development of cartography, This gave rise to the preparation of his great "Facsimile Atlas to the Early History of Cartography" (1889), translated by Ekelöf and Sir Clements Markham, and to the equally large complementary work, illustrated with numerous facsimile reproductions of ancient manuscript maps and portolani, and issued in 1897 under the title "Periplus: an essay on the early history of Charts and sailing directions," the English translation being by F. A. Bather. Nordenskiöld, indeed, was half a bookworm, and thus it is that when the *Vega* reached Japan, he employed his stay there in buying up every book and manuscript he could lay hands on, thus forming the finest collection of Japanese books in Europe. A catalogue of it, by Professor Léon de Rosny, was published at Paris in 1883.

A feature of Nordenskiöld's work, even in its most active manifestations, was always the underlying philosophy, sometimes appearing to the public very remote and speculative, sometimes fantastical if not absolutely erroneous, but leading as a rule to success and to results of practical value. Thus his views on the origin of cracks in igneous rock, originally sketched out thirty-three years ago in a paper on the geology of Spitzbergen, led ultimately to numerous deep borings for water in the gneiss and granite of Sweden and Finland; some account of these was published in *Natural Science* for September, 1895. Nordenskiöld also busied himself with a project for an expedition to the Antarctic, which, however, came to nothing at the time. It is interesting, however, to note that his nephew Otto Nordenskiöld has been appointed to take command of the Swedish Antarctic expedition.

At various periods from 1869 onwards Nordenskiöld added to his other duties those of politician, sitting in the Swedish Parliament, first as Liberal member for Stockholm, and subsequently in the Upper House. It is not long since he took part in the deputation that journeyed in vain to St. Petersburg to lay before the Tsar a petition on behalf of the Finnish nation.

Baron Nordenskiöld leaves a widow, a married daughter, and a son, whose mourning is shared by the whole Swedish nation, and by people of culture throughout the world. The son, Erland, is now on an exploring expedition in Patagonia; his elder brother, Gustaf Erik Adolf, died in 1895, at the age of 27, thus cutting short a career that promised to be one of excellence both as geologist and archæologist.—F. A. B.

Errata.—Mr. J. P. Johnson asks us to make the following corrections in his article "Some Sections in the Cretaceous Rocks around Glynde," which appeared in the June number: p. 249, last line of text, and p. 250, line 11 from bottom, for *Cuvieri* read *Brongniarti*.—In Mr. F. R. Cowper Reed's article, August number, page 358, for *Pleurotomaria reniformis*, Salter, read *Pleurotomaria uniformis*, Salter.

THE

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No. X.—OCTOBER, 1901.

ORIGINAL ARTICLES.

I.—On some Carboniferous Shale from Siberia.

By Professor T. Rupert Jones, F.R.S., F.G.S., etc.

(PLATE XVI.)

Introduction.

In December last M. J. Tolmatschow, Conservator of Geology in the Museum of the Imperial Academy of Sciences in St. Petersburg, sent for my examination a quantity of two fossiliferous shales from the (Upper?) Coal-measures in the Basin of Kousnetzk, thinking that specimens of *Estheria* might be found in them.

Both the shales came from sections on the Upper Ters River, a right affluent of the Tan River. From one locality (on the Toostooérr River) most of the shale, like that from the other locality (Boogtasch Mountain), is very flaky and friable; but some beds of the former constitute a hard and thick *Posidonomya*-shale.

Both shales are dark in colour, here and there somewhat bituminous, and accompanied by a film of coal in one specimen. The surfaces of the shale bear crowds of flattened valves of *Anthracomyæ* and *Posidonomyæ*, often much distorted by pressure, rarely keeping the shell, and usually presenting only a black shiny film.

Description of Specimens. (Plate XVI.)

No. I (Figs. 1–4).—This is a right valve, flattened and lengthened by pressure; obliquely ovate, nearly straight above, elliptically rounded below; higher behind than in front; extremities rounded; the posterior more produced than the anterior end, at an angle of 25°–30° with the superior border (hinge-line). Concentric lines thin and numerous.

These features seem to agree with some of Dr. W. Hind's figures of *Anthracomya minima* (Ludwig), as published in his Mon. Pal. Soc., 1895, pt. ii, p. 116, pl. xvi, figs. 21, 22, 24–30. Fig. 23 is referred (perhaps wrongly) to a variety of *A. lævis*, Dawson, but has much of the appearance of *A. minima*.

Posidonomya membranacea, McCoy (Synop. Carb. Foss., p. 78, pl. xiii, fig. 14), is an elongate form with delicate concentric lines; but it is larger, and differs in shape from Fig. 1; it also has some longitudinal lines crossing the others. *P. lateralis*, Sowerby & Phillips, is also one of the obliquely elongate species, but it is much larger, and it has coarse concentric wrinkles.

No. II (Figs. 6 and 7).—This right valve is evidently allied to the foregoing, but has proportionately less length, a fuller convexity of the postero-inferior margin, and a greater obliquity, at an angle of 40° with the hinge-line. This may probably belong to *Anthracomya lævis*, Dawson.

No. III (Fig. 5).—This is a left valve, having features similar to those of Figs. 6 and 7, but much more pronounced. The obliquity is 65° instead of 40°. The hinge-line is short, and the postero-inferior margin is elongate-elliptical. The concentric lines are not so neat. This is possibly a *variety* of *A. lævis*, modified by pressure.

No. IV (Figs. 16, 17).—This left valve has a much more truly rounded inferior margin than that of Fig. 5, and approximates to a semicircle; its obliquity to the hinge-margin is greater (75°). It may be compared with some of the figures of *Anthracomya Valenciensis*, R. Etheridge, jun., given by Dr. W. Hind (Mon. Pal. Soc., 1895, p. 113, pl. xvi, figs. 44–48).

No. V.—Figs. 8–15 are subovate *Posidonomyæ* (*P. subovata*), having the umbo either more or less excentric or just in the middle of the hinge-line. They have a nearly semicircular inferior margin, and numerous concentric lines, ridgelets, or rugulæ. Fig. 10 has the umbo near the middle of the upper margin; and is very similar in shape to *Posidonomya punctatella*, Jones, from a Lower Carboniferous shale in Western Scotland. It measures 8 mm. transversely, by 6 mm. in height. Many larger valves, found in the same shales, having a similar shape, but with fewer and stronger concentric ridges, have been regarded as adult individuals, measuring 32 × 22, 30 × 18, 29 × 22, 28 × 20, 20 × 11, as I was informed by my old friend the late Dr. J. Young, of Glasgow, who sent me many sketches of them, with strong concentric ridges and nearly semicircular valves. These shales, especially at Dalry in Ayrshire and Thornliebank near Glasgow, bear crowds of *Posidonomyæ*, concentrically ribbed, oblong-ovate in shape, mostly equilateral, with more or less median umbo and semicircular inferior margin. Among them, at Linn Spout,[1] Dalry, and at Arden quarry, Thornliebank, occurred the *P. punctatella*, Jones,[2] once regarded as an *Estheria* (1869), but afterwards proved to be a *Posidonomya* (1890), and it is

[1] For a section of the Upper Linn limestone and *Posidonomya* bed of the Lower Carboniferous Series at Linn Spout, see the Mon. Brit. Pal. Phyll., Palæont. Soc., 1899, pt. iv, p. 208.

[2] Trans. Geol. Soc. Glasgow, 1867, vol. ii, p. 71, pl. i, fig. 5; 1890, vol. ix, pp. 85–87, pl. v, fig. 7.

well-matched in shape by our Fig. 10; but the latter is destitute of the punctate ornament, and the former may be the young form of a different species (*P. subovata*, nov.).

The shell-structure in our specimens is not pitted nor clearly prismatic, but is full of delicate lines of fissure, parallel with the thick, radiating breakages, corrugations, or pressure-folds; and causing the shell to come away in subquadrangular pieces, which are variously modified by decomposition before they are quite removed from the internal cast. The straightness of the microscopic fissures, and the regular edges of the separated pieces of the shell, may be due to the presence of a crystalline or quasi-prismatic structure not otherwise indicated.

In Figs. 8–15, as also in Figs. 5–7, the vertical markings crossing the concentric lines and riblets are due to pressure reducing the convexity of the original shell.

P. corrugata, R. Etheridge, jun. (Geol. Mag., 1894, p. 304, Pl. XIII, Figs. 4–6), occurring in the same shale at Linn Spout,[1] has a distant relationship with *P. punctatella* and *subovata*. Its concentric lines, however, are crossed by rough crumplings; and in its shape it differs from the other. Its variable and coarse radial lines are evidently regarded by the author as congenital, like the vertical ribs in *P. costata*, McCoy (Synop. Carb. Foss., p. 78, pl. xiii, fig. 15), and, if the figures which he gives are of the natural size, *P. corrugata* is much larger than Figs. 8–15.

No. VI. Fig. 18 (*Posidonomya concinna*, nov.).—This is part of a larger *Posidonomya*, with numerous, distinct, narrow, concentric ridges, with smaller parallel lines between. There are more perfect specimens of this rotundo-ovate form in the collection, measuring 18 mm. vertically and 20 mm. transversely.

This is characteristically abundant in some of the more solid shale at the Toostooérr River, accompanied by small *Posidonomyæ* and numerous obscure organic fragments.

No. VII (*Beyrichia Kirkbyana*, nov.).—Scattered throughout the shales, especially those from the Boogtasch Mountain, are numerous specimens of a small *Beyrichia*, about 1 mm. long.

It is characterized by the two moieties of the valve being always swollen, and separated by a dorso-medial sulcus, within and on one side of which is a little tubercle; and the whole surface is neatly reticulate.

This little Entomostracon is related to other Carboniferous *Beyrichiæ*, such as *B. impressa* (McCoy) and *B. cratigera* (G. S. Brady).

I propose to dedicate it to my lately deceased friend and fellow-worker James Walker Kirkby, for whose work among the minute fossils of the Carboniferous and Permian Series geologists owe great thanks.

[1] Catal. West. Scot. Fossils, 1876, p. 52.

EXPLANATION OF PLATE XVI.

Fig. 1.—*Anthracomya minima* (Ludwig), Hind. Right valve. Natural size, 10 by 5 mm.—Fig. 2, magnified.
,, 3.—*A. minima* (Ludwig), Hind. Right valve. Natural size, 13 by 8 mm.—Fig. 4, magnified.
,, 5.—*A. lævis*, Dawson. Variety. Left valve, magnified. Natural size, 8 by 6 mm.
,, 6.—*A. lævis*, Dawson. Right valve. Natural size, 7 by 5 mm.—Fig. 7, magnified.
,, 8.—*Posidonomya subovata*, sp. nov. Left valve. Natural size, 7 by 5 mm.—Fig. 9, magnified.
,, 10.—*P. subovata*, nov. Right valve, magnified. Natural size, 8 by 6 mm.
,, 11.—*P. subovata*, nov. Left valve. Natural size, 4½ by 3 mm.—Fig. 12, magnified.
,, 13.—*P. subovata*, nov. Left valve. Natural size (of Fig. 15), 6 by 4½ mm.
,, 14.—*P. subovata*, nov. Left valve, showing the interior; magnified. Natural size, 8⅓ by 6 mm. This is not the magnified view of Fig. 13.
,, 15.—*P. subovata*, nov. Magnified view of Fig. 13.
,, 16.—*Anthracomya Valenciensis*, Etheridge. Left valve. Natural size, 7 by 7 mm.—Fig. 17, magnified.
,, 18.—*Posidonomya concinna*, nov. Fragment. Size of the original shell, 20 by 18 mm.

The enlarged Figures are magnified about three times.

II.—Preliminary Note on some Recently Discovered Extinct Vertebrates from Egypt. (Part II.)

By Chas. W. Andrews, D.Sc., F.G.S., British Museum (Nat. Hist.).

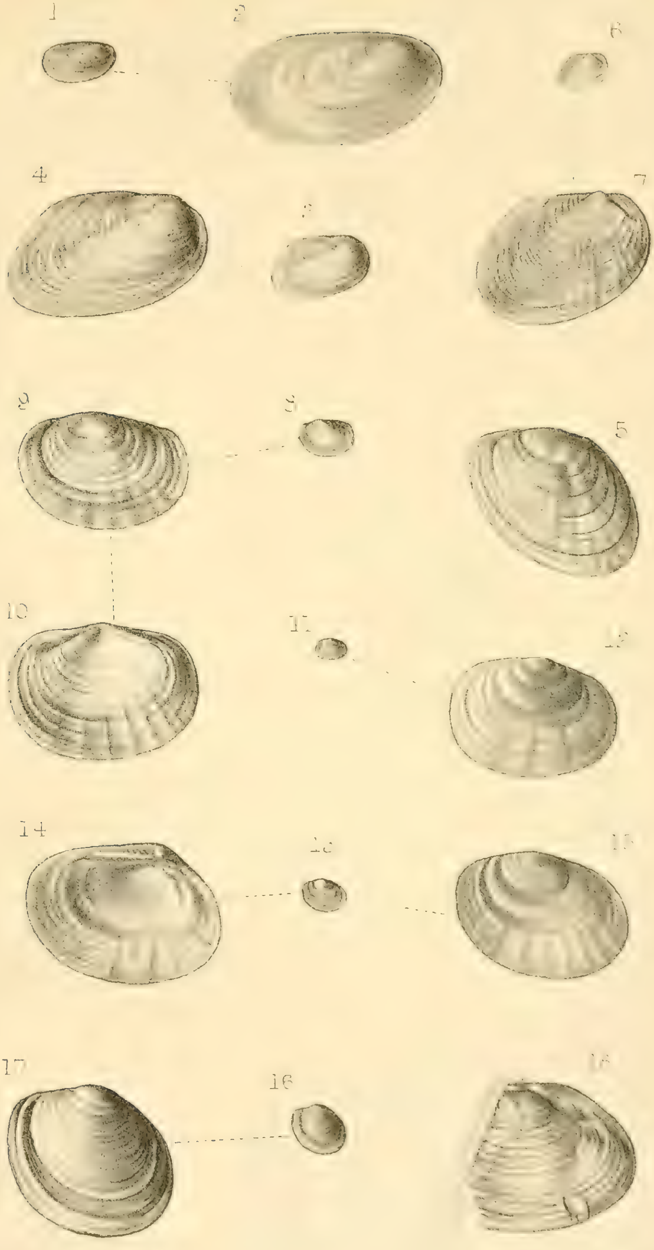
Mammalia (*continued*).

Eotherium ægyptiacum, Owen.

In the lower beds remains of a Sirenian are very common, and several more or less complete skulls associated with some portions of the skeleton were found. The skull in most respects resembles that of *Halitherium*. The snout is strongly deflected and bears a pair of downwardly directed incisor tusks. There are about seven cheek-teeth, resembling in pattern those of *Halitherium*. The roof of the skull between the temporal fossæ is flat. A cast of the brain-case has been made, and in most respects it resembles that described by Owen[1] as the type of *Eotherium ægyptiacum*, from the Mokattam of Cairo. Since this seems to have come from nearly the same horizon as our specimens, I believe that there is the highest probability that they are referable to this same species, in spite of some differences between the shape of the natural cast described by Owen and that artificially made from one of our specimens.

The mandible has a sharply deflected symphysis, which is much thickened below, and it appears that teeth occurred along nearly its whole length. The vertebræ, scapula, and os innominatum are almost exactly as in *Halitherium*. It is, in fact, very remarkable that in a form so old as this (possibly Mid-Eocene, see below) there is no trace of a more generalized structure than in the later *Halitherium*, and we are apparently no nearer the primitive mammalian stock from which the Sirenians sprang.

[1] Quart. Journ. Geol. Soc., vol. xxxi (1875), p. 100.



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

Siberian Anthracomyæ &c.

Zeuglodon Osiris, Dames.[1]

Zeuglodon remains are not uncommon, and we obtained many vertebræ, a fine mandible, and a large part of two skulls, from one of which it will be possible to get a cast of the brain-case. There are two forms, a large and a small, as described by Dames. The smaller is certainly the *Zeuglodon Osiris* of that author, who considers that the differences between the larger and smaller species are merely sexual. Of this there seems to be much doubt, but for the present, until further information is available, it will be convenient to accept this view.

Reptilia.

The reptilian remains collected were very numerous and include some forms of great interest. In many cases the bones were in a wonderfully perfect state of preservation and had been almost completely freed from the matrix. Some of the more important new forms only will be noticed here; these include two species of snakes, three Chelonians, and a Crocodilian.

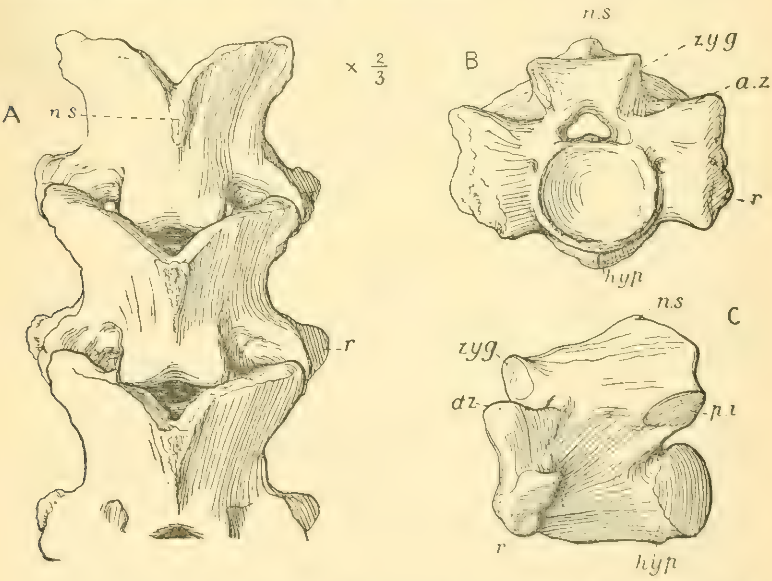


Fig. 1.—Vertebræ of *Gigantophis*. Two-thirds natural size. (A) Three articulated vertebræ from above; (B) vertebra from front; (C) vertebra from side. *a.z.* anterior zygapophysis; *hyp.* hypapophysis; *n.s.* neural spine; *p.z.* posterior zygapophysis; *r.* articular facet for rib; *zyg.* zygosphene.

Ophidia.

The fossil remains of snakes are, as a rule, very rare, but in the lower beds in which our collections were made Ophidian vertebræ

[1] Palaeont. Abhand., neue Folge, Bd. i (1894), p. 189.

were very common. They belong to two types, one an extremely large *Python*-like form, and the other a smaller, though still large snake, the chief characteristic of which is the great height of the neural spines. These two types are briefly described below.

Gigantophis Garstini, gen. et sp. nov. (Fig. 1.)

The large vertebræ of this species occur very commonly in the lower beds associated with remains of *Mœritherium*, Zeuglodonts, and Sirenians. In one case a series of about twenty vertebræ were found in their natural relations to one another and beautifully weathered out of the matrix by the action of sand-drift (Fig. 1A).

The form of these vertebræ (Fig. 1) approaches most nearly to that seen in *Python*, to which genus it seems probable that this species was nearly related. The articular region of a mandible lends support to this view.

In the vertebræ the anterior cup of the centrum is transversely oval, and the corresponding posterior convexity is similar in shape and looks somewhat upwards. The neural spine (*n.s.*) is short and stout, and has a flat truncated extremity; the neural canal is relatively much smaller than in the recent type, but has the same somewhat trilobate form. The articular surfaces of the anterior zygapophyses (*a.z.*) are slightly above the level of the floor of the neural canal. The form of the zygosphene (*zyg.*) and zygantrum are as in *Python*. The transverse processes form massive protuberances, bearing on their outer ends articular surfaces (*r.*) for the ribs, and are of similar form to those seen in *Python*. The hypapophysis (*hyp.*) in most of the vertebræ is small, and consists mainly of a small tuberosity near the hinder end of the centrum.

These vertebræ are all of large size, much larger than in any existing Ophidian. If the proportions of this snake were the same as in the existing *Python sebæ* it probably reached a length of about 30 feet.

The dimensions of one of these vertebræ are as follows:—

	mm.
Greatest height (from top of neural spine to end of hypapophysis) ...	57·5
Greatest width (between the ends of the transverse processes) ...	63
Width of zygosphene	29
Width of articular cup of centrum	22
Height of articular cup of centrum	19
Width of articular ball of centrum	23
Extreme length of centrum	40
Width of neural canal ... ... (approx.)	12

To this form the generic name *Gigantophis*, referring to its large size, may be given, the specific name being *Gigantophis Garstini*, in honour of Sir William Garstin, K.C.M.G., the Under Secretary of State for Public Works in Egypt.

Mœriophis Schweinfurthi, gen. et sp. nov. (Fig. 2.)

Perhaps the commonest fossils in the lower beds are the vertebræ of a large snake, which in the main points agree with those upon which Owen founded the genus *Palæophis*. Owen's specimens are from the Eocene (Lower and Middle) of Sheppey and Bracklesham, and it is very interesting to find a similar form occurring in the Lower Tertiary deposits of Egypt. Some shells which occur associated with these remains have lately been described by Cossmann[1] from almost the same locality; they are referred by him to the Middle Eocene (Nummulitic), so probably it may turn out that the beds in which *Mœritherium*, *Bradytherium*, and the reptiles described in this paper are found, are somewhat older than stated in Part I, and are in fact Middle Eocene. This question will no doubt be settled by Mr. Beadnell in the section relating to the stratigraphy of the district.

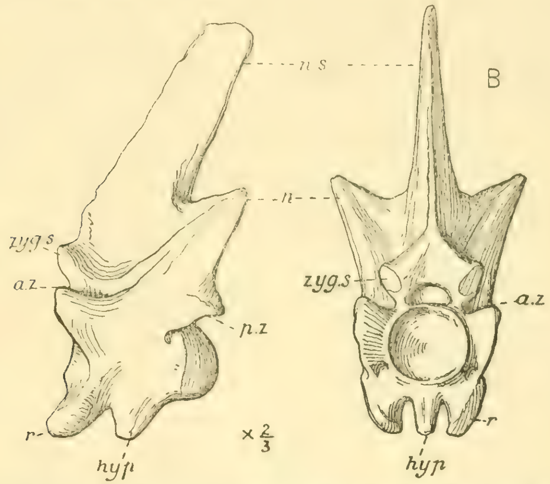


Fig. 2.—Vertebra of *Mœriophis*. Two-thirds natural size. (A) From side; (B) from front. *a.z.* anterior zygapophysis; *hyp.* hypapophysis; *n.* process on back of neural arch; *n.s.* neural spine; *p.z.* posterior zygapophysis; *r.* facet for rib; *zyg.s.* zygosphene.

The chief characteristic of these vertebræ is the great height of the neural spine (Fig. 2, *n.s.*), and with this seems to be correlated the relative narrowness of the centrum in proportion to its length and the ventral and downwardly directed position of the transverse processes (*r.*). All these characters occur to a less degree in *Palæophis*. Another point of similarity is the presence on either side of the posterior part of the neural arch of a large backwardly and upwardly projecting process (Fig. 2, *n.*), from the tip of which a ridge runs downward and forward to the base of the anterior zygapophysis. This process is more developed here than in *Palæophis*, to which, according to Owen, it is almost peculiar, only a trace being found in other Ophidian vertebræ.

The transverse processes project downward below the level of the centrum, and their lower ends may even be slightly bent in

[1] Cossmann: "Additions à la Faune Nummulitique d'Egypte" (Institut Egyptien, Cairo, 1901).

towards the middle line. The hypapophysis (*hyp.*) consists of two processes, one near the middle of the centrum, the other close to its anterior border; the latter, together with the transverse processes, is strongly inclined forward.

The whole form of the vertebra seems to me to indicate that the body was deep and laterally compressed, as in some water-snakes, and to point strongly to the conclusion that this animal was aquatic in its habits. Its association with the remains of Zeuglodonts, Sirenians, and marine turtles seems to support this.

This snake is no doubt a close ally of *Palæophis,* and must be referred to the same family; but the greater height and narrowness of the vertebræ, the more ventral position of the transverse processes, and of their surfaces for articulation with the ribs (*r.*), as well as several points in the structure of the neural arch and its articulations, justify the generic separation of this type. I propose for it the name *Mœriophis,* referring to the locality in which it was found, and its specific name will be *M. Schweinfurthi,* after Dr. G. Schweinfurth, who has done so much to add to our knowledge of Egypt in so many directions, and who seems to have been the first to collect vertebrate remains in the Fayûm.

The dimensions of one of these vertebræ are as follows:—

	mm.
Greatest height (from top of neural spine to end of hypapophysis) ...	85
Greatest width (between ends of transverse processes)	25
Width of zygosphene	19
Width of articular cup of centrum	16
Height of articular cup of centrum	14
Extreme length of centrum	31
Width of neural canal	7

Chelonia.

Chelonian remains are fairly common in the lower beds in which *Mœritherium* and *Gigantophis* occur, and some nearly complete skulls and carapaces were collected. The latter are not in very good condition for the determination of their characters, being, as a rule, traversed in all directions by cracks and coated with gypsum, so that the sutures cannot be clearly made out.

The Chelonians collected include representatives of the three chief groups, viz., the *Athecæ, Pleurodira,* and *Cryptodira.*

Psephophorus eocænus, sp. nov.

The *Athecæ* are represented by a humerus and possibly some masses of scutes.

The humerus (Fig. 3) differs widely from that of all land and fresh-water tortoises and of all the marine turtles, except *Sphargis.* In fact, it belongs to the most specialized type of swimming humerus found among the pelagic Chelonia (*parathalassic type* of Wieland, Am. Journ. Sci., ser. IV, vol. ix, 1900, p. 420). Among the forms of Athecate Chelonia of which the humerus is known, the present species (Fig. 3) seems to approach most nearly to *Psephophorus,* the chief points of difference being that the ulnar crest (*a*) is more prominent and rises farther above the head (*b*), and the form of the proximal portion of the radial process (*c*) is different in several respects. For the present, until further remains are collected, it will be best to refer this form to *Psephophorus.* The specific name will be *P. eocænus.*

Dimensions of Humerus.

Total length	190 mm.
Width of shaft immediately below radial process ...	42 ,,
Width of head	40 ,,

Thalassochelys libyca, sp. nov.

Another Chelonian, represented in the collection by several more or less crushed skulls, is a Cryptodiran with roofed temporal fossæ, apparently closely allied to *Chelone.* In two cases the skulls are greatly crushed from above downward, giving them a quite misleading appearance of being low and flattened, but another specimen, including the back of the skull as far forward as the epipterygoid (columella), is quite uncrushed, and is here referred to.

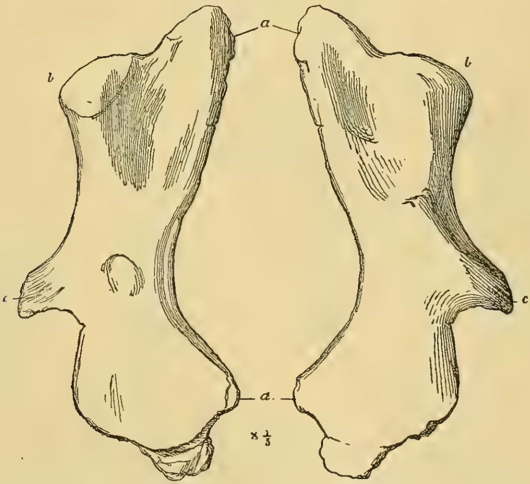


Fig. 3.—Dorsal and ventral views of left humerus of *Psephophorus eocænus*, Andrews. One-fifth natural size. (*a*) Ulnar crest; (*b*) head; (*c*) radial crest; (*d*) entocondyle.

The form of the tympanic ring, which is incomplete posteriorly, resembles that seen in *Chelone*, showing that this species is not a Pleurodiran. The presence of the columella shows that it is not one of the Athecate group, as from the occurrence of the humerus above described seemed not impossible. The roofing of the temporal fossa, as far as can be seen, is the same as in the Chelonidæ, and it may be referred provisionally to that family. The occipital condyle is trilobate, the basi-occipital extending up to the foramen magnum. The basi-sphenoidal platform is much less prominent than in *Chelone*, and there is no deep fossa beneath its hinder border as in that genus.

In this region the skull resembles that of *Thalassochelys* very nearly. There are some differences, however, the most notable of which being the greater length of the quadrate in the fossil. Nevertheless, I prefer at present to refer this species provisionally to *Thalassochelys*, with the specific name *T. libyca*.

Stereogenys Cromeri, gen. et sp. nov.

The most interesting of the Chelonian remains are several more or less complete skulls of a Pleurodiran tortoise, which presents a number of peculiar features. The Pleurodiran nature of this species is shown by (1) the completeness of the quadrate ring for the tympanum; (2) the form of the articular surface of the quadrate.

The temporal fossa is roofed as in *Podocnemis* alone among living Pleurodira. In the Mesozoic *Rhinochelys* also the temporal fossa is roofed in, but in quite a different manner from that occurring in *Podocnemis* and our fossil. So far as I can determine, this species approaches *Podocnemis* more nearly than any other Chelonian, but on the other hand there are some very important differences. The most important of these are found in the structure of the palate (Fig. 4A),

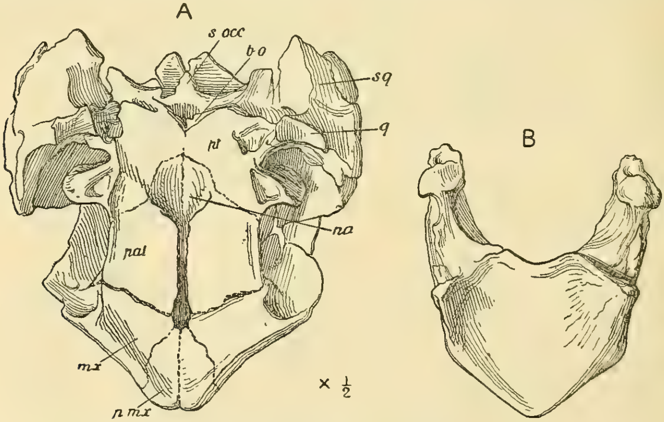


Fig. 4.—Skull and mandible of *Stereogenys Cromeri*. One-half natural size. (A) Palatal surface of skull; (B) upper surface of mandible. The premaxillæ are restored from another specimen. *b.o.* basi-occipital; *mx.* maxilla; *na.* internal nares; *p.mx.* premaxillæ; *pal.* palatines; *pt.* pterygoids; *q.* quadrate; *s.occ.* supra-occipital; *sq.* squamosal.

in which the palatine bones (*pal.*) are much longer than in *Podocnemis*, and are produced inward towards the middle line, where in some specimens they seem to have united in a median suture, in others to have remained separated by a narrow cleft, which in life was no doubt closed by membrane, so that in either case the opening of the internal nares (*na.*) was carried far back to the level of the ectopterygoid wings. This arrangement of the palatines seems to be unique among Chelonia. There is a small anterior vacuity between the hinder ends of the palatal portions of the premaxillæ (*p.mx.*) and the maxillæ (*mx.*). The pterygoids (*pt.*)

are short and broad, and have a very small extension on the palate compared to that seen in *Podocnemis*, and they seem to have been nearly excluded from the middle line by the backward prolongation of the palatines.

Four or five more or less complete skulls of this type were collected, and it will be possible from them to give a detailed account of the cranial characters.

The symphysis of the mandible (Fig. 4B) is very long, and the symphyseal region forms a broad pentagonal plate, the two anterior sides of which form the labial borders, while the two lateral bear the high pointed coronoid processes. The posterior side is slightly concave. The dorsal surface of the symphyseal surface was probably covered by a strong horny plate, which, judging from the large size and anterior position of the coronoid process and the depth of the muscle impressions, must have formed a powerful crushing apparatus. The backward position of the internal nares seems to be correlated with the existence of this arrangement, the union of the palatines extending just far enough backwards to bring the opening behind the level of the symphysis. Probably the anterior part of the palate in front of the narial opening was also covered with a horny plate.

To this new form I propose to apply the generic name *Stereogenys*, the species being called *S. Cromeri*, after the Earl of Cromer, the British Agent and Consul-General at Cairo.

The dimensions of the figured skull and mandible are :—

Skull.	
Extreme length as figured	96 mm.
Extreme width [1]	98 ,,
Width between ends of ectopterygoid wings	65 ,,
Width between outer ends of articular surface of quadrates	74 ,,
Width of articular surface of quadrate	14 ,,
Mandible.	
Total length	71 mm.
Length of symphysis	45 ,,
Width at coronoid	55 ,,
Width at articulation for quadrate	64 ,,

Several carapaces and plastra were collected which probably belong to this form. Their Pleurodiran character is shown by the fusion of the lower ends of the pubes and ischia with the plastron. As a rule the mode of preservation is such that it is extremely difficult to make out the position of the sutures, even in specimens otherwise in excellent preservation. In one plastron, however, it seems fairly clear that there were small lateral mesoplastrals and that a large intergular plate was present.

Crocodilia.

Tomistoma africanum, sp. nov.

Remains of Crocodilians are very common in the lower beds in some localities, and in some cases attain a very large size. Vertebræ and scutes, either isolated or in groups, most commonly occur, but occasionally a large part of the skeleton was seen. When

[1] This specimen is somewhat crushed, so that the width is slightly exaggerated.

the material is fully examined it is probable that two or three species will be found. At present it will only be necessary to mention one, to which the finest specimens collected are referable. These include an almost perfect mandible and the anterior portion (about 34 cm. in length) of a snout, with the upper and lower jaws in their natural positions with regard to one another.

In the mandible the symphysis is very long and Gavial-like, but in this region there are only 14 teeth on each side, the total number in each ramus being 19–20. The splenial enters largely into the formation of the symphysis. The first and second teeth are large, the third smaller, the fourth large again, then the remainder somewhat smaller, and of nearly the same size throughout except a few of the hindermost.

There are four premaxillary teeth, of which the second and third are the largest; the fourth is small, and behind it there is a diastema into which the large fourth lower tooth bites. Only the first four of the maxillary teeth are preserved. The teeth are nearly circular in section. The premaxillary region is very slightly flattened and expanded, and the nasal opening is heart-shaped, with the point directed backwards: the relations of the premaxillaries and nasals to it cannot be made out, none of the sutures being visible.

Comparison of this Crocodile with other types shows that without doubt it is referable to the genus *Tomistoma*, the only living species of which occurs in the rivers of the Malay Peninsula, Borneo, and the neighbouring islands, while fossil representatives, or very closely allied types, occur in the Miocene of Malta and Eggenburg.

This species differs from the recent form in the slightly greater expansion of the premaxillary region and the somewhat greater length and slenderness of the articular process of the mandible. Apart from these and some other peculiarities, the difference in the horizon and locality of this form entitles it to specific distinctness; it may be called *Tomistoma africanum*.

The dimensions of the mandible are:—

	cm.
Total length	103
Length of symphysis	49·5
Width of jaw at symphysis	11·2
Width of articular surface for quadrate	6·8
Depth of ramus at symphysis ... ... (approx.)	4·2

In another specimen of the front of the snout the premaxillary expansion is nearly 8 cm. wide, while the somewhat contracted region immediately behind the premaxillary teeth is only 5 cm. in width.

Pisces.

Fish remains were collected in considerable quantity, but have not yet been examined in detail; they seem to be mostly portions of the skeleton of large Siluroids, but remains of a Saw-fish (? *Propristis Schweinfurthi*, Dames) are not uncommon, one complete rostrum being obtained.

III.—On the Circulation of Salt in its Relations to Geology.

By William Ackroyd, F.I.C., F.C.S., Public Analyst for Halifax.

A SEA-BREEZE is salt-laden in varying degree. On a fine dry day it may contain as much as 22 milligrams of salt per cubic metre of air (Armand Gautier, Bull. Soc. Chim., 1899 [iii], 21, 391–392). This invisible salt is washed out of the atmosphere by rains, and finds its way back to the sea.

Salt circulation is more evident in times of storm, when the amount carried on to the land from the sea may be enormous. Thus, during the storm of January 6th and 7th, 1839, newspaper records make it apparent that tons of salt per acre were spread over Lancashire and Yorkshire, which had been brought by the gales from the Irish Sea; right away over the Pennine hills the trees were white with salt.

The phenomenon has been entirely ignored in our physiographic literature, and credit is due to Professor Joly for having made an allowance of 10 per cent. for such transported salt in his calculation of the age of the Earth. I have attempted to give the subject of salt circulation its due importance in a paper read before the Yorkshire Geological and Polytechnic Society, which will duly appear with Addenda in the Society's Proceedings. A preliminary report appeared in the *Chemical News* for June 7th, 1901. In the course of the paper I venture the opinion that 99 per cent. ought to be allowed for cyclic sea-salt in employing soluble river contents as a measure of time; to this Professor Joly replied on June 28th, and my rejoinder in the same journal will be found on August 2nd. I am here concerned with his article in the August number of this Magazine.

On the Origin of the Saltness of Salt Lakes.—Many determinations of chlorine in rain-water are on record, but a fulness of information is decidedly wanting. The chlorine fluctuates widely, and the laws determining the variations have yet to be experimentally worked out. A six months' study of one locality will be found in my paper "On the Origin of Combined Chlorine" (Journ. Chem. Soc., 1901, vol. lxxix, pp. 673 and 674), where records of the fluctuations of chlorine in the rain-gauge and reservoir of Widdop on the Lanc.-Yorks. border are given. It is necessary to say here, a point which will again be referred to, that it is customary among chemists to make chlorine a measure of sodium by calculating the chlorine in rainfall into sodium chloride. Employing this convention, Bellucci calculates that 37·8 lbs. of common salt per acre is deposited every year at Perugia, some 75 miles from the sea-coast, and I may add that I find in the Pennine hills the deposit calculates out to 172 lbs. per acre per year. Such facts, taken in conjunction with observations like Gautier's, make it probable that wherever sea-winds reach to carry moisture there the falling rains bring down chlorides, and the general disposition of iso-chlors proves this. It is justifiable, then, to suppose that an inland lake may owe much of its salt to this source. I have shown by calculations that the Pennine reservoir already referred to with a capacity of 640·5 millions of gallons has in it some 55 tons of salt, and as the water is being continually drawn off for municipal use, and as continually being replenished by rains falling on a saltless area of Millstone Grit, it follows that its chlorides must be derived from the sea. The available data show further that if it had no outlet and the inflow were balanced by the effects of evaporation it would become salter than the Dead Sea in a period of time less than one-seventh of that usually assigned to the Pleistocene Age. The mind naturally turns from such considerations to a case like that of the Dead Sea, for it is little further removed from the Mediterranean than Widdop is from the Irish Sea; there is a rainfall in Palestine higher than that of the Pennine hills, and in the past there has been an intensity of meteorological conditions of which we at the present day can form but an inadequate conception (Tristram, "The Land of Israel," p. 320). All the conditions are present, but what of the results? The various points of similarity and of dissimilarity are in favour of such a hypothesis; it will be convenient to deal with them after the next paragraph.

Indiscriminate comparisons of salt-lake analyses lead to confusion. This is illustrated by Professor Joly's remarks on p. 346 of this Magazine for August. A principle is here overlooked which may be thus briefly stated:—Where a solution of mixed salts, among them being magnesium chloride and sodium chloride, undergoes concentration, as the more soluble magnesium chloride increases in amount the common salt is precipitated. The only reference on which I can lay my hands at the moment is to the work of Precht and Wittjen in 1881 (Journ. Chem. Soc., November, 1881, p. 978), who show that a 20 per cent. solution of magnesium chloride at 20° C. dissolves only 5·1 per cent. of potassium chloride and 5·8 per cent. of sodium chloride. Now in this strong light let us examine the waters of the Elton Lake of the Kirghis Steppe as they vary with the season:—

	In Spring (Göbel).	In Summer (Erdmann).	In Autumn (Rose).
Sodium chloride, $NaCl$	13·1	7·4	3·8
Magnesium chloride, $MgCl_2$	10·5	16·3	19·7
Potassium chloride, KCl	0·2	—	0·2
Calcium chloride, $CaCl_2$	—	—	—
Potassium sulphate, K_2SO_4	—	0·04	—
Magnesium sulphate, $MgSO_4$ ...	1·6	2·20	5·3
Water	74·4	73·50	70·8
	99·8	99·44	99·8

On Professor Joly's line of argument the first and last analyses ought not to belong to the same lake, but they are beautifully in keeping with the principle I have enunciated. Nor does it at all seem strange that in the case of the Great Salt Lake, where there is so little magnesium chloride there should be so much common salt.

To return now to the Dead Sea. It will be at once recognized that the large percentage of magnesium chloride present, arising from ages of concentration, is favourable to precipitation of common salt, which in the southern parts of the lake forms quite a paste (Tristram). The ratio of chlorine to bromine in the surface waters of the Dead Sea and of the Mediterranean are nearly alike (100 : 2·1), and the only divergence one looks for is in the increase of the bromine figure for the Dead Sea as its sodium chloride is precipitated, and this one finds to be the case. It is also to be noted here that all attempts to find traces of bromine in the springs and rivers of Palestine have hitherto failed (Watts' Dictionary of Chemistry, vol. v, p. 183). All these points are compatible with the Dead Sea having derived the greater part of its salts from the Mediterranean. As one recognizes, however, that solvent denudation must play an important part in adding to the soluble contents of inland lakes, it is to its extensive limestone gathering-ground that the Dead Sea must owe its calcareous character, and the contrast in this respect with the Mediterranean is increased by the latter possessing and the former being without a lime-secreting fauna.

On the Proportion of Chlorides supplied by Solvent Denudation.— It was of interest and of importance to know approximately what in a river water was due to solvent denudation and what to atmospheric transportation. To find the proportion of chlorides due to solvent denudation the following line of reasoning suggested itself to me. A sample of Malham Cove water in Craven had a hardness of 10°, i.e. it contained 10 grains of calcium carbonate per gallon or its equivalent of dolomitic compound. Analysis showed the limestone to have in it ·01 per cent. of combined chlorine. The 10 grains therefore contained ·001 grain of chlorine. Now the whole gallon of water gave ·7 grain of chlorine, whence it follows that only a fifth of 1 per cent. of all the combined chlorine in the water was due to solvent denudation, or of the load of salt carried to the sea approximately 99·8 per cent. was sea-salt. Professor Joly, in his criticism in the *Chemical News*, does not appreciate this result; in the Geological Magazine he ignores it altogether. It is capable of wide application. Thus, in some 40 full analyses of limestones and dolomites published by the United States Geological Survey (Bull., 148, pp. 254-274), 31 samples show no trace of chlorine, 2 only traces, and 9 samples from ·01 up to ·14 per cent. The average quantity of chlorine in the last 9 samples is ·06 per cent., and in the whole 40 samples ·01 per cent. Limestone is one of the most soluble of all rocks, and will probably furnish the largest share of chlorine to the rivers, and these figures demonstrate that so far as the North American continent is concerned its limestones are not likely to supply any greater proportion of this element than the limestones of Yorkshire. Reference to other facts confirm this view of things. Before proceeding farther let me give the atomic proportions of sodium and chlorine in some of the bodies we have to deal with, premising for the benefit of the non-chemical reader that a molecule of common salt or sodium chloride contains two atoms, one of chlorine and one of sodium.

		Atomic Proportions. Sodium.		Chlorine.
1.	In common salt	1	:	1
2.	In the solids dissolved in sea-water	1	:	1·17
3.	In Pierre's rain	1	:	1·3
4.	In the solids dissolved in average river-water (from Sir J. Murray's data)	1	:	0·345
5.	In the older crust of the earth (from Professor F. W. Clarke's data)	1	:	0·0024

Compare 4 and 5. In the earth's crust there is only one atom of chlorine to 417 atoms of sodium, while in river-water to each atom of chlorine we have three atoms of sodium. Therefore average river-water contains a proportion of over 140 times more chlorine atoms than the earth's crust could supply it with. Where does it get them from if transported sea-salt does not enter into the composition of the so-called average river-water? This difficulty presented itself in another form to the Rev. Osmond Fisher when he asked: "Whence came the chlorine? The amount of 0·01 per cent. stated to occur in crystalline rocks seems insufficient" (Geol. Mag., March, 1900, p. 129).

The Age of the Earth.—Now come we to the knotty question of the bearing of the foregoing facts on the rate of solvent denudation used as a measure of time. Here I have to point out the important fact that in estimating the numerator *all the sodium of the sea has been calculated from sodium chloride.* This involves the tacit assumption that all the sodium going into the sea throughout the ages has either gone there allied with chlorine or has finally taken the form of sodium chloride. In either case the chemist's convention of taking chlorine as a measure of sodium in rain- and river-water is serviceable, and cannot involve more final error in connection with this problem than that indicated by the ratio of these elements in sea-water. Our estimate of 99 per cent. for cyclic sea-salt therefore still stands, and, being applied to Professor Joly's calculation, brings the age of the Earth to over 8,000 millions of years; and even if we were inclined to be prodigal in this respect and only deduct so little as 80 per cent. for cyclic salt the age of the Earth would still come to over 400 millions of years!

I will not go further into this matter here than to point out that Professor Joly's grounds for making an allowance of 10 per cent. for cyclic sea-salt is not convincing reading. We are invited to contrast the chlorine content of average *river*-water, put at ·3 part per 100,000, with the chlorine content of *rainfall* at Ootacamund in India, which is given as ·04 part per 100,000. It would have been more conducive to progress in this discussion if relevant particulars had been given of the Ootacamund region. Knowing as I do that chlorine content and amount of rainfall bear an inverse relation to each other, and that in some parts of India the rainfall is prodigious in amount, any isolated fact concerning the chlorine content of a sample of rain does not add to our enlightenment, because for anything we know to the contrary the nearest river-water may give no higher figure; the Mahanuddy, emptying itself into the Bay of Bengal, has only a chlorine content of ·17 per 100,000 after passing over 440 miles of its course (Nicholson, Journ. Chem. Soc., 1873, p. 229).

IV.—The Periodicity of Earthquakes.

By R. D. Oldham, Superintendent of the Geological Survey of India.

Many are the attempts that have been made to discern some law in the occurrence of earthquakes, and to trace the influence of the sun, the moon, or even of the planets as a cause, if partial, of their origin. Many patient investigators have discovered, or thought they have discovered, periods of fluctuating seismic activity, varying in length from semi-diurnal to annual or even longer, but so conflicting have been their conclusions that little weight can be, or has been, attached to the results of their calculations; and one of the most industrious of all these investigators, the Commandante de Montessus de Ballore, has declared his conviction that no periodicity can be detected, and that the causes of earthquakes are purely terrestrial and in no way affected by any celestial body. Yet, in spite of this, the attempts and the calculations go on, and one of the most recent of these is a discussion by Herr M. Becke of some three hundred earthquakes recorded in the region round Karlsbad between 24th October and 25th November, 1897.[1]

Tabulating these, according to the hour of occurrence, he finds that there are two well-defined maxima at about three hours on either side of midnight, while the minimum is at midday with a minor one at midnight. He rightly observes that if this be due to the influence of the sun a similar but much more marked relation should be observed in the case of the moon, and after dividing each lunar day into twenty-four hours and tabulating the earthquakes according to this lunar time he finds that the curve of frequency so obtained does not correspond to that deduced from solar times. From this he concludes that the apparent maxima do not represent real maxima of occurrence of earthquakes, but merely maxima of record, due to the fact that slight earthquakes, which would be noticed and recorded in the morning and evening hours of repose, would be overlooked in the active prosecution of daily avocations, or in the slumber of the night. To this the obvious objection may be raised, that persons who are asleep by midnight are not likely to be awake at 3 o'clock in the morning.

Apart from this, there seems to be a more serious flaw in the argument. Herr Becke appears to have expected that the curve of frequency by lunar time should show maxima at about three hours on either side of the time of lower meridian passage of the moon. This again depends on the assumption, tacitly made by every calculator with whose work I am acquainted, that the frequency may be expected to be a function of the hour angle.

[1] M. Becke, "Bericht über das Graslitzer Erdbeben, 24 October bis 25 November, 1897": Sitzber. k. Akad. Wiss. Wien, 1898, cvii, Abth. 1, pp. 789–959.

This would be true if the frequency were such a function of the zenith distance of the sun or moon that the one might be expected to increase or decrease continuously with the other. This is, however, by no means necessarily, or even probably, the case, for if the attraction of the sun or the moon have any effect it is probably through the strains set up by the tide-producing forces.

Now these have three separate maxima distributed in two points and three circles: at the extremities of the diameter pointing to the sun or moon, as the case may be, the upward vertical tide-producing force is at its maximum; the maximum of the downward tide-producing force lies along the great circle at right angles to this diameter; while the maximum horizontal tide-producing force lies along the small circles half-way between. If, then, external attraction is in any way the cause of earthquakes, we may look for the frequency to have some relation to the times of passage of one or other of these points or circles over the place where the earthquakes originated. I am at present engaged in a discussion of the records of the after-shocks of the great earthquake of 1897, with a view to seeing whether any such relation can be traced; the discussion is not yet far enough advanced to have yielded any results, and the matter would not have been referred to but that in the paper quoted above the records are tabulated in a form which makes it possible, without lengthy calculation, to roughly test the hypothesis that the frequency of earthquakes is influenced by the tide-producing force generated in the earth by the sun and moon.

The three hundred earthquakes, recorded during a period of little over a lunar month, are classified, according to time of occurrences, and also with regard to the phases of the moon, as to whether the earthquake occurred nearer to the syzygies or the quadratures. In the table printed below the figure opposite to 0 is the total recorded

	Solar Times.			Lunar Times.		
Hour.	Syz.	Quad.	Total.	Syz.	Quad.	Total.
0	7	13	20	9	6	15
2	14	31	45	4	9	13
4	16	17	33	9	13	22
6	16	16	32	13	11	24
8	4	14	18	12	17	29
10	4	4	8	18	12	30
12	3	8	11	8	21	29
14	9	9	18	14	15	29
16	15	6	21	13	14	27
18	18	12	30	17	11	28
20	19	17	36	12	20	32
22	14	13	27	10	11	21
24	7	13	20	9	6	15

in the hour preceding and that following the lower culmination, that opposite 2 being the total recorded between one and three hours after the lower culmination, and so on.

Taking the solar times first, the sun's declination was south, and increasing slowly throughout the period of the record; the mean value may be taken as 16° south and the mean latitude of the origins of the earthquakes 50° north. Hence the sun was always more than 60° from the zenith at its upper culmination, and the circle of maximum horizontal tide-producing force nearest the sun never reached the place of origin of the earthquakes. That furthest away from the sun did, however, cross this, and an easy calculation shows that, for a latitude of 50° north and a declination of 11° south, the times of crossing would be about 2½ hours before and after midnight. The observed maxima accord very fairly well with the times of passage of the circle of maximum horizontal tide-producing force due to the attraction of the sun.

Turning to the moon, the problem is not so simple, for, instead of preserving a fairly constant declination like the sun, the moon ranged from its extreme northerly to its extreme southerly declination. Luckily, however, the syzygies happened to nearly coincide with the extreme declinations, while the quadratures were as close to the times when the moon crossed the equator. Now when on the equator the circles of maximum horizontal tide-producing force would never reach 50° north latitude, and only when the declination increased to 5° would one of them touch it, at the upper or lower culmination as the case might be. Moreover, as the rate of change has probably more effect than the amount of the force, and as this rate of change would be small in the case of such tangential passage of the circle, we might expect the effect to be small, but so far as it goes to show a slight tendency to maxima coincident with the upper and lower culmination.

As a matter of fact, there is no marked sign of periodicity except a small increase in frequency about the upper and a decrease at the lower culmination which may be accidental.

At the syzygies the moon was near its maximum declination, and for a declination of 25° one circle of maximum horizontal tide-producing force would never touch latitude 50° north, while the other would cross the place of origin at five hours before and after the upper or lower culmination, according as the moon's declination was north or south. As the declination decreased this interval would decrease, but would not fall much below three hours before the moon passed the half-way point between the syzygies and quadratures; and as the declination was north during half the period of record and south during the other half, the result is that we should expect to find no well-defined maxima, but a greater number of earthquakes occurring more than three hours from the culminations and fewer occurring within three hours of them. Such is practically the case, and the accordance is as close as could reasonably be expected from so limited a record.

So far, then, from the tabulated results showing no indication of any influence of the sun and the moon, they distinctly support the hypothesis of a maximum frequency at the time of passage of the circle of maximum horizontal tide-producing force. They are far from sufficient to establish this hypothesis, but as it has been clearly shown that there is no relation between hours and frequency which holds good for all times and places, it is in this direction that investigation must now be turned before we can finally say that the attraction of the sun and moon has or has not an effect on the occurrence of earthquakes. If it be found that there is no diurnal periodicity corresponding to the tidal forces produced by them, it may safely be said that any periodicity of longer period, which may appear to correspond with the movements of these or any other heavenly bodies, cannot be due to their attraction; and, unless we assume a hyperphysical or astrological influence of the sun and planets, we must finally conclude that earthquakes are as purely terrestrial in their cause as in their effect.

NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science. Glasgow, September 12th, 1901.

Address to the Geological Section, by John Horne, F.R.S. L. & E., F.G.S., President of the Section.

Recent Advances in Scottish Geology.

THE return of the British Association after the lapse of a quarter of a century to the second city of the empire, which since 1876 has undergone remarkable development, due in no small measure to the mineral wealth of the surrounding district, suggests the question, Has Scottish geology made important advances during this interval of time? Have we now more definite knowledge of the geological systems represented in Scotland, of their structural relations, of the principles of mountain-building, of the zonal distribution of organic remains, of the volcanic, plutonic, and metamorphic rocks so largely developed within its borders? It is true that many problems still await solution, but anyone acquainted with the history of geological research must answer these questions without hesitation in the affirmative. In the three great divisions of geological investigation — in stratigraphical geology, in palæontology, in petrology—the progress has indeed been remarkable.

. . . .

The belt of Archæan gneisses and schists, which may be said to form the foundation-stones of Scotland, have been mapped in great detail by the Geological Survey since 1883 along the western part of the mainland in the counties of Sutherland and Ross. In that region they occupy a well-defined position, being demonstrably older than the great sedimentary formation of Torridon Sandstone and overlying Cambrian strata. The mapping of this belt by the Survey staff and the detailed study of the rocks both in the field and with the microscope by Mr. Teall have revealed the complexity of the structural relations of these crystalline masses, and have likewise thrown considerable light on their history. These researches indicate that, in the North-West Highlands, the Lewisian (Archæan) gneiss may be resolved into (1) a fundamental complex, composed mainly of gneisses that have affinities with plutonic igneous products, and to a limited extent of crystalline schists which may without doubt be regarded as of sedimentary origin; (2) a great series of igneous rocks intrusive in the fundamental complex in the form of dykes and sills.[1]

The rocks of the fundamental complex which have affinities with plutonic igneous products occupy the greater part of the tract between Cape Wrath and Skye. Mr. Teall has shown that they are essentially composed of minerals that enter into the composition of peridotites, gabbros, diorites, and granites; as, for example, olivine, hypersthene, augite (including diallage), hornblende, biotite, plagioclase, orthoclase, microcline, and quartz. In 1894 he advanced a classification of these rocks, based mainly on their mineralogical composition and partly on their structure, which has the great merit of being clear, comprehensive, and independent of theoretical views as to the history of the rock-masses. Stated broadly, the principle forming the basis of classification of three of the groups is the nature of the dominant ferro-magnesian constituent, viz., pyroxene, hornblende, or biotite, while the members of the fourth group are composed of ferro-magnesian minerals without felspar or quartz.[2] The detailed mapping of the region has shown that these rock-groups have a more or less definite geographical distribution. Hence the belt of Lewisian gneiss has been divided into three districts, the first extending from Cape Wrath to Loch Laxford, the second from near Scourie to beyond Lochinver, and the third from Gruinard Bay to the island of Raasay. In the central area (Scourie to Lochinver) pyroxene gneisses and ultrabasic rocks (pyroxenites and hornblendites) are specially developed, while the granular hornblende rocks (hornblende gneiss proper) and the biotite gneisses are characteristic of the northern and southern tracts. These are the facts, whatever theory be adopted to explain them.

In those areas where the original structures of the Lewisian gneiss have not been effaced by later mechanical stresses it is possible to trace knots, bands, and lenticles of unfoliated, ultrabasic, and basic rocks, to note the imperfect separation of the ferro-magnesian from the quartzo-felspathic constituents, to observe the gradual development of mineral banding and the net-like ramification of acid veins in the massive gneisses. Many of these rocks cannot be appropriately described as gneiss. Indeed, Mr. Teall has called attention to the close analogy between these structures and those of plutonic masses of younger date.

In the Report on Survey Work in the North-West Highlands published in 1888, the parallel banding, or first foliation, as it was then termed, of these original gneisses was ascribed to mechanical movement.[3] But the paper on "Banded Structure of Tertiary Gabbros in Skye," by Sir A. Geikie and Mr. Teall,[4] throws fresh light on this question. In that region the gabbro displays the alternation of acid and basic folia, the crumpling and folding of the bands like the massive gneisses of the Lewisian complex. Obviously in the Skye gabbro the structures cannot be due to subsequent earth-movements and deformation. The authors maintain that they are original structures of the molten magma, and, consequently, that much of the mineral banding of the Lewisian gneisses, as distinguished from foliation, may be due to the conditions under which the igneous magma was erupted and consolidated. Whatever theory be adopted to explain the original mineral banding of the Lewisian gneisses,

[1] Report on the Recent Work of the Geological Survey in the North-West Highlands of Scotland, based on the field-notes and maps of Messrs. B. N. Peach, J. Horne, W. Gunn, C. T. Clough, L. W. Hinxman, and H. M. Cadell: Quart. Journ. Geol. Soc., vol. xliv, p. 387; and Ann. Rep. Geol. Surv., 1894, p. 280, and 1895, p. 17.

[2] Ann. Rep. Geol. Surv., 1894, p. 280.

[3] Quart. Journ. Geol. Soc., vol. xliv, p. 400.

[4] Ibid., vol. L, p. 645.

it is certain that they possessed this banding, and were thrown into gentle folds before the uprise of the later intrusive dykes.

The crystalline schists that have affinities with rocks of sedimentary origin occupy limited areas north of Loch Maree and near Gairloch. The prominent members of this series are quartz schists, mica schists, graphitic schists, limestones and dolomites with tremolite, garnet and epidote.[1] They are there associated with a massive sill of epidiorite and hornblende schist. The relations which these altered sediments bear to the gneisses that have affinities with plutonic igneous products have not been satisfactorily determined. But the detailed mapping has proved that north of Loch Maree they rest on a platform of Lewisian gneiss, and are visibly overlain by gneiss with basic dykes (Meall Riabhach), and that both the gneiss complex and altered sediments have been affected by a common system of folds. In the field, bands of mylonized rock have been traced near the base of the overlying cake of gneiss, and the microscopic examination of the latter by Mr. Teall has revealed cataclastic structures due to dynamic movement. It is obvious, therefore, that, whatever may have been the original relations of the altered sediments to the gneiss complex, these have been obscured by subsequent earth-stresses.

The great series of later igneous rocks which pierce the fundamental complex in the form of dykes and sills is one of the remarkable features in the history of the Lewisian gneiss. In 1895 Mr. Teall advanced a classification of them,[2] but his recent researches show that they are of a much more varied character. For our present purpose we may omit the dykes of peculiar composition and refer to the dominant types. These comprise : (1) ultrabasic rocks (peridotite), (2) basic (dolerite and epidiorite, and (3) acid (granite and pegmatite). The evidence in the field points to the conclusion that the ultrabasic rocks cut the basic, and that the granite dykes were intruded into the gneisses after the eruption of the basic dykes. The greater number of these dykes consists of basic materials. It is important to note that the basic rocks best preserve their normal dyke-like features in the central tract between Scourie and Lochinver, where they traverse the pyroxene gneisses. But southwards and northwards of that tract, in districts where they have been subjected to great dynamic movement, they appear as bands of hornblende schist, which are difficult to separate from the fundamental complex. The acid intrusions are largely developed in the northern tract between Laxford and Durness ; indeed, at certain localities in that region the massive and foliated granite and pegmatite are as conspicuous as the biotite gneisses and hornblende gneisses with which they are associated.

After the eruption of the various intrusive dykes the whole area was subjected to enormous terrestrial stresses, which profoundly affected the fundamental complex and the dykes which traverse it. These lines of movement traverse the Lewisian plateau in various directions, producing planes of disruption, molecular rearrangement of the minerals, and the development of foliation. It seems to be a general law that the new planes of foliation both in the gneiss and dykes are more or less parallel with the planes of movement or disruption. If the latter be vertical or nearly horizontal the inclination of the foliation planes is found to vary accordingly.

Close to the well-defined disruption planes, like those between Scourie and Kylesku, the gneiss loses its low angle, and is thrown into sharp folds, the axes of which are parallel with the planes of movement. The folia

[1] Ann. Rep. Geol. Surv., 1895, p. 17.
[2] Ibid., p. 18.

are attenuated, there is a molecular rearrangement of the minerals, and the resultant rock is a granulitic gneiss. Indeed, the evidence in the field, which has been confirmed by the microscopic examination of the rocks by Mr. Teall, seems to show that granulitic biotite and hornblende gneisses are characteristic of the zones of secondary shear. A further result of these earth-stresses is the plication of the original gneisses in sharp folds, trending N.W. and S.E. and E. and W., and the partial or complete recrystallization of the rocks along the old planes of mineral banding.

In like manner, when the basic dykes are obliquely traversed by lines of disruption, they are deflected, attenuated, and within the shear zones appear frequently as phacoidal masses amid the reconstructed gneiss. These phenomena are accompanied by the recrystallization of the rock and its metamorphosis into hornblende schist. Similar results are observable when the lines of movement are parallel with the course of the dykes. All the stages of change from the massive to the schistose rock can be traced—the replacement of the pyroxene by hornblende, the conversion of the felspar, and the development of granulitic structure with foliation. Here we have an example of the phenomena developed on a larger scale by the Post-Cambrian movements, viz., the production of common planes of schistosity in rocks separated by a vast interval of time, quite irrespective of their original relations. For both gneiss and dykes have common planes of foliation, resulting from earth-stresses in Pre-Torridonian time.

It is important to note also that linear foliation is developed in the basic dykes where there has been differential movement of the constituents in folded areas. In the case of the anticline mapped by Mr. Clough, near Poolewe in Ross-shire, he has shown that the linear foliation is parallel with the pitch of the folds. All these phenomena tend to confirm the conclusions arrived at by Mr. Teall, and published in his well-known paper "On the Metamorphosis of Dolerite into Hornblende Schist." [1]

The ultrabasic and acid rocks likewise occur in the schistose form, for the peridotites pass into talcose schists and the granite becomes gneissose.

In connection with the development of schistosity in these later intrusive rocks it is interesting to observe that where the basic dykes merge completely into hornblende schist, and seem to become an integral part of the fundamental complex, biotite gneisses and granular hornblende gneisses prevail. Whatever be the explanation the relationship is suggestive.

The unconformability between the Lewisian gneiss and the overlying Torridon Sandstone, which was noted by Macculloch and confirmed by later observers, must represent a vast lapse of time. When tracing this base-line southwards through the counties of Sutherland and Ross, striking evidence was obtained by the Geological Survey of the denudation of that old land surface. In the mountainous region between Loch Maree and Loch Broom it has been carved into a series of deep narrow valleys with mountains rising to a height of 2,000 feet. In that region it is possible to trace the orientation of that buried mountain chain and the direction of some of the old river courses. This remnant of Archæan topography must be regarded as one of the remarkable features of that interesting region.

In 1893 the various divisions of the Torridon Sandstone, as developed between Cape Wrath and Skye, were tabulated by the Geological Survey, and may here be briefly summarized. They form three groups : a lower, composed of epidotic grits and conglomerates, dark and grey shales

[1] Quart. Journ. Geol. Soc., vol. xli, p. 133.

with calcareous bands, red sandstones, and grits ; a middle, consisting of a great succession of false-bedded grits and sandstones ; an upper, comprising chocolate-coloured sandstone, micaceous flags with dark shales and calcareous bands. The total thickness of this great pile of sedimentary deposits must be upwards of 10,000 feet, and if Mr. Clough's estimate of the development of the lower group in Skye be correct, this amount must be considerably increased. Of special interest is the evidence bearing on the stratigraphical variation of the Torridon Sandstone when traced southwards across the counties of Sutherland and Ross. The lower group is not represented in the northern area, but southwards, in Ross-shire, it appears, and between Loch Maree and Sleat varies from 500 to several thousand feet in thickness. These divisions of the Torridon Sandstone are of importance in view of the correlation of certain sediments in Islay with the middle and lower Torridonian groups which there rest unconformably on a platform of Lewisian gneiss.

In continuation of the researches of Dr. Hicks, published in his paper "On Pre-Cambrian Rocks occurring as Fragments in the Cambrian Conglomerates in Britain,"[1] Mr. Teall has specially investigated the pebbles found in the Torridon Sandstone. The local basement breccias of that formation have doubtless been derived from the platform of Lewisian gneiss on which they rest, but the pebbles found in the coarse arkose tell a different story.[2] He has found that they comprise quartzites showing contact alteration, black and yellow cherts, jaspers with spherulitic structures which indicate that they have been formed by the silicification of liparites of the 'Lea-rock' type and spherulitic felsites that bear a striking resemblance to those of Uriconian age in Shropshire. These interesting relics have been derived from formations which do not now occur anywhere in the western part of the counties of Sutherland and Ross, and they furnish impressive testimony of the denudation of the Archæan plateau in Pre-Torridonian time.

These Torridonian sediments, like the sandstones of younger date, contain lines of heavy minerals, such as magnetite, ilmenite, zircon, and rutile.[3] The dominant felspar of the arkose group is microcline, that of the basal group oligoclase. In the calcareous sediments of the upper and lower groups fossils might naturally be expected, but the search so far has not been very successful. Certain phosphatic nodules have been found in dark micaceous shales of the upper group which have been examined by Mr. Teall. From their chemical composition these nodules might be regarded as of organic origin ; but he has found that they contain spherical cells with brown-coloured fibres, which appear to be débris of organisms.[4]

Early in last century the Torridonian deposits were referred by Macculloch[5] and Hay Cunningham[6] to the 'Primary Red Sandstone,' and by Murchison,[7] Sedgwick, and Hugh Miller to the Old Red Sandstone. The structural relations of the Torridon Sandstone to the overlying series of quartzites and limestones were first clearly shown by Professor Nicol,[8] who traced the unconformability that separates them for 100 miles across the counties of Sutherland and Ross. When Salter pointed out the Silurian facies of the fossils found in the Durness Limestone by Mr. Charles Peach, the Torridonian formation was correlated with the Cambrian rocks

[1] Geol. Mag., Dec. III, Vol. VII (1890), p. 516.
[2] Ann. Rep. Geol. Surv., 1895, p. 20.
[3] Ann. Rep. Geol. Surv., 1893, p. 263.
[4] Ibid., 1899, p. 185.
[5] Trans. Geol. Soc., ser. I, vol. ii, p. 450 ; "The Western Isles of Scotland," vol. ii, p. 89.
[6] Trans. Highland and Agricultural Society of Scotland, vol. xiii (1839).
[7] Trans. Geol. Soc., ser. II, vol. iii, p. 155.
[8] Quart. Journ. Geol. Soc., vol. xiii, p. 17.

of Wales by Murchison.[1] The discovery of the *Olenellus* fauna, indicating the lowest division of the Cambrian system, in the quartzite-limestone series by the Geological Survey in 1891[2] demonstrated the Pre-Cambrian age of the Torridon Sandstone. In view of that discovery, which proves the great antiquity of the Torridonian sediments, it is impossible to climb those picturesque mountains in Assynt or Applecross without being impressed with the unaltered character of these deposits. Yet it can be shown that under the influence of Post-Cambrian movements they approach the type of crystalline schists.

Before proceeding to the consideration of the Durness series of quartzites and limestones and their relations to the Eastern Schists, brief reference must be made to the controversy between Murchison and Nicol regarding the sequence of the strata.

The detailed mapping of the belt between Eriboll and Skye by the Geological Survey has completely confirmed Nicol's conclusions (1) that the limestone is the highest member of the Durness series ; (2) that the so-called 'Upper Quartzite' and 'Upper Limestone' of Murchison's sections are merely the repetition of the lower quartzite and limestone due to faults or folds ; (3) that there is no conformable sequence from the quartzites and limestones into the overlying schists and gneiss ; (4) that the line of junction is a line of fault indicated by proofs of fracture and contortion of the strata. It is true that in the course of his investigations Nicol's views underwent a process of evolution, and that even in the form in which he ultimately presented them he did not grasp the whole truth. We now know that he was in error when he regarded portions of the Archæan gneiss, occurring in the displaced masses, as igneous rocks intruded during the earth-movements, and that he failed to realize the evidence bearing on dynamic metamorphism resulting from these movements. But I do not doubt that the verdict of the impartial historian will be that Nicol displayed the qualities of a great stratigraphist in grappling with the tectonics of one of the most complicated mountain chains in Europe.

The period now under review embraces the reopening of that controversy in 1878 by Dr. Hicks, and its close in 1884 after the publication of the "Report on the Geology of the North-West of Sutherland" by the Geological Survey.[3] The Survey work has confirmed Professor Bonney's identification of the Lewisian gneiss and Torridon Sandstone in Glen Logan, Kinlochewe,[4] brought into that position by a reversed fault ; and Dr. Callaway's conclusions regarding overthrust faulting at Loch Broom, in Assynt and in Glencoul.[5] Special reference must be made to the remarkable series of papers by Professor Lapworth on "The Secret of the Highlands," in which he demonstrated the accuracy of Nicol's main conclusions, and pointed out that the stratigraphical phenomena are but the counterpart of those in the Alps as described by Heim.[6] His researches, moreover, led him to a departure from Professor Nicol's views regarding the age, composition, and mode of formation of the Eastern Schists, for in the paper which he communicated to the Geologists' Association in 1884 he announced that their present foliated and mineralogical characters had been developed by the crust-movements which operated in that region since the time of the Durness quartzites and limestones.[7] Allusion must

[1] Ibid., vol. xv, p. 353.
[2] Ibid., vol. xlviii, p. 227.
[3] *Nature*, vol. xxxi, p. 29, November, 1884.
[4] Quart. Journ. Geol. Soc., vol. xxxvi, p. 93.
[5] Ibid., vol. xxxix, p. 416.
[6] Geol. Mag., Dec. II, Vol. X (1883), pp. 120, 193, 337.
[7] Proc. Geol. Assoc., vol. viii, p. 438 ; Geol. Mag., Dec. III, Vol. II (1885), p. 97.

be made also to his great paper "On the Discovery of the *Olenellus* Fauna in the Lower Cambrian Rocks of Britain," in which he not only chronicled the finding of this fauna at the top of the basal quartzite in Shropshire, but suggested the correlation of the Durness quartzites and limestones with the Cambrian rocks elsewhere.[1] That suggestion was strikingly confirmed within three years afterwards by the discovery of the *Olenellus* fauna in Ross-shire.

The detailed mapping of the belt of Cambrian strata has proved the striking uniformity of the rock sequence. There is little variation in the lithological characters or thicknesses of the various zones. Basal quartzites, pipe-rock, Fucoid-beds, Serpulite (*Salterella*) grit, limestone, and dolomite form the invariable sequence, for a distance of a hundred miles, to the west of the line of earth-movements. This feature is also characteristic of the fossiliferous zones, for the sub-zones of the pipe-rock, the *Olenellus* fauna in the Fucoid-beds, and the *Salterella* limestone have been traced from Eriboll to Skye. Owing to the interruption of the sequence by reversed faults or thrusts, the higher fossiliferous limestone zones are never met with between Eriboll and Kishorn, but they occur in Skye, where they were first detected by Sir A. Geikie.[2]

Regarding the palæontological divisions of the system, my colleague, Mr. Peach, concludes "that the presence of three species of *Olenellus* in the Fucoid-beds and Serpulite grit of the North-West Highlands, nearly allied to the American form *Olenellus Thomsoni*—the type species of the genus—together with *Hyolithes*, *Salterella*, and other organisms found with it, prove that these beds represent the Georgian terrane of America, which, as shown by Walcott, underlies the *Paradoxides* zone." Hence he infers that there can be no doubt of the Lower Cambrian age of the beds yielding the *Olenellus* fauna in the North-West Highlands. Mr. Peach further confirms Salter's opinion as to the American facies of the fossils obtained from the higher fossiliferous zones of the Durness dolomite and limestone. He states that "the latter fauna is so similar to, if not identical with, that occurring in Newfoundland, Mingan Islands, and Point Levis, beneath strata yielding the *Phyllograptus* fauna of Arenig age, that the beds must be regarded as belonging to the higher divisions of the Cambrian formation."

The intrusive igneous rocks of the Assynt region, of later date than Cambrian time, and yet older than the Post-Cambrian movements, have been specially studied by Mr. Teall, who has obtained results of special importance from a petrological point of view. This petrographical province embraces the plutonic complex of Cnoc na Sroine and Loch Borolan, and the numerous sills and dykes that traverse the Cambrian and Torridonian sediments, and even the underlying platform of Lewisian gneiss. He infers that the plutonic rocks have been formed by the consolidation of alkaline magmas rich in soda. At the one end of the series is the quartz-syenite of Cnoc na Sroine, and at the other the basic augite-syenite, nepheline-syenite, and borolanite. The basic varieties occur on the margin, and the acid varieties in the centre. The sills and dykes comprise two well-marked types, camptonites or vogesites, and felsites with alkali felspar and ægirine, which he believes to represent the dyke form of the magmas that gave rise to the plutonic mass.[3]

The striking feature in the geology of the North-West Highlands is the evidence relating to those terrestrial movements that affected that region in Post-Cambrian times, which are without a parallel in Britain. The geological structures produced by these displacements are extremely complicated, but the vast amount of evidence obtained in the course of the

[1] Geol. Mag., Dec. III, Vol. V (1888), pp. 484–487.
[2] Quart. Journ. Geol. Soc., vol. xliv, p. 62.
[3] Geol. Mag., Dec. IV, Vol. VII (1900), p. 385.

survey of that belt clearly proves that, though the sections vary indefinitely along the line of complication, they have certain features in common which throw much light on the tectonics of that mountain chain. Some of these features may thus be briefly summarized :—

1. By means of lateral compression or earth-creep the strata are thrown into a series of inverted folds which culminate in reversed faults or thrusts.

2. Without incipient folding, the strata are repeated by a series of minor thrusts or reversed faults which lie at an oblique angle to the major thrust-planes and dip in the direction from which the pressure came, that is, from the east.

3. By means of major thrusts of varying magnitude the following structures are produced : (*a*) the piled-up Cambrian strata are driven westwards along planes formed by the underlying undisturbed materials ; (*b*) masses of Lewisian gneiss, Torridon Sandstone, and Cambrian rocks are made to override the underlying piled-up strata ; (*c*) the Eastern Schists are driven westwards and, in some cases, overlap all major and minor thrusts till they rest directly on the undisturbed Cambrian strata.

When to these features are added the effects of normal faulting and prolonged denudation, it is possible to form some conception of the evolution of those extraordinary structures which are met with in that region. Some of the features just described occur in other mountain chains affected by terrestrial movement, as in the Alps and in Provence ; but there is one which appears to be peculiar to the North-West Highlands. It is the remarkable overlap of the Moine Thrust-plane—the most easterly of the great lines of displacement. Along the southern confines of the wild and complicated region of Assynt, that plane can be traced westwards for a distance of six miles to the Knockan cliff, where the micaceous flagstones rest on the Cambrian Limestone. In Durness we find an outlier of the Eastern Schists reposing on Cambrian Limestone, there preserved by normal faults, at a distance of about ten miles from the mass of similar schists east of Loch Eriboll, with which it was originally continuous.

Though many of these structures appear incredible at first, it is worthy of note that some have been reproduced experimentally by Mr. Cadell.[1] He took layers of sand, loam, clay, and plaster of Paris, and after the materials had set into hard brittle laminæ, in imitation of sedimentary strata, he applied horizontal pressure under varying conditions. The results, some of which may here be given, were remarkable.

1. The compressed mass tends to find relief along a series of gently inclined thrust-planes, which dip towards the side from which pressure is exerted.

2. After a certain amount of heaping up along a series of minor thrust-planes, the heaped-up mass tends to rise and ride forward bodily along major thrust-planes.

3. The front portion of a mass being pushed along a thrust-plane tends to bend over and curve under the back portion.

4. A thrust-plane below may pass into an anticline above ; and a major thrust-plane above may and probably always does originate in a fold below.

Now these important experiments confirm the conclusion reached by the Geological Survey from a study of the phenomena in the field, viz., that under the influence of horizontal compression or earth-creep the rocks in that region behaved like brittle rigid bodies which snapped across, were piled up, and driven westwards in successive slices. But, further, these displacements were accompanied by differential movement of the materials which resulted in the development of new structures. These phenomena culminate along the belt of rocks in immediate association with the Moine

[1] Trans. Roy. Soc. Edinburgh, vol. xxxv, p. 337.

Thrust, where the outcrop of that thrust lies to the east of a broad belt of displaced materials. There, Lewisian gneiss, Torridon Sandstone, and Cambrian quartzite are sheared and rolled out, presenting new divisional planes parallel with that of the Moine Thrust. The Lewisian gneiss shades into flaser gneiss and schist, and ultimately passes into a banded rock like a platy schist. The pegmatites show fluxion structure with felspar 'eyes' like that of the rhyolites. At intervals in these zones of highly sheared rocks, phacoidal masses of Lewisian gneiss appear, in which the Pre-Torridonian structures are not wholly effaced. The sills of camptonite and felsite intrusive in the Cambrian rocks become schistose, and together with the sediments in which they occur appear in a lenticular form. All these mylonized rocks show a characteristic striping on the divisional planes, due to orientation of the constituents in the direction of movement.

Still more important evidence in relation to the question of regional metamorphism is furnished by the Torridon Sandstone. In the case of the basal conglomerate the pebbles have been flattened and elongated, and a fine wavy structure has been developed in the matrix. In the district of Ben More, Assynt, planes of schistosity, more or less parallel with the planes of the Ben More Thrust, pass downwards from the Torridon conglomerate into the underlying gneiss. Both have a common foliation irrespective of the unconformability between them. Again, along the great inversion south of Stromeferry, foliation has been developed in the Torridon conglomerate and overlying Lewisian gneiss, parallel to the plane of the Moine Thrust. The Torridon grits and sandstones south of Kinlochewe and between Kishorn and Loch Alsh are similarly affected by the Post-Cambrian movements. Mr. Teall has shown that the quartz grains have been drawn out into lenticles and into thin folia that wind round 'eyes' of felspar. A secondary crypto-crystalline material has been produced, sericitic mica appears in the divisional planes, and in some instances biotite is developed. In short, he concludes that in these deformed Torridonian sediments there is an approximation to the crystalline schists of the Moine type. The stratigraphical horizon of these rocks can be clearly proved. The subdivisions of the Torridon Sandstone have been recognized in those displaced masses which lie to the east of the Kishorn Thrust and to the west of the Moine Thrust. It is worthy of note also that in the belt of highly sheared gneiss south of Stromeferry that comes between the Torridonian inversion in the west and the Moine Thrust on the east Mr. Peach has found folded and faulted inliers of the basal division of the Torridon Sandstone that have a striking resemblance to typical Moine schists.

Regarding the age of these Post-Cambrian movements, it is obvious that they must be later than the Cambrian Limestone and older than the Old Red Sandstone, for the basal conglomerates of the latter rest unconformably on the Eastern Schists, and contain pebbles of basal quartzite, pipe-rock, limestone, and dolomite derived from the Cambrian rocks of the North-West Highlands.

East of the Moine Thrust or great line of displacement extending from Eriboll to Skye, we enter the wide domain of the metamorphic rocks of the Highlands, a region now under investigation, and which presents difficult problems for solution. Two prominent types of crystalline schists (Caledonian series, Callaway, and Moine schists of the Geological Survey) have been traced over wide areas in the counties of Sutherland, Ross, and Inverness, and across the Great Glen to the northern slopes of the Grampians. Consisting of granulitic quartzose schists and muscovite-biotite schist or gneiss, they appear to be of sedimentary origin, though crystalline. They are associated with recognizable masses of Lewisian gneiss covering many square miles of ground and presenting many of the structures so characteristic of that complex in the undisturbed areas already described. Within the belt of Lewisian gneiss at Glenelg Mr. Clough has mapped a series of rocks presumably of sedimentary origin, including graphitic schists, mica schists, and limestones, but the gneiss with which they are associated possesses granulitic structure like that of the adjoining Moine schists.[1] Further, in the east of Sutherland, and also in the county of Ross, foliated and massive granites appear which are interleaved in the adjoining Moine schists, forming injection gneisses and producing contact metamorphism.[2]

In the Eastern Highlands the Moine series disappears and is replaced by a broad development of schists, admittedly of sedimentary origin, which have been termed the Dalradian series by Sir A. Geikie. Within recent years it has been divided into certain rock-groups which have been traced by the Geological Survey from the counties of Banff and Aberdeen to Kintyre. It has been found that, though highly crystalline in certain areas, they pass along the strike into comparatively unaltered sediments, as proved by Mr. Hill in the neighbourhood of Loch Awe.[3] Before the planes of schistosity were developed in these Dalradian schists they were pierced by sills of basic rock (gabbro and epidiorite) and acid material (granite), both of which must have shared in the movements that affected the schists, as they merge respectively into hornblende schists and foliated granite or biotite gneiss. Both seem to have developed contact metamorphism; indeed, Mr. Barrow[4] contends that the regional metamorphism so prominent in the South-East Highlands is mainly, if not wholly, due to the intrusion of an early granite magma, now exposed at the surface in the form of local bosses of granite and isolated veins of pegmatite.

The age of the Dalradian schists has not been determined. Though there seems to be an apparent order of superposition, in this series it is still uncertain whether that implies the original sequence of deposition. Since Sir A. Geikie applied the term Dalradian to the Eastern Highland schists in 1891,[5] evidence has been obtained[6] that suggests the correlation of certain rocks along the Highland border with the Arenig and younger Silurian strata of the Southern Uplands. Consisting of epidiorite, chlorite schist, radiolarian cherts, black shales, grits, and limestone, they have been traced at intervals from Arran to Kincardineshire. In the latter region Mr. Barrow contends that they are separated by a line of disruption from the Highland schists to the north; but no such discordance has been detected in the Callander district or in Arran. Though these rocks of the Highland border have been much deformed, yet their occurrence in the same order of succession in that region and in the Southern Uplands is presumptive evidence for their correlation.

In view of this evidence it is not improbable that the Dalradian series may contain rock-groups belonging to different geological systems. Indeed, the result of recent Survey work in Islay tends to support this view. For in the south-west part of that island there is a mass of Lewisian gneiss overlaid unconformably by sedimentary strata which have been correlated with the lower and middle divisions of the Torridon Sandstone. Unfortunately the sequence ends here, as both the gneiss and overlying

[1] Summary of Progress Geol. Surv. 1897, p. 37.

[2] "On Foliated Granites and their Relations to the Crystalline Schists in Eastern Sutherland": Quart. Journ. Geol. Soc., vol. lii, p. 633.

[3] Ann. Rep. Geol. Surv., 1893, p. 265.

[4] "Intrusion of Muscovite-biotite Gneiss in the South-East Highlands and its accompanying Metamorphism": Quart. Journ. Geol. Soc., vol. xlix, p. 330.

[5] Quart. Journ. Geol. Soc., vol. xlvii, p. 72.

[6] Ann. Rep. Geol. Surv., 1893, p. 266; 1895, p. 25; 1896, p. 27.

sediments are separated by a line of disruption or thrust-plane from the strata in the eastern part of the island. And yet, notwithstanding this break, the evidence obtained in the latter district is remarkable, whatever theory be adopted to explain it. There the Islay limestone and black slates appear to be covered unconformably by the Islay quartzite containing Annelid tubes and followed in ascending sequence by Fucoidal shales and dolomites, suggestive of the Cambrian succession in Sutherland and Ross. The Islay quartzite passes into Jura, thence to the mainland, and it may eventually prove to be the Perthshire quartzite, while the Islay limestone and black slate are supposed to be the prolongations of the limestone and slate of the Loch Awe series in Argyllshire.[1]

From the foregoing data it will be seen that much uncertainty prevails regarding the age and structural relations of the metamorphic rocks of the Highlands, but the difficulties that here confront the observer are common to all areas affected by regional metamorphism.

A prominent feature in the geology of the Eastern Highlands is the great development of later plutonic rocks chiefly in the form of granite ranging along the Grampian chain from Aberdeenshire to Argyllshire. In connection with one of these masses a remarkable paper appeared in 1892 which in my opinion has profoundly influenced petrological inquiry in Scotland from the light which it threw on the relations of a connected series of petrographical types in a plutonic complex. I refer to the paper on the "Plutonic Rocks of Garabal Hill and Meall Breac," by Mr. Teall and Mr. Dakyns.[2]

The authors showed that this plutonic mass comprises granite, tonalite, augite-diorite, picrites, serpentine, and other compounds. Mr. Teall regards the members of this sequence as products of one original magma by a process of differentiation, the peridotites being the oldest rocks, because the minerals of which they are composed are the first to form in a plutonic magma. As the process of consolidation advances, rocks of a varied composition arise, in the order of increasing acidity, viz., diorites, tonalites, and granites. The most acid rock consists of quartz and orthoclase, which may represent the mother liquor after the other constituents had separated out. Mr. Teall concludes that progressive consolidation of one reservoir gives rise to the formation of magmas of increasing acidity, and hence that basic rocks should precede the acid rocks. This theory of magmatic differentiation—so strenuously advocated by Brögger, Vogt, Rosenbusch, Iddings, Teall, and others—was first applied to the interpretation of varied types of plutonic masses in Scotland by Mr. Teall in the paper referred to. Since then he has extended its application to the granite masses in the Silurian tableland of the south of Scotland, which include rocks ranging from hyperites at the one end to granitite with microcline and aplite veins at the other.[3] Many of the phenomena presented by the newer granite masses of the Eastern Highlands seem to lend support to this theory. These views, indeed, have permeated the petrological descriptions of the granitic protrusions in the counties of Aberdeen and Argyll which have been given by Messrs. Barrow, Hill, Kynaston, and Craig[4] in recent years.

One of the remarkable advances in Scottish geology during the period under review is the solution of the order of succession and tectonic

[1] Summary of Progress Geol. Surv. 1899, p. 66.

[2] Quart. Journ. Geol. Soc., vol. xlviii, p. 104.

[3] Ann. Rep. Geol. Surv., 1896, p. 40; see also "The Silurian Rocks of Scotland," Geol. Surv. Memoir, 1899, p. 607.

[4] Ann. Rep. Geol. Surv., 1897, p. 87; 1898, pp. 25–28. See also paper on "Kentallenite and its Relations to other Igneous Rocks in Argyllshire": Quart. Journ. Geol. Soc., vol. lvi, p. 531.

relations of the Silurian rocks of the south of Scotland by Professor Lapworth. The history of research relating to that tableland, and of all his contributions to the problems connected with it, has been given in detail in the recent volume of the Geological Survey on that formation. At present it will be sufficient to refer to his three classic papers, which, in my opinion, record one of the great achievements in British geology. The first, on "The Moffat Series,"[1] demonstrated, by means of the vertical distribution of the graptolites, the order of succession in those fine deposits (black shales and mudstones), which were laid down near the verge of sedimentation, and are now exposed in anticlinal folds in the central belt. The second, on "The Girvan Succession,"[2] showed how certain graptolite zones of the Moffat shales are interleaved, in the Girvan region, with conglomerates, grits, sandstones, flagstones, mudstones, shales, and limestones, charged with all the varied forms of life found in shallow seas or near shore. In the third, on "The Ballantrae Rocks of the South of Scotland and their Place in the Upland Sequence,"[3] he indicated the distribution and variation of the Moffat terrane (Upper Llandeilo to Upper Llandovery) and of the Gala terrane (Tarannon), which form the greater part of the uplands. He further pointed out how the rocks and the fossils vary across the uplands according to the conditions of deposition. Finally, he proved that the complicated tectonics of the Silurian tableland, its endless overfolds, its endoclinal and exoclinal structures, can be unravelled by means of the graptolite zones. These researches disposed of the order of succession based on Barrande's doctrine of Colonies, and established the zonal value of graptolites as an index of stratigraphical horizons. So complete was the zonal method of mapping adopted by Professor Lapworth, and so accurate were his generalizations, that few modifications have been made in his work.

In the course of the re-examination of the Silurian tableland by the Geological Survey some important additions were made to our knowledge of the Silurian system as there developed. Underlying all the sediments of the uplands there is a series of volcanic and plutonic rocks of Arenig age, the largest development of which occurs at Ballantrae in Ayrshire, where their igneous character was recognized by Professor Bonney. But they appear in the cores of numerous anticlines over an area of about 1,500 square miles, forming one of the most extensive volcanic areas of Palæozoic age in the British Isles. These volcanic rocks are overlain by a band of cherts and mudstones, succeeded by black shales yielding Glenkiln graptolites of Upper Llandeilo age. The cherts, which are abundantly charged with Radiolaria, implying oceanic conditions of deposition, are about 70 feet thick, and have been traced over an area of about 2,000 square miles. The deposition of the Radiolarian ooze must have occupied a long lapse of time. Indeed, the cherts and mudstones represent the strata which, in other regions, form the Upper Arenig and Lower Llandeilo divisions of the Silurian system. They furnish interesting evidence of the oceanic conditions which here prevailed in early Silurian time, and form a natural sequel to Professor Lapworth's researches bearing on the graptolitic deposits of the Upper Llandeilo period, which must have been laid down on the sea-floor near the limit of the land-derived sediment.

Of special interest is the new fish fauna found by the Geological Survey in the Ludlow and Downtonian rocks between Lesmahagow and Muirkirk, which the researches of Dr. Traquair have shown to be of great biological and palæontological value.[4] This discovery has enabled

[1] Quart. Journ. Geol. Soc., vol. xxxiv, p. 240.
[2] Ibid., vol. xxxviii, p. 537.
[3] Geol. Mag., Dec. III, Vol. VI (1889), p. 20.
[4] Trans. Roy. Soc. Edinb., vol. xxxix, p. 827.

him to give a new classification of the Ostracodermi, and to enlarge the order of the Heterostraci, which now includes four families, instead of the Pteraspidæ alone. He has further shown that the Cœlolepidæ were not Cestraciont sharks to which the *Onchus* spines belonged, but Heterostraci, though probably of Elasmobranch origin, judging from the shagreen-like scales. The Cœlolepidæ are common fishes in the Ludlow and Downtonian rocks of Lanarkshire. The genus *Thelodus*, first described by Agassiz from detached scales in the Ludlow bone-bed, and subsequently figured and described by Pander and Rohon from scales in the Upper Silurian rocks of Oesel, is here represented for the first time by nearly complete forms. But it is remarkable that no *Onchus* spines, nor any Pteraspidæ, nor Cephalaspidæ have been found in the Lanarkshire strata, the nearest related genus to *Cephalaspis* being *Ateleaspis*, which, however, represents a distinct family.

The group of sandstones, conglomerates, shales, and mudstones that form the passage-beds between the Ludlow rocks and the Lower Old Red Sandstone in Lanarkshire are now regarded as the equivalents of the Downtonian strata in Shropshire, and are linked with the Silurian system. The mudstones of this group, containing the new fish fauna, likewise yield ostracods, phyllocarid crustaceans, and eurypterids—forms which connect these beds with the underlying Ludlow rocks. The band of greywacke-conglomerate, that extends from the Pentland Hills into Ayrshire, composed largely of pebbles derived from the Silurian tableland, is now taken as the base-line of the Lower Old Red Sandstone on the south side of the great midland valley of Scotland.

The period under review has been marked by important additions to our knowledge of the Old Red Sandstone formation. In 1878 appeared a valuable monograph by Sir Archibald Geikie on "The Old Red Sandstone of Western Europe,"[1] by far the most important treatise on this subject since the publication of Hugh Miller's classic work in 1841. Following up the view maintained by Fleming, Godwin-Austen, and Ramsay, that the deposits of this formation were laid down in lakes or inland seas, he defined the geographical areas of the various basins in the British area, giving to each a local name. He gave an outline of the development of the rocks north of the Grampians in Caithness, Orkney, and Shetland. He advanced an ingenious argument in favour of correlating the Caithness flagstone series (middle division, Murchison) with the Lower Old Red Sandstone south of the Grampians. He contended that "the admitted palæontological distinctions between the two areas are probably not greater than the striking lithological differences between the strata would account for, or than the contrast between the ichthyic faunas of adjacent but disconnected water basins at the present time." Sir A. Geikie further gave a table showing the vertical range of the known fossils of the Caithness series from data partly supplied by the late Mr. C. Peach.

During the last quarter of a century Dr. Traquair has made a special study of the ichthyology of the Old Red Sandstone and Carboniferous strata of Scotland, which has enabled him to throw much light on the distribution of fossil fishes in these rocks and on their value for the purpose of correlation. His researches show that the fish fauna of the formation south of the Grampians resembles that of the Lower Old Red Sandstone of the West of England and adjoining part of Wales in the abundance of specimens of *Cephalaspis*, the common species in Forfarshire (*C. Lyelli*, Ag.) being also indistinguishable from that in the Herefordshire beds. *Pteraspis* occurs in both regions, though of different species. Of Acanthodians *Parexus recurvus*, Ag., occurs in both, together with

[1] Trans. Roy. Soc. Edinb., vol. xxviii, p. 345.

Climatius (*C. ornatus*, Ag.). The abundance of *Cephalaspis* (*C. Campbelltonensis*, Whit., *C. Jexi*, Traq.) and of *Climatius* spines is characteristic of the Lower Devonian rocks of Canada.

The Old Red Sandstone of Lorne has recently yielded organic remains, akin to those found in Forfarshire, south of the Grampians, viz. *Cephalaspis Lornensis* (Traq.), and two species of myriapods (*Campecaris Forfarensis* and a species of *Archidesmus*).[1]

In the deposits of Lake Orcadie, north of the Grampians, quite a different fish fauna from that of Forfarshire appears. Dr. Traquair has noted that there are no species common to the two areas, and only two genera, viz. *Mesacanthus* and *Cephalaspis*. The latter genus is, however, represented in Caithness only by a single specimen of a species (*C. magnifica*, Traq.) different from any found elsewhere. It might here be observed that *Cephalaspis* is represented also in the Upper Devonian rocks of Canada by a single specimen of a peculiar species (*C. laticeps*, Traq.), and hence Dr. Traquair has shown that, though *Cephalaspis* is most abundant in the Lower Devonian, it extends also into the upper division of that system. It further appears that Osteolepidæ (*Osteolepis*, *Diplopterus*), Rhizodontidæ (*Tristichopterus*, *Gyroptychius*), Holoptychiidæ (*Glyptolepis*), Asterolepidæ (*Pterichthys*, *Microbrachius*), Ctenodontidæ (*Dipterus*) are abundant in the Orcadian fauna, none of which has occurred in the Lower Old Red Sandstone of Forfarshire, the West of England, or in the Lower Devonian rocks of Canada. Dr. Traquair recognized, however, the identity of the fishes from the well-known fish band in the basin of the Moray Firth with those brought from the west part of Orkney, though these forms did not quite agree with the fossils from the Thurso district. He subsequently found that the fish fauna from the Orcadian beds in the Moray Firth basin is represented in Caithness by that of Achanarras; and, further, that two other faunas occur in the Caithness area—that of Thurso and that of John o' Groats, as given below:—

John o' Groats . . .	*Tristichopterus alatus*, Egert. *Microbrachius Dicki*, Traq.
Thurso	*Coccosteus minor*, H. Miller. *Thursius pholidotus*, Traq. *Osteolepis microlepidotus*, Pander.
Achanarras	*Pterichthys*, three species. *Cheirolepis Trailli*, Ag. *Osteolepis macrolepidotus*, Ag.

In 1898 appeared an important paper by Dr. Flett on "The Old Red Sandstone of the Orkneys,"[2] in which he described the results of his detailed examination of the islands. He proved the existence there of three fish faunas, and their correspondence with those identified in Caithness by Dr. Traquair. From the evidence in the field he adopted the following order of succession and correlation of the strata:—

3. Eday Sandstones and John o' Groats beds.
2. Rousay and Thurso beds.
1. Stromness, Achanarras, and Cromarty beds.

A further important result of Dr. Flett's researches in the Old Red Sandstone of these northern isles was communicated to the Royal Society of Edinburgh this year. He has found in the Shetland beds, which had previously yielded no fossils save plants, fragments, identified by Dr. Traquair as *Holonema*, a fish new to Britain, but occurring in the Chemung group of North America, the subdivision of the Upper Devonian that immediately underlies the Catskill red sandstones, with remains of

[1] Summary of Progress Geol. Surv. 1897, p. 83.
[2] Trans. Roy. Soc. Edinb., vol. xxxix, p. 383.

Holoptychius. Dr. Traquair has also recognized in Dr. Flett's collection fragments of *Asterolepis*, a genus characteristic of the Upper Old Red Sandstone, and which, as proved by Dr. Flett, occurs in the 'Thurso beds' of the Orkneys. The interest attaching to this discovery is very great, for Dr. Flett contends that it indicates a fourth life-zone in the Orcadian series, and, further, that it tends to span the break between the Orcadian division and Upper Old Red Sandstone.

In the Upper Old Red Sandstone on the south side of the Moray Firth, Dr. Traquair recognized two life-zones, and subsequently, with the assistance of Mr. Taylor, Lhanbryde, a third; in the following order. The lowest is that of the Nairn sandstones with *Asterolepis maxima* (Ag.); the second, that of Alves and Scaat Craig with *Bothriolepis major* (Ag.), *Psammosteus Taylori* (Traq.); and the highest, that of Rosebrae, the fauna of which, according to Dr. Traquair, has a striking resemblance to the assemblage in the Dura Den Sandstones in Fife.

Before 1876 all the Carboniferous areas in the great midland valley of Scotland had been mapped by the Geological Survey. The extent and structural relations of the various coalfields were determined according to the information then available, and shown in the published maps. But the rapid development of certain fields in the east of Scotland necessitated a revision of them, which has lately been done. The Fife Coalfield has been re-examined by Sir A. Geikie, Mr. Peach, and Mr. Wilson, and the oil-shale fields in the Lothians have been mapped by Mr. Cadell. An important memoir by Sir A. Geikie on "The Geology of Central and Western Fife and Kinross" has just been issued by the Geological Survey, in which the structure of these coalfields is described. Mr. Cadell lately gave an account of the geological structure of the oil-shale fields in his presidential address to the Edinburgh Geological Society.

Within the period under review detailed researches of great importance on the fossil flora of British Carboniferous rocks have been carried out by Mr. Kidston, to which reference ought to be made. The results are of the highest value for correlating the strata in different areas.[1] By means of the plants he arranges the Carboniferous rocks of Scotland in two great divisions: a lower, comprising the Calciferous Sandstone and Carboniferous Limestone series; and an upper, including the Millstone Grit and the Coal-measures, there being a marked palæontological break at the base of the Millstone Grit. He shows that the upper and lower divisions of the system, not only in Scotland but in Britain, are characterized by a different series of plants, not one species passing from the lower division, save in the case of *Stigmaria*, into the upper. From his researches it appears that, among ferns, *Neuropteris* is all but unknown in the lower division, whereas in the upper it is very abundant. The Sphenopterids are proportionately common in both divisions; but those of the lower are usually characterized by cuneate segments, while those of the upper have generally rounded pinnules. *Alethopteris*, so common throughout the whole of the upper series, is entirely absent from the lower. The genus *Calamites*, which is extremely plentiful in the upper, is almost entirely absent from the lower division, where its place is taken by *Asterocalamites.* The *Cordaiteæ* are also rare below the Millstone Grit, though very plentiful above that horizon. *Sigillaria*, so rare in the Lower Carboniferous rocks, is extremely abundant in the upper division, and particularly in the middle Coal-measures. In short, Mr. Kidston concludes that the floras of the two main divisions of the Carboniferous system, though belonging to the same types, are absolutely distinct in species and in the relative importance of the genera.

[1] "On the various Divisions of British Carboniferous Rocks as determined by their Fossil Flora": Proc. Roy. Phys. Soc. Edinb., vol. xii (1893), p. 183.

By means of the fossil plants Mr. Kidston correlates the Coal-measures of Scotland underlying the red sandstones with the lower division of the Coal-measures of England, and the overlying red sandstones of Fife with the middle division of the English Coal-measures.

It is remarkable that the evidence supplied by the fossil fishes has led Dr. Traquair independently to a similar conclusion. He holds that fossil ichthyology proves the existence of only two great life-zones in the Carboniferous rocks of Central Scotland—an upper and a lower—the boundary-line between the two being drawn at the base of the Millstone Grit. The Scottish Carboniferous rocks, being mostly estuarine, give an opportunity of comparing the estuarine fishes of both divisions. He finds the Coal-measure fishes of Scotland to be the same as those in the English Coal-measures, while those occurring below the Millstone Grit in Scotland are mostly different in species, and often, too, in genera, from the forms above that horizon.

Of special interest, as bearing on the former extension of this system in Scotland, is the discovery made by Professor Judd [1] in 1877 of a patch of Carboniferous sandstones and shales, with well-preserved plant remains in Morven. Another small outlier of this formation has recently been found in the Pass of Brander by the Geological Survey.[2]

The reptiles from the Elgin sandstones, recently described by Mr. E. T. Newton,[3] add fresh interest to the study of these rocks. The structural relations of these sandstones have been fully treated by Professor Judd in his great paper on the Secondary Rocks on the East of Scotland,[4] and again in his presidential address to this Section at Aberdeen,[5] who confirmed Huxley's well-known correlation of these beds with the Trias. The Dicynodont skull, identified by Professor Judd and Dr. Traquair at the Aberdeen meeting of the British Association in 1885, and other remains found in the reptilian sandstones in Cutties Hillock Quarry, where they rest on Upper Old Red Sandstone with *Holoptychius*, have been described by Mr. Newton. He confirmed their affinity with Dicynodonts, though they were referred to the genera *Gordonia* and *Geikia*. But the most remarkable specimen was the skull named by Mr. Newton *Elginia mirabilis*. This extraordinary creature, with a pair of horns projecting like those of a short-horned ox, and with smaller spines and bosses, numbering thirty-nine, is related to the great *Pareiasaurus* from the Karoo beds of South Africa. Two other reptiles are described by Mr. Newton from this quarry, namely, a small crocodile-like animal, *Erpetosuchus Granti*, apparently nearly allied to *Stagonolepis*, and *Ornithosuchus Woodwardi*, which is probably a small Dinosaurian.

Mr. Newton has raised an interesting point in connection with his researches. He calls attention to the fact that the reptilian remains from the Cutties Hillock Quarry differ from those found at other localities in the Elgin district. For example, the Lossiemouth sandstones have yielded *Stagonolepis*, *Hyperodapedon*, and *Telerpeton*; and the Cutties Hillock sandstones, the Dicynodonts (*Gordonia* and *Geikia*), the horned reptile (*Elginia*), the small crocodile-like *Erpetosuchus*, and the little Dinosaurian *Ornithosuchus*. Does this distribution indicate different stratigraphical horizons? is virtually the point raised by Mr. Newton. In connection with this inquiry he cites the evidence obtained in other countries. Thus, in the Gondwana beds of India, the series of reptiles similar to those of Elgin occur at different localities and on different

[1] Quart. Journ. Geol. Soc., vol. xxxiv, p. 685.
[2] Summary of Progress Geol. Surv. 1898, p. 129.
[3] Phil. Trans., vol. clxxxiv (1893), p. 431; ibid., vol. clxxxv (1894), p. 573.
[4] Quart. Journ. Geol. Soc., vol. xxix, p. 98.
[5] Rep. Brit. Assoc., 1885, p. 994.

stratigraphical horizons Dicynodonts and Labyrinthodonts being found in the lower Panchet rocks, while *Hyperodapedon* and *Parasuchus* (allied to *Stagonolepis*) are met with in the higher Kota-Maleri beds. Again, in the Karoo beds of South Africa the Dicynodonts and the great *Pareiasaurus*—the latter being the nearest known ally of the horned reptile (*Elginia mirabilis*) from Cutties Hillock, Elgin—occur low down in that formation. Further light is thrown on the question by the interesting discoveries of Amalitzky in Northern Russia, where a number of reptilian remains have been found closely allied to *Pareiasaurus*, *Elginia*, and *Dicynodon*, in beds which are referred to the Permian formation, and accompanied by plants and mollusca which seemingly confirm this reference.[1]

In view of these foreign discoveries Mr. Newton concludes that the Elgin sandstones may probably represent more than one reptilian horizon, and that we are confronted with the possibility of their being of Permian age.

The difficulty of drawing a boundary-line between the Trias and the Upper Old Red Sandstone of Elgin, which impressed the mind of the late Dr. Gordon, has had to be faced elsewhere in Scotland. In Arran, my colleague Mr. Gunn has shown that the Trias there rests on the Upper Old Red Sandstone, both formations having a similar inclination. Even he, with his ripe experience, has had great difficulty in drawing a boundary between them on the west side of the island ; but when the base-line of the Trias is traced eastwards to Brodick it passes transgressively on to Carboniferous rocks.

Of special importance is the recent discovery in Arran of the fossils of the *Avicula contorta* zone[2] by Mr. Macconochie, of the Geological Survey, to whose skill as a fossil collector Scottish geology owes much. With these occur Lower Liassic fossils, in sediments which are not now found in place in the island. These fossiliferous patches are associated with fragmental volcanic materials filling a great vent, the age of which will be referred to presently. This discovery has fixed the Triassic age of the red sandstones and marls in the south of Arran. The detailed mapping of the island by Mr. Gunn has demonstrated that the Triassic sandstones rest partly on the Old Red Sandstone, partly on the Carboniferous Limestone Series, and partly on the Coal-measures.

In 1878 appeared the third of Professor Judd's great papers on the Secondary Rocks of Scotland, wherein he unravelled the history of these strata as developed in the east of Scotland and in the West Highlands. His admirable researches, in continuation of the work done by Bryce, Tate, and others, embraced the identification of the life-zones, their correlation with those of other regions, the history of the physical conditions which prevailed in Scotland during Mesozoic time, and the working out of the structural relations of the strata.[3] He showed that their preservation on the east of Scotland was due to the existence of great faults, and those in the West Highlands to the copious outpouring of the Tertiary lavas. He was the first to detect the occurrence of Cretaceous rocks in the West Highlands, and to show the marked unconformability which separates them from the Jurassic strata. His main life-zones and his main conclusions regarding the Secondary Rocks of Scotland have so far been confirmed by the detailed mapping of the Geological Survey. An interesting addition to our knowledge of these rocks was made by my colleague Mr. Horace B. Woodward, in the course of his field-work, who

[1] Y. Amalitzky: "Sur les fouilles de 1899 de débris de vertébrés dans les dépôts Permiens de la Russie du nord," Varsovie, 1900.

[2] Summary of Progress Geol. Surv. 1899, p. 133.

[3] Quart. Journ. Geol. Soc., vol. xxix, p. 97 ; vol. xxxiv, p. 660.

found the oolitic iron-ore in the Middle Lias of Raasay, the position of which corresponds approximately with that of the Cleveland ironstone.[1]

The extensive plateau of Tertiary volcanic rocks in the Inner Hebrides has been a favourite field of research ever since the time of Macculloch, the great pioneer in West Highland geology. During the period under review much work has been done in that domain. According to Professor Judd, that region contains the relics of five great extinct volcanoes and several minor cones, indicating three periods of igneous activity. The first was characterized by the discharge of acid lavas and ashes, the molten material consolidating down below as granite; the second by the outburst of basic lavas, now forming the basaltic plateau, connected with deep-seated masses that appear now as gabbro and dolerite; the third by the appearance of sporadic cones, from which issued minor streams of lava.[2]

In 1888 Sir A. Geikie communicated his elaborate monograph on the history of Tertiary volcanic action in Britain to the Royal Society of Edinburgh,[3] which has been incorporated, with fuller details, in his recent work on "The Ancient Volcanoes of Great Britain." His main conclusions may thus be briefly stated: (1) The great basaltic plateaux did not emanate from central volcanoes, but are probably due to fissure eruptions; (2) the basaltic lavas were subsequently pierced by laccolitic masses of gabbro, which produced a certain amount of contact alteration on the previously erupted lavas; (3) the protrusion of masses of granophyre and other acid materials by means of which the basic rocks were disrupted.

During the last six years Mr. Harker has been engaged in mapping the central part of the Isle of Skye and in the petrographical study of the rocks, the results of which have been summarized in the annual reports of the Geological Survey. As regards the basaltic lavas, he finds that while they have been of vast extent the individual flows have been of feeble volume, and show no evident relation to definite centres of eruption. There were two local episodes, however, which took the form of central eruptions: one represented by a number of explosive outbursts at certain points; the other, in the basalt succession, gave rise to rhyolitic rocks.

Mr. Harker further finds that the succeeding plutonic phase of activity, confined in Skye to what is now the central mountain tract, is represented by three groups of plutonic intrusions, in the following order: peridotites, gabbros, and granites. The metamorphism set up in the basaltic lavas near the large plutonic masses presents points of interest, especially the widespread formation of new lime-soda-felspars from the zeolites in the lavas.

After the intrusion of the granite of the Red Hills, Mr. Harker finds that igneous activity took the form of intrusions of smaller volume, but in some cases of wide distribution. The great group of dolerite sills belongs to this period. An enormous number of acid and basic dykes followed, of several distinct epochs. A set of minor basic intrusions of quite late date is found in the gabbro district of the Cuillins, the most interesting of which takes the form of sheets of dolerite, parallel at any given locality, but always dipping towards the centre of the gabbro area. Mr. Harker considers that this remarkable system of injections presents a new problem in the mechanics of igneous intrusion. The latest phase of vulcanicity in the Cuillin district is a radial group of peridotite dykes. As regards the local group of rock in Central Skye Mr. Harker finds that the order of increasing acidity which ruled in the plutonic phase was reversed for the minor intrusions which followed.

In connection with the great development of volcanic activity in the

[1] Geol. Mag., Dec. III, Vol. X (1893), p. 493.
[2] Quart. Journ. Geol. Soc., vol. xxx, p. 220.
[3] Trans. Roy. Soc. Edinb., vol. xxxv, pt. 2, p. 23.

West of Scotland in Tertiary time reference must be made to the remarkable volcanic vent in Arran, the recognition of which is due to the suggestion of my friend Mr. Peach. This volcanic centre covers an area of about eight square miles, and lies to the south of the granite area of the island.[1] The vent is now filled with volcanic agglomerate and large masses of sedimentary material, some of which have yielded the Rhætic and Lower Lias fossils already referred to, the whole being pierced by acid and basic igneous rocks. One of the interesting features connected with it is the occurrence of fragments of limestone with the agglomerate, which has yielded fossils of the age of the Chalk, thus proving that the vent is post-Cretaceous. There is thus strong evidence for referring the granite mass in the north of the island and most of the intrusive, acid, and basic igneous rocks to the Tertiary period. It furnishes remarkable proof of the Tertiary age of the Arran granite suggested by Sir A. Geikie in 1873.[2] The story unfolded by this discovery is like a geological romance. The former extension of Rhætic and Lower Lias strata and of the Chalk in the basin of the Clyde, and the evidence of extensive denudation in the south of Scotland, appeal vividly to the imagination.

This outline of the researches in the solid geology of Scotland would be incomplete without reference to the publication of Sir A. Geikie's great work on "The Ancient Volcanoes of Great Britain" (1897), in which the history is given of volcanic action in Scotland from the earliest geological periods down to Tertiary time. To investigators it has proved invaluable for reference. Nor can I omit to mention the new edition of his volume on "The Scenery of Scotland," wherein he depicts the evolution of the topography of the country with increasing force and fascination. In this domain it may be said of the author, "Nihil quod tetigit sed ornavit."

II.—Egyptian Geology.—We have much pleasure in noticing "Geological Survey Report, 1899, Part III, Farafra Oasis; its topography and geology, by Hugh J. L. Beadnell," issued in July, 1901, by the Survey Department, Public Works Ministry at Cairo. This, the second report issued, follows closely on Part II, and consists of 39 pp., 4 maps, and many sections. The report is divided into Introduction; Topography, with notes on the Wells, Population, etc.; Geology; the Desert between Farafra and Dakhla; and Geological Summary. The geological summary shows that in the district under notice the lowest rocks met with are correlated with the Danian of Europe. These consist of, from below up, clays and sandstones of Ain el Wadi, with plant remains and silicified wood; hard blue-grey limestones and White Chalk with brachiopods, lamellibranchs, annelids, etc. Above these come shales, occasionally present, with an abundance of fossils, beds probably representing locally the upper part of the White Chalk. The Eocene is represented in its lower part only by limestones of the plateau with numerous echinids, lamellibranchs, and many foraminifera (Libyan series) at the top, while below come the Esna Shales, in part fossiliferous and with *Operculina* limestone occasionally at the base. The recent deposits are seen in the soils and clays of springs with recent fresh-water shells, blown sand, and local and unfossiliferous marls and clays. The report will be of the highest value, and like

[1] Quart. Journ. Geol. Soc., vol. lvii (1901), p. 226.
[2] Trans. Geol. Soc. Edinb., vol. ii, p. 305.

its predecessor is exceedingly well got up; we await the future parts with the greatest interest. One thing we would ask of the Director-General, Captain Lyons, and that is, to allow the word 'Egypt' to appear somewhere on the title-page.

III.—Economic Geology.—Messrs. John C. Branner and John F. Newsom have issued a second edition of their "Syllabus of a course of Lectures on Economic Geology," 1900, in a volume printed on one side of the paper only, of 368 pp. One of the most important things a student of economic geology needs to learn is where to find and how to use information that has been published. The authors have therefore given references, first, to works on the general subject; second, to periodicals in which articles are to be looked for upon various economic subjects; third, to papers and reports on special subjects. Naturally in a book issued by the Professors of the Leland Stanford junior University, more space is given to the economic geology of the United States than to that of other countries. The book has a good index, and is illustrated by a number of charts and sections. The compositions of minerals are mainly taken from Dana.

IV.—Canadian Geology. Sessional Paper No. 26, 64 Victoria, Summary Report of the Geological Survey Department, for the year 1900, is an octavo of 203 pages and forms an important and interesting document. It has, moreover, a melancholy interest in that it is the last report from the pen of the late G. M. Dawson. In this report especial prominence is given to the results of field-work, "thus affording an early publication of a preliminary kind for any new facts obtained," an object that entitles this report to especial attention. During the year 1900 twelve new maps were completed and finished, and eighteen others were either in the engraver's hands or in the press. Mr. James White has completed his Altitudes in the Dominion of Canada, and this will shortly be issued. Attention is again drawn to the inadequate safety of the present Museum and offices. It is a penny-wise-and-pound-foolish policy to allow such precious and costly records to continue exposed to the danger of fire. After a series of reports on economic minerals, a good account is given of the exhibit sent by Canada to the Paris Exhibition, and the report proper opens on p. 37 with a detailed account of the Yukon district. The areas explored are those of the Stewart and Yukon rivers, the coals and lignites of the Klondike river, and the copper deposits of White Horse. From p. 52 work accomplished in British Columbia is detailed, and a map of the Atlin Goldfields is appended, the geology of which is provided by Mr. J. C. Gwillim. Mr. J. M. Bull reviews the explorations carried out in the Mackenzie district, after which the report deals with Canada proper, New Brunswick, and Nova Scotia. As regards zoology, the chief item of interest is the announcement that Professor H. F. Osborn is at work upon the vertebrate remains collected from the Cretaceous rocks of the Red Deer River, and drawings have already been prepared for the report which it is hoped will soon be issued. Lambe's "Revision of the Genera and Species of the Madreporaria Aporosa and Madreporaria Rugosa" has been published, and Whiteaves' fourth part of Mesozoic Fossils was issued in November, 1900.

V.—Canadian Palæozoic Corals. — Lawrence M. Lambe has issued part ii of his Revision of the Genera and Species of Canadian Palæozoic Corals, as Contributions to Canadian Palæontology, vol. iv, pt. 2. This part deals with the Madreporaria Aporosa and the Madreporaria Rugosa, and consists of 200 pages and 13 plates. The work is of considerable value and seems to have been prepared with much care; there is little new in it, but that perhaps shows more exactly the attention which the author has paid to his predecessors. Perhaps Nicholson's work might have been more carefully studied. We do not grasp the author's reasons for rejecting the genus *Heliophyllum* and placing the species under *Cyathophyllum*, or for using *Arachnophyllum* in the place of *Strombodes*. The monograph is a valuable addition to the literature of the Palæozoic Madreporaria, and we hope the author will be encouraged to continue it.

VI.—Palæozoic Crustacea.—In the 54th annual report of the New York State Museum, 1900 (1901), J. M. Clarke has some notes on new Crustacea. One of these, the peculiar, eyeless, semi-trilobitic merostome, called *Pseudoniscus* by Nieszkowski in 1859, has been found in the *Eurypterus* dolomites of Litchfield, Herkimer County, and is described under the name of *P. Roosevelti*. Some of the American specimens are perfect, and Mr. Clarke has been enabled to add a good deal to our knowledge of the animal. The other new Crustacea described in his paper are *Ceratiocaris præcedens*, *Emmelezoe decora*, and *Estheria Ortoni*; the latter is a Coal-measure form and was found at Carrollton.

VII.—New Geological Map of the Mont Blanc Massif.—Professors Duparc and Mrazec have issued the map to accompany their memoir on Mont Blanc, published in 1898 by the Société Physique et d'Histoire Naturelle de Genève. They had the collaboration of Dr. Pearce for the Val Ferret region and for the Courmayeur synclinal. The map is based on that of Albert Barbey, but includes Mont Catogne; its scale is 1 : 50,000, and it is clearly printed and lightly tinted in colour. The publisher is Comptoir Minéralogique et Géologique Suisse, Minod, 6, Rue St. Léger, Geneva. Price not quoted. The publishers also announce the completion of collections of rocks referred to in Professors Duparc and Mrazec's memoir, 49 specimens for 180 francs.

VIII.—Geology of the Philippine Islands.—The United States Geological Survey has included in its twenty-first annual volume a report on the Geology of the Philippine Islands. The work was entrusted to George F. Becker, who has produced an admirable resumé of the work of all who have gone before, and has added to that observations of his own, taken at considerable disadvantage owing to the unsettled state of the Islands. The report is rather an attempt to bring together all that is known than to provide a new and complete account of the geology of the Philippines. Becker lists some 100 papers on the subject, and has provided a translation of Martin's paper on the Tertiary Fossils which was published in 1895. He also gives two excellent maps of the Islands, drawn by the Jesuit Fathers, and has utilized a sketch of the mineral resources compiled for him from the archives of the Inspección de Minas by Luis Espina. Becker accompanied General Otis to Manila, and remained in the Islands fourteen months, but could accomplish little original work because of the attitude of the natives. The paper will be very useful to all subsequent workers, and this seems to be its real purpose.

IX.—New Brachiopoda, etc.—(1) Suppl. zu d. Beschreibung der Silurischen Craniaden der Ostseeländer. Friedrich Hoyningen Huene. K. Russ. Mineralog. Gesellsch. zu St. Petersburg, 1900, Ser. ii, Bd. xxxviii, No. 1, with 3 plates. (2) Ueber *Aulacomerella*, ein neues Brachiopodengeschlecht. Idem, with plate. (3) Beiträge zur Beurtheilung der Brachiopoden. F. H. Huene. Centralblatt für Mineralogie, etc., 1901, woodcut. (4) Cambrian Brachiopoda: *Obolella*, subgenus *Glyptias*; *Bicia*; *Obolus*, subgenus *Westonia*; with Descriptions of New Species. C. D. Walcott. Proc. U.S. National Museum, 1901, vol. ii.

The first of these four pamphlets contains figures and descriptions of species belonging to different genera of Silurian Craniadæ, illustrations of the shell-structure of two genera, *Pseudocrania* and *Pseudometopoma*, geographic-geologic tables, and other important matter. In the second contribution two species of a new genus, *Aulacomerella*, are described and figured. The genus is said to show senile characters; and also to be a homœomorph of *Aulacorhynchus*, a fact referable, the author suggests, to "repetition of development." The third paper is a later contribution by the same author. It discusses the bearing of certain facts upon studies of Brachiopods, dealing especially with some important anatomical results of F. Blochmann. The author also calls attention to the great confusion in the nomenclature of the shell muscles, pleading for a uniform Latin system. The last paper is a forerunner of a monograph. A new genus, two new subgenera, and several new species are described; but there are no figures. We much regret to find so eminent a palæontologist as Dr. Walcott countenancing so very undesirable a practice.

REVIEWS.

I.—Fauna der Gaskohle und der Kalksteine der Perm-formation, Bohems. By Dr. Anton Fritsch. Vols. i–iv: pp. 552, 394 text-figures and 165 chromolithographic plates.

After devoting thirty years of almost continuous work to its study and elucidation, the author, Dr. Anton Fritsch, has completed the illustration and description of the Permian Fauna of Bohemia, the marvellous richness of which has surprised all students of palæontology; and we congratulate our distinguished fellow-worker upon having lived to achieve so important an undertaking.

In 1860 only thirteen species of vertebrates were known from these formations in Bohemia ; now 123 species have been recorded, and 66 of invertebrates, making together 189 species, all figured and described.

In monographing and carefully drawing more than sixty species of Stegocephalia, the author has been cautious not to advance any phylogenetic speculations, seeing that the group does not lend much help in explaining the evolution of amphibians, and we are led to the conclusion that a long series of unknown vertebrates must have existed before these formations were deposited—the ancestors, in fact, of these Permian forms.

The osteological details given in this work will certainly prove of great value in future comparative anatomical investigations. The beautifully preserved remains of Dipnoi, including even an entire specimen, demonstrate how little that group has changed from the Carboniferous *Ctenodus* to the living *Ceratodus* of Australia. In the order Selachii the author has adduced important evidence as to the structure of the fins in *Pleuracanthus* (*Xenacanthus*), and his opinion that they have been developed from a series of parallel rays has only a short time subsequently been confirmed by the discovery of the fin of *Cladoselache* in the Upper Devonian of Ohio. Many figures from this work have been reproduced by Wiedersheim and other authors who have written lately on the fins of recent Selachii. The tribe of Acanthodians has been augmented by two new and important genera—*Traquairia* and *Protacanthodes*, which latter is a predecessor of the true Acanthodians of later times. The notes on Silurian Acanthodians are very interesting and most valuable. Amongst the Palæoniscidæ, the new genus *Trissolepis*, with three kinds of scales, is most remarkable, showing the gradual development of the ganoid scales beginning near the tail.

In the fourth volume, which is devoted to the Invertebrata, evidence is brought forward to show that insects with complete metamorphosis were already represented in Palæozoic times by the Trichopteroid genus *Phryanæa* and by the larva of a beetle (*Archicarabides pater*). The myriopods, of which thirty-five species have been recorded, are treated with especial care, being represented in Permian times by a greater number of distinct families than at the present day. The discovery that they possessed three simple thoracic segments is very important. The Arachnida were represented by Tetrapneumonous spiders, and the Merostomata by *Prælimulus Woodwardi*, a *Limulus* with simple extremities to its legs. The Entomostraca have long been determined with the valuable assistance of Professor T. Rupert Jones, and the plates show that in some specimens the soft parts and internal structures of the animal have been preserved within the test, and even embryos. To the systematic worker in the Malacostraca the restored figure of *Gampsonyx* from Lebach will be of the greatest interest, as it shows that this Crustacean was not provided with bifurcated appendages, like *Mysis*, but with simple ones. A new genus of Crustaceans, *Gasocaris* (a rather barbarous name), has also seven equal pairs of simple legs, and forms with

Gampsonyx and the American genus *Acanthotelson* a new suborder—Simplicipoda.

In a supplement, Dr. Anton Fritsch introduces the figure of a true reptile, *Naosaurus*, which, like the American species from the Permian of Texas, possessed lateral spines attached to the long neurapophyses of the vertebral column. Amongst the new Stegocephalia is a very fine skeleton of the remarkable genus *Ptyonius*.

It is not too much to say that during the past century no single worker has produced a monograph on Palæozoic palæontology of equal importance. We are glad to be able to record that the value of Dr. Fritsch's labours has been recognized by the Council of the Geological Society of London, who awarded him the Lyell Geological Fund in 1881, on the issue of the author's first volume; whilst the Paris Academy presented Dr. Fritsch with the Cuvier Prize on the completion of his great work. We feel sure that all palæontologists will rejoice to see the completion of this important monograph, and will join with us in complimenting its author on the successful termination of his arduous labours.

II.—Geology of the South African Republic of the Transvaal. By G. A. F. Molengraaf. Bull. Soc. Géol. de France (4), 1901, i, pp. 13–92, 19 text-figures and 2 plates. Pl. i: Geological Sketch at 1 : 1,500,000. Pl. ii: Geological Sections.

The geological researches in the Transvaal are considerably favoured by the dry and mild climate and the scarce vegetation, as well as by the simplicity of the structure of the country. The greatest drawback is the absence of determinable fossils in the sedimentary formations, with the exception of the Upper Karroo. The geological map must therefore be considered as a mere diagrammatical sketch.

Viewed in the abstract, after passing the Jurassic, Cretaceous, and more recent formations near the littoral, the chief rocks of the Transvaal are as follows, in descending order:—

III. The Karroo System.
II. The Cape System.
I. The Primary South African System.

This classification had already been adopted by Bain for the Cape Colony and by Schenk for the whole of South Africa.

I. Primary South African System.

The Primary South African System is composed of stratified deposits associated with numerous intrusive massifs of granite; the structure of the former has been subjected to contact-metamorphism produced by the intrusion of the latter.

The gold-mines are chiefly in the Primary System and in the neighbourhood of Barberton; the series of the famous Witwatersrand has been calculated by De Launay at 7,500 metres. The gold is mostly found in the conglomerates, there being much less in the quartzites.

The age of the Primary South African system is unknown. In the Cape Colony, however, an undoubtedly Devonian formation overlies unconformably the Malmesbury Series and the massifs of granite by which it is traversed. The Malmesbury Series being part of the Primary South African System, this last must be Pre-Devonian, viz. either Silurian or Pre-Cambrian.

II. Cape System.

The Cape System is composed of the following divisions, enumerated from above downwards:—

5. Series of the Waterberg Sandstone.
4. Plutonic Series of the Boschveld.
3. Pretoria Series.
2. Series of the Dolomites.
1. Series of the Black-reef.

The Bokkeveld strata of Cape Colony, corresponding to the Dolomites of the Transvaal, are the only deposits anterior to the Karroo System in which fossils—marine organisms of the Lower Devonian—have been found.

The physical features of the deposits where the Dolomites predominate offer a great resemblance to the Austrian Karst. Caves are frequent, many of them being ossiferous; the organic remains have not, up to the present, been studied. In many places rivulets, penetrating through fissures at the surface, form subterranean watercourses and lakes, and reappear again in the form of numerous and voluminous watercourses, which scarcely diminish during the dry season. To these remarkable constant sources of supply almost all the perennial rivers of the Western Transvaal owe their existence.

III. Karroo System.

In the Transvaal the Karroo System rests unconformably on the before-mentioned older formations, and generally in a horizontal position. Two primary subdivisions are to be distinguished, the *Lower* and the *Upper Karroo.*

1. *Lower Karroo.*

Generally speaking, the strata of the Lower Karroo are horizontal, although following more or less the undulations of the ground. In the whole of South Africa geologists have adopted the subdivision of the Lower Karroo into two *étages*, viz. the *Dwyka Conglomerate* and the *Ecca strata.*

The author adheres to the opinion of those geologists (Sutherland, Griesbach, Stow, Schenk, etc.) who consider these two *étages* as deposits of undoubtedly glacial origin, probably of the Permian period. We must be prepared to find all the phenomena of a prolonged glacial action in much larger and more imposing proportions than the *diluvium* of the Northern Hemisphere.

The problem of the glaciation of South Africa, during the Permo-Carboniferous period, presents more than a local interest. The geological researches in India and Australia have shown that in these countries formations exist of striking analogy. In India the *Gondwana* System may be identified with the system of the Karroo.

At its base are found the *Talchir Conglomerates*, absolutely comparable with the *Dwyka Conglomerate.* The older underlying rocks (*Vindhyan limestones*) have been found to be polished and striated in various localities, e.g. near Chanda in the Central Provinces of India. The *Talchir shales* are associated with this conglomerate; they offer all the characters of the Ecca strata, and like the latter they are almost everywhere devoid of fossils. On these glacial deposits rest sandstones comparable to the sandstone of the Upper Karroo, and in which has been found a *Glossopteris* flora, very similar to that of the Karroo.

In Australia the traces of an ancient glaciation are not less evident, and the glacial deposits which there also, as in the Salt Range of India, are associated with sediments containing marine fossils, show that the glaciation of these two continents was contemporaneous and took place during the last period of the Palæozoic era. Moreover, the general affinities between the *Karroo* and the *Gondwana* System are so evident that we must admit the contemporaneity of the Permian glacial deposits in South Africa, India, and Australia.

2. *Upper Karroo.*

The strata of the Upper Karroo are almost everywhere found in a normal and horizontal position; they are composed of sandstones, argillites, arenaceous argillites, Carboniferous clays, and Carboniferous strata.

Horizon of the Coal.—In the Upper Karroo of the Transvaal, provisionally called by the author the *Hoogeveld formation*, are found the Carboniferous strata which, on account of the continual increase of the Witwatersrand mining industry, must prove a great wealth to the country. The deposits are immense: the coal-mines of the Transvaal will certainly supply the demands of the whole of Africa for at least a hundred years.

The Carboniferous strata of the Transvaal seem to be vegetable alluvia, deposited by the action of torrents. Fragments of trunks of *Sigillaria*, and trunks, branches, and leaves of several species of *Glossopteris*, largely compose these coal-beds.

The mode of formation of the Upper Karroo may be imagined to have taken place in the following manner. After the retreat of the glaciers the *paysage morainique* predominated in this region, where the Dwyka Conglomerate was in a great measure covered, and on all sides surrounded, by the Ecca strata. Erosion soon began to exercise its destructive action, and the Lower Karroo deposits were doubtless, in places, completely *remaniés*; at the same time a series of sediments, constituting the Upper Karroo, were being deposited. These fresh-water deposits were accumulated partly in the watercourses, partly in the lakes; they were made up of obliquely stratified sandstones and clays, and sometimes also of strata of plant-remains, transported by the torrents; the latter strata have become the present Carboniferous beds. Only a small portion of the enormously developed Karroo System has been preserved, the remainder having been destroyed during the period of denudation following its formation; this period continues at the present day.

As to the age of these deposits, the researches of Seward and Zeiller on the plant-remains have shown that the lower *étage* of the Upper Karroo of the Transvaal is of Permo-Carboniferous age.

The wording of the title of the paper here reviewed is somewhat surprising. We remember that the author figured as delegate of the "South African Republic" at last year's International Geological Congress. But then the Congress was somehow connected with the Exhibition. In the present instance we are sorry to state that a scientific society does not refrain from imparting a political bias to a purely scientific paper, which, coupled with the expressions of the President of the French Geological Society when welcoming the author (p. 9), seems hardly friendly towards this country.

CORRESPONDENCE.

JURASSIC BRACHIOPODA.

Sir,—May I beg a little of your valuable space to make a correction in my paper "Homœomorphy among Jurassic Brachiopoda" (Proc. Cotteswold Nat. F.C., vol. xii). Therein I have figured and described a new species as *Zeilleria subcornuta*, the specific name being the same as was used between Dr. Davidson and myself twenty years ago in correspondence about the same shell. But there is already a *subcornuta* used by Quenstedt, and it would also be *Zeilleria subcornuta*. Wherefore I desire to change the name of my species to *Zeilleria cornutiformis*. I would take this opportunity to thank you for your kindly notice of this paper, but may I ask if your reviewer has quite separated "time-table" from a table of strata when he surmises that perhaps I claim no more than a local value for my "elaborate time-table." Certainly I made no definite claim; but I own to thinking that a time-table, as such, is of worldwide application. There is no local limit to time, and there can be no local limit to a time-table. Whether the records of the rocks in distant localities may be sufficiently perfect to enable their dates to be stated with as great exactitude as in my time-table, is another matter. But the table of strata which I have given in connection with this time-table shows that from Yorkshire to Dorset, from Dorset to Würtemberg, the time-table is a means of exactly dating Jurassic events; therefore it has much more than a local value. But in that table I gave the results of only my own work, and refrained, except in one or two striking instances, from quoting literature. Had I done so, it would have shown even more clearly that the time-table is a means whereby Jurassic events over a large part of Europe can be exactly dated now; and there is good reason to think that the same may be said of a far wider field in the future.

S. S. Buckman.

FOSSILS AND GARNETS.

SIR,—On p. 165 of the current volume of this Magazine we read that to the writer of the article there printed "it is very difficult to understand how such a fossil as a belemnite could have retained its characteristic form while molecular changes of such importance were taking place in the matrix of the rock . . . . The results of contact-metamorphism most nearly resemble the crystalline schists. In them, so far as my [the writer's] experience goes, garnet, and still more staurolite, are not formed until the materials of the rock have undergone such great molecular changes as to obliterate all traces of a sedimentary origin" . . . .

On p. 140 of "Études Synthetiques de Géologie expérimentale par A. Daubrée," dated 1879, we read statements which when translated into English are to the following effect:—

"It is well known that the crystallization that is brought about by the proximity of eruptive rocks has not always effaced the traces of the fossils. There still remain very distinct vestiges of them in the middle of rocks crowded with crystalline silicates. One need only recall the fossiliferous Silurian limestone of Norway, which contains at Brevig paranthine and garnet, and at Gjellebeck amphibole and epidote . . . . and lastly, in the Vosges the amphibole rock of Rothau, in which the corals have been replaced, without being deformed, by crystals of amphibole, garnet, and axinite. In some places the rock now consists entirely of a mixture of lamellar pyroxene, epidote, and compact garnet, with flecks of galena. In the middle of this rock, composed entirely of silicates of this nature, I have recognized perfectly preserved impressions of numerous corals (more especially of *Calamopora spongites*, Goldf.) and Flustras . . . . More than this, the very cavities left by the partial disappearance of the calcareous matter of these corals are lined with crystals of the same minerals as form the bulk of the rock . . . .

"Now it is the same thing in the case of the crystalline masses we are considering . . . . MM. Lardy and Strider have found in the neighbourhood of St. Gotthard belemnites in the middle of micaceous schists with garnets."

VERBUM SAP.

OBITUARY.

JOHN STORRIE, A.L.S.

BORN 1844. DIED MAY 2, 1901.

JOHN STORRIE, for many years Curator of the Cardiff Museum, and an earnest worker at the natural history of Glamorganshire, was born at Muiryett, in Lanarkshire. His early years were spent at Glasgow, where he was apprenticed to the printing-trade, and about the year 1872 he found employment in the *Western Mail* printing works at Cardiff. The writings of David Page had given to Storrie an interest in geology, and he pursued the subject with zeal when he came to reside in South Wales. The Silurian rocks of

Rumney and the Rhætic beds of Penarth attracted his special attention. He obtained a new Silurian alga which was named *Nematophycus Storrei*, and he found in Triassic strata a new species of *Mastodonsaurus*. His researches on these subjects, and many important articles on local botany and archæology, were published in the Transactions of the Cardiff Naturalists' Society. He was awarded the proceeds of the Barlow-Jameson Fund in 1896 by the Geological Society of London. An interesting account of his life and labours, accompanied by a portrait, appeared in the "Public Library Journal" of Cardiff for June, 1901.

JAMES WALKER KIRKBY, F.G.S. Edinb.

Born April 10, 1834. Died July 30, 1901.

This well-known geologist of Leven, Fife, was author of many good papers on the strata and fossils, Permian and Carboniferous, of Durham and Fifeshire. One paper, in 1882, was written in company with E. W. Binney, for whom he managed the Pirnie Coal-mine. His first paper was published in 1858, and the two last appeared in the Transactions of the Edinburgh Geological Society, 1901, vol. viii, pt. 1. From 1859 onwards numerous papers on the Upper Palæozoic Ostracoda were produced by Messrs. J. W. Kirkby and T. Rupert Jones, as joint authors, having worked together in determining and describing these microzoa.

He was an invalid for years, yet his persistent energy enabled him to throw much light on the succession and characters of the long series of Carboniferous and Permian strata, by his personal research, and largely by the aid of his exact knowledge of the Ostracoda and their associated fossils. The Murchison Geological Fund was awarded him in 1879 by the Geological Society of London.

Having a retiring and modest disposition and very poor health, Mr. Kirkby did not move much beyond the circle of home neighbours and loving friends, but he had many admirers abroad who knew and appreciated his work.

We have to record the death from apoplexy of Professor Edward Waller Claypole, D.Sc. Lond., B.A., F.G.S., of Throop Polytechnic Institute, Pasadena, California, U.S.A., one of the founders and for many years editor of the *American Geologist.*

Martin Fountain Woodward, Demonstrator in Biology, Royal College of Science, South Kensington, and Secretary of the Malacological Society of London, was unfortunately drowned on the night of September 15th by the capsizing of a boat in a squall at Moyard, near Letterfrack, co. Galway, Ireland, whilst in charge of the Marine Biological Laboratory of the Joint Committee of the Department of Agriculture (Fisheries Branch) and the Royal Dublin Society, at Ballinakill, during the Summer vacation. He was a naturalist of great promise and author of several important papers on the dentition of the Mammalia, on *Pleurotomaria* and other Mollusca, etc. He was the second son of the Editor of the Geological Magazine.

THE

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ORIGINAL ARTICLES.

I. — On the Bone-beds of Pikermi, Attica, and on similar Deposits in Northern Eubœa.

By A. Smith Woodward, LL.D., F.R.S.

AT the suggestion of the British Minister at Athens, Sir Edwin H. Egerton, K.C.B., the Trustees of the British Museum recently undertook a series of excavations in the well-known bone-beds of Pikermi, in Attica, and I was honoured by being entrusted with the supervision of the work. The owner of the estate, Mr. Alexander Skousés, former Minister of War, most cordially assented, and gave every possible facility for the undertaking; while Sir Edwin Egerton's unflagging interest and zeal combined to ensure the greatest success. My wife and I went into residence at the farm of Pikermi early in April, and we continued to occupy the simple but comfortable room which Mr. Skousés had kindly placed at our disposal, until the cessation of digging in the middle of July. During much of the time we were accompanied by Dr. Theodore Skouphos, Conservator of the Geological Museum in the University of Athens, which claims some share of the results of all such excavations made in Greece. We have to thank him for much help in dealing with the workmen, who spoke only a language with which I was at first unfamiliar.

The bones are occasionally exposed by the small stream in the ravine of Pikermi, and they seem to have been first observed by the English archæologist George Finlay, who presented some to the Athens Museum in 1835. Three years later a Bavarian soldier took a few specimens to Munich, where Pikermi and its fossils were first brought to the notice of the scientific world by Professor Andreas Wagner. Within the next decade, more bones were sent to Munich by Lindermayer and described by Wagner; while during the Winter of 1852–53 the young Bavarian naturalist Roth made the great collection which was described by himself and Wagner in 1854, and still constitutes one of the chief treasures of the Munich Old Academy. About the same time Chooretis presented a few specimens to the Paris Museum; while the late Professor

Mitzopoulos, uncle of the present distinguished Rector of the University of Athens, made a valuable and extensive collection for the Athens Museum, which seems to have remained unnoticed until 1883, when the late Professor Dames, of Berlin, studied it, and wrote a brief account of some unique specimens contained in it.[1] By far the most important excavations hitherto made at Pikermi, however, are those which were undertaken by Professor Albert Gaudry, under the auspices of the Paris Academy of Sciences, between 1855 and 1860. These researches made known nearly all the essential facts concerning the extinct mammalian fauna entombed in the Pikermi formation, and led to several brilliant generalizations first published in Professor Gaudry's well-known work on the geology and fossils of Attica in 1862.[2] During the last 40 years only insignificant diggings have been attempted, among them being those of the late Professors Neumayr, of Vienna, and Dames, of Berlin.

Owing to the permanent mark left by former excavations it was easy to choose sites for the new explorations of the British Museum. Three pits dug in continuation of former workings soon yielded bones, and eventually furnished a very extensive collection. Two trial pits at other points and in slightly different horizons produced nothing except two decayed bone-fragments. Water still occurs even in dry weather a little beneath the bed of the stream; but the difficulties from this source are now much less than formerly, owing to Mr. Skousés' system of irrigation, by which the flowing stream of the ravine is usually diverted at a point high up in its course.

The Pikermi formation has already been well described by Professor Gaudry. It consists chiefly of red marl, varied with lenticular masses of rounded pebbles and occasional yellowish sandy layers. Some of the pebble-beds are cemented into hard conglomerate. The materials are such as might have been derived from the mountain mass of Pentelicon which forms the neighbouring high ground, the marl itself being apparently the detritus of marble or other calcareous rock. The formation is of great extent in Attica, and has only attracted special notice at Pikermi because a stream happens to have cut a deep ravine through it and exposed fine sections of the beds.

As already observed by Professor Gaudry, the bones at Pikermi occur on two definite horizons, those in the lower bed being less fragile and better preserved than those in the upper bed.[3] In two of our new pits where the upper horizon is well exposed, it is subdivided into two distinct layers by a nearly barren deposit of marl from 30 to 45 cm. in thickness. The rotten nature of the bones is partly due to their having once been close to or at the surface,

[1] W. Dames, "Hirsche und Mäuse von Pikermi in Attika": Zeitschr. deutsch. geol. Ges., 1883, p. 92, pl. v.

[2] A. Gaudry: "Animaux Fossiles et Géologie de l'Attique," Paris, 1862. This work contains references to previous literature.

[3] A. Gaudry, "Résultats des Recherches faites à Pikermi (Attique), sous les Auspices de l'Académie": Comptes Rendus, vol. xlii (1856), p. 291.

and eroded by the present stream before being covered with the three or four metres of superficial gravel which now preserves them. The bones are also broken by the penetrating rootlets of trees. The lower horizon is at a depth varying from one to two metres below the upper horizon, and thus secure from destruction by surface agencies. Like each of the two upper bone-beds, it is rarely more than 30 cm. in thickness; while the marl above and below it is almost destitute of bones, rarely yielding more than rotten fragments, but quite prolific in scattered land and fresh-water shells. The deepest excavations beneath the lower bone-bed descended for about three and a half metres, and furnished the bone-fragments and shells throughout. No traces of vegetable matter were observed in any layer.

So far as can be judged at present from the new excavations, the three bone-beds of Pikermi are all of the same nature and contain the same mammalian remains. The bones are massed together in inextricable confusion, and are often mixed with a few pebbles. Large and small bones, whole specimens and splintered fragments, all occur together; but the small bones are usually most numerous at the bottom of the layer. Several specimens of approximately the same shape and size are often met with in groups, as if they had been sorted by water in motion. On one occasion, for example, the scattered remains of many gazelles were found together; in another spot there were several skulls of *Tragoceras* in one mass; in other cases nearly all the bones belonged to limbs of *Hipparion*; while one area was specially characterized by pieces of vertebral columns of Ruminants and *Hipparion*. The elongated bones and elongated groups, however, were never observed to trend in one definite direction, but were always disposed quite irregularly; thus indicating that in the region where the bones eventually accumulated, the water by which they had been transported either became still or moved only in gentle eddies.

Very few nearly complete skeletons occur, and even when chains of vertebræ are preserved most of the ribs are lacking. The only approximately complete skeletons observed during the recent excavations were those of some Carnivora (*Ictitherium*, *Metarctos*, and *Machærodus*). It is, however, obvious that many of the bones were still held together by ligaments at the time when they were buried; for numerous complete feet and nearly complete limbs are found with all the bones in their natural position. It is also to be noted that in most cases these limbs are sharply bent so that the two or three segments are almost parallel, as if they had retained the contraction assumed at death. Some decomposition of the soft parts had already taken place even in these instances; for a few of the phalanges of the hipparions and ruminants are often wanting when the other bones of the limb are still in their natural association, while the phalanges of the rhinoceros feet seem to be always lost, though the three associated metapodials are quite common. Similarly, the loosely articulated mandible of the Ungulata is nearly always removed from the skull; it is only commonly preserved in place in the Carnivora and Quadrumana.

The majority of the bones are quite isolated, and most of the skulls of the antelopes are so much broken that only the frontlets with horn-cores remain. A large proportion of the limb-bones are also sharply fractured, some having completely lost both extremities; and small pointed splinters of bone, apparently most of *Rhinoceros*, are often very numerous. Some of the breaking must have taken place before the soft parts had entirely decayed, as is shown by certain feet of *Rhinoceros* and many limbs of *Hipparion* and antelopes. In a few cases I found the three associated metapodials of *Rhinoceros* with the distal ends as sharply removed as if they had been cut off with one blow of a hatchet. In several instances I carefully extracted the nearly complete hind limbs of *Hipparion* from the soft marl, and in all except one I found that the tibia ended abruptly in a sharp, oblique fracture at its middle, with no trace of the proximal end of this bone or of the femur. Moreover, nearly all the isolated tibias of *Hipparion* were similarly fractured; while among about fifty examples of humerus of the same animal only three complete specimens were found, all the others being sharply broken at the weakest point of the shaft. It is therefore evident that the limbs were often torn from the trunk by a sharp break at the weakest point before the decomposition of the soft parts had proceeded far enough to destroy the ligaments.

The new researches make scarcely any additions to the known fauna of the Pikermi bone-beds, and confirm Professor Gaudry's statement that the smaller rodents, insectivores, and bats are absent. The only striking discovery consists in fragmentary evidence of a gigantic tortoise, at least as large as the largest hitherto found in Europe. Many specimens, however, afford important new information concerning the species already described. Notable among these are a few portions of skull and a mandible of *Pliohyrax*, a skull of *Samotherium*, a skull of *Hystrix primigenia*, and the greater part of a skeleton of *Metarctos*. Remains of *Hipparion* are the most abundant fossils, and the new series of specimens illustrates variations and growth-stages more satisfactorily than any collection hitherto made. Isolated bones and skulls of *Rhinoceros* are also common, and antelope remains occur everywhere in great profusion. Limb-bones of Giraffidæ are found abundantly in the lower bone-bed. *Mastodon* is rarer, but two small skulls were obtained from the new excavations, and several very large limb-bones were found. Among Carnivora, *Ictitherium* is the commonest form; but remains of *Hyæna* are not infrequent, and evidence of four individuals of *Machærodus* was discovered during the present diggings. Coprolites of some bone-feeding Carnivore, probably *Hyæna*, also occur. Skulls and other portions of *Mesopithecus* are frequently met with. The shells of the small *Testudo marmorum* are sometimes complete, but always lack the skull and other bones of the skeleton. The Chelonian shells themselves are, indeed, more frequently broken and disintegrated, and a large proportion of the bone-fragments discovered between and below the bone-beds are recognizable as pieces of them. It is noteworthy that a good specimen of *Testudo* *marmorum* was found in the marl between the upper and lower bone-beds in one pit; and a small undetermined snake was discovered in a similar position in another pit.

While the excavation of these fossils was in progress at Pikermi, Mr. Frank Noel, of Achmet Aga in Northern Eubœa, accompanied Sir Edwin Egerton on one of his visits. He recognized that the Pikermi marls were similar to some containing fossil bones on his own estate. He also perceived the identity of the remains of *Hipparion* at Pikermi, with the commonest fossil bones with which he was familiar at Achmet Aga. Many years ago he had sent some of these bones to the Athens Museum; but they seemed to have been lost and had never received any attention from the Greek naturalists. He therefore invited the British Museum to examine the discovery on his estate, and decide whether or not the extinct Pikermi fauna was there represented.

A brief visit to the locality where the bones occur, near Achmet Aga, sufficed to confirm Mr. Noel's impressions. The interesting spot is in a deep ravine on the steep slope just below the village of Drazi, at an elevation of nearly 200 metres above the sea-level.[1] The torrent has cut through a thick deposit of red, indurated marl, much like that of Pikermi; and bones are noticeable in the section at many points. Three days' digging at one place revealed two bone-beds separated by a thin layer of marl. The bones seem to be as abundant and varied as those at Pikermi, and they exhibit exactly the same features. *Hipparion* is again the commonest fossil, and mingled with the complete bones are splintered fragments. Land and fresh-water shells also occur in great abundance, especially a species of *Planorbis*.

Nearly all the bones discovered during this brief visit were too rotten for preservation; but the weathered face of the section alone was explored, and the fossils would doubtless be found in good condition further inwards. Among them could be recognized, besides the innumerable remains of *Hipparion*, parts of a skull and tibia of *Rhinoceros*, a frontlet of *Gazella brevicornis*, jaws of a small ruminant, a large ruminant metapodial (probably *Samotherium*), part of a skull and mandible of *Ictitherium*, and some small carnivore vertebræ. There was also part of the skull of a small species of *Orycteropus*, which I was able to preserve and bring for comparison with the skull of the same genus from Samos now in the British Museum.

From these observations it is evident that the Pikermi bone-beds are not merely a local accident, but are due to some widespread phenomenon. The two localities described are about 60 miles apart, and seem to be situated in two distinct Tertiary basins separated by a barrier of Cretaceous limestones and earlier rocks. Whatever the catastrophe may have been by which the animals were suddenly destroyed, it clearly happened in both places at least twice, if not three times, within a comparatively short period. The

[1] For a brief account of the district see F. Teller, "Der Geologische Bau der Insel Euboea": Denk. k. Akad. Wiss., math.-naturw. Cl., vol. xl (1880), pp. 156–160.

powerful force which broke up and transported the bodies before they had completely decomposed, was probably the same in each case; while the final resting-place of the bones both at Pikermi and Drazi must have been beneath comparatively tranquil water, where they could be quickly buried in mud. The absence of all trace of vegetable matter is curious; but the most plausible explanation of the broken limbs and torn portions of trunks seems to be, that the bodies were hurried by torrential floods through thickets or tree-obstructed watercourses, before they reached the lakes in which they finally rested. Accompanying stones in rapid motion may account for some of the bone-fragments.

II.—On some Crustacea collected by Miss Caroline Birley and Miss L. Copland from the Upper Cretaceous of Faxe, Denmark.

By Henry Woodward, LL.D., F.R.S., V.P.Z.S., F.G.S.

(PLATE XII.)

It is, I regret to say, some long time since my friend Miss Caroline Birley placed in my hands the series of Crustacea which she had, with the assistance of Miss L. Copland, collected from the Upper Cretaceous of Faxe, Denmark.

As in the interval, K. O. Segerberg has figured and described many of these species in Sweden,[1] I propose to give a translation of his descriptions of such species as I find to be identical with those in Miss Birley's collection, it being obviously needless to describe them over again.

Miss Birley has favoured me with the following note on the Upper Cretaceous quarry of Faxe, Denmark:—

"Dr. Henry Woodward, having kindly undertaken to report on the Crustacea obtained by Miss L. Copland and myself on two visits to the Upper Cretaceous (Danian) beds of Faxe, Denmark, has asked for a note on the locality, known to English geologists far better by repute than from actual experience.

"Situated in the south-east of the island of Zealand or Seeland, where, though the land is rich and fertile, the scenery is merely pretty with beech-woods and grass meadows, Faxe offers little to the ordinary tourist, and when we were there only three trains daily connected it with Copenhagen, the journey occupying from $2\frac{3}{4}$ hours to $6\frac{3}{4}$. There were then three stations with the name of Faxe—Faxe, Faxe Strand (now Stubberup), and Faxe Laderplads—and Faxe being an inland hill, and not an island, as the usual misspelling of the name indicates, we dismounted at the first, and saw opposite, a little hostel, the only visible building. Here a genial couple made us so comfortable, in homely Danish fashion, that I can only add the fact that there *is* a more orthodox-looking inn in Faxe village, a mile or so away. From either end, the quarry is reached in a few minutes walk. Danish is the only language

[1] Geol. Fören. Stockholm, 1900.

spoken, but a little of it goes a long way with the intelligent and friendly people.

"Approaching the quarry from the north, the low green hill rises before one like a high railway embankment, and on entering by an upland path, or through the cutting for the transport railway, one finds that a large portion of the hill has already been excavated, in a shape between the letter L and a high boot narrowed at the top. The greatest length, about half a mile, is from east to west, and the cliffs or walls which practically surround the quarry, rise to heights varying from 60 to 80 feet. The character of the rock ranges from a compact creamy or pale yellow limestone, used for building purposes, to ordinary white chalk, coral occurring in large masses in this ancient coral-reef. Unfortunately I have no notes of the sequence of the beds, and probably the zones have not yet been worked out. The fossils of most frequent occurrence are the coral *Cladocora dichotoma*, carapaces of *Dromiopsis rugosa*, and casts of *Nautilus* (*Hercoglossa*) *danicus* and *Trochus lævis*. *Baculites Faujusii*, always mentioned as characteristic of this deposit, must be more frequent or better preserved in the 'Faxelaget' of Stevns Klint and the island of Moen. If we met with it at all in Faxe, it was rarely. The prevalence of Gasteropods is a marked feature, and among the more striking of our acquisitions are a *Voluta* allied to *V. Lamberti* and a large *Pleurotomaria*. The shells almost always occur as casts.

"Fallen boulders of pink granite may occasionally be noticed in the quarry, and one at least was then *in sitû* near its northern entrance."—*C. Birley*.

The youngest member of the Cretaceous formation of Scandinavia is the Danian of Faxe (spelt incorrectly 'Faxoe' by Darwin,[1] Prestwich, and others). This stage is wanting in England, but has its equivalent in the Danian and Maestrichtian systems of Belgium and Holland, and the Calcaire Pisolitique and Calcaire à *Baculites* of France. According to Prestwich it is from 45 to 50 feet thick, and consists almost entirely of fragments of corals and Polyzoans (Bryozoa), with *Nautilus Danicus*, *Belemnitella mucronata*, *Baculites Faujasii*, *Cypræa bullaria*, etc.[2]

K. O. Segerberg[3] writes:—"The lower layer of the Faxe Chalk is composed of compact or hard tubular limestone, largely composed of corals, hence called coral-chalk. Here and there one finds a lighter and less compact bed almost wholly composed of Bryozoa. Both the coral-chalk and the Bryozoa-chalk are very rich in fossils, contrasting in this respect with the Saltholms Chalk, which is a more homogeneous, and in its upper layer looser, chalk-rock, formed under other conditions than the Faxe Chalk, which is the remains of an old coral-reef."

[1] Charles Darwin described some remains of Cirripedia (*Pollicipes striatus*, *P. elegans*) from Faxe (incorrectly spelt Faxoe), Denmark: Pal. Soc., 1851, pp. 70, 76. It is, I regret, spelt 'Faxoe' on the Plate accompanying this paper.—H. W.

[2] Prestwich's "Geology," 1888, vol. ii, pp. 7 and 302.

[3] "De Anomura och Brachyura Dekapoderna inom Skandinaviens Yngre Krita": Geol. Fören. I Stockholm Förhandl., 1900, Bd. xxii, H. 5, p. 1.

In Miss Birley's collection there is (in addition to various portions) an entire carapace of *Galathea* which agrees best with *Galathea munidoides*, K. O. Segerberg (Pl. XII, Fig. 8). I have also referred to this species the small detached chela (Pl. XII, Fig. 9). I mentioned the carapace of *Galathea* in my second year's Anniversary Address to the Geological Society of London.[1]

The subjoined descriptions have been most obligingly translated for me by Mr. C. A. Ryman, from Mr. K. O. Segerberg's paper "De Anomura och Brachyura Dekapoderna inom Skandinaviens Yngre Krita."[2]

MACROURA—ANOMALA.

Fam. GALATHEIDÆ, Dana.

1888. *Galatheidæ*, Henderson: Anomura, p. 116.
1894. *Galathéidés*, Milne-Edwards et Bouvier: Galathéidés, p. 191.
1897. *Galathéidés*, Milne-Edwards et Bouvier: Dredging by "Blake," xxxv.

One often finds both in the coral-chalk and the Bryozoan-chalk fragments or casts of carapaces with those peculiar cross striæ which are characteristic of the different genera of this family. Steenstrup had already noticed these, and created the species *Galathea strigifera*. Lundgren was the first who attempted to describe and illustrate such fragments. Along with these Crustacean remains are found small claws, which from their size, flat form, and finely serrated edges agree with the type peculiar to this family. Von Fischer-Benzon was the first who noticed and identified these claws. This is all that is mentioned about the fossil representatives of this group in the earlier literature. In 1897 Moericke has contributed some valuable information on the genus *Galathea* in "Die Crustaceen der Sternberger Schichten." In this are recorded no less than four species of this family from the youngest Jurassic formation, all, however, of a type alien to the Danian. We may also refer to Pelseneer (Decapod. du Maestricht, p. 166) and Ristori (Crost. Pliocen, p. 36).

When studying the collections from Faxe in the Mineralogical Museum at Copenhagen, K. O. Segerberg says, "I was fortunate enough to find amongst the matrix of Bryozoan-chalk several well-preserved specimens with the rostrum in more or less good condition. By means of this material I have also been able to give a complete description of *Galathea strigifera*, Steenstrup." [This species is not represented in Miss Birley's collection.]

Galathea strigifera, Steenstrup, sp.

? *Galathea strigifera*, Steenstrup, sp.
1866. ,, ,, Von Fischer-Benzon: Das Alter d. Faxekalkes, p. 28, pl. v, figs. 4–6.
1867. ,, ,, Lundgren: Faxekalken, p. 11.
1900. ,, ,, Segerberg: De Anomura och Brachyura Dekapoderna in. Skandinav. Yngre Krita, pl. i, figs. 1, 2 ?

[1] Quart. Journ. Geol. Soc., February 21, 1896, vol. lii, p. cviii.
[2] Geol. Fören. I Stockholm Förhandl., 1900, Bd. xxii, H. 5, pp. 42, 3 plates.

Length (of the specimen in the diagram), 6 mm.; breadth, 4 mm. The greatest breadth is just behind the middle.

Rostrum triangular; its superior surface is concave, with three or four sharp spines on each side, which are directed forwards and diminish in size from before backwards. Anterior margin narrow and a little elevated near the point. Lateral margin curved somewhat outwards behind the centre, and provided anteriorly with small pointed teeth which are directed forwards, and of which the anterior one is a little larger than the rest. The occipital sulcus and its branches are shallow. The surface of the carapace is characterized by more or less well-marked cross-lines, of which the two anterior ones are drawn out into a short point directed forwards and the posterior ones run from side to side. Between these, as well as on the rostrum, the surface is more or less granulated. Cardiac region more or less prominent, and in some specimens provided with a sulcus in front.

This species varies in this respect, that the teeth on the rostrum are sometimes fairly large, and sometimes are very minute, needle-shaped, and nearly invisible.

Regarding the carapace, *G. strigifera* shows a great similarity with *G. strigosa* (found in the North Sea), and is perhaps a precursor of this form.

This species occurs abundantly both at Annetorp and Faxe.

The following species of *Galathea* is in Miss Birley's collection:—

GALATHEA MUNIDOIDES, K. O. Segerberg. (Pl. XII, Figs. 8, 9.)

(Figures enlarged 4 times nat. size.)

K. O. Segerberg: Geol. Fören. I Stockholm Förhandl., 1900, Bd. xxii, H. 5, pl. i, fig. 5.

This species is represented by two rather incomplete specimens, preserved as casts, both from Faxe. The length of the specimen figured in Pl. XII, Fig. 8 is 7 mm., the breadth about 4·5 mm.

The rostrum is narrow and triangular, its superior surface smooth and slightly concave, the borders are smooth and provided on each side of the base with a tooth directed forwards. The anterior margin of the rostrum is fairly well raised; the lateral margin is curved in front of and behind the antero-lateral branch of the occipital furrow, but is otherwise straight with indistinct, blunt teeth. The occipital furrow and its branches are well marked. The cross-lines are elevated, and run posteriorly from side to side in a way peculiar to this species. The cardiac region is not prominent. The gastric region anteriorly is sharply distinguished from the frontal region, which is situated on a lower level; in the centre it is provided with a ridge which is continued on to the rostrum. On both sides of this ridge, a little behind the front border, are four small prominences arranged in a semicircle and diminishing in size outwards.

This species exhibits, particularly in the form of its rostrum, an interesting transitional form between the genera *Galathea* and *Munida*. The triangular form of the rostrum and its superior surface being slightly concave show its relationship to *Galathea*, and on the other hand the non-serrated ridges and the two teeth situated at the base on either side are found in the *Munida*-type, which is represented by *Munida primæva*, n.sp.

Several existing species are known which, as regards the formation of the rostrum, are transitional forms between *Galathea* and *Munida*, which, however, have been arranged as separate genera. Such are the *Pleuroncodes* of Stimpson and the *Grimothea* of Dana. In both these genera one finds a small, triangular, non-serrated rostrum, provided with teeth on each side at the base.

Pleuroncodes[1] differs, however, both from *Galathea* and *Munida*, amongst other peculiarities, in its breadth. Recent authors[2] consider *Grimothea* to belong to the genus *Munida*. Of the living species of *Galathea*, *G. pusilla*, Henderson,[3] is nearest to *G. munidoides*; but its rostrum is provided with a small tooth on each side in front.

MUNIDA PRIMÆVA, K. O. Segerberg.

K. O. Segerberg: Geol. Fören. I Stockholm Förhandl., 1900, Bd. xxii, H. 5, p. 8, pl. i, fig. 6.

Only one specimen of this species has been found from Faxe, preserved as a cast; still, the shell can be partially seen at the sides, but the rostrum and lateral teeth are broken. The greatest breadth at the centre of the carapace is 5 mm.; the length from the base of the rostrum to the posterior margin is 6 mm. The rostrum is narrow, spear-shaped, provided with a small tubercle on its superior surface, from which runs a fine ridge along the middle line as far as the occipital furrow; at the base of the rostrum there is on each side a pointed tooth.[4] The anterior margin is well defined on either side of the rostrum, and still more along the lateral margin. The lateral margins are slightly but evenly curved, and provided with small pointed teeth directed forwards; of these the anterior one is much larger than the rest, and forms the demarcation of the angle between the anterior margin and the lateral margin. The occipital furrow and its branches are deep and distinct. The regions on the border are well defined, and are thinly but sharply granulated. Besides this the superior surface shows several ridges, anteriorly alternately longer and shorter, and here and there are small tubercles. The cardiac region is short and broad, with a narrow, straight sulcus in front and behind; it is crossed by three lines, the two anterior ones converging towards the sides. The middle part in front of the occipital furrow forms an oval area pointed towards the sides. On the gastric region, near the middle line, in front, are two tubercles (on the carapace itself there have probably been teeth corresponding to these); outside and below these are smaller, more or less pointed ones (on both the cast and

[1] Ortmann: Arthropoda, p. 1150.
[2] Milne Edwards: "Crustacés du Cap Horn," p. 32.
[3] Henderson: Anomura, p. 121, pl. xii, fig. 1.
[4] After the original specimen had been drawn it was being still further developed, and in this operation the rostrum was unhappily destroyed.—K. O. S.

the test). A similar form of rostrum, with lateral teeth placed closely together at the base, is also found in recent species of *Munida*, e.g. *M. forceps*, Milne-Edw.[1]

Lundgren says, in the description of *Galathea strigifera*, "that the lateral parts, defined by the above-mentioned curved lines, are granulated, and that the middle one is most prominent." This shows probably that Lundgren, amongst his specimens of *Galathea*, had also the above described species of *Munida*.

BRACHYURA—ANOMALA.

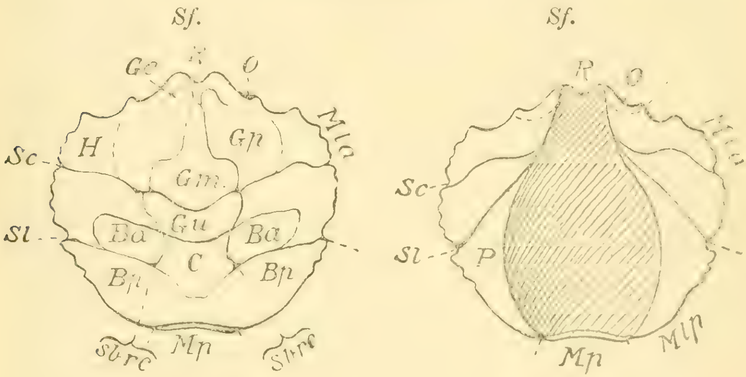
Fam. DROMIDÆ, Stebbing.

Gen. Dromiopsis, Reuss.

1859. *Dromiopsis*, Reuss: Fossil. Krabben, p. 18.
1866. *Dromia*, Von Fischer-Benzon: Alter d. Faxekalkes, p. 23.
1900. *Dromiopsis*, K. O. Segerberg: Geol. Fören. I Stockholm Förhandl., Bd. xxii, II. 5, p. 9.

The carapace is circular or pentagonal, a little broader than long, much arched in front, flatter behind. The rostrum is triangular and bent downwards, with a shallow sulcus or furrow along the

Diagram of Regions and Divisions of Carapace in a Brachyuran Decapod Crustacean.



Upper Surface. Under Surface.

Sf.	frontal furrow.	*Gc.*	epigastric lobe.
R.	rostrum.	*Gm.*	mesogastric lobe.
O.	orbits.	*Gp.*	protogastric lobe.
Mla.	antero-lateral margin.	*Gu.*	urogastric lobe.
Mlp.	postero-lateral margin.	*H.*	hepatic region.
Mp.	posterior margin.	*C.*	cardiac region.
Sc.	cervical or occipital furrow.	*Ba.*	antero-branchial lobe.
Sl.	lateral furrow.	*Bp.*	postero-branchial lobe.
Sbrc.	branchio-cardiac furrow.	*P.*	pterygostomial region.

middle line; its borders are even and raised; the orbits are rather small, somewhat close together, and are open internally towards the rostrum, from which they are only separated by a small ridge of the posterior wall. The inferior orbital border is provided with

[1] Milne-Edwards et Bouvier: Dredging of SS. "Blake," p. 28, pl. ii, fig. 8.

two teeth, of which the external one is the larger. The antero-lateral margins (*Mla.*) are long, much curved, and provided with teeth varying in number and often confluent. The postero-lateral margins (*Mpl.*) are shorter, nearly straight, and curving inwards; they are provided in front with one or two more or less indistinctly marked teeth. The posterior margin (*Mp.*) is generally short and somewhat incurved. The superior surface of the carapace is divided transversely into three areas by two sulci (or furrows), the anterior of which is named the *cervical* furrow (*Sc.*) (called also the occipital furrow), and the posterior the *branchio-cardiac* furrow (*Sbrc.*) or lateral furrow (*Sl.*). The branchio-cardiac furrow is more or less bent backwards, and often takes a sharp curve forwards, and, having received a smaller sulcus from the part in front, it continues on to the arched margin of the carapace forming the lateral furrow (*Sl.*). This sulcus, which marks the middle of the superior surface of the carapace, is indicated only by a notch on the lateral margin over which it passes, and is continued forwards upon the inferior orbital border of the pterygostomial region (*P.*).

Of the different regions observed on the carapace the epigastric (*Ge.*) and the mesogastric lobes (*Gm.*) appear in front of the occipital furrow (also called the cervical furrow) (*Sc.*). The two epigastric lobes (*Ge.*) are nearly always well marked, and are separated by the frontal furrow (*Sf.*). The mesogastric lobe (*Gm.*) is prolonged in front into a narrow point, and divided behind into two parts by a sulcus running lengthwise, and in decorticated specimens, from which the shell has been dissolved away, this furrow is always well defined by two well-marked raised surfaces (these marks being due to the insertion of muscles on the interior of the carapace). Behind the occipital furrow (also called the *cervical* furrow), in the front part of the centre of the carapace, is the broad urogastric lobe (*Gu.*) (not always well defined). This is separated from the next region by a narrow, plane or concave surface. The cardiac region (*C.*) is pentagonal, with the pointed portion directed backwards, and on decorticated specimens nearly always marked by three tubercles, forming a triangle; on each side, behind the occipital furrow, are the two large branchial regions (*Ba.* and *Bp.*). The anterior branchial regions (*Ba.*), situated in front of the lateral sulcus or furrow, possess on decorticated specimens, in the centre, a pointed elevation. The posterior branchial regions (*Bp.*) are of a more or less marked rhomboidal form. Two tubercles can always be seen in decorticated specimens in the middle of the occipital furrow. The pterygostomial region (*P.*) is very narrow. On this, behind the lower border of the orbit, is a transverse furrow or sulcus, which is often sharply marked, particularly on the inner part, where the region behind is more or less pointed.

The superior surface is granulated or smooth, the curved part nearly always smooth. In the collections both from Annetorp and Faxe there are isolated well-preserved claws, which in their short, stout form and the direction of the index and pollex resemble the

Dromia-type, but which are devoid of the denticulations peculiar to *Dromia.* These claws belong, no doubt, to representatives of the genus *Dromiopsis,* which is so stated in one case (cf. *D. lævior*); among others of the figured species one is granulated in the same way as the shell of *D. rugosa,* and belongs probably to that species.

Of the genus *Dromiopsis* four species are already described, all belonging to the newer Chalk formation, and all except *D. elegans* known only from the Faxe Chalk. *Dromiopsis gibbosus,* Schlüt.,[1] from the *Belemnites mucronatus* Chalk formation of Westphalia, does not belong to this family, but ought probably to be referred to the family *Homolopsis* of Bell.

Dromiopsis resembles in many respects *Dromia,* and Von Fischer-Benzon considered these two to be identical. Lundgren is also of the same opinion. This is easily explained, as the genus *Dromia* formerly comprised many more types than are now included with our present knowledge of the genus. (Ortmann, "Arthropoda," p. 114.)

"After examining recent specimens in the Zoological Museum of Copenhagen I have been able to show distinct generic differences between *Dromia* and the genus *Dromiopsis* as proposed by Reuss. *Dromia* differs very distinctly from *Dromiopsis* by its three-toothed rostrum, and also by its long, nearly straight posterior border, much larger pterygostomial region, and its very peculiarly serrated claws. The genus *Dromiopsis* ought thus to be maintained and to be considered as a precursor of *Dromia.* This last-mentioned genus appears first in the Tertiary period, from which Bittner[2] has described several types all with the rostrum three-toothed. But as regards the pterygostomian region these Tertiary species of *Dromia* resemble *Dromiopsis* (cf. Bittner, 'Brachyuren v. Vicenza, Neue Beiträge,' p. 307)."

"The genus *Dromilites* of Milne-Edwards,[3] belonging to the Tertiary formation, with which *Dromiopsis* has also been considered as identical, ought necessarily to be revised. The species belonging to this genus differ more or less from *Dromiopsis* by the denticulations on the lateral borders, by more distinct regions, and by the shape of the branchial regions. Zittel's[4] diagnosis of the relationship both of *Dromiopsis* and *Dromia* is now inapplicable."

Dromiopsis rugosa, Schlotheim, sp. (Pl. XII, Figs. 3*a*, *b*, and 4*a–c*.)

1820. *Brachyurites rugosus,* Schlotheim: Petrefactenkunde, p. 36, pl. i, fig. 2.
1851. *Brachyurites rugosus,* Quenstedt: Petrefactenkunde, p. 401, pl. xxxi, fig. 11.
1859. *Dromiopsis rugosa,* Reuss: Fossil. Krabben, p. 10, pl. iii, figs. 2, 3; pl. v, fig. 6.
1866. *Dromia rugosa,* Von Fischer-Benzon: Alter d. Faxekalkes, p. 24, pl. iii, figs. 1–3.
1867. *Dromia rugosa,* Lundgren: Faxekalken, p. 10.
1900. *Dromiopsis rugosa,* Schlotheim, sp.: K. O. Segerberg, Geol. Fören. I Stockholm Förhandl., Bd. xxii, H. 5.

[1] Schlüter: Krebse d. nördl. Deutschl., p. 610.
[2] Bittner: Brachyuren v. Vicenza, Neue Beiträge, p. 306, pl. i, fig. 5; Decapoden d. pannon. Tertiär, pp. 21, 25, pl. ii, figs. 5, 6.
[3] Bell: "Crust of London Clay," p. 27, pl. v, figs. 1–9; pl. vi.
[4] Zittel: Palaeont., ii, p. 703.

The carapace in outline is of a rounded pentagonal form, with its greatest breadth a little anterior to the middle; of nearly the same length as breadth (1 : 1·1); very convex, particularly anteriorly, the posterior part being flatter and often having a depression in the centre. In size it varies from a breadth of a few millimetres up to 40 mm.; generally it is from 20 to 25 mm. The rostrum (*R.*) is strongly depressed; the orbits (*O.*) are deep; their inferior border forms a blunt process with two teeth. The antero-lateral margin commences with a sharp tooth somewhat below the inferior orbital border; in other respects the lateral margins agree generically. The posterior margin is sometimes short and much curved, in others long and less curved; this is probably due to difference in sex. The occipital and lateral sulci or furrows are deep and sharply defined; somewhat broader on the superior surface than on the curved part. On the inner half of the anterior branchial regions there runs parallel to these a much shallower middle sulcus, which forms a right angle externally and ends in the lateral furrow (on some specimens there are traces of such a curved furrow going off anteriorly towards the occipital or cervical furrow). The epigastric lobes form two pointed eminences. The mesogastric lobe is well defined, and elevated posteriorly. The protogastric lobes are not so well defined in this type. The urogastric lobe is characterized by irregular eminences. Between this and the cardiac region there is a saddle-like depression, the anterior part of which, towards the sides, blends with the above described middle sulcus. The centre of the cardiac region is more or less elevated, and anteriorly it is externally defined by the branchio-cardiac furrow, which on some specimens is shallower, and runs forwards and outwards and unites with the occipital or cervical furrow. The superior surface is ornamented with granules varying in size, which become less posteriorly and are not so well defined (except on the nearly smooth sulci). The inferior surface has granules only on its anterior part.

The above described details are readily seen on all decorticated specimens and are present on even very small specimens; on larger and older examples they have often been more or less obliterated. Specimens with the surface of the shell well preserved are not rare; the granules in these are very distinct, and do not diminish in size posteriorly, and are seen also on the arched part of the carapace.

Dromiopsis rugosa is not only without doubt one of the most common decapods of the Faxe Chalk, but also generally one of its most common fossils.

Of this little varying type Segerberg records having found the following different forms (see Pl. XII, Figs. 4*a*–*c*, × 2 nat. size).

(*a*) *Forma inflata*, small, more strongly and more uniformly arched, with the regions less markedly distinguished; several specimens. (Segerberg, op. cit., 1900, pl. i, fig. 10.)

(β) *Forma angusta*, small, strongly arched from side to side; somewhat longer than broad, quickly tapering behind the occipital furrow towards the very short posterior margin. The posterior part of the mesogastric lobe separated by a well-marked sulcus from the protogastric lobes, which are pointed downwards and inwards. This is probably a variety of *D. rugosa.* (Segerberg, op. cit., 1900, pl. i, fig. 2.)

(γ) *Forma nodosa*, large, with its middle lobes much accentuated and elevated (particularly the posterior part of the mesogastric lobe and the inner half of the antero-branchial regions); the protogastric lobes on the antero-lateral border are also elevated. (K. O. Segerberg, op. cit., 1900, pl. i, fig. 12.)

DROMIOPSIS MINOR, Von Fischer-Benzon, sp.

1866. *Dromia minor*, Von Fischer-Benzon: Alter d. Faxekalkes, p. 25, pl. iii, figs. 4–6.
1867. ,, ,, Lundgren: Faxekalken, p. 11.
1900. ,, ,, K. O. Segerberg: Geol. Fören. I Stockholm Förhandl., Bd. xxii, H. 5, pl. i, fig. 14.

Circumference nearly round; the breadth is to the length as 16 : 15; the arching is fairly uniform all over, but a little flatter posteriorly. The size varies from 15 to 27 mm. in breadth. The rostrum is broad, triangular, and not so much depressed as in *D. rugosa.* The lateral margins are evenly curved; the antero-lateral margin begins close to and on the same level as the inferior orbital border, and has 5–6 short conical teeth, generally well separated. The postero-lateral margin anteriorly is marked by a tooth. The posterior margin is longer and less curved than in *D. rugosa.* The occipital furrow is fairly deep, forming an angular bend on the pterygostomial region. Lateral furrow shallow. The different regions much less prominent than in the preceding species. The cardiac region is defined anteriorly by a fine straight line.

The superior surface sparsely provided with small, mostly pointed tubercles, forming a row on each side of the lateral furrow. The cardiac region and the postero-branchial lobes are provided with much fewer tubercles, or they are absent altogether. In other respects it corresponds with *D. rugosa.*

This species, described by Von Fischer-Benzon, was by him supposed to be identical with *D. minuta* of Reuss.[1] The description by Reuss, however, is very vague, differing little from *D. elegans* as this species is described and illustrated by Reuss[2] himself, and it is therefore probably only a form of this very variable species from which he has formed his description. *D. minuta*, Reuss, ought thus to be abolished.

D. minor appears rarely both at Annetorp and at Faxe.

DROMIOPSIS ELEGANS, Steenstr. et Forchh., sp.

? *Dromilites elegans* (*elegantulus*), Steenstr. et Forchh. MS.
1859. *Dromiopsis elegans*, Reuss: Fossil. Krabben, p. 15, pl. iv, figs. 1, 2.
1859. *Dromiopsis minuta* (?), Reuss: Fossil. Krabben, p. 13, pl. iv, fig. 3.
1866. *Dromia elegans*, Von Fischer-Benzon: Alter d. Faxekalkes, p. 26, pl. iv, fig. 2.
1867. ,, ,, Lundgren: Faxekalken, p. 11.
1900. ,, ,, K. O. Segerberg: Geol. Fören. I Stockholm Förhandl., Bd. xxii, H. 5, pl. i, figs. 16, 18, 19.

[1] Reuss: Fossil. Krabben, p. 13, pl. iv, fig. 3.
[2] Op. cit., p. 15, pl. iv, figs. 1, 2.

This species is very variable in form, but the following characters seem to be fairly constant:—

The circumference is more or less elliptical; the ratio between the length and the breadth is generally as 1 : 1·2; the arching often less than in the preceding species, particularly across the posterior part. The size varies from 5 to 20 mm. in breadth. The lateral margins are provided with small, often indistinct teeth, 7–8 in number. The lateral furrow is shallow, but distinct, being defined behind by a small raised border which is generally noticeable even behind the cardiac region. The posterior part of the mesogastric region and the epigastric lobes is well marked and elevated; the last-mentioned are elliptical and situated transversely. The limit anteriorly being often indistinct. On some specimens the anterior angle seems to run out into a fine line, which ends in a small tubercle.

Of this species two types can be distinguished. One of these particularly is more arched posteriorly, and a little broader than long, with the largest breadth a little in front of the middle of the carapace. The posterior margin is short, strongly curved, and nearly smooth. The second type is broader, with its greatest breadth over the middle. The posterior margin is long and faintly curved; it is more or less granulated, the granules being small, thinly and irregularly scattered. Both types, however, pass by many intermediate forms into each other, and seem to appear just as frequently, and thus it is impossible to distinguish between a typical specimen and its variety.

D. elegans is fairly common at Faxe, and still more so at Annetorp. This species appears also in Maestrichtien supérieur at Mont de Saint-Pierre and at Ciply.[1]

DROMIOPSIS LÆVIOR, Steenstr. et Forchh., sp.

? *Dromiopsis lævior*, Steenstr. et Forchh. MS.
1859. ,, ,, Reuss: Fossil. Krabben, p. 16, pl. iii, figs. 4–6.
1866. *Dromia lævior*, Von Fischer-Benzon: Alter d. Faxekalkes, p. 27, pl. iv, fig. 1.
1900. *Dromiopsis lævior*, Steenstrup: K. O. Segerberg, Geol. Fören. I Stockholm Förhandl., Bd. xxii, H. 5, pl. i, fig. 15.

Larger, more strongly and evenly arched than the preceding species. Circumference rounded. The size varies between 25 and 42 mm. The rostrum is broad, triangular, with its borders strongly raised. The orbits are deep. The external angle of the orbit is interrupted by a broad incision which runs outwards into a wide sulcus. The external tooth of the inferior orbital border is considerably larger than the inner one. The antero-lateral margin begins a little below the inferior orbital border, and its teeth are generally confluent, forming a sharp ridge which is divided by the occipital furrow; both serrations are pointed anteriorly and blunt posteriorly. The posterior margin is somewhat curved inwards. Both the occipital furrow and the lateral furrow are shallow; the last-mentioned is broad, defined behind by a sharp crest, which is

[1] Pelseneer: Decapod. du Maestricht, p. 172.

pointed at the lateral margin, and is continued on to the inferior surface. The epigastric lobes are placed transversely and provided with small prominences. Between these and the antero-lateral margin there are some elevated tubercles, arranged in a row. From an area in the middle of the anterior lateral region, which is full of small depressions and nearly circular in shape, another row of similar tubercles runs in a curve backwards and inwards. The mesogastric lobe is only distinct posteriorly by its conspicuously raised surface. The middle area of the antero-branchial lobes is well marked by the dotted elevation already referred to in the description of the genus. Otherwise the surface of the carapace in the cast is quite smooth, and this is also the case when the shell is preserved.

Of this species one specimen appears with the claw belonging to it, although this is incompletely preserved.[1] The shell of this species is smooth, except a few granules on the shortest side; the cast is more or less reticulated. The claw referred to in Segerberg's paper, p. 17, pl. ii, fig. 2 belongs probably to this species. Only rarely met with at Annetorp and Faxe.

DROMIOPSIS? DEPRESSA, K. O. Segerberg, 1900.

1900. *Dromiopsis? depressa*, K. O. Segerberg: Geol. Fören. I Stockholm Förhandl., Bd. xxii, H. 5, p. 18, pl. ii, figs. 3, 4?

Of this species only one specimen was obtained from Annetorp. The rostrum is not preserved. The specimen is decorticated. The form of the carapace is nearly pentagonal; breadth 26 mm. The distance from the superior orbital border to the posterior margin is 24 mm. In front of the lateral furrow the carapace is strongly arched; behind the same it becomes narrower, with the lateral parts depressed. The orbits are small, narrow, and transverse. The two teeth on the inferior orbital border are of nearly equal size. The antero-lateral margins commence in a line with the inferior orbital border; in front of the occipital furrow the margin is marked by a prominence and is curved; behind the same it is prolonged forwards into a tooth or point, but otherwise (as on the postero-lateral margins) it is only faintly marked, and curved inwards. The posterior margin is long and slightly curved. The occipital furrow is very indistinct, particularly in its inner course. The lateral furrow (*Sl.*), on the other hand, is distinct, but very shallow, without any well-defined margin. Behind the cardiac region there is a transverse depression. Otherwise the details of the carapace are fairly similar to the preceding species.

This species is in some respects very similar to *Dromia lator*, a recent form from the West Indies.[2] But as only one specimen of the former has been found without a rostrum, and as on the whole it is nearly related to *D. lævior*, I have (with some doubt) referred it to the genus *Dromiopsis*.

In the collections from Faxe, K. O. Segerberg has figured a very incomplete specimen, which he thinks is probably a younger form of this species.

[1] K. O. Segerberg: op. cit., pl. ii, figs. 1, 2.
[2] Loc. cit., fig. 5.

Dromiopsis Birleyæ, H. Woodw., sp. nov. (Pl. XII, Figs. 1*a*, *b*.)

Description.—Carapace broader than deep (16 mm. broad and 12 mm. deep); antero-lateral border slightly concave; frontal margin prominent, with a central depression. Lateral margins rounded; postero-lateral margin sloping inwards; posterior margin (8 mm.) broad and nearly straight; surface sparsely granulated, but generally smooth; with the exception of the epigastric prominences, and the posterior margin of the mesogastric region, the lobes of the carapace are generally very obscurely defined; the cervical furrow (*Sc.*) is most distinct and is very slightly curved; the lateral furrow (*Sl.*) is faintly rugose, but less distinct than the cervical furrow; at the base of the mesogastric lobe is a short granulated band in front of the cervical furrow, and two small pointed prominences (divided by the median furrow), the points directed backwards, each being marked by a minute tubercle; the cardiac region is depressed and only faintly outlined, its surface being marked by three small equidistant tubercles, two in front and one behind; four small tubercles mark the border of the antero-branchial lobe, and three the antero-lateral border. The two rounded prominences near the anterior border of the epigastric lobes are very distinct. The rostrum, which is rounded, is bent downwards between the orbits, and is deeply indented by the frontal furrow. The orbits are elongated transversely, and are open internally towards the rostrum.

Remarks.—Two apparently full-sized specimens of this well-marked species (16 × 12 mm.) are in Miss Birley's collection, also one young specimen measuring 9 mm. in breadth by 6 mm. in depth; all three are preserved in hard compact limestone, which contains also traces of the limbs. The species is distinguished by its well-marked form, being broader in proportion to its depth than *D. rugosa*, although specifically they are no doubt nearly related. The rostral and frontal border is less prominent in *D. Birleyæ*, and the posterior margin is wider and straighter than in *D. rugosa*. All three examples have been decorticated.

I dedicate this species to my friend Miss Caroline Birley, who has given so much time and attention to the study of geology and palæontology both at home and abroad, and whose private collection bears testimony to her devotion to science.

Formation and Locality.—Hard Upper Cretaceous Limestone (Danian) of Faxe: coll. Miss Birley.

Dromiopsis Coplandæ, H. Woodw., sp. nov. (Pl. XII, Figs. 2*a*, *b*.)

Description.—Carapace slightly broader than deep (9 × 7 mm.); anterior border semicircular; frontal region broad, depressed; orbits large, prominent, visible from above, and placed somewhat diagonally; enclosed externally, but open towards rostrum; postero-lateral margins contracting rapidly towards the posterior margin, which is narrow, only 3 mm. wide, and emarginate. Cervical furrow distinct; lateral furrow faint, but more strongly marked on the margin of carapace; antero-lateral margin very bluntly dentated or undulated; mesogastric and epigastric lobes slightly prominent; carapace generally smoothly rounded and lobes obscure.

Remarks.—This is a very well-marked glabrous form and quite distinct in outline from any of the other species; the sides being narrower and contracting posteriorly, and more rounded and depressed in front; with the orbits visible from above, which is not the case in any other species of *Dromiopsis.*

Among the smaller specimens of *Dromiopsis* I have detected a minute, very round, smooth form; the carapace is 6 mm. broad and 5 mm. deep; it agrees generally with the larger example (Figs. 2*a*, *b*). The cardiac region in this small specimen is more clearly defined, and has three equidistant tubercles on its surface; the orbits are large and prominent, and the outline of the back is very globular; this latter character is probably due to its being a young individual.

I dedicate this species to Miss Copland, who participated with Miss Birley in her geological labours and collected many of the specimens with her own hands at Faxe.

Formation and Locality. — Uppermost Cretaceous (Bryozoa Chalk), Faxe: original specimens in Miss Birley's collection.

Homolopsis transiens, K. O. Segerberg.

1900. *Homolopsis transiens*, K. O. Segerberg: Geol. Fören. I Stockholm Förhandl., Bd. xxii, H. 5, pl. ii, figs. 6–8.

K. O. Segerberg obtained several specimens of this species both from Annetorp and Faxe, preserved as casts, nearly all, curiously enough, without frontal or lateral margins being preserved (cf. Carter, Decapod. Crust., p. 22).

Anteriorly depressed, otherwise nearly even; the length about 22 mm. (on the larger, figured specimen). Rostrum narrow, triangular, and depressed, provided with a small tubercle on each side. Lateral and posterior margins long, straight, elevated into a ridge. Occipital furrow deep and broad at the sides, narrower between the mesogastric and the urogastric lobes, and having two pointed elevations in the centre. Lateral furrow narrow, faintly defined; nearly straight on each side of the middle line; directed outwards and forwards. The different regions are all very conspicuous and limited by deep sulci. The epigastric lobes are marked by two distinct tubercles. One sees three other similar tubercles on the protogastric lobes. The mesogastric lobe is well defined on all sides. The urogastric lobe is pointed at the sides. The cardiac region is pentagonal and elevated. The antero-branchial lobes are divided on the inner side into two parts, of which the superior one is the shorter. The postero-branchial regions are triangular and large; there is a tubercle on the inner posterior part. The superior surface is more or less thinly and irregularly granulated. On a younger specimen (op. cit., pl. ii, fig. 7) similar granules can be seen, particularly on the mesogastric and cardiac lobes. On an older one (op. cit., pl. ii, fig. 6) one sees these granules both on the cardiac and postero-branchial lobes arranged transversely in short rows; on account of this arrangement the casts have a somewhat ridged appearance. Another old specimen, on the contrary (pl. ii, fig. 8), has the posterior part nearly smooth, and the tubercles on the protogastric lobes are but little conspicuous. (This is also the case with a single specimen preserved in Miss Birley's collection.)

This species is in many respects very similar to *H. Edwardsii*, Bell,[1] from the Gault and Greensand of England, a very peculiar form, to a knowledge of which the late Mr. James Carter[2] has made some very valuable contributions. In regard to the granulation on the postero-branchial lobes the species from the Uppermost Chalk (here described by Segerberg) is very similar to the Tertiary genus *Dromilites*,[3] which is also closely related to *Homolopsis*, and seems thus to be a transitional form between these two genera.

A single, very imperfect carapace is preserved in Miss Birley's collection from the Danian of Faxe.

CARPILIOPSIS.

Carpiliopsis ornata, Von Fischer-Benzon, sp. (Pl. XII, Figs. 5*a*, *b*.)

1867. *Carpiliopsis ornata*, Von Fischer-Benzon, sp.: Alter d. Faxekalkes, p. 28, pl. ii, figs. 1–3.

1900. ,, ,, K. O. Segerberg: Geol. Fören. I Stockholm Förhandl., Bd. xxii, H. 5, p. 28, pl. iii, figs. 15, 17, 18?

Description.—The carapace is sub-elliptical, equally convex longitudinally; the lateral margins are acute; the antero-lateral margins are short, rounded, and curved backwards. The postero-lateral margins are longer and are curved inwards. The orbits are oval, and when seen from above marked by emarginations on either side (Pl. XII, Fig. 5*a*) of a broad, bluntly rounded, and slightly notched rostrum (Pl. XII, Fig. 5*b*). The posterior margin is narrow and emarginate. The upper surface of carapace is punctate, and ornamented by raised lines and tubercles peculiar to the species; the general surface is very minutely ornamented with microscopic granules.

The mesogastric lobe is marked by two minute tubercles and a small, short, raised line behind, probably affording the only evidence of the presence of the cervical furrow; there is a slight trace of a median ridge and furrow, and a rather larger tubercle marks the centre of each epigastric lobe. One tubercle on either side and a few minute granules scattered over the protogastric and hepatic regions are the only interruption to the otherwise smooth anterior surface of the carapace. The cardiac region bears three minute tubercles, and is enclosed on either side by a lyre-shaped ridge and furrow, which bending back upon itself forms the short lateral furrow.

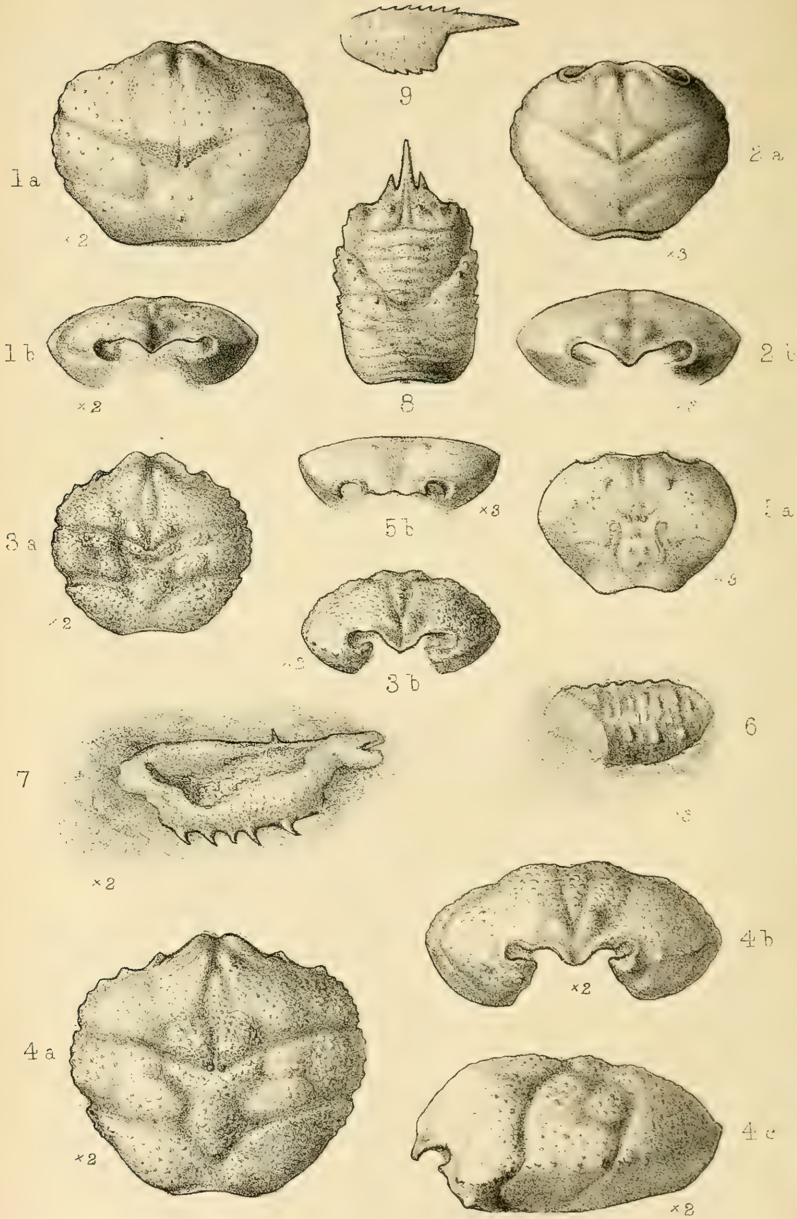
Remarks.—This well-marked form is represented by two examples in Miss Birley's collection, the larger measuring 12 mm. in breadth by 7 mm. in depth, the lesser example being 9 mm. broad and 6 mm. in depth. Both are from the uppermost Cretaceous formation of Faxe, Denmark.

The following is a list of the species of Crustacea from Faxe recorded by K. O. Segerberg and H. Woodward:—

[1] Bell, Crust. of Gault and Greensand: Mon. Pal. Soc., 1862, p. 23, pl. v, figs. 1, 2.

[2] Carter: Decapod. Crust., 1898, p. 21.

[3] Bell: Crust. of London Clay, p. 27.



G.M.Woodward
B.Potter. } del.et lith.

West,Newman imp.

Cretaceous Crustacea from Faxoe.

GALATHEIDÆ.

Galathea strigifera, Steenstr. Danian: Annetorp and Faxe.
* ,, *munidoides*, K. O. S. Danian: Faxe.
Munida primæva, K. O. S. Danian: Faxe.

DROMIACEA.

**Dromiopsis rugosa*, Schlüt., sp. Danian: Faxe.
,, *minor*, Von Fischer-Benzon, sp. Danian: Annetorp and Faxe.
,, *elegans*, Steenstr. et Forchh., sp. Danian: Annetorp and Faxe.
,, *lævior*, Steenstr. et Forchh., sp. Danian: Annetorp and Faxe.
,, *depressa*, K. O. S. Annetorp and Faxe.
* ,, *Birleyæ*, H. Woodw., sp. nov. Danian: Faxe.
* ,, *Coplandæ*, H. Woodw., sp. nov. Danian: Faxe.
Plagiophthalmus pentagonalis, K. O. S. Faxe.
**Homolopsis transiens*, K. O. S. Annetorp and Faxe.

RANINOIDEA.

Raninella Baltica, K. O. S. Faxe.

OXYSTOMATA.

Necrocarcinus senonensis, Schlüt., sp. Annetorp and Faxe.
,, *insignis*, K. O. S. Annetorp.
,, *bispinosus*, K. O. S. Saltholm's Chalk: Limhamn.

CYCLOMETOPA.

Titanocarcinus, sp. Annetorp.
**Carpiliopsis ornata*, Von Fischer-Benzon, sp. Annetorp and Faxe.
Xanthilites cretaceus, K. O. S. Annetorp.
Panopeus faxensis, Von Fischer-Benzon, sp. Annetorp and Faxe.
,, *subellipticus*, K. O. S. Faxe.
,, *incertus*, K. O. S. Annetorp and Faxe.

NOTE.—Those marked by a * are represented in Miss C. Birley's collection.

EXPLANATION OF PLATE XII.

CRUSTACEA FROM THE UPPERMOST CHALK ('DANIAN') OF FAXE, DENMARK.

FIG. 1.—*Dromiopsis Birleyæ*, H. Woodward, sp. nov. × 2 times nat. size.
a, dorsal aspect of carapace or cephalo-thorax.
b, frontal aspect of carapace, showing orbits and rostrum.

,, 2.—*Dromiopsis Coplandæ*, H. Woodward, sp. nov. × 3 times nat. size.
a, dorsal aspect of carapace.
b, frontal aspect of carapace, showing orbits and depressed rostrum.

,, 3.—*Dromiopsis rugosa*, Schlotheim, sp. Small, round, much granulated variety. × 2 times nat. size.
a, dorsal aspect of carapace.
b, frontal aspect of carapace, showing arched form of carapace and depressed rostrum.

,, 4.—*Dromiopsis rugosa*, Schlotheim, sp. Typical, most abundant form. × 2 times nat. size.
a, dorsal aspect of carapace.
b, frontal aspect of carapace, showing rounded form of back.
c, side view, showing inflated form of frontal region and strongly marked, transverse cervical and lateral furrows.

,, 5.—*Carpiliopsis ornata*, Von Fischer-Benzon, sp. × 3 times nat. size.
a, dorsal aspect of carapace, showing the peculiar lyre-shaped markings on the centre enclosing the cardiac region.
b, frontal aspect of carapace, showing the broad blunt rostrum which widely separates the small orbits.

,, 6.—Portion of a chela. × 3 times nat. size.

,, 7.—Portion of a chela. × 2 times nat. size.

,, 8.—*Galathea munidoides*, K. O. Segerberg. Dorsal aspect of cephalo-thorax. × 4 times nat. size.

,, 9.—*Galathea munidoides*, K. O. Segerberg. Penultimate joints of chela. × 4 times nat. size.

III.—On the Rate of Increase of Underground Temperature.

By Professor W. J. Sollas, LL.D., D.Sc., F.R.S.

IN the 22nd Report of the Committee appointed to investigate the rate of increase of underground temperature, read this year before the British Association in Glasgow, some remarks previously made by me are animadverted upon; and as the Secretary, Professor Everett, has invited me to discuss the matter with him, I take the opportunity of entering somewhat more fully into the question of conductivity than has hitherto seemed necessary. We read in the Report ". . . . in view of the fact that the President of Section C last year characterised the variation in the British Isles 'from 1° in 34 feet to 1° in 92 feet' as 'a surprising divergence of extremes from the mean,' it is well to emphasise the connection between gradient and conductivity. If there is anything like uniformity in the annual escape of heat from the earth at different places, there must necessarily be large differences in geothermic gradients, since the rate of escape is jointly proportional to the gradient and the conductivity."

So well known a fact as the statement in the last sentence seems to me scarcely to require emphasis, since it must assuredly be present in the mind of everyone capable of discussing the question: but it is not sufficient to make general statements of this kind; it must also be shown, if the argument is to be of any real value, that the known divergences of extremes from the mean may be definitely connected with known differences in conductivity. Hitherto this has not been attempted, and in the Address to Section C last year it was expressly stated that "many cases exist which cannot be explained in such a manner, but are suggestive of some deep-seated cause, such as the distribution of molten matter below the ground." Before proceeding to enter into calculations which may illustrate this statement, it may be worth while to observe that we have no evidence to suggest, much less to prove, that "there is anything like uniformity in the annual escape of heat from the earth at different places"; the indications are altogether to the contrary: the mere existence of volcanos obviously invalidates the statement as an absolute affirmative, and ancient laccolites show that in past time at least concealed sources of heat have existed not very remote from the surface.

If, then, there is *not* uniformity in the annual escape of heat from the earth at different places it may be thought unnecessary to labour the question in greater detail, yet in view of the importance of the subject to geological inquiry it may be worth while to consider some special cases. If we turn to the "Summary of the Results in the first 15 Reports by Professor Everett" (1882) we shall find a table of mean conductivities from several kinds of rocks given in C.G.S. measure, from determinations made by Professor Herschel, but these, following the direction of Professor Everett, must be multiplied by a correcting factor 1·4 for use in calculation. For our purpose we select the following:—

Rock-salt	·0113	Clay	·0025
Sandstone	·0060	Shale	·0019
Flagstone	·0046	Coal	·0008

Rock-salt heads the list, and consequently in borings made through this mineral the thermometric gradient should be lower than the average. If, now, we turn to the results given on p. 88 of the British Association Report for 1882 we find that the deep Sperenberg boring, which passed chiefly through rock-salt, shows a temperature increase of 1° for $51\frac{1}{2}$ feet, and this result is regarded by the Committee as so remarkably accurate that the effect of quadrupling it when calculating a mean rate is thought worthy of consideration. On p. 84 we read, "The Sperenberg bore, near Berlin, in rock salt, with a depth of 3,492 English feet . . . . gave an average of 1° in 51·5 feet. This result is entitled to special weight, not only on account of the great depth, but also on account of the powerful means employed to exclude convection." The mean result for all observations given in the same Report is 1° for 64 feet, which was corrected in a later Report to 1° for 60 feet.

Thus, the gradient of the Sperenberg bore, so far from being below the average, such as the conductivity of rock-salt would have led a believer in the uniform rate of loss of heat to expect, actually rises above it. The average rate at which heat escapes through the earth is given in the Report (1882) as 41·4 gramme degrees annually through each square centimetre of a horizontal section of the earth's substance. There is an error in this number, no doubt typographical; it should read 51·4.

Let us calculate from the data afforded by Sperenberg the average flow of heat through the rock-salt of that district. The gradient of 1° in 51·5 feet reduces to 0·0003537 of a degree Centigrade per centimetre. The conductivity of rock-salt, according to the Report, is $\cdot 0113 \times 1\cdot 4 = \cdot 01582$ and $0\cdot 0003537 \times \cdot 01582 = 55955 \times 10^{-10}$, which is the flow of heat in gramme degrees per second across one square centimetre, or $55955 \times 315 \times 10^{-4} = 176\cdot 2$ gramme degrees per year per square centimetre. In other words, if the influence of conductivity be fairly considered, it leads to the conclusion that the rate of escape of heat at Sperenberg is more than thrice as great as that of the mean (51·4). The data at our disposal in the case of coal-mines do not appear to be sufficient for the purposes of discussion; all that can be said is, that while the sinkings were made in similar rocks the temperature gradients obtained differ widely among themselves. Without detailed information of the thickness and nature of the various beds passed through in the several cases from which the average is reduced, calculation is impossible.

A matter of extreme importance has, however, to be mentioned in this connection. In the Report for this year we read (p. 6, separate copy): "In some condensed reports of Bergrath Köbrich's communication (but not in the full paper as given in 'Glückauf'), the irregularities are attributed to chemical action in the coal seams, causing in some cases a heating and in others a cooling; but in the absence of more direct evidence this explanation seems rather forced." Putting aside the possibility of cooling, the effect of chemical action in evolving heat from coal-seams is well known, and an important paper on the subject was read in 1899 by Dr. Haldane and Mr. Meachem before the Society of Mining Engineers. It was clearly shown by these investigators that the heat resulting from the oxidation of marcasite in coal-seams is three times as much as is required to account for the total rise in temperature which the air of the ventilating current undergoes in passing through the mines. Dr. Haldane, who has given great attention to this subject, informs me that he considers the effect of this chemical action has been too little considered, and that he has no doubt it has led to an exaggerated estimate of the mean thermometric gradient in coal borings. While recognizing the great value of the Reports issued by the Committee of which Professor Everett is Secretary, to whom all geologists must feel grateful for the investigation of a question which is of the first importance to their inquiries, I still consider that, owing to various disturbing factors, the average rate of temperature increase with descent into the crust may have been overestimated, and that divergence from the mean may in some cases be connected with an irregular distribution of molten matter below the ground.

IV.—Circulation of Salt and Geological Time.

By Professor J. Joly, M.A., D.Sc., F.R.S.

In the Geological Magazine for August I gave the major limit to the period of time we can assign to the geological age of the Earth by the solvent-denudation method, when it is assumed that *all* the chlorine of rivers is derived directly from the ocean, and that all such chlorine (falling, as assumed, in rain) carries its full complement of sodium from the ocean. The major limit with these assumptions is 141 million years. A second estimate is given on the more moderate assumption that one-third the amount of chlorine in rivers is derived from the sea and brings with it its full equivalent of sodium; this affords 105 millions of years as the age. Finally, there is the original estimate based on a 10 per cent. deduction from the chlorine of rivers as rain-borne, affording 96 millions of years.

Among such numbers we may take our choice. Outside the upper limit we cannot go if we rely on the mean river analyses of Sir John Murray, and of course accept the principle of uniformity involved. It is a perfectly simple matter, which may be stated as follows:—There is a large excess of sodium over chlorine appearing in the mean analysis of 19 chief rivers of the world. The numbers are 157×10^6 tons of sodium and 84×10^6 tons of chlorine carried to the ocean per annum; or, dividing by the atomic weights, the relative numbers of ions are as 68 sodium to 24 chlorine. The consequence is that even if the whole of the chlorine be supposed derived from the sea and none at all from denudation, and to reach the rivers fully satisfied with marine sodium, there remains over such an excess of sodium that the age *cannot exceed* 141×10^6 years.

Now this was fully pointed out in my previous paper; it should be perfectly well known to Mr. Ackroyd; but we find still that Mr. Ackroyd maintains that "the chemist's convention of taking chlorine as a measure of sodium in rain- and river-water is serviceable, and cannot involve more final error in connection with this problem than that indicated by the ratio of these elements in sea-water."

As regards the first part of this statement, we have seen that "the chemist's convention" would give hopelessly erroneous results if applied to river analysis. As to the ratio of the chlorine and sodium in sea-water, this has nothing to do with the matter beyond indicating that as there is a large excess of chlorine over sodium in the sea we may expect a similar excess to obtain in rain-water. We may also observe that if "the chemist's convention" were applied to sea-water an entirely erroneous result would be obtained on the other side; the sodium would be greatly overestimated.

On the strength of this convention, however, Mr. Ackroyd again quotes his analyses of the Aire (a small coastal stream), and, preferring it to the mean analysis of the large rivers, again arrives at some thousands of millions of years. That, following similar reasoning, a stream could be found giving an infinite age to the earth, goes without saying. Why will Mr. Ackroyd not have the 19 rivers? The only objection I have heard urged against them (and it is one of considerable weight) is that they are not numerous enough. This is Professor Sollas' criticism.

Coming now to the question of the origin of the salts of inland seas, a question which Mr. Ackroyd has raised in connection with the allowance proper for rain-borne sodium, I see in his last paper in this Magazine that Mr. Ackroyd would explain the wide differences in chemical composition of these waters by the effects arising from concentration. The enormous amounts of precipitated salts required by this hypothesis must, however, here be considered. Let it be assumed, as he desires, that sea-water reaching closed lakes in rain-water has concentrated until the balance between 20 per cent. of $Mg\,Cl_2$ and 5 per cent. of $Na\,Cl$ is attained. In sea-water there is but 0·38 per cent. of $Mg\,Cl_2$. There is, on the other hand, 2·73 per cent. of $Na\,Cl$. To reach the required percentage of $Mg\,Cl_2$ a concentration of 53 times the original is necessary. This involves a concentration of the $Na\,Cl$ amounting to 145 per cent. Deducting the 5 per cent. that remains in solution, but remembering that $Na\,Cl$ will by no means be the only salt precipitated, also allowing the small imported amount of $Mg\,S\,O_4$ as a set-off against dolomitizing actions, we finally arrive at the conclusion that the precipitated salts amount to well over $1\frac{1}{2}$ times the entire mass of the existing inland sea. This is the *least* quantity we must look for in such a case, for it is the amount thrown down if the concentration had only just attained the existing state.

I do not contend that the existence of such masses is out of comparison with known salt deposits; but their absence in the particular localities would constitute a fatal objection to supposing such extreme concentration. When it is remembered that the Dead Sea sinks to depths of 400 metres we may realize that very great deposits must be supposed existing immediately around and beneath its waters if Mr. Ackroyd's views are to be entertained. The fact quoted by Mr. Ackroyd that "common salt in the southern parts of the lake forms quite a paste" will evidently not suffice.

It is needless to quote here the views of geologists on this question. The observations of Lartet (Bull. S.G.F., [2] xxiii, p. 719) quoted by De Lapparent show that "tous les sels contenus dans l'eau de la mer Morte et celle du Jourdain sont également (à l'exception peut-être du brome) renfermés dans les eaux des sources chaudes du même bassin, notamment celles de Zara, de Callirhoë, et d'Emmaüs" (vol. i, p. 488). The absence of iodine, so characteristic of sea-water, the presence of bituminous and sulphurous odours, the very local variations in composition, further lead M. de Lapparent to the view that the intervention of sea-water cannot be looked for in accounting for its composition; but that it represents a fresh-water lake modified by volcanic agencies of comparatively recent date.

Having no leisure to discuss the matter further, I would close my remarks by stating once more that the carriage of sea-salts into many inland lakes is very certainly a fact. The difference between Mr. Ackroyd's and my own views on the matter is one of degree only. If my own original estimate, that 10 per cent. of river chlorine is from the ocean, were correct, this would involve considerable importations of sea-salts in process of time into inland waters.

V.—The Sequence of the Tertiary Igneous Rocks of Skye.

By Alfred Harker, M.A., F.G.S.

(Published by permission of the Director of the Geological Survey.)

THIS communication is the outcome of work carried out during the years 1895–1901 in the service of the Geological Survey of Scotland. Although this systematic work has been confined to the Isle of Skye, information incidentally acquired, and the published literature of the British Tertiary rocks, indicate for the conclusions arrived at a much wider application. In this place the results must be set down without the detailed observations upon which they are based.

Here, as in numerous other areas and at various geological periods, igneous activity has manifested itself successively under three different phases, the *Volcanic*, the *Plutonic*, and the *Phase of Minor Intrusions* (often called the Dyke Phase). There is further an important distinction to be observed, neglecting which the whole sequence is thrown into confusion. The various events recorded in the succession fall into two distinct categories of very different orders, which may be termed the *Regional Series* and the *Local Series*. Those of the former class affected a very wide area—perhaps in some cases the whole Brito-Icelandic Province, extending from the

British Isles to beyond the Arctic Circle. The episodes of the Local Series, on the other hand, were closely related to certain special foci of activity, declared at a very early epoch, one of which was situated beneath what is now the mountain district of Central Skye. While events of the two classes often alternated in our area, and are integral parts of one complete record, they may be regarded as in some degree independent and as bound up with two distinct orders of crust-movements, viz. the continent-building and the mountain-building respectively. Of the two parallel series of eruptions, the Regional retained throughout a basic character, while the Local developed wide petrographical differences among the several groups. It follows that the successive episodes of the Regional Series are much more difficult to separate and arrange in order than those of the Local Series, and the following condensed scheme is confessedly imperfect, especially as regards the basic lavas and the basic dykes.

(0) Pre-Volcanic Phase: *Local Series.*—Here may be noticed certain plutonic intrusions nowhere exposed at the surface and known only from fragments in the volcanic agglomerates. They are confined to the central mountain district, and include, in order, (*a*) gabbro and (*b*) granite.

(1) Volcanic Phase.—Regional activity almost continuous; local chiefly confined to two well-marked episodes.

Regional Series.—Fissure-eruptions of basic (with some sub-basic) lavas throughout the region. Besides the prevalent olivine-basalts, there are some hypersthene-basalts, augite-andesites, etc., but no ordered sequence has been made out.

Local Series.—Central, not fissure-eruptions.

(*a*) Paroxysmal outbursts at certain centres, marked by great accumulations of volcanic agglomerate; the large vents confined to the mountain district. The chief masses of agglomerate underlie all the lavas, and thus represent the earliest overt manifestation of igneous activity.

(*b*) Eruptions, only in part paroxysmal, of intermediate and acid rocks in one limited area on the northern border of the Cuillins. Generalized sequence: (i) trachytes, (ii) rhyolitic tuffs and breccias, (iii) rhyolites. This group is intercalated as a local episode in the midst of the basic lavas.

(2) Plutonic Phase.—Regional activity in abeyance; local at maximum of intensity and at the same time narrowly localized.

Local Series. — Plutonic intrusions in the forms of complex laccolitic masses and bosses. Three groups, in order of increasing acidity, with little or no intervals.

(*a*) Peridotites of the south-west Cuillins; viz., olivine-anorthite rocks, picrites, and typical peridotites, including dunite.

(*b*) Gabbros of the Cuillins, etc.

(*c*) Granites and granophyres (plutonic) of the Red Hills.

(2 to 3) Transitional Phase, *Local Series* only.—The phase of Minor Intrusions shows, as compared with the Plutonic, a reversal of order among the groups of local intrusions. There seems to have

been a certain *critical epoch*, at which in some places basic and acid rocks were intruded almost simultaneously, the basic, however, being slightly the earlier. Remarkable reactions resulted between the two rocks so intimately associated. Here belong :—

Composite sills and dykes, composed of basic and acid rocks, usually with triple symmetry ; occurring along a belt outside the border of the Red Hills.

(3) Phase of Minor Intrusions in the form of sills, sheets, and dykes. Resumption of regional activity in a new form (intrusive instead of extrusive); local activity at certain epochs. Waning intensity indicated during this phase by generally diminishing volume of intrusions, both individually and as groups, and, at least in the Local Series, by intervals of quiescence.

Regional Series.—Rocks still exclusively basic and (exceptionally) sub-basic, so that no law of chemical variation in time can be laid down.

(*a*) Great group of basic sills. These are by far the most important intrusive rocks in the whole suite, making up more than half of the total thickness of the basaltic group over most of the area, besides appearing in considerable force in the underlying Jurassic. Their intrusion constituted the first episode of the Phase of Minor Intrusions. They are here included in the Regional Series as having clearly no relation to the special focus of Central Skye. They are most developed in the north and west of the island, and die out towards the mountains.

(*b*) Basic dykes, mostly with directions near N.W.–S.E., intruded in vast numbers throughout the region at various epochs, the division into successive groups being possible only in a very partial degree. These basic dykes are to be regarded as self-constituted intrusions; others of earlier dates being merely the feeders of lava-flows and sills.

Local Series.—Three chief groups, having restricted areas of distribution, each standing in relation with the corresponding plutonic centre. Order of increasing basicity.

(*a*) Minor acid intrusions (dykes, irregular sills, etc.). Area of distribution a roughly elliptic tract, centring in the granite of the Red Hills but extending beyond, with long axis in the general direction of the dykes (N.N.W.–S.S.E.).

(*b*) Minor basic intrusions. Area of distribution nearly coincident with the gabbro of the Cuillins. The most remarkable set of intrusions takes the form of numerous parallel sheets inclined inwards, towards the centre of the area. In addition there is a radiate set of dykes, partly feeders of the sheets, partly older; also, much less perfectly developed, a tangential set of dykes.

(*c*) Minor ultrabasic intrusions, in the form of a radiate set of dykes ; distributed with reference to the Cuillins, or rather to the south-western half of the Cuillin area, where the plutonic peridotites occur.

Subsidiary Groups.—There remain certain groups of dykes, of small importance as regards number and magnitude, concerning which more data are needed. They belong in all cases to very late episodes, but their precise places in the sequence have not been satisfactorily fixed.

(*a*) Trachyte and trachy-andesite dykes. Most of these, occurring about Broadford and in the Sleat district, seem to belong to a group which has its chief area of distribution farther south-east, on the Scottish mainland, and these rocks therefore cannot be attached to the local series of the Skye focus.

(*b*) Augite-andesite dykes, usually with glassy base, and others of acid pitchstone. Dykes and sills of these two rocks are more numerous in the Isle of Arran, where, as Professor Judd has shown, the two types are closely associated, sometimes in composite intrusions. In Skye the known occurrences of acid pitchstone all lie on a narrow belt passing through the granitic tract and having a direction corresponding with that of the dykes themselves. They thus seem to connect themselves with the Local Series as a final and feeble recrudescence of activity about the acid Red Hills centre.

The reversion in the closing stages to intermediate and finally to acid types seems to suggest a new reversal of the order of eruptions, and the composite intrusions (augite-andesite and acid pitchstone) of Arran may perhaps be taken as pointing to a second critical epoch during transitional conditions. These sporadic manifestations of an igneous activity nearing its point of extinction do not, however, afford any very firm ground for such deductions.

VI.—Geological Notes on the Neighbourhood of Ladysmith, Natal. No. 1: On some Igneous Rocks.

By Dr. H. Exton, F.G.S.

(Communicated by Professor T. Rupert Jones, F.R.S., F.G.S.)

WRITING from the Station Hospital at Ladysmith, Dr. Henry Exton, F.G.S., has communicated his observations on the geology of the country near Ladysmith, in the northern part of Natal, in letters to Professor T. Rupert Jones. A very noticeable geological feature is the prevalence of an igneous rock (intrusive andesitic diabase) on all the hills from Umbulwana, four miles east by south from Ladysmith, to the famed Spion Kop, sixteen miles west from here.

This rock covers all the hills, in rounded, smooth, and almost polished boulder-like blocks, of a rusty brown hue on the surface, with a clean blue crystalline fracture, and giving out a ringing sound when struck. It is called by the Dutch *yzad-klip* (ironstone). The hill-sides around about here can be ascended on foot only where a military road has been cleared to the summit. The slopes of the hills are so profusely strewn with the rounded ironstone blocks that riding along them is impossible, and even walking is a tedious task. The surface of the boulders is generally so rounded and smooth that one has to tread between them, not upon them, as the foot is apt to slide off. Of course, on the summits, where these rocks are in mass, the rounding of the edges is not so apparent, but they are alike weathered to a rich brown colour, very different from the blue crystalline surface of a recent fracture.

In Pearson's "Story of Ladysmith," p. 108, it is stated that in ascending Gun Hill, to capture the Boer guns, the soldiers found that the boulders, rounded and worn by the storms of ages, were slippery to tread on, and occasionally the foot would become wedged between them.

The photograph marked, No. 3, gives a general view of a ridge, on the upper level, near the hospital, from which loose blocks have fallen to the slopes below. The upper portion of the ridge consists of a fine-grained sandstone (? Upper Karoo beds).

On the hill-tops of the district the igneous masses show some flat surfaces, and a further effect of weathering is seen in numerous shallow depressions more or less circular, with a diameter of an inch and a half to two inches.

About half a mile in a north-westerly direction from this hospital some military trenches have been cut across the summit of a low hill. The stones there exposed are similar to the surface-rock of the country (dolerite or diabase) elsewhere; but they vary in size from a mere flake to a ton in weight, and are cemented together by a yellow ferruginous sandy matrix, and each separate stone is encrusted by a coating of the same firmly adherent. The pieces have mostly fairly angular edges without any rounded or water-worn aspect.

It is very probable that this red matrix in which the diabase is imbedded is the result of decomposition. If so, these stones of hard crystalline rock, thinning out to thin sheets (such as the specimens sent), appear to have been either intrusive or overflowing lavas.

Mr. Fred. Chapman, A.L.S., who has kindly examined the specimens sent home, states that the so-called diabase is an altered augite-andesite (porphyrite). The specks of magnetite scattered throughout have decomposed and given rise to the vivid orange-red or brick-red exterior. The weathering action has, no doubt, been accentuated by extremes of temperature.

VII.—On the Origin of the Gravel-Flats of Surrey and Berkshire.[1]

By Horace Woollaston Monckton, F.L.S., V.P.G.S.

In the south-east of England considerable tracts are covered by sheets or patches of gravel. It is mainly composed of flints from the Chalk, has a thickness of, say, from 6 to 20 feet, is generally stratified, and rests upon an uneven surface of the older strata. The top is nearly always flat and inclined at a low angle.

These sheets of gravel lie at various levels: thus, at Cæsar's Camp, Aldershot, there is a large gravel-covered flat the highest part of which is 600 feet above the sea. A little to the north-east there is another flat, named the Fox Hills, at a level of 360–390 feet, and a few miles to the north there are Hartford Bridge Flats, which lie 330 feet above the sea. (These are in Sheets 284 and 285 of the new series one-inch ordnance map.)

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

On the side of the Fox Hills (Sheet 285) there is a sheet of gravel south of Mitchet House, with a level of about 250 feet; and at Eversley, Shinfield, and Hurst, in Sheet 268, there are flat expanses of gravel almost flush with the alluvium of the rivers Blackwater and Loddon, and at levels of 180 to 120 feet.

There are many other sheets of gravel in this neighbourhood, but I have mentioned sufficient to show that there are here a series at very various levels, from the high ground of Cæsar's Camp, Aldershot, down to the level of the alluvium of the rivers which drain the area.

If we continue our course down the Thames we find similar gravel-flats practically down to the present level of the sea.

I have said that these gravels consist mainly of chalk-flints, but they also contain other stones, and a careful examination of these convinced me that the gravels are of fluviatile origin, the nature of their composition depending upon the geological structure of the drainage area of different rivers.[1]

If, then, these sheets of gravel are, as I believe, river gravels, they must all have been originally deposited at the bottom of a valley, and where, as in several of the cases above mentioned, they are now on plateaux or terraces, this position must be due to denudation, which has destroyed the sides of the valleys since their deposition. It is pretty clear that this is the case, for every stage may be found between the gravel terrace in a valley and the gravel-capped plateau with valleys all round it.

There is a good example at Maidenhead, where there are three well-marked terraces of gravel, as shown in a sketch-map by Mr. Whitaker.[2] They are lying on the side of the Thames Valley, but if we follow the highest terrace southwards we find that between Bray Wick and Maidenhead the progress of denudation has been sufficient to make the terrace into a plateau with valleys all round it.

Now it has for some time seemed to me that these gravel-flats may have something in common with the terraces which we see in so many places on the coast and in the fjords of Norway. In the first place there are several points of resemblance—

1. They are formed of gravel and sand.
2. They have a flat and somewhat sloping top.
3. Several flats occur one above the other.
4. Between the flats there is a steep slope.
5. They appear to be mainly the work of rivers.

Now the explanation of the Norwegian terraces which, I believe, finds favour in Norway is as follows:—

The rivers carry with them sand, clay, and small stones, much of which is deposited in the valleys. The remainder sinks to the bottom before the mouths of the rivers in the sea or fjords, and is spread out as a slightly inclined plain where circumstances are

[1] Quart. Journ. Geol. Soc., 1892, vol. xlviii, p. 29; 1898, vol. liv, p. 184.
[2] "Geology of London": Mem. Geol. Surv., 1889, vol. i, p. 391.

favourable. There is often, therefore, at the head of the fjords a shallow which is called *ör*. It ends abruptly a little distance out with a steep slope, where the water all at once becomes some fathoms deep.

Suppose, now, that the land is raised up; we shall have a long, slightly sloping plain of sand and clay, with an abrupt steep slope where the deep water was. The river will at first throw itself over the steep slope as a waterfall, but by degrees it will cut down into the plain and begin to form a new shallow out of the materials. The terraces are just such plains, with so gradual a slope up above the floor of the valleys that they appear horizontal, and ending outside with a steep precipice. At the mouths of most of the valleys, one sees many such terraces rising staircase-like one above the other. These terraces seem to show that the land has rapidly risen many feet at a time, a rise for each terrace, and between them have been long periods of repose, during which the *ör* were formed.

The above is roughly translated from a small Norwegian school geology by Corneluissen, and seems to me to afford a good explanation of the step-terraces of Norway; but does it not also explain the gravel-flats of England? It seems to me that short, rather rapid elevations, separated by long periods of repose, would produce precisely the result which we see in Surrey, Berkshire, and other parts of the country.

The flats are due partly to excavation and partly to deposition. Assume that an elevation of the Thames Valley to an amount of 20 feet took place now. The river would at once begin to cut down its channel to the new level, and in our soft strata its progress back from the sea would be very rapid. We should have a new plain excavated, and the gravel now at the level of the river alluvium would stand up as a terrace; part of it would, moreover, be destroyed, and the materials spread out as a gravel sheet at the lower level. In England, where the rock is soft and easily eroded, the gravel-flats are wide-spread, but in many of the Norwegian valleys the rock is very hard, and the terraces are consequently of very limited extent.

The gravel-flats are best seen on the south of the Thames. North of that river similar flats occur, but there drift questions are much complicated by the presence of glacial beds; indeed, the elevation of the south of England and the deposition of most of the gravels appears to have taken place whilst the north of the country was under glacial conditions, and after they ceased the country seems to have undergone but little further elevation. In Norway, on the other hand, movements of elevation seem to have taken place from time to time up to a much more recent date, and so we find the step-terraces, which are post-Glacial and were formed after southern England had entered upon a period of repose.

The gravel beds upon these flats differ materially from most or all of the older geological deposits of this country. The fact that the stones are to a large extent subangular, and but little water-worn, distinguishes them from the Eocene pebble beds; nor do they resemble the old breccias with which I am acquainted; but if the suggested explanation be correct the gravels were formed during a period of elevation of the land, whereas most or all of our older deposits were formed during periods of slow subsidence. But, though the explanation now suggested accounts for much of the problem presented to us by the gravels near the Thames, it must be admitted that there are certain facts which it does not explain. Thus, the *Corbicula fluminalis* bed at Crayford and Grays bears so strong a resemblance to deposits which have been clearly formed during a long, slow depression of the surface, that I can only think that at some time this particular part of the Thames Valley sank whilst the remainder was either rising or, more probably, was lying stationary during a period of repose.

The deep channel of drift in the valley of the Cam described by Mr. Whitaker[1] also seems to me to point to an area of local depression.

The conclusions to which I have come are, therefore, four in number:—

1. That the gravels of which I have spoken are river gravels, formed since the country last rose above the sea.

2. That the process of elevation was not continuous, but that short periods of rapid movement were separated by long periods of repose.

3. That the gravel-flats are the work of rivers during the periods of repose.

4. That the earth-movements did not affect the whole area uniformly, and that local depression occurred.

VIII.—Evidences of Ancient Glacier-dammed Lakes in the Cheviots.[2]

By Percy F. Kendall, F.G.S., and Herbert B. Muff, B.A., F.G.S.

It is uncertain whether Cheviot itself was overridden by extraneous ice, but striæ on Thirl Moor and Baker Crag, recorded by the Geological Survey, probably indicate that that portion of the watershed was overridden by ice from the Tweed Valley, and Professor James Geikie mentions the occurrence of till and striated stones on the tops of the Cheviot Hills at 1,500 feet. The transport of erratics shows movement along both sides of the axis of the range from S.W. to N.E. at some stage of the glaciation. Across the northern end and for at least ten miles down the eastern side, however, a distribution of erratics from the Tweed Valley, together with other indications to be mentioned, points to an ice-flow veering round through easterly to a north to south direction. Our observations go to confirm the above conclusions with respect to the area north and east of Cheviot.

During a few days spent in the district, we observed certain features which throw much light on the later stages of the Ice Age

[1] Quart. Journ. Geol. Soc., 1890, vol. xlvi, p. 333.

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

in this area. Mr. Clough mentions[1] "dry, steep-sided little valleys crossing over watersheds, which do not appear to lie along lines of weakness or the outcrops of soft beds. It is suggested that they might have been formed by streams from glaciers."

Some of the valleys observed by us run along the sides of hills or occur as loops detaching portions of the walls of valleys, and the general characters of similar valleys have been described by us separately.[2] Their mode of occurrence, and the relations to the relief of the country as well as to the position occupied by the ancient ice-sheets, show that they can be ascribed only to the overflow of water from lakelets held up by an ice-barrier. In the country between Yeavering Bell and Ingram we found that each of the spurs separating the valleys which radiate from Cheviot was cut across by one or more sharp gorge-like channels, draining, with one significant exception, to the south. The spur between Roddam Dean and the Breamish River is cut, near Calder Farm, by a channel, bounded on the east by the moraine, draining to the south, but a higher portion of the same spur is traversed by a channel draining in the opposite direction, i.e. to the north.

The highest member of a series across any given spur is usually just above the boundary of the drift, containing extraneous boulders. At the outlets of the valleys there are in several cases deltas, represented by masses of gravel.

Conclusions.—The existence of the series of overflow channels points clearly to the former presence of a chain of small lakes held in the radial system of valleys of the Cheviots by a barrier of ice. The ice-stream, by the boulders which it bore, may be inferred to have swept round the end of the Cheviots out of the Tweed Valley. The margin of the sheet at its maximum extension rose to about 1,000 feet along the arc from Yeavering Bell to Brands Hill, beyond which it may have declined. Along the south-eastern slopes of the Cheviots, another extraneous glacier swept in a north-east direction. Where their confluence took place, or whether they were not in succession rather than simultaneous, is not easy to decide, but the Roddam Burn channel points very clearly to the preponderating influence of the southern stream, while the Calder Farm overflow lower down the same ridge shows by its southerly slope that the northern ice later acquired the mastery. If the two glaciers were confluent, then the overflowing waters of the lakes must have been discharged either beneath the ice, as at present happens to the overflow from a chain of ice-dammed lakes on the Malaspina glacier, or over the top of the ice.

An important and unexpected result of our brief examination has been the discovery that while 'foreign' ice was rising along the flanks of the Cheviots to an altitude of 1,000 feet, not only were the spurs free from any native ice-sheet, such as Cheviot or

[1] "The Geology of the Cheviot Hills": Geol. Surv. Mem.

[2] P. F. Kendall, "On Extra-morainic Drainage in East Yorkshire": Brit. Assoc. Rep., 1899. A. Jowett & H. B. Muff, "Preliminary Notes of the Glaciation of the Bradford and Keighley District": ibid., 1900.

Hedgehope might have been expected to support, but even the lower ends of the intervening valleys were occupied, not by great native glaciers, but by lakes.

The conditions thus described may have some relation to the fact that, while the porphyrites of the Cheviots have furnished the most abundant types of erratics in the Drift of the Yorkshire Coast, the granite, if present, which is not quite certain, is very rare.

IX.—Note on the Volcanic Agglomerate of Forkill, Co. Armagh.

By Joseph Nolan, M.R.I.A., late Senior Geologist (retired), Geological Survey of Ireland.

In a paper by Messrs. J. R. Kilroe and A. M'Henry, M.R.I.A., which appeared in vol. lvii of the Q.J.G.S., published last August, the following statement concerning the above rock is made: "In parts they [the rock masses] consist of brecciated slate or brecciated granite and felsite, the fragments being embedded in a scanty andesitic matrix." Now this description is quite erroneous, the great and almost unique characteristic of the Forkill agglomerate being that the greater portion is made up of non-volcanic materials—in some places of granite pieces for the most part, in a groundmass of finely comminuted material of the same rock, and in others of Silurian slate fragments in a correspondingly derivative base. This I have described long ago in the official memoir to accompany Sheet 70 of the Geological Survey Map of Ireland, as also in the following papers: "On a Remarkable Volcanic Agglomerate near Dundalk" (J.R.G.S., Ireland, new series, vol. iv, pt. 4) and "On the Ancient Volcanic District of Slieve Gallion" (Geol. Mag., Dec. II, Vol. V, October, 1878).

Recently Sir Archibald Geikie, D.C.L., has examined this district, and the results of his investigations are published in his book on the "Ancient Volcanoes of Great Britain," vol. ii, p. 423: "The Slieve Gallion District," where he particularly comments on the remarkable absence of volcanic fragments in the upper and greater part of the mass, which, as already stated in my own essays, graduates downwards into a rock with felsitic matrix and ultimately into the underlying igneous rock.[1]

[1] "The most remarkable features of this agglomerate, which has been well described by Mr. Nolan, are the notable absence of truly volcanic stones in it, and the derivation of its materials from the rocks around it. I found only one piece of amygdaloid, but not a single lump of slag, no bombs, no broken fragments of lava crusts, and no fine volcanic dust or enclosed lapilli. The rock may be said to consist entirely of fragments of Silurian grits and shales where it lies among these strata, and of granite where it comes through that rock. Blocks of these materials, of all sizes up to two feet in breadth, are confusedly piled together in a matrix made of comminuted débris of the same ingredients. . . . . The essentially non-volcanic material of the agglomerate shows, as Mr. Nolan pointed out, that it was produced by æriform explosions, which blew out the Silurian strata and granite in fragments and dust. These discharges probably took place either from a series of vents placed along a line of fissure running in a north-westerly line, or directly from the open

From the inseparable association with the igneous core there can be no doubt that this peculiar agglomerate or breccia is due to æriform explosions by which the pre-existing crust was broken up while the volcanic energy ceased without any appearance of the uprising lava.

NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science. Seventy-first Annual Meeting, held at Glasgow, Sept. 11–18, 1901.

List of Papers read in Section C (Geology).

John Horne, F.R.S., President.

President's Address. (See p. 452.)

W. Gunn.—Recent Discoveries in Arran Geology.

G. Barrow.—On Variations in a certain Zone of the Eastern Highland Schists.

P. Macnair.—On the Crystalline Schists of the Southern Highlands, their Physical Structure, and its probable manner of Development.

Professor J. Geikie, F.R.S., and Dr. J. S. Flett.—The Granite of Tulloch Burn, Ayrshire.

Dr. J. S. Flett.—On Crystals Dredged from the Clyde near Helensburgh, with analyses by Dr. W. Pollard.

H. B. Woodward, F.R.S.—Note on a Phosphatic Layer at the Base of the Inferior Oolite in Skye. (See p. 519.)

——— Further Note on the Westleton Beds.

Professor W. W. Watts.—Report of the Committee for the Collection and Preservation of Geological Photographs.

Sir A. Gekie, D.C.L., F.R.S.—Time-intervals in the Volcanic History of the Inner Hebrides.

A. Harker.—The Sequence of the Tertiary Igneous Rocks in Skye. (See p. 506.)

A. M'Henry and J. R. Kilroe.—On the Relation of the Old Red Sandstone of N.W. Ireland to the adjacent Metamorphic Rocks, and on its similarity to the Torridon Rocks of Sutherland.

J. R. Kilroe and A. M'Henry.—On the Relation of the Silurian and Ordovician Rocks of the North-West of Ireland to the great Metamorphic Series.

G. H. Kinahan.—Notes on the Irish Primary Rocks with their associated Granitic and Metamorphic Rocks.

——— Some Laccolites in the Irish Hills.

Dr. R. H. Traquair, F.R.S.—The Geological Distribution of Fishes in the Carboniferous Rocks of Scotland.

——— On the Geological Distribution of Fishes in the Old Red Sandstone of Scotland.

fissure itself. Possibly both of these channels of escape were in use, detached vents appearing at the east end, and a more continuous discharge from the fissure further west. After the earliest explosions had thrown out a large amount of granitic and Silurian detritus, andesitic lava rose in the fissure, and, solidifying there, enclosed a great deal of the loose fragmentary material that fell back into the chasm." ("Ancient Volcanoes of Great Britain," vol. ii, p. 423.)

Miss C. A. Raisin, D.Sc.—Perim Island, and its Relation to the Area of the Red Sea.

R. L. Jack, LL.D.—The Artesian Water Supply in Queensland.

B. N. Peach, F.R.S.—The Cambrian Fossils of the N.W. Highlands.

Professor W. J. Sollas, F.R.S.—On a New Method in the Investigation of Fossil Remains. With illustrations, *Monograptus, Ophiura, Palæospondylus.*

R. Kidston, F.R.S.E.—Notes on some Fossil Plants from Berwickshire.

Dr. Wheelton Hind.—Report of the Committee for studying Life-zones in the British Carboniferous Rocks.

J. R. Kilroe.—Geology regarded in its Economic Applications to Agriculture by means of Soil Maps.

A. M. Bell.—Plants and Coleoptera of Pleistocene Age from Wolvercote, Oxfordshire.

Vaughan Cornish, D.Sc.—Report of the Committee on Terrestrial Surface Waves and Wave-like Surfaces.

Dr. R. F. Scharff.—Report of the Committee to Explore Irish Caves.

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II.—NOTE ON A PHOSPHATIC LAYER AT THE BASE OF THE INFERIOR OOLITE IN SKYE. By HORACE B. WOODWARD, F.R.S., of the Geological Survey.[1]

AT the southern end of the great cliffs of Ben Tianavaig, south of Portree, in Skye, the basement beds of the Inferior Oolite, which contain large dogger-like masses of calcareous sandstone, rest in a hollow of the Upper Lias Shales, owing to local and to a certain extent contemporaneous erosion. Lining this hollow there is an irregular and nodular band, two or three inches thick, of dark brown oolitic and phosphatic rock; a fact of interest, as instances of local erosion are often attended by the accumulation of phosphatic matter in beds, nodules, and derived fossils.

Mr. George Barrow, who made a rough analysis of the rock, estimated the amount of phosphate of lime at about 50 per cent.; and Mr. Teall, who examined a section under the microscope, noted,

[1] Read before the British Association, Section C (Geology), Glasgow, Sept., 1901, and communicated by permission of the Director of the Geological Survey.

in addition to the oolite grains, fragments of molluscan shells and echinoderms, and foraminifera, in a finely granular matrix formed of calcite. He observed that the central portions of some of the oolite grains were formed of a nearly isotropic brown substance in which the typical concentric structure of the oolite grains was well preserved. This substance was no doubt phosphatic.

III.—NOTE ON THE DISCOVERY OF A SILICIFIED PLANT SEAM BENEATH THE MILLSTONE GRIT OF SWARTH FELL, WEST RIDING OF YORKSHIRE. By JOHN RHODES, of the Geological Survey.[1]

BY kind permission of the British Association Committee on Carboniferous Zones I am enabled to record the discovery of a silicified plant seam beneath the Millstone Grit at Swarth Fell, and two miles north-west of Hawes Junction.

The exact geological position of the overlying strata is doubtful, but apparently they occupy the horizon of the grindstone or ganister of the district.

At this particular place, however, the grindstone or ganister is absent, and its place is taken by flaggy silicious limestones with marine shells and by a bed of highly silicious grit with plant remains, the latter resting more or less directly on the silicified plant seam.

Chert occurs, probably as lenticles in the uneven surface of the seam, and contains a mass of detached silicious sponge spicules, apparently rod-like bodies, which may belong to the anchoring ropes of hexactinellid sponges. In the same chert are included fragments of silicified plant remains beautifully preserved.

In the plant seam included pebbles of silicious grit occur, which contain a few spicules similar to those in the chert, and also plant remains. The plant seam rests on a layer of silicified shale containing a few fragmentary sponge spicules, mostly rod-like forms, one piece belonging to an hexactinellid sponge. The beds below are more or less rotted clay shales with ironstone nodules.

I am indebted to Dr. G. J. Hinde for notes on the sponge remains directly associated with the plant seam. The plants have not been determined, but have been placed in the hands of R. Kidston, Esq., F.R.S.E., F.G.S., Stirling.

IV.—THE COPPER-BEARING ROCKS OF SOUTH AUSTRALIA. By F. P. MENNELL.[1]

THE author drew attention to the fact that the copper ores of Yorke's Peninsula in South Australia were the first metallic minerals worked on the Australian continent. They occurred in rocks of Archæan age, which at Moonta and Wallaroo had been subjected to crushing and shearing to such an extent that they presented but few traces of their original structures, except in the case of a diorite at Wallaroo, which was of a typically plutonic character. Most of the rocks were mylonites, and in some instances

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

they had been reduced to a compact flinty type in which none of the minerals could be recognized with certainty. Where the original constituents had survived they were of a fragmentary character. Oligoclase seemed to have best resisted the crushing, and orthoclase occasionally remained in lenticles, but the brittle quartz had been invariably reduced to powder. Mr. Mennell thought that the economic aspect of the examination was of considerable importance, for the mines had been shut down several times when the ore had thinned out owing to doubts as to its permanence. From the character of the rocks it was, however, obvious that they occurred in a true 'fissure lode,' and no doubts need be felt as to the continuance of the ore to the limit of workable depths.

V.—The Geologic Distribution of *Pollicipes* and *Scalpellum*.[1]

By F. A. Bather, D.Sc., F.G.S.

In a valuable memoir on the "Hudson River Beds near Albany, and their taxonomic equivalents," published as Bulletin of the New York State Museum, No. 42, April, 1901, Dr. Rudolph Ruedemann describes a number of variously shaped valves found in the Upper and Lower Utica Shale of Green Island and Mechanicsville, N.Y. (p. 578, pl. ii). These he believes to "find their homologues in parts of the capitula of the pedunculate cirriped genera *Scalpellum* and *Pollicipes*, notably of the latter. On this account the various valves have been united under the caption *Pollicipes siluricus*, in full consciousness of the enormous gap existing between the appearance of this Lower Siluric type and the next Upper Triassic (Rhætic) representatives of these genera." Confirmation of Dr. Ruedemann's ascription may be derived from the fact that "the enormous gap" does not exist. Early in 1892 Dr. C. W. S. Aurivillius[2] published the descriptions of *Pollicipes signatus* from bed *e* (= Lower Ludlow), *P. validus* from bed *c* (= Wenlock Shale), *Scalpellum sulcatum*, *S. varium*, *S. granulatum*, *S. strobiloides*, *S. procerum*, *S. cylindricum*, and *S. fragile*, all from bed *c*, of the island of Gotland. The species of *Scalpellum* are founded on peduncles, *Pollicipes validus* is represented by a broken scutum only, but *P. signatus* is based on an almost perfect specimen. The occurrence of more than one species of both these genera in the Silurian lends significance to the diversity of form presented by Dr. Ruedemann's specimens. The ornament on his fig. 18 most nearly resembles that of *P. signatus*, while the rostrum, fig. 22, is also not unlike that species. Figs. 16, 17, and 19 may belong to more than one other species, while 24 (with which presumably 25 is to be associated) may belong to a *Scalpellum*, as Dr. Ruedemann seems to hint. In the circumstances it is specially regrettable that Dr. Ruedemann has selected no one of these specimens as the holotype of *Pollicipes siluricus*. If he does not do so soon, confusion is pretty certain to arise.

[1] Reprinted from *Science*, July 19th, 1901, p. 112 (n.s., vol. xiv, No. 342).

[2] Bihang Sveska Vet.-Akad. Handl., xviii, Afd. iv, No. 3.

Figs. 13, 14, and 15 are referred to *Turrilepas* (?) *filosus*, n.sp. A recent examination of the plates of that genus suggests to me that the note of interrogation is fully justified.

Aurivillius considered that *Pollicipes signatus* showed a closer approach to the Balanidæ than any other of the Lepadidæ, but he too, in ignorance of the Devonian *Protobalanus*, Whitf., discoursed needlessly about the gap in the distribution. Now that the range of the Lepadidæ has been extended to the Ordovician, we may look confidently for further discoveries. We may also hope that the time has now come when even the textbooks may awake to the fact that the genera *Pollicipes* and *Scalpellum* existed in Palæozoic times.

My apology for insisting on this is not merely that both Dr. Aurivillius and Professor Lindström, who supplied him with the material, have unhappily passed away, but that I had the good fortune to be the discoverer of the beautiful specimen of *Pollicipes signatus*, when developing a specimen of *Gissocrinus verrucosus* from the *Pterygotus* bed of Wisby Waterfall, in May, 1891. The very fragile specimen was subsequently licked into shape (no metaphor is intended) by Mr. G. Liljevall, to whom the excellent drawing of it is due.

VI.—The Caucasian Museum, Tiflis, is publishing a complete Catalogue of its Collections, in both the Russian and German languages, the title in the latter tongue being: "Die Sammlungen des Kaukasischen Museums im Vereine mit Special Gelehrten bearbeitet und herausgegeben von Dr. Gustav Radde, Direktor, etc." The catalogue is in the form of quarto volumes, in boards, measuring 31 × 23 cm. Volume III, which has been sent to us for review, deals with the geological collections, and is by Professor N. I. Lebedev. It consists of xii + 322 pp. and 8 plates. The material is arranged under the heads of the several collections, which are classified quite roughly, apparently following the localities in the order in which they were visited. Among the collections that of Abich from Daghestan is one of the most famous; this is accompanied by a descriptive catalogue which is in greater detail than the present one and will be published *in extenso* in *Mittheilungen des Kaukasischen Museums*. There are also donations by successive chiefs of the Office of Mines; the collections of F. Bayern, chiefly of value for the exactness of the localities given, and worked over by Arzruni, Valentin, and Lebedev; other collections that have afforded material for the writings of these geologists, of Simonovitsch, and others. The preceding are all local, but there are also collections serviceable for comparison, especially those from the Crimea, Bessarabia, and Transcaspian, as well as a fine series from various horizons and localities in Western Europe, partly purchased and partly the gift of Mr. J. de Morgan. The present catalogue does not profess to be much more than a rough list, and, as is only natural in a work produced under such disadvantageous conditions as regards literature and the help of specialists, the determinations are clearly lacking in precision. The work will nevertheless be useful to two classes of students; those who are investigating the geology and physical history of the Caucasus, and specialists in petrology or palæontology who desire to see all the material available for their researches. In his readiness to enter into relations with specialists Dr. Radde pursues an enlightened and liberal policy, so that readers of the catalogue need not imagine that because the specimens are in Tiflis it is no use to trouble about them. The collotype plates illustrating this volume afford a sample of the treasures within; two are of rock-sections, one of undescribed species of Ammonites, and two of species of *Cardium, Congeria, Dreissenia, Rissoa, Neritina,* and *Natica*; one of the figures is labelled "*Cardium apscheronicum*, n.sp.," but we can find no description.

VII.—Geology of Devonshire.—The main part of No. 3 of the Proceedings of the Geologists' Association of London is devoted to an account of the excursion made by the members to the Start, Prawle, and Bolt districts during Easter this year. The report is written by W. A. E. Ussher, who gives in his introductory remarks, as well as in his report, a good deal of interesting matter which will be much appreciated by Devonians especially. In the report are incorporated many notes by A. R. Hunt. The result enabled those who enjoyed the excursion to realize the geological difficulties of the region, and served to whet their appetites for the long-expected memoir upon it.

VIII.—On a New Fossil Lizard from the Beds of the Lower Chalk Formation in the Island of Lesina [Coast of Dalmatia]; by A. Kornhuber.—"Ueber eine neue Fossile Eidechse aus den Schichten der unteren Kreideformation auf der Insel Lesina." (Verhandlungen der k.k. geol. Reichsanstalt, 1901.)—In this paper the author describes another of the remarkable reptilian skeletons from the thinly bedded Lower Cretaceous limestones of the island of Lesina. In this instance the skeleton is that of a lizard about 1·4 metres long, apparently in its general structure related to the Varanidæ, but in its dentition approaching the Mosasauridæ. The specimen is made the type of a new genus, *Opetiosaurus*, the specific name being *O. Bucchichi*.

IX.—Shorter Notices.—Georgia Bauxite.—The most important article in the *American Geologist* for July is T. L. Watson's account of the Bauxite deposits of the Coosa Valley region of Georgia and Alabama. Discovered in 1887, these fields now provide the entire home consumption of the United States. After a sketch of the geology of the area and the geological position of the mineral, the author deals with the associated minerals, chemical composition, origin, and age of the deposits. This latter is apparently the close of the Eocene period.

Beach Structure.—Another article in the same Journal of considerable interest is H. L. Fairchild's "Beach Structure in Medina Sandstone," which is illustrated by five plates of reproductions from photographs. The author describes the various appearances due to abrupt change of material, oblique bedding, ripples, wave-lines, ridges, and troughs, and has come to the conclusion that this 1,075 feet of arenaceous shale is a typical sandy beach deposit.

Chili and Argentina.—The long dispute over the boundary-line between these two countries is further illustrated by Charles Rabot in La Géographie, No. 4, 1901. As the frontier line involves the watershed, the arbitration at present proceeding is of vital importance to both countries. Rabot gives some excellent reproductions from photographic views of the glacial phenomena of the district, and a particularly clear map showing the differences between the claims of the two countries.

Professor C. E. Beecher gives an account in the Yale Scientific Monthly for June, 1901, of the mounting of the complete skeleton of the dinosaur *Claosaurus annectens.* This is the first complete skeleton of a dinosaur yet set up, and came from the Laramie beds. It belonged to the Marsh Collection, is 29 feet in length, and is placed in the Yale University Museum. A plate accompanies the notice.

"Maryland and its Natural Resources" is the title of a pamphlet which has been prepared by W. Bullock Clarke as the official publication of the Maryland Commissioners at the Pan-American Exposition.

Indian Tertiary Belemnites.—The announcement is made in the Report of the work carried on by the Geological Survey of India, 1900–1901, that Dr. F. Noetling has found great numbers of true Belemnites in Lower Eocene beds near Jhirrak, in Sind.

The Typhoon, Luzon.—The typhoon which swept Luzon on the 8th September, 1900, forms the subject of a memoir by Padre José Coronas, S.J., which was issued by the Observatorio di Manila, 1900. Beyond generalities, however, it has little geological interest.

Woodwardian Museum, Cambridge.—The additions made last year comprised, among other things, the collections of the late C. J. A. Meÿer, the greater part of a skeleton of *Lutra vulgaris* from the peat of Barwell, and part of the S. S. Buckman Collection of Inferior Oolite Ammonites. Mr. Reed has been at work on the British and Foreign Palæozoic fossils, Mr. Woods on the Cretaceous fossils, and Mr. Asher on the fossil plants. The identification of figured specimens continues to make satisfactory progress, and we hope a revised catalogue of types will soon be attempted.

Professor J. M. Clarke, State Palæontologist of New York, announces in the 54th Annual Report of the New York State Museum that a catalogue of the type fossils used throughout the history of the "Palæontology of New York" is in hand. Specimens of type fossils, as they are identified and can be replaced by duplicates, are removed to a fireproof building, in accordance with the vote of the Regents in 1882. It would be a good plan to have casts made of them, for inclusion in the general collection.

Messrs. C. Davies Sherborn and B. B. Woodward are issuing a series of papers on the dates of publication of various French Voyages which appeared between 1800 and 1900. The papers will be found in the Annals and Mag. Nat. Hist. for April, August, and October, and contain many notes on geological papers which have heretofore presented difficulties as to date.

New Foraminifera.—R. J. Schubert has a paper on some Foraminifera from the Upper Chalk of East Galicia, in the Jahrb. k.k. geol. Reichs., l (4), 1901. The chief novelty is a curious form to which he gives the name of *Karreria cretacea.* J. Grzybowski writes on the Foraminifera of the *Inoceramus* beds of Gorlice. His paper appears in the Bull. Internat. Ac. Sci. Cracovie for April, 1901. Two plates, chiefly devoted to arenaceous forms, are given.

From the Report of Progress of the Manchester Museum we gather that the Geological Department has been enriched by the Barnes Collection of Carboniferous invertebrates, and some selections from the Jukes-Browne Collection. Fossil plants have received a good deal of attention, the types and figured specimens of Oolitic species, which were examined by Mr. Seward, having been labelled and displayed. Mr. R. D. Darbishire has presented the Museum with a specimen of the recent *Pleurotomaria adansoniana* from Barbados, an important and valuable acquisition to any collection.

New Jersey Geology.—The annual report of the State Geologist of the Geological Survey of New Jersey for 1900 contains an administrative report; Report on the Palæozoic Formations, by Stuart Weller, consisting of Hardiston Quartzite, Kittatinny and Trenton Limestones, and Hudson River Beds; Report on the Portland Cement Industry, by H. B. Kümmel; Artesian Wells in New Jersey, by Lewis Woolman; Mineralogical Notes, by A. C. Chester; Chlorine in the Natural Waters of the State, by W. S. Myers; and the Mining Industry, by H. B. Kümmel.

Portuguese Geology.—Paul Choffat has published in the Bull. Soc. Belge Geol., xv, May, 1901, an important paper on the "Limite entre le Jurassique et le Crétacique en Portugal." From a careful study of the different exposures and the fossils contained in the beds, he comes to the conclusion that the limit between the two systems in Portugal must be regarded as only a conventional one. He finds that both the fauna and flora show an almost imperceptible passage between the two formations in certain places.

CORRESPONDENCE.

FOSSILS AND GARNETS.

Sir,—If your correspondent "Verbum Sap." had signed his own name I would have endeavoured to explain to him my reasons for writing the paragraph which he quotes, though I knew that the "traditions of the elders" might be cited against me by dealers in second-hand science. As it is, I content myself with remarking that the maxim "Verbum sat sapienti" has only a very limited application in scientific matters, for there a diet of words is both innutritious and flatulent. But as he evidently loves "wise saws" I will add another to his store, "Words are the counters of wise men and the money of fools." T. G. BONNEY.

INTRUSIVE IGNEOUS ROCKS IN IRELAND.

SIR,—With reference to the interesting paper on "Intrusive, Tuff-like, Igneous Rocks and Breccias in Ireland," by Messrs. Kilroe and M'Henry, published in the August number of the Q.J.G.S., it is noteworthy that there are in the neighbourhood of Snowdon several instances of intrusive rocks of so fragmentary and brecciated a character as to resemble volcanic agglomerates. Such is the case in part with the diabase occurring in Cwm Llan, S.S.E. from the summit of Snowdon. Other instances of this character that I have observed are a small boss of brecciated diabase at the base of the felstone of Cribiau, near Bwlch Ehediad, and another, also of a fragmentary character, amidst the felsitic rocks on the south-east side of Llyn Gwynant. Somewhat similar too is the greenstone on Glyder Fawr, which Ramsay in his memoir on North Wales describes as a "great vesicular, rubbly-looking patch."

J. R. DAKYNS.

SNOWDON VIEW, NANT GWYNANT, BEDDGELERT.
October 10, 1901.

EBBING AND FLOWING WELLS AND SPRINGS.

SIR,—Some time back you were good enough to print a communication from me on the ebbing and flowing well between Buxton and Castleton in Derbyshire. In the *Illustrazione Popolare* of August 18th of this year is a paper on a phenomenon of the Lago di Garda of kindred character, of which I submit a substantial translation.

"The Lago di Garda is one of the largest lakes in Italy, admired for the fertility of the country that surrounds and for the beauty of the gardens that adorn its shores. There happens in these days a phenomenon that impresses the surrounding population; a flux of thirty centimetres of height every forty minutes is observed, according to the boatmen. Many newspaper readers wish to explain it as a result of volcanic action.

"The phenomenon may have a volcanic origin, since from the beginning of 1800 Count Bettoni, a studious naturalist, had to verify in the lake a species of flux and reflux, not perilous but irregular and inconstant; and not only is it in the Lago di Garda observed, but in the lake of Geneva the water rises and falls in a notable manner.

"The phenomenon cannot be attributed to the action of the sun and moon, since the action of these two stars should produce a rise and fall regularly as in the level of the sea.

"Some scientists were of opinion that the rise and fall were the result of wind action, but how can the rise and fall be explained when there is sometimes not a breath of wind? Others were of opinion that the rise and fall might be due to unexpected melting of the snow, and to the action of electric clouds, but if so, why not a like action on all other Italian lakes?

"The most probable cause of such uprising, according to the hypothesis of the Engineer Pedrini, is found in the gases which, arising from the bed of the lake and seeking a vent pass across the water, produce undulations, and sudden upward movements of like nature to those observed in the lake of Geneva by Lembari. In the Lago di Garda emanate continuously an infinity of gas bubbles, and thermal springs are observed.

"The action of the sun upon the Mediterranean raises the water only eighteen inches, and if this attraction on so large a surface is thus weak, the surface of the Lago di Garda is too small comparatively to be at all affected.

"In the bay of Peschiera, about a hundred steps from Sermione, there are at three different points springs with an unpleasant odour, manifesting the existence of sulphuretted hydrogen gas. Incrustations from thermal waters are to be seen on the eastern side of the lake, about one mile distant from the grotto of Catullus.

"The fishermen take particular care to extend their nets a distance from these springs; if they happen to draw the nets over them, they rot in a short time." T. E. Knightley.

106, Cannon Street, E.C.
September 9, 1901.

OBITUARY.

EDWARD WALLER CLAYPOLE.

Born June 1, 1835. Died August 17, 1901.

Professor E. W. Claypole, one of the many noted geologists of the United States, was of English extraction, having been born at Ross, Hereford, on 1st June, 1835. He was educated privately and graduated at the London University, taking his B.A. in 1862 and becoming D.Sc. in 1888. In 1871 he emigrated to the United States, and in 1873 became Professor of Natural Science at Antioch College, Ohio, a post which he held until 1881. He was Palæontologist to the "Second Geological Survey of Pennsylvania" and Professor of Natural Science at Buchtel College, Akron, Ohio, from 1883 to 1898, when he succeeded Professor A. J. McClatchie as Instructor of Biology (to which Geology was afterwards added) at the Throop Institute, Pasadena, California. This office he retained until his sudden death from apoplexy at Long Beach, California, 17th August, 1901. He was a genial and successful teacher, much beloved of his pupils, while his varied attainments find reflection in the scope of his numerous scientific papers, although geology holds the principal place.

His more important contributions to scientific literature were:—On the oldest-known fossil tree (*Glyptodendron Eatonense*), from the Upper Silurian of Eaton (Geol. Mag., 1878); papers on the Migration of Animals and Plants between Europe and America, published in 1880 and 1881; on the discovery of Pteraspidian Fish in the Upper Silurian of North America (Quart. Journ. Geol. Soc., vol. xli, 1885); The Lake Age in Ohio (8vo, 1888); on the Head of *Dinichthys* (Amer. Geol., 1892); and on the Cladodont Sharks of the Cleveland Shale (Amer. Geol., 1893). He was also one of the Editors of and largely contributed to the *American Geologist* from its foundation in 1888.

Professor Claypole was elected a Fellow of the Geological Society of London in 1879, of that in Edinburgh in 1887, and was one of the original members of the American Geological Society when it was founded in 1888.

MISCELLANEOUS.

Brachylepas cretacea.—Since the publication of my paper (Geol. Mag., n.s., Dec. IV, Vol. VIII, April, 1901, p. 145) on the interesting find of this new form of Cirriped from the *mucronata*-zone of the White Chalk of Norwich, I have received from Dr. A. W. Rowe, the finder, a second specimen. This latter comes from the *mucronata*-zone, Whitway pit, South Dorset, and gives the fossil an interesting geographical range. At present *Brachylepas cretacea* has not yet been found outside the *mucronata*-zone, and it is possible that Dr. Rowe has discovered yet another fossil of considerable zonal value.—H. W.

Geological Survey of Great Britain and Ireland. — The following geologists have been appointed to fill vacancies in the Staff of the Geological Survey, caused by the retirement of Sir A. Geikie, Mr. R. G. Symes, Mr. J. Nolan, Mr. A. C. G. Cameron, and Mr. A. J. Jukes-Browne, and by the deaths of Mr. F. W. Egan and Mr. J. H. Blake: Dr. J. S. Flett, M.A., M.B., to take charge of Petrographical work; Mr. J. Allen Howe, B.Sc., and Mr. H. H. Thomas, B.A., on the English Staff; Mr. H. B. Muff, B.A., on the Scottish Staff; and Mr. W. B. Wright, B.A., on the Irish Staff.

A sixth edition of Mr. Whitaker's handy little "Guide to the Geology of London" has just been issued by the Geological Survey. It has been thoroughly revised by the author and many illustrations have been added, including figures of Palæolithic implements and a few characteristic fossils. The first edition, published in 1875, comprised 72 pages; the present edition reaches 102 pages. The price remains 1*s*.

Erratum.—In the September part of the Geological Magazine, 1901 (p. 408), the name *Bradytherium* was employed for a genus of large Ungulates from the Eocene of Egypt. This name seems to have been employed some months earlier by G. Grandidier for a large extinct Edentate from Madagascar, and the designation of the Egyptian genus is therefore amended to *Barytherium* (see "Nature," October 10th, 1901, p. 577).—C. W. Andrews.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VIII.

No. XII.—DECEMBER, 1901.

ORIGINAL ARTICLES.

I. — Devonian Fossils from Devonshire.

By the Rev. G. F. Whidborne, M.A., F.G.S., V.P. Pal. Soc.

1. Coblenzian Fossils from Lynton.

(PLATE XVII.)

THE specimens described below were collected by my friend Mr. J. G. Hamling, F.G.S., and kindly placed by him in my hands for description. Being casts and often much obscured by injury and distortion, their identification must be in a degree problematical, but for the most part they seem to agree with German species of the Upper Coblenzien age.

Bellerophon, sp.

A slab with several poor casts comes from the "Cliff path, W. of Woodabay." They appear high with rounded back.

Pterinea fasciculata, Goldfuss, sp. (Pl. XVII, Figs. 1, 2.)

1834–40. *Pterinea fasciculata*, Goldfuss: Petref. Germ., vol. ii, p. 137, pl. cxxix, fig. 5.
1853. ,, ,, Sandberger: Verst. Rhein. Nassau, p. 293, pl. xxx, fig. 7.
1885. ,, ,, Follman: Devon Aviculaceæ, p. 187, pl. iii, fig. 3.
1889. ,, ,, Kayser: Abh. k.p. Geol. Landes., n.s., pt. i, p. 20, pl. vii, fig. 11.
1891. ,, ,, Frech: Abh. Geol. Specialk. Preuss., vol. ix, pt. 3, p. 84, pl. viii, fig. 1; pl. ix, fig. 1.

Left valve convex, somewhat produced at the postero-inferior margin. Front wing large, rounded, not truncated in front. Hind wing large, long, rather narrow, sigmoid behind. Surface having on the body six or seven strong, high, nodulate, distant ribs, with flat interspaces each of which bears five or six minute irregular minor ribs; on the front wing, three or four closer and more confluent ribs; and on the hind wing, ten or twelve small close ribs; the whole being crossed by very numerous, minute, regular, crenulated growth-lines. Hinge with four strong, irregularly horizontal teeth in front of the umbo, below which is a small deep muscle-mark. Hind teeth unseen in English specimens.

Size: length 45 mm., height 30 mm.

Eight specimens from "Woodabay, above Pier," "Quarry in road above Crock Point, Woodabay," and "Cutting under Railway N. of Barhrick Mill, Lynton."

Upper (and Lower) Coblenzien.

Actinopteria, sp.

From the "East side of Lee Bay, Lynton," are two very fragmentary specimens of an oblique *Avicula*, with rather fine alternating striæ (in one finer than in the other). They are exceedingly like some of the *Actinopteriæ* from the Barton Beds and from the Upper Devonian of Germany, but they do not admit of identification.

Modiomorpha lamellosa, Sandberger, sp. (Pl. XVII, Figs. 3, 4.)

1895. *Modiomorpha lamellosa*, Beushausen: Abh. k.p. Geol. Landes., n.s., pt. xvii, p. 18, pl. i, figs. 19–21.

Cast very oblique, transverse, almond-shaped, obliquely depressed down the centre. Umbo situate at about the anterior fifth of the length. Anterior end narrow, rounded. Anterior muscle-mark large, prominent, terminal. An oblique triangular tooth under the umbo of the right valve, and two or three long transverse striations on the arching hinge-line behind.

Size: about 60 mm. long and 30 mm. high.

There are six specimens from the "East side of Lee Bay, Lynton." They seem chiefly to differ from Sandberger's and Beushausen's figures in being rather narrower and more produced at the anterior end, and are probably no more than a variety. The internal arrangements agree exactly with Kayser's figure of *Modiomorpha bilsteinensis*, Beushausen (Jahrb. k.p. Geol. Landes. für 1894, p. 127, pl. iii, figs. 4–6), a much shorter and more oval species.

Upper Coblenzien.

Nucula Lodanensis, Beushausen. (Pl. XVII, Fig. 5.)

1895. *Nucula Lodanensis*, Beushausen: Abh. k.p. Geol. Landes., n.s., pt. xvii, p. 48, pl. iv, figs. 6, 7; 14?

From the "Cutting under Railway N. of Barhrick Hill, Lynton," is the cast of a *Nucula*, which appears almost exactly to agree with Beushausen's species. Our figure does not give a very clear idea of its real shape, the back of the cast having been sheared off, and thus lessening its apparent height. It was evidently thick-shelled and deep; there are signs of a few strong teeth; its umbo is somewhat to the rear, and bends slightly forward; its posterior end is rounded, its anterior end narrow and subangular, and its lower margin decidedly curved; its posterior muscle-mark is large and faint, and its anterior deep and occupying the upper half of the anterior end.

Size: 14 mm. long, 9 mm. high.

This shell is larger and rounder than *N. Krachtæ*, F. A. Römer, to which M'Coy appears to have referred it, and very much smaller than *Lima Neptuni*, Giebel, which is referred to *Nucula* by Kayser.

Upper Coblenzien.

PANENKA RIGIDA, F. A. Römer, sp.

1866. *Cardium rigidum*, F. A. Römer: Betr. Harzgeb., pt. v, p. 10, pl. iii, fig. 1.
1879. *Cardiola? rigida*, Kayser: Abh. Geol. Specialk. Preuss., vol. vi, pt. 1, p. 122, pl. xviii, figs. 2, 3.

A specimen from "Heddon's Mouth (new road)" evidently belongs to this magnificent species. It is a blurred cast in bluish micaceous schistose grit, retaining the surface-ornament round the margins and showing the inner line of the shell beneath the umbo. Its size and marginal contour exactly agree with the German figures. Its ribs, while slightly more numerous than those of the figured specimens, are no more than the number mentioned in Kayser's description.

Size: 80 mm. long, 67 mm. high.

Unter Wieder Schiefer (below Haupt Quarzit).

SPIRIFERA DALEIDENSIS, Steininger. (Pl. XVII, Fig. 6.)

1840. *Spirifera aperturata*, Phillips: Pal. Foss., p. 77, pl. xxx, fig. 133.
1864. ,, *canalifera*, Davidson: Brit. Foss. Brach., vol. iii, p. 26.
1889. ,, *Daleidensis*, Kayser: Abh. k.p. Geol. Landes., N.S., vol. i, pp. 27, 84, pl. i, figs. 5, 6; pl. x, fig. 11.

A dorsal valve from "East side of Lee Bay, Lynton," appears to agree with the species defined by Kayser, though it is so crushed and defective that little of its character remains. It seems to have been somewhat wider than long, with a strong elevated fold having at least three ribs, which perhaps divaricate in front in the manner of that species, and with nine strong ribs on each wing.

This is no doubt the same as Phillips' shell, for which Davidson had found a still earlier name than Schlotheim's, but which Kayser (1878, Abh. Geol. Specialk. Preuss., vol. ii, pt. 4, p. 174, note) considered more probably to belong to *S. Daleidensis* than to the species to which Phillips had referred it. Phillips' figure shows four ribs on the fold.

Upper Coblenzien.

SPIRIFERA PARADOXA, Schlotheim, sp. (Pl. XVII, Fig. 7.)

1853. *Spirifer paradoxus*, Schnur: Palæontogr., vol. iii, p. 198, pl. xxxii *b*, fig. 1.
1889. ,, ,, Kayser: Abh. k.p. Geol. Landes., N.S., vol. i, p. 28, pl. ii, figs. 6, 7.

Nine specimens from "Quarry on road above Crock Point, Woodabay," appear to belong to an extremely transverse variety of this species, being more like those quoted above than are most of the numerous figures given of it by various authors. The central fold is large and probably prominent, the flatness seen in our figured specimen having been most likely caused by pressure. The lateral ribs are small, visible almost to the angles, and almost 50 in number. The wings appear to be acute and alate at their extremities.

Size: about 15 mm. long and 75 mm. wide.

Upper Coblenzien.

Orthotetes hipponyx, Schnur, sp. (Pl. XVII, Fig. 8.)

1878. *Streptorhynchus Devonicus*, Kayser: Abh. Geol. Specialk. Preuss., vol. ii, pt. 4, p. 199, pl. xxix, figs. 3, 4.
1897. *Orthotetes hipponyx*, Œhlert: Bull. Soc. Géol. Fr., ser. III, vol. xxiv, p. 856, pl. xxvii, figs. 9–11.

Numerous specimens of a shell akin to *O. umbraculum* come from the "Cutting under Railway N. of Barhrick Mill, Lynton." They appear to belong to a widespread Lower Devonian species, to which Œhlert, rejecting D'Orbigny's name *Devonicus*, has applied the one which Schnur had first adopted, but afterwards dropped upon wrongly identifying his shell with Vanuxem's.

Œhlert gives various distinguishing characters which, even in the imperfect condition of our shells, seem to hold good, except that ours are not of so large a size. Our shells are remarkable for the very great size and irregularity of the hinge-area of the ventral valve. This sometimes appears triangular in shape and higher than its length, and sometimes irregular in shape but still high. The rest of the shell seems little affected by this contortion of the umbo. The hinge-line, though sometimes auriculate, is not generally equal to the greatest width of the valve. It seems also to differ from *O. umbraculum* by being more circular, by the method of increase of its ribs, by not being roughened by the existence of dense transverse striations, and by other particulars.

It is rather curious that this irregular shape and great size of the hinge-area should be so pronounced in a Lower Devonian form, when it does not appear in higher Devonian zones, but becomes again exceedingly noticeable in Carboniferous varieties of *O. crenistria*, as witness Davidson's plates.

Our figure, unfortunately, does not show the distinguishing characters of the shell, which I did not realize until after it had been drawn.

Coblenzien.

Orthis longisulcata, Phillips. (Pl. XVII, Fig. 9.)

1840. *Orthis longisulcata*, Phillips: Pal. Foss., p. 62, pl. xxvi, fig. 105.

From the "Cutting under Railway N. of Barhrick Mill, Lynton," and "Woodabay, above Pier," are several specimens of a rather large *Orthis*. It has a transversely oval form, rather elevated umbo and short hinge-line, and is covered with very fine divaricating striæ, which arch outwards on the shoulders. Its muscular area is large.

This appears to be the species described by Phillips, though his drawing is rather smaller. It was doubtfully united by Davidson to *O. arcuata*, Ph., from Hope's Nose, from which, I think, it is really quite distinct. It bears much resemblance to the shell figured by Kayser and Œhlert as *Orthis palliata*, Barrande, but our shells present no evidence of a double hinge-line.

Phyllopora aspera, Ulrich ?

1890. *Phyllopora aspera*, Ulrich: Geol. Surv. Illin., vol. viii, p. 613, pl. xliv, fig. 5.

Specimens from the "Road Section above Watersmeet" and the "Quarry in road above Crock Point, Woodabay," show little to separate them from this American species. Possibly the fenestrules may be arranged in rather more regular lines and in some parts the cells may be rather more numerous, but this seems only accidental.

Upper Helderberg Beds.

FENESTELLA, sp.

Several fragmentary specimens come from the "Quarry in road above Crock Point, Woodabay," but they are quite unrecognizable.

2. LOWER DEVONIAN FOSSILS FROM TORQUAY.

(PLATE XVIII.)

It is not often that a Museum can supply its shelves with specimens dug from its actual site. Such, however, was the case with the Torquay Natural History Society, when, in digging the foundation of the "Pengelly Memorial" Hall, which it added to its Museum in 1894, a rich fossiliferous bed, 4 feet thick, was found in the soft slates on which that building stands. Hundreds of fossils were carefully collected from it by the Curator, the late Mr. Else, and by the kindness of the Society I have been permitted to attempt their description below. The fossils are entirely moulds or casts, and have suffered very greatly from squeezing and distortion, but in some cases minute structure is beautifully preserved. It will be seen that they may on the whole be referred to the Upper Coblenzien, or to a slightly higher horizon. The richness of the band is in striking contrast to the general barrenness of the adjoining strata.

Mr. A. Somervail, F.G.S., Secretary to the Society, thus writes of the position of the slates :—"A slight examination of the structure of the Torwood Valley would at once reveal the relations of the slates to the adjoining rocks. The valley runs in a nearly E.N.E. and W.S.W. direction, lying between the long ridges of the Lincombe and Warberry Hills. The valley at its commencement on its S.W. side traverses limestones, and a little in its N.E. course the slates at the Museum, which pass below the limestones. Still further on in the same direction another series of slates and grits, forming the Lincombe and Warberry ridges, in their turn pass below the slates exposed at the Museum ; so that, as we ascend the Torwood Valley from the Strand, we walk over rocks in a descending sequence, the highest being the limestones, the lowest the Lincombe and Warberry grits, the fossiliferous slates at the Museum holding an intermediate position."

PHACOPS SCHLOTHEIMI, Bronn, sp. ?

1825. *Calymene Schlotheimi*, Bronn : Leonhard's Zeitsch., pt. i, p. 319, pl. ii, figs. 5–8.
1876. *Phacops latifrons*, F. Römer : Leth. Palæoz., pt. i, pl. xxxi, fig. 2.
1884. ,, *Schlotheimi*, Kayser : Jahrb. k.p. Geol. Landes., 1883, p. 35.
1897. ,, ,, Kayser : Zeitsch. Deutsch. Geol. Gesell., p. 285.

The head of a small trilobite occurs, which is too much covered with matrix for certain identification. What can be seen of it, however, points to its belonging to the small common form from the Eifel, which Bronn, and afterwards independently Kayser, separated from *Ph. latifrons.* The eyes are large and level with the top of the glabella, which overhangs the strong marginal rim of the front. There are eight lenses in the vertical rows of the eye. Though it is a cast, indications remain that the glabella was as roughly tuberculate as in Römer's figure, which Kayser refers to this species.

Calceola-schists and Eifelkalk.

ORTHOCERAS, sp.

The cast, probably, but not certainly, of a body-chamber, shows a central siphuncular opening. It is widely oval in section, but has been somewhat squeezed. It might possibly belong to *O. ellipticum*, Münster.

ORTHOCERAS HERCYNICUM, Kayser?

1879. *Orthoceras hercynicum*, Kayser: Abh. Geol. Specialk. Preuss., vol. ii, pt. 4, p. 72, pl. x, figs. 7, 8, 11.

Another cast appears to approach, or to belong to, this species. Its section is oval, with diameters of 21 mm. and 18 mm., and the siphuncle is situated on the longer diameter, nearly half-way from the centre. The chambers are about four times as wide as high, and are very obliquely placed.

Haupt Quarzit.

CAPULUS PRISCUS, Goldfuss? (Pl. XVIII, Fig. 1.)

? 1878. *Capulus priscus*, Kayser: Abh. Geol. Specialk. Preuss., vol. ii, pt. 4, p. 94, pl. xvi, fig. 5; pl. xx, figs. 11, 14, 15.

A flattened cast may perhaps belong to Goldfuss's species, but it does not retain sufficient character to admit of certainty. All that can be said is that what remains of the fossil agrees with it, and that the curvature of the apex and the rate of increase of the whorl are the same. A few spots on the cast may perhaps indicate the tubercles of that shell; but they are far too indistinct to be relied on, and may be entirely accidental marks.

Upper Coblenzien and Eifelkalk.

CONOCARDIUM cf. CUNEATUM, F. A. Römer, sp.

? 1895. *Conocardium cuneatum*, Beushausen: Abh. k.p. Geol. Landes., N.S., pt. xvii, p. 407, pl. xxx, figs. 9–13.

A large species of *Conocardium* is represented by a specimen crushed almost beyond recognition. It measured about 18 mm. across the valves, and its plaits were strong, squared, and close-set. It appears not to have had any flattened central region. What is seen of it suggests that it might be a small specimen of Römer's shell, which, however, often reaches much larger dimensions.

Passage beds of Lower Devonian to Calceola-schists.

ATHYRIS CONCENTRICA, von Buch, sp. (Pl. XVIII, Fig. 6.)

1895. *Athyris concentrica*, Kayser: Ann. Soc. Géol. Belg., vol. xxii, p. 207, pl. iii, figs. 7, 8 ?, 9 ?

A few rather small and obscure specimens are referable to this species. The fold, though pronounced, seems similar in character to Davidson's figures from Hope's Nose, and is not subangular as in *A. undata*, Defr. A mould of the closed valves shows the characteristic strong concentric ridges.

Coblenzien of Belgium, but not in the Rhenish Lower Devonian (Kayser).

SPIRIFERA CURVATA, Schlotheim, sp. (Pl. XVIII, Figs. 2, 3, 3*a*.)

1853. *Spirifer curvatus*, Schnur: Palæontogr., vol. iii, p. 208, pl. xxxvi, figs. 3*a*, *b*.

Several specimens of a very large *Spirifer* occur, but all in a fragmentary and distorted condition. They are apparently a good deal wider than long, and are entirely without ribs. The fold is elevated, rounded, and very much produced in front; and the sinus is deep from near the umbo, and forms a very long tongue-shaped projection in the front of the ventral valve. Some specimens (Fig. 3*a*) preserve the surface-ornament, and show it to consist of fine, regular, concentric, elevated lines, bearing minute punctations, which are the endings of still more minute, discontinuous, radiating lineations.

These shells seem to be like Schnur's figure quoted above and Davidson's from Hope's Nose, though probably they were wider. I am not inclined to follow Beushausen in regarding the very variable form of the Lummaton Beds as more than a variety of this species.

Upper Coblenzien and higher beds.

SPIRIFERA PRIMÆVA, Steininger.

1895. *Spirifer primævus*, Béclard: Bull. Soc. Belg. Géol., vol. ix, p. 137, pl. xi, figs. i–vii, 1–12.

Several rather small casts and moulds appear to belong to this species, exactly resembling *S. Beaujeani*, Béclard, which that author afterwards merged into Steininger's shell. They are a good deal wider than long, with rather rounded cardinal angles, a very deep sinus, and (in the smallest specimen) five strong rounded ribs on the wing. The surface is covered by very strong close-set concentric ridges, becoming coarser in front, and united by strong radiating lines. One specimen is 50 mm. wide.

Throughout Lower Devonian of Europe.

ATRYPA RETICULARIS, Linné, sp.

This shell seems rare, being represented by a single mould.

Upper Coblenzien and higher beds.

PENTAMERUS GALEATUS, Dalman, sp. (Pl. XVIII, Figs. 4, 5.)

1853. *Pentamerus galeatus*, Schnur: Palæontogr., vol. iii, p. 196, pl. xxix, fig. 2.

Cast large, globose. Umbo large, much recurved. Area wide, undefined laterally. Dorsal valve smaller than the ventral and with a deep, flattened, receding sinus, a corresponding fold being on the ventral valve. Shell covered with strong ribs, reaching nearly to the umbo; from three to five being on the fold and five or six on each side.

Size: A specimen that has hardly been distorted is 40 mm. in length and width, and 20 mm. in depth. A flattened specimen is nearly 50 mm. long.

This species is the prevailing shell of the locality. Very large numbers of specimens have been found, but always in the condition of casts.

From Silurian to Middle Devonian (Kayser).

ORTHIS HYSTERITA, Gmelin.

1853. *Orthis Beaumonti*, Schnur: Palæontogr., vol. iii, p. 215, pl. xxxvii, fig. 9.
1889. ,, *vulvarius*, Barrois: Ann. Sci. Géol. Nord, vol. iii, p. 72.
1889. ,, *hysterita*, Kayser: Abh. k.p. Geol. Landes., N.S., pt. i, p. 53, pl. v, figs. 1, 7–9.

Some casts of the double valves, showing the internal arrangements, appear to agree exactly with the shell by Schnur referred to *O. Beaumonti*, De Vern., and by Gosselet and Barrois to *O. vulvarius*, Schlot.; the latter remarking that it is distinguished from *O. striatula*, Schlot., by its long and stronger muscular impressions. Other larger casts of single valves equally correspond to Kayser's figures of the same shell, for which, following Quenstedt, he adopts a still earlier name.

The shape of these fossils is a transverse oval, the dorsal valve is deeply convex, the ventral valve is concave laterally and has a broadly arched sinus. The valves meet in a deep sweeping curve in front. The muscular area reaches rather more than half-way forwards in the smaller examples, and less than half-way in the larger. Only marginal traces of the very fine ribs remain.

Size: about 30 mm. long by 45 mm. wide.

Throughout the Lower Devonian of Germany.

ORTHIS, sp. (Pl. XVIII, Figs. 10*a*, *b*.)

Cast longer than broad, tumid. Dorsal valve very convex, larger than the other. Ventral valve apparently nearly flat, with a wide shallow sinus in front and reflexed sides, and massive near the umbo with a wide oblique hinge-area. Hinge-line as long as the width of the shell. Cardinal angles gently rounded. Valves meeting in front in a sweeping curve. Muscular impressions extremely large and strong, reaching very nearly to the front margin of the shell in both valves. Surface covered with very numerous small rounded striæ, which seem to divaricate close to the margins. Shell-structure thick.

Size: about 20 mm. long, 15 mm. wide, and 11 mm. deep.

There is a cast of the closed valves and an exterior of the dorsal valve, which retains the surface though much decayed. These specimens, together, show a good deal of the character of the species, which seems to me very distinctive. Internally, it appears very like *O. Monnieri*, Roualt, from the Lower Devonian, but it differs from it in shape and in the size of the hinge-area. I have seen very similar specimens from the Lower Devonian of Cornwall.

ORTHOTETES UMBRACULUM, Schlotheim, sp. (Pl. XVIII, Figs. 7, 7*a*.)

1865. *Streptorhynchus umbraculum*, Davidson: Brit. Foss. Brach., vol. iii, p. 76, pl. xvi, fig. 6; pl. xviii, figs. 1–5.

A few moulds of this species occur, which are interesting from their having well preserved the minute surface-ornament, which has been described by Davidson, but is rarely, if ever, fully seen in the numerous specimens from Lummaton and other higher beds. A wax-cast shows this to consist of very numerous and regular "scale-like projections on the striæ," which are not only connected in the interspaces by the corresponding growth-lines, but by a still finer superficial series of elevated microscopic lineations, slightly irregular and arching, and at the rate of about five to each growth-line. This finer ornament is so minute that it can only be seen by a strong lens, but it is extremely beautiful.

Lower and Upper Coblenzien and higher beds.

STROPHOMENA RHOMBOIDALIS, Wilckens.

This species is represented by a fine cast of the closed valves and by an interior of the lower valve. The former appears to have been a very deep shell, and shows much detail; its characteristic ornament can be discerned on the covering mould.

Upper Coblenzien and higher beds.

STROPHEODONTA TÆNIOLATA, Sandberger, sp. (Pl. XVIII, Figs. 8, 8*a*, 8*b*, 9, 9*a*, 9*b*.)

? 1842. *Orthis Sedgwickii*, D'Arch. & De Vern.: Geol. Trans., ser. II, vol. vi, p. 371, pl. xxxvi, fig. 1.

1853. *Strophomena tæniolata*, Sandberger: Verst. Rhein. Nassau, p. 360, pl. xxxiv, fig. 11.

Shell apparently convex, somewhat deflexed in front, and about as long as wide. Hinge-area narrow, as long as the width of the shell, bearing numerous strong dentations. Ornament consisting of multitudinous, fine, straight, regular striæ, divided into groups of five or six by somewhat stronger ribs, half of which only reach half-way to the umbo.

Size: about 20 mm. long by 25 mm. wide.

This species is not very rare in these beds, but the specimens are very much squeezed and fragmentary, probably from its being a delicate shell. Its ornamentation was evidently very beautiful.

It appears exactly to agree with the shell figured by Sandberger, who quotes *O. Sedgwickii* as a synonym. If that be so, of course this latter name would have priority; but I am by no means sure of its identity with that shell, whether as described by De Verneuil or by Schnur, and am more inclined to believe it to be the species attributed by Schnur and by Barrois to *Leptæna interstrialis*, Phillips, which itself is certainly distinct from it.

Spiriferen-sandstein of Daleiden (Sandberger).

FENESTELLA TORWOODENSIS, n.sp.

Some specimens, apparently of a frondose habit, have been found. Their branches are slight (being much narrower than the fenestrules), appear to divaricate about once to seven or eight fenestrules, and bear a very much elevated, blade-like keel within. The fenestrules are long flattened ovals, about 6 to 10 mm. in length and 13 to 10 mm. across. There are four or five cells to a fenestrule.

This probably belongs to the species figured by Phillips as *F. antiqua*, var. *a*, from Lynton; but it also comes extremely close to the Hope's Nose fossil, which I have referred to his *F. arthritica*, differing from it in probably branching more rapidly and in certainly having the cell-mouths and keel on the outside face.

Hallia quadripartita, Frech.

1886. *Hallia quadripartita*, Frech: Palæont. Abhandl., vol. iii, pt. 3, p. 83, pl. viii, figs. 20, 21.

Simple, cornute, oval in section; axis excentric. Cup deep. Major septa 28. Septal fossula deep, extending to centre and containing the principal septum, which does not reach the centre. Opposed and lateral septa reaching centre. Septa of each principal quadrant 5, pinnate against the septal fossula; and those of each opposed quadrant 7, pinnate against its lateral septum. Minor septa 28, long.

Size: about 23 mm. wide.

There is one specimen from this locality, but the above description has been completed from an example from near "Walls Hill," which is in better preservation and contains forty-six septa. It seems perfectly to correspond with Frech's German species.

Lower ? *Stringocephalus* Beds of Gerolstein.

Amplexus, sp.

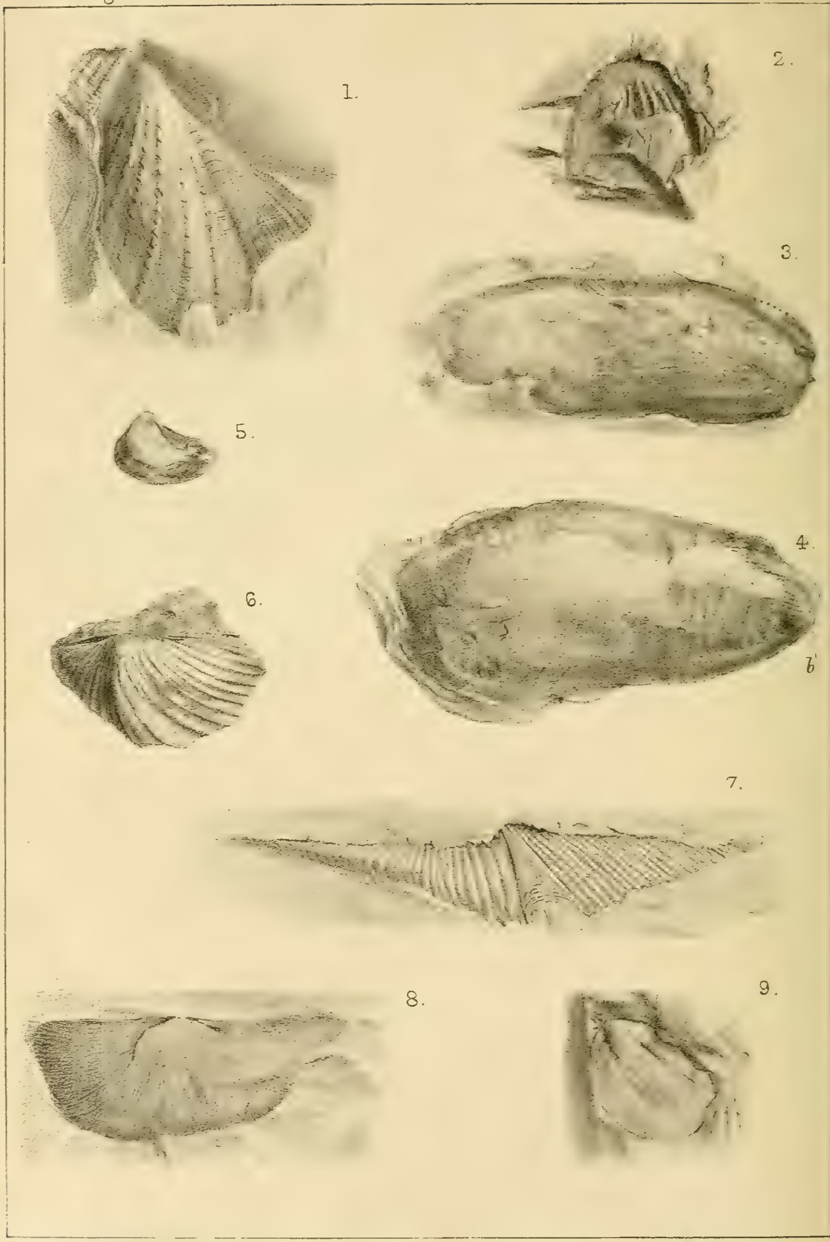
Conical. Cup very deep (about 25 mm. deep by 25 mm. wide), flattened at the base. Major septa 28, reaching half-way to the centre. Minor septa rudimentary. Tabulæ (as seen at the base of the cup) irregularly flat, extending to the sides, and marginally deflexed. Septal fossula very deep, marginal, not extending half-way to the centre, and containing a short septum, while the adjoining septa arch round its sides. No dissepiments.

The specimen, being only the distorted cast of the cup, is not easy to decipher, but belongs, I think, clearly to this genus. As far as can be seen, it approaches somewhat nearly to the Carboniferous *A. cornu-bovis*, Edwards & Haime.

Metriophyllum Elsii, n.sp.

Small, apparently elongate, sub-conical, about 10 mm. wide. Major septa 16, reaching to the centre, where they are slightly deflexed. Minor septa 16, long. Signs of a large pseudo-columella, which appears to be formed by the invagination of the centre of the arching tabulæ.

This form seems the commonest true coral of the zone, though rather rare. It is so similar in style and structure to *Metriophyllum gracile*, Schlüter, that it is doubtless congeneric; but it differs from it specifically in the central twisting of the septa, the probably looser structure of the columella, and other points.



F. H. Michael del. et lith. Mintern Bros. imp.

Devonian Fossils; Lynton.

CLADOCHONUS cf. SCHLÜTERI, Holzapfel. (Pl. XVIII. Fig. 11.)

Cf. 1895. *Cladochonus Schlüteri*, Holzapfel: Abh. k.p. Geol. Landes., N.S., pt. xvi, p. 305, pl. xii, figs. 1, 2, 4, 5, 7.

Two specimens of *Cladochonus* come very near to Holzapfel's species, which Schlüter had before referred to *Cl. alternans*, F. A. Römer, sp. They differ from each other considerably in size, suggesting that our species was very variable. Nor do they agree very well with Holzapfel's coral as against Römer's; for, while they have the habit of the former, they are more like the latter in the stoutness of the stems. Our material is, however, insufficient to define them properly.

PLEURODICTYUM? PACHYPOROIDES, n.sp. (Pl. XVIII, Figs. 12, 12*a*.)

Corallum forming masses, which often become very elongate and ramose. Base and epitheca unknown. Corallites large, short, polygonal, obliquely radiating, with thick walls, which are pierced by a few irregularly placed, straight, horizontal canals; a few corallites being much smaller than the rest.

Size of corallites: 2 or even 3 mm. in diameter; about 5 or 6, or rarely 9 or 10 mm. long.

This abundant species is very perplexing. It appears to have the structure of *Pleurodictyum*, but the habit of *Pachypora*. In one instance a specimen appears attached to the mould of a crinoid-stem, and has in one place all the appearance of an ordinary *Pleurodictyum*, radiating from a centre. In this case the epitheca may have been destroyed, the crinoid-marks being obliterated from the mould, which is covered by minute longitudinal lines. Occurring only as casts, the connecting-rods are very noticeable. They are sometimes nearly 1 mm. long. They are placed on the flat sides, and have sometimes an irregularly vertical arrangement. The state of preservation is such as to allow no signs of septal striæ or tabulæ. The corallites are very much larger and shorter than those of *Pachypora cervicornis*, De Blain.

EXPLANATION TO PLATE XVII.

DEVONIAN FOSSILS FROM LYNTON.

The specimens are in Mr. J. G. Hamling's collection, and are drawn natural size.

FIG. 1.—*Pterinea fasciculata*, Goldfuss. Left valve, restored from the mould and cast. Woodabay.

FIG. 2.—The same, cast of anterior end. This has been accidentally drawn with the anterior end upward, and should be turned through a quarter circle for examination.

FIG. 3.—*Modiomorpha lamellosa*, Sandberger, sp. Cast of right valve, showing part of hinge, defective in front. Lee Bay.

FIG. 4.—The same, cast of both valves, showing the anterior muscle-mark (*b*). Lee Bay.

FIG. 5.—*Nucula Lodanensis*, Beushausen. Cast of right valve, imperfect on the back. Barhrick Mill.

FIG. 6.—*Spirifera Daleidensis*, Steininger. Distorted cast of dorsal valve. Lee Bay.

FIG. 7.—*Spirifera paradoxa*, Schlotheim, sp. Dorsal valve, restored from a cast and mould. Woodabay.

FIG. 8.—*Orthotetes hipponyx*, Schnur. sp. Dorsal valve of a young specimen, one side of which is irregularly alate.

FIG. 9.—*Orthis longisulcata*, Phillips. Cast of ventral valve. Barhrick Mill.

EXPLANATION TO PLATE XVIII.

Devonian Fossils from Torquay.

The specimens belong to the Torquay Natural History Society, and were obtained from the foundations of its Museum. They are drawn to natural size.

Fig. 1.—*Capulus priscus*, Goldfuss?
Fig. 2.—*Spirifera curvata*, Schlotheim, sp. Portion of ventral valve.
Fig. 3.—The same. Central part of the front of dorsal valve, showing the fold. Fig. 3*a*, portion of surface magnified.
Fig. 4.—*Pentamerus galeatus*, Dalman, sp.
Fig. 5.—The same.
Fig. 6.—*Athyris concentrica*, von Buch, sp. A small dorsal valve.
Fig. 7.—*Orthotetes umbraculum*, Schlotheim, sp. Mould showing the minute ornamentation. Fig. 7*a*, portion of the mould magnified.
Fig. 8.—*Stropheodonta tæniolata*, Sandberger, sp. Lower valve and hinge-line. Fig. 8*a*, portion of hinge-line magnified. Fig. 8*b*, portion of front of the valve magnified, showing the double series of striæ.
Fig. 9.—The same. Lower valve showing internal arrangements. Fig. 9*a*, portion of hinge-line magnified. Fig. 9*b*, portion of ovarian area, showing its pitted surface.
Fig. 10.—*Orthis*, sp. Fig. 10*a*, cast of dorsal aspect. Fig. 10*b*, cast of ventral aspect.
Fig. 11.—*Cladochonus* cf. *Schlüteri*, Holzapfel. Mould of the part of a specimen.
Fig. 12.—*Pleurodictyum ? pachyporoides*, n.sp. Portion of a ramose cast. Fig. 12*a* portion of one of the corallites magnified, showing the arrangement of the rods.

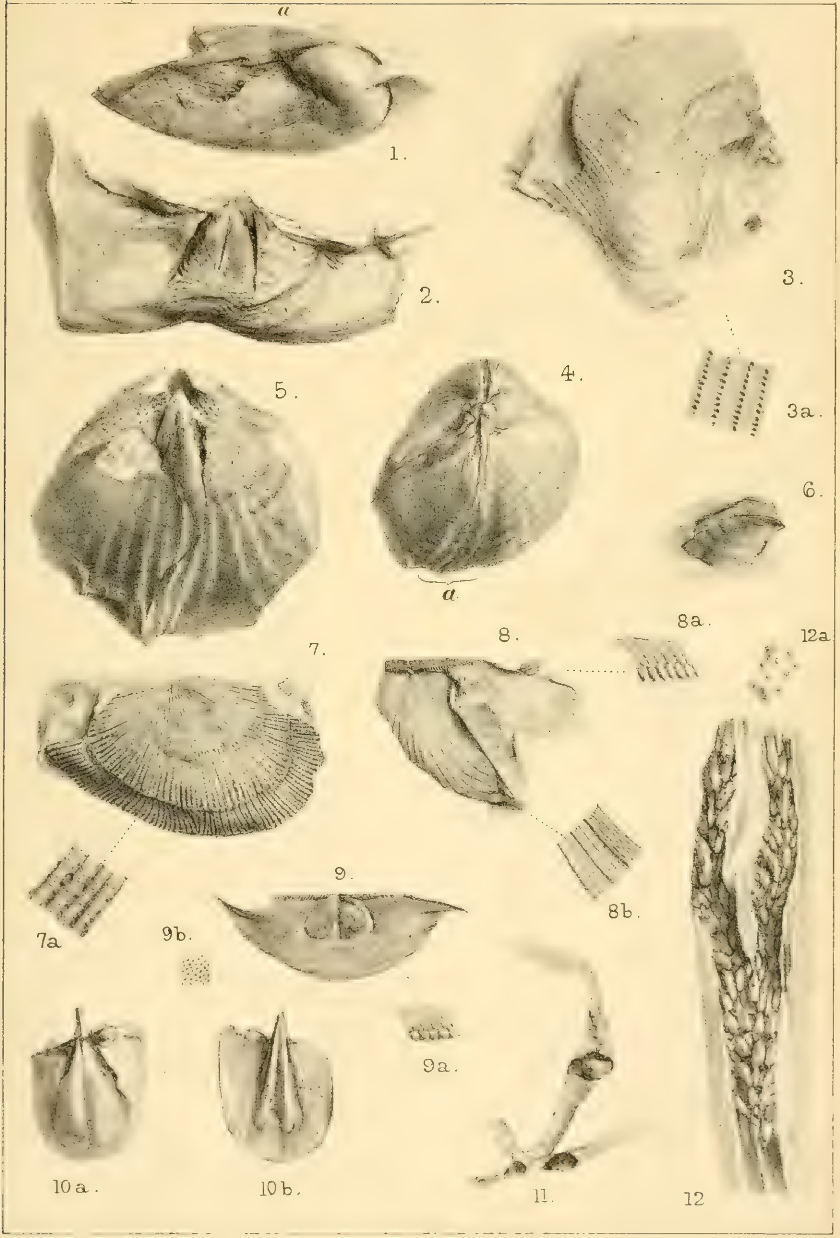
II.—The Fayûm Depression: A Preliminary Notice of the Geology of a District in Egypt containing a new Palæogene Vertebrate Fauna.[1]

By Hugh J. L. Beadnell, F.G.S., F.R.G.S., of the Geological Survey of Egypt.

THE Fayûm, one of the largest depressions of the Libyan Desert, is situated some 50 miles south-west of Cairo. It is cut out in rocks of Eocene and Oligocene age, while still younger deposits of Pliocene and Post-Pliocene date are found within the hollow. The depression owes its origin to the action of the ordinary subærial denuding agents, which I have shown in previous papers were capable of producing the oases-depressions of Baharia, Farafra, Dakhla, etc. Faulting, which has played so important a part in the formation of the Nile Valley, appears to have had little or nothing to do with the production of the Fayûm and other depressions of the Libyan Desert.

During my survey of the Fayûm in 1898 I found that certain strata of the Middle Eocene were veritable 'bone-beds,' being crowded at many points with vertebrate remains, such as the ribs of cetaceans, crocodile vertebræ, fish-bones, and coprolites. Up to that time the only vertebrate fossils which had been obtained from the district were remains of *Zeuglodon* and some fragments of a mandible thought to belong to *Chœropotamus*; these had been collected by Schweinfurth and noticed by him in 1886.

[1] Communicated in abstract to the British Association at Glasgow, 1901, by permission of Sir William Garstin, K.C.M.G., Under-Secretary of State, and Capt. H. G. Lyons, Director-General of the Survey Department, Cairo.



F H Michael del et lith. Mintern Bros. imp.

Devonian Fossils; Torquay.

In the early part of 1901 I spent a short time in the Fayûm exploring the borders of the Birket el Qurun lake, on which occasion Dr. C. W. Andrews, of the British Museum, who happened to be in Egypt at the time, accompanied me. On our return journey to Cairo we visited some of the localities I had found to be bone-bearing in 1898, and on our last day's march were most fortunate in crossing the Eocene escarpments at a point where a number of well-preserved marine and terrestrial vertebrate remains lay exposed on the surface of the outcrop of the bone-beds. On reporting, Capt. H. G. Lyons, Director-General of the Survey Department, at once organized a special collecting expedition; Dr. Andrews again accompanied me, and together we succeeded in obtaining a unique collection of almost entirely new mammals and reptiles. A brief description of these is now being published by my companion in the Geological Magazine (see September and October issues), and the object of the present paper is to give a preliminary account of the geology of the district from which these interesting remains were obtained.

General Succession.

The oldest beds found in the depression are the clays, marls, and limestones, with *Nummulites gizehensis*, of Middle Eocene age. These are succeeded by a group of white marly limestones and gypseous clays, which largely underlie the cultivated land of the Fayûm. They are followed by a series consisting of clays, sandstones, and calcareous grits, some beds of which are characterized by the abundance of *Operculina*. The latter series is followed by the uppermost marine Eocene beds (Carolia beds), an alternating group of clays, sandstones, and limestones, characterized by an abundant vertebrate and invertebrate fauna, and equivalent to the Upper Mokattam beds of Cairo. Above the 'Carolia beds,' and well marked off from them, both lithologically and palæontologically, is found a great thickness of variegated sands and sandstones, clays, and marls, divided near the summit by one or more thick intercalated lava sheets. These variegated beds are largely of fluvio-marine origin and are of Upper Eocene – Lower Oligocene age. No Miocene deposits have been recognized within the area, but further north, as at Mogara, Lower Miocene beds occur, and it is probable that a continuous conformable series of lithologically similar deposits extends from the summit of the Fayûm escarpment (Lower Oligocene) to the Mogara Miocene beds.

The Pliocene is probably represented by the great masses of gravel, or raised beaches, which form such a marked feature in the geology of the district. Fossiliferous Pliocene deposits have also been recorded from the south part of the area by Schweinfurth. Of Post-Pliocene age we may mention the ancient high-level lacustrine clays, the cultivated alluvial loams, and the desert sand-dunes.

The following table shows the sequence of strata known in the Fayûm and the classification adopted by the writer :—

Recent and Pleistocene.	Alluvial soil, blown sand, and high-level lacustrine sands and clays.
Pliocene.	Shell-borings on exposed rocks. Fossiliferous deposits of Sidmant. Gravel terraces.
Lower Oligocene and Upper Eocene.	5. Fluvio-marine Series (Gebel el Qatrani beds).
Middle Eocene.	4. Qasr el Sara Series (Carolia beds). 3. Birket el Qurun Series (Operculina-Nummulite beds). 2. Ravine Beds (fish-scale marls). 1. Wadi Rayan Series (*Nummulites gizehensis* beds).

1. Wadi Rayan Series.

The wadis of Rayan and Mouailla, on the southern side of the Fayûm depression, are cut out in the clays and limestones of this group, equivalent to part of the Lower Mokattam of the Nile Valley. The uppermost bed of limestone, characterized by the profusion of the large foraminifer *Nummulites gizehensis,* forms a considerable part of the floor of the depression west of the Fayûm cultivation, stretching from Gebel Rayan northwards to the foot of Gar el Gehannem, 28 kilometres west of the western extremity of the Birket el Qurun.

2. Ravine Beds.

This series, estimated at 25 metres thick, consists of gypseous clays and white marly limestones, and is met with bordering the cultivated land on the east, west, and north sides. The same beds are frequently exposed in the deep ravines of El Butts and El Wadi which intersect the cultivation. The beds yield shell-impressions of *Leda, Tellina,* etc., with fish-teeth and numerous scales. No vertebrate remains have as yet been obtained from this or the underlying series. Beds of this group form the base of the island 'Geziret el Qorn' and the lower part of the northern shore of the Birket el Qurun.

3. Birket el Qurun Series.

The beds of this group, some 60 metres thick, form the main part of the escarpment immediately overlooking the north shore of the lake. The series appears to be the equivalent of the upper part of the white beds (limestones) of Gebel Mokattam, although lithologically there is considerable difference. Certain beds of the series are characterized by the abundance of two foraminifera, *Nummulites Fraasi* and *Operculina discoidea.* A well-marked molluscan fauna is also present, and cetacean and fish remains are not uncommon. The series is well seen in the desert separating the Fayûm and Nile Valley, along the northern boundary of the cultivation and of the lake, and westwards in the cliffs to the outlying hill-mass of Gar el Gehannem.

In the northern part of the Fayûm the series is divisible by a very constant well-marked bed of hard sandstone, which almost invariably weathers out into a number of huge globular masses. The lower beds are seen in the island of Geziret el Qorn, and from them Schweinfurth first collected cetacean remains. The mollusca from these beds were described by Mayer-Eymar (Zittel, *Palæontographica*, N.F., x, 3 (xxx)) as having on the whole a Bartonian aspect, but his determination seems much open to doubt, as they underlie the Upper Mokattam (Qasr el Sara series), the Parisian age of which appears to be well established. The cetacean remains were described by Dames, who compared them with the American *Zeuglodon macrospondylus* and *Z. brachyspondylus*, but did not consider them to represent a new species. The same author, however, subsequently described similar but more complete remains (also collected by Schweinfurth, from beds belonging to my Qasr el Sara series) as a new species, *Z. Osiris*. The upper division of the Birket el Qurun series is lithologically rather similar, consisting of alternating clays and sandstones. The beds, however, are generally much richer in organic remains. In the uppermost beds very large cetacean vertebræ occur, and these probably represent a second species of *Zeuglodon*, as although Dames considered the difference in size of the bones of separate individuals to be sexual, the apparently much greater upward range of the smaller type suggests the existence of two species.

4. Qasr el Sara Series.

The exact junction between this and the last-described series is purely arbitrary, some of the commonest fossils passing from one to the other. The name of the series is taken from an ancient ruined temple near which the beds are well developed. The Qasr el Sara series (or Carolia beds) is perhaps the most important and best marked division of the Fayûm succession; it forms a bold escarpment of great length and height, consisting of a series of very fossiliferous clays and limestones, with sands and sandstones in the upper part of a total thickness of 175 metres. The 'Carolia beds' closely correspond to the Upper Mokattam division of the Eocene at Cairo, but are much more fully developed in the Fayûm, where they occupy a large part of the northern desert. In the cliffs about 8 kilometres north of the Birket el Qurun the beds form a steep double escarpment, running nearly parallel to the northern shore of the lake.

Vertebrate remains may be found in places in most of the beds of this division, but the most prolific horizon is the 'bone-beds' proper, a double band of clay separated by two layers of limestone, and occurring about midway in the series. In this bed groups of skeletons, or portions of skeletons, are occasionally met with, suggesting that they were carried out to sea by a strong river current and deposited at the tail-end of the latter. That the Qasr el Sara series was deposited in fairly shallow water at no great distance from land seems certain, no less from the common occurrence of terrestrial animal remains than from the general lithological character of the beds. The clays abound with impressions of plants, much lignitic matter occurs, current-bedding is well seen in many of the more sandy beds, while the thin interbedded bands of limestone are more or less impure and do not indicate conditions of any great depth.

The commonest and perhaps the most important mammal from these beds is *Mœritherium Lyonsi*, Andr., which Dr. Andrews considers to be a generalized forerunner of the Mastodon type of Proboscidean; a second species may also be present. The mandible and upper teeth, together with some of the limb bones of a large heavily built ungulate, somewhat resembling *Dinotherium*, have also been described as *Barytherium grave*. Sirenian remains are not at all rare and may belong to *Eotherium ægyptiacum*, Owen, the type of which was a natural brain-cast from the Mokattam beds of Cairo. It is possible, however, that the Fayûm animal may yet prove to be distinct from *Eotherium*. Cetacean remains are remarkably common in these beds, and all appear to belong to *Zeuglodon Osiris*; the larger cetacean bones, mentioned as occurring in the underlying beds, have not here been detected. Reptiles are represented by two new genera of snakes, the larger of which, *Gigantophis Garstini*, Andr., was a python-like type, and probably attained a length of 30 feet. The remains of the smaller *Mœriophis Schweinfurthi*, Andr., in the shape of well-preserved vertebræ, are remarkably abundant. Two new species and one new genus of chelonians were obtained from this series and have been described as *Psephophorus eocænus*, *Thalassochelys libyca*, and *Stereogenys Cromeri*. Crocodilian remains abound, the most important new species being *Tomistoma africanum*, Andr. Fish-remains occur throughout the series, one of the commonest forms being a large, and probably new, species of Siluroid. Fragments of the Saw-fish, *Propristis Schweinfurthi*, are also frequently met with.

5. Fluvio-marine Series.

In the north of the Fayûm, the Qasr el Sara series is always conformably overlain by a unique series of variegated sands and sandstones, with alternating clayey and marly bands. The often repeated bands of limestone of the underlying division are now only represented by an occasional bed of calcareous grit or impure limestone. Near the top of the series occurs a horizontal sheet of basalt, in all probability contemporaneously interbedded. For the most part the series is barren of organic remains, but certain bands in the upper part yield numerous individuals of *Unio*, *Spatha*, *Mutela*, *Ampullaria*, *Turritella*, *Cerithium*, *Melania*, and *Potamides*. From such a facies, we may without doubt conclude that the conditions of deposition of these sediments were estuarine or fluvio-marine. Moreover, the enormous quantities of silicified wood, in the shape of hundreds of trees of great length and girth, associated with the remains of terrestrial animals (*Palæomastodon*, etc.), show that rivers of considerable size emerged from the land to the south, the coastline of which was probably not very far distant.

The series attains a maximum thickness of about 250 metres. With regard to age, I have already stated[1] that the lower part of

[1] Beadnell: "Recent Geological Discoveries in the Nile Valley and Libyan Desert"; London, 1901.

the series may be regarded as Upper Eocene, while the higher beds above the interbedded basalt marks the base of the Lower Oligocene. It seems probable that this age-determination will hold good, although whether it will ever be possible to draw a precise junction between the Eocene and Oligocene is more than doubtful. The series is quite continuous in the field, and the passage from the one to the other formation appears to be perfectly gradual, both lithologically and palæontologically.

Occasional fragments of bone may be observed in many parts of the series, but, so far, the only remains of value obtained were unearthed from the lowest bed, and are thus certainly of Upper Eocene (Bartonian) age. The most important terrestrial animal is *Palæomastodon Beadnelli*, Andr., a small generalized form of proboscidean, and probably a direct descendant of *Mœrithium Lyonsi* of the Qasr el Sara series below. Part of the mandible of another and different ungulate was also obtained, but has not yet been determined. In addition, remains of crocodiles and turtles are not uncommon in the basal beds of the 'Fluvio-marine Series.' The post-basalt portion of the series forms the highest part of the escarpment on the north of the Fayûm depression. These beds cover the desert to the north, stretching to beyond the latitude of Cairo. To the north-west, however, they appear to pass gradually up into younger deposits, as at Mogara Lower Miocene rocks occur.

Space does not permit of any details being given here of the younger Tertiary and Post-Tertiary Fayûm deposits.

General Remarks.

The Eocene rocks of the Fayûm are of special importance, owing to the presence in them of a new and highly interesting succession of vertebrate remains, enabling us to gain some insight into the nature of the fauna at that time inhabiting the great African land-mass to the south. In the region to the west of the Nile Valley, comparatively shallow water existed from probably the beginning of the Middle Eocene, and numerous rivers entered the sea in this neighbourhood, bringing quantities of forest trees and floating carcases of animals from the south. To the east deeper water must have existed, as limestones continued to be accumulated until the latter part of the Middle Eocene period, and even then the amount of land sediment deposited was much less than in the Fayûm. Later, in Upper Eocene times, while the Fayûm appears to have been the site of an enormous delta, no deposits of the same age at all appear to have been laid down to the east of the present Nile Valley, as there the top beds of the Middle Eocene (Upper Mokattam) are unconformably overlain by the Oligocene deposits of Gebel Ahwar, etc.

It is to be hoped that further exploration in the Fayûm and surrounding desert regions may in time lead to palæontological discoveries of the highest importance. Some of the primitive ancestors of the proboscidea have already been discovered, and it is not improbable that in the still lower Rayan series earlier and still more generalized forms may eventually be unearthed. Up to the present time it has been maintained, by some authors at least, that at the close of the Pliocene or commencement of the Pleistocene period a great immigration of the Europasian ungulates took place into Africa; whereas the recent discoveries in Egypt show this theory to be untenable, as it was in the ancient African Continent itself that the elephants, and possibly some other groups, were evolved.

III.—Notes on Royle's Types of Fossil Plants from India.

By E. A. Newell Arber, B.A.,

Trinity College, Cambridge; University Demonstrator in Palæobotany.

In his Illustrations of the Botany of the Himalayan Mountains, published in 1839, Royle[1] figures several important fossil plants from the Burdwan Coalfield of India. These are of especial interest, not only as being the first mention of several of the best known fossil types from the Lower Gondwanas of India, but also as among the earliest descriptions of members of the *Glossopteris* flora.

Royle's types are now in the Geological Department of the British Museum (Natural History), Cromwell Road. The object of this notice is to call attention to the whereabouts of these types, and to some of the more important morphological features which they present. A full account of the literature, in which reference is made to these fossils, will be found in Feistmantel's[2] Flora of the Lower Gondwanas of India, and need not be recapitulated here. The horizon in the Lower Gondwanas, from which these plants were obtained, is the Rániganj group of the Damuda Series.

Sphenophyllum speciosum (Royle). [V. 4,190.][3]

1837. *Trizygia speciosa*, Royle: ibid., p. xxix*, pl. ii, fig. 8.
1881. ,, ,, Feistmantel: ibid., p. 69, pls. xi *a*, xii *a*, figs. 1, 2.

The type figured by Royle under the name *Trizygia speciosa* is a very interesting one. It is a fine specimen, 6 inches long and $2\frac{1}{2}$ inches across, and showing nine whorls of leaves. The stem is slender, $\frac{1}{32}-\frac{1}{16}$ inch across. The internodes have two fairly prominent longitudinal ridges, but the preservation is not sufficiently good to show that these ridges are continuous at the node. Each node bears a whorl of three pairs of leaves, unequal in size, and consisting of four elongate-ovate, entire, and spreading leaves, $1\frac{1}{8}$ inch long by $\frac{3}{8}$ inch broad, and a smaller pair, $\frac{5}{8}$ inch by $\frac{3}{8}$ inch, ovate and reflexed. The successive whorls are superposed.

In the arrangement and unequal size of the leaves, *S. speciosum* differs from the majority of European Sphenophyllums, to which,

[1] Royle: "Illustrations of the Botany and other branches of Natural History of the Himalayan Mountains, and of the Flora of Cashmere"; London, 1839.

[2] Feistmantel, "The Fossil Flora of the Gondwana System": Mem. Geol. Surv. India, 1881, ser. XII, vol. iii. (The Flora of the Damuda and Panchet Divisions, 1880.)

[3] Registered number of specimen in the Geological Department, British Museum.

however, it is in other respects nearly related. Feistmantel,[1] for these, and for other reasons which M. Zeiller and Mr. Seward[2] have since shown to be untrustworthy, supported Royle in assigning the Indian plant to a separate genus, *Trizygia.* But M. Zeiller[3] has further shown that the unequal size and arrangement of the leaves in such specimens is not a constant feature of either generic or specific value, and that it sometimes occurs among such European species as *S. oblongifolium* and *S. filiculme,* from the Upper Coal-measures and Permian. M. Zeiller therefore rejects the genus *Trizygia,* a view which Mr. Seward[4] has supported in his textbook on Fossil Plants.

The occurrence of such a typical Coal-measure genus as *Sphenophyllum,* in association with members of the *Glossopteris* flora in the Lower Gondwanas of India, is a point of special interest, as showing that in India, as in similar beds in South Africa, and in South America, there occur plants which are typical of the flora of Europe and North America in Permo-Carboniferous times.

VERTEBRARIA INDICA, Royle. [V. 4,189.]

1839. *Vertebraria indica,* Royle: ibid., p. xxix*, pl. ii, figs. 1–3, 5–7.
1881. ,, ,, Feistmantel: ibid., pl. xii *a*, figs. 10, 11; pls. xiii *a*, xiv *a*, fig. 11; pl. xiv *a* bis, fig. 3.

Royle says "the shales of Ranigunj and Chinnakooree contain abundant vegetable remains of the Ranigunj Reed, *Vertebraria indica,* and *Vertebraria radiata.*" It is now known that both these species represent different views of the rhizome of *Glossopteris*;[5] *V. radiata,* the transverse section, and *V. indica,* the surface view.

Three specimens of each of these are figured by Royle. I have only been able to identify one large specimen[6] figured as *V. indica.* This is 5¾ inches long, and ¾ inch across. It is composed of two regular longitudinal rows of small square (3/8 × 3/8 inch), or slightly oblong (¼ × 5/8 inch) areas.

As seen in transverse section, judging by Royle's figures, the structure of *Vertebraria indica* is very similar to that of *Vertebraria australis* (McCoy). In surface view, however, there is less resemblance. The areas, which represent the broad outer edges of the wedge-like segments composing the fossil, are in the Indian specimens small, and fairly regular, in size. From other Indian specimens figured by Feistmantel, this would seem to be a constant characteristic. In Australian specimens[7] they appear to be often very irregular, and to vary greatly in size. Oldham[8] has pointed out that the *Vertebraria* described by Zeiller from South Africa also differs from

[1] Feistmantel: Rec. Geol. Surv. India, 1879, xii, p. 163.
[2] Seward: Mem. and Proc. Lit. Phil. Soc. Manchester, 1889, vol. iii, p. 1.
[3] Zeiller: Bull. Soc. géol. France, 1890–91, ser. III, vol. xix.
[4] Seward: "Fossil Plants," vol. i; Cambridge, 1898.
[5] Zeiller: Bull. Soc. géol. France, 1896, ser. III, vol. xxiv, p. 349.
[6] Pl. ii, fig. 1.
[7] Feistmantel: Mem. Geol. Surv. N.S. Wales, Palæont., No. 3, 1890, pl. xiv, fig. 6; pl. xv, figs. 1–3.
[8] Oldham: Rec. Geol. Surv. India, 1897, vol. xxx, pt. 1.

Indian specimens. Although it is highly probable that all these species are the remains of the rhizome of one and the same plant, *Glossopteris Browniana*, Brongt., yet it would not seem possible to unite them, on account of the variation in structure[1] which they present.

MACROTÆNIOPTERIS DANÆOIDES (Royle). [V. 4,191.]

1839. *Glossopteris danæoides*, Royle: ibid., p. xxix*, pl. ii, fig. 9.
1881. *Macrotæniopteris danæoides*, Feistmantel: ibid., p. 88, pls. xx *a*, xxi *a*, figs. 1, 2.

This specimen, which is beautifully preserved, measures $5\frac{1}{2}$ inches, and nearly $2\frac{1}{2}$ inches across. The midrib ($\frac{3}{32}$ inch across) gives off at right angles parallel veins, which are distant ($\frac{1}{32}$ inch), and simple, or occasionally dichotomizing. There is no regular alternation between the simple and branched veins. The leaf is oval-lanceolate, and the margin entire or undulate.

The generic value of *Macrotæniopteris* is a doubtful one. It would perhaps have been better, in the present state of our knowledge, to have included such forms under the broad definition which Mr. Seward[2] has adopted in dealing with similar remains. The chief distinctions between *Macrotæniopteris* and *Tæniopteris* are apparently the simple frond of large size—a point of doubtful value—and the distant secondary nerves, in the former case. It is therefore open to question whether a generic distinction based only on such characters will eventually be found to hold good.

CLADOPHLEBIS ROYLEI, Arber. [V. 4,192.]

1839. *Pecopteris Lindleyana*, Royle: ibid., p. xxix*, pl. ii, fig. 4.
1881. *Alethopteris Lindleyana*, Feistmantel: ibid., p. 80, pl. xviii *a*, figs. 2, 2*a*; pl. xix *a*, figs. 3, 4.

Royle's specimen is a large bipinnate frond, the main axis of which is nearly 7 inches long, and some of the pinnæ are of a similar length. The pinnules, which are badly preserved, are somewhat oblong in shape, and attached by a broad base. The apex is rounded. They average $\frac{1}{2}$ inch long, by $\frac{5}{16}$ inch broad. There is a strong median nerve, from which dichotomizing secondary nerves are given off. Feistmantel's figures show the nervation accurately, but those of Royle, and especially of McClelland,[3] are somewhat misleading.

The general habit and the nervation recall certain fronds of a British Jurassic fern, *Todites Williamsoni* (Brongt.); so much so that Feistmantel[4] originally placed the Indian species in a group with *Alethopteris Whitbyensis*, Heer, a plant very possibly identical with *T. Williamsoni* (Brongt.).[5] The fructification of Royle's plant is known, and is of the Polypodiaceous type, and thus differs from that of Heer's plant, as Feistmantel[6] later admitted. It would seem

[1] Etheridge: Proc. Linn. Soc. N.S. Wales, 1894, ser. II, vol. ix.
[2] Seward: Brit. Mus. Cat., "The Wealden Flora," 1894, pt. i, p. 124.
[3] McClelland: Rep. Geol. Surv. India, 1849–50, pl. xiii, figs. 10*a*, 10*b*, 10*c*, 11.
[4] Feistmantel: Journ. As. Soc. Bengal, 1876, vol. xlv, p. 360.
[5] Seward: Brit. Mus. Cat., "The Jurassic Flora": I. The Yorkshire Coast, p. 88; London, 1900.
[6] Feistmantel: ibid., p. 80.

best to refer Royle's type to the genus *Cladophlebis*, a group of fossil ferns whose fructification resembles that of recent Polypodiaceæ, and of which the best known representative is *Cladophlebis denticulata* (Brongt.), from the English Oolite. I have called Royle's type *Cladophlebis Roylei*, as the term *Pecopteris Lindleyana* was in any case inadmissible, for it had been earlier applied by Presl to a fern now known as *Coniopteris arguta* (L. & H.).[1] The nervation in *Cladophlebis* and *Todites* is of the same general type, but the evidence of the fructification would seem to be strongly in favour of referring Royle's plant to the former genus.

Pustularia Calderiana, Royle.

No scientific description is given by Royle of any of his types. All the plants he mentions are, however, figured, with the exception of one which he merely refers to as having been named by him *Pustularia Calderiana.*[2] The rock-specimen with *Cladophlebis Roylei* contains several other smaller fragments, and also bears a label with "*Pustularia Calderiana*" in probably Royle's handwriting. These specimens are imperfect, and perhaps for this reason were not figured. They apparently consist of slender branched specimens of *Vertebraria indica*, Royle, similar to those figured by Feistmantel.[3] As, however, Royle's plant was neither figured nor described, the name *Pustularia Calderiana* has no significance.

IV.—Geological Notes on the Neighbourhood of Ladysmith, Natal. No. 2: On some Travelled Blocks in the Ecca Shales.[4]

By Dr. H. Exton, F.G.S.

(Communicated by Professor T. Rupert Jones, F.R.S., F.G.S.)

On both sides of the Klip River running through this district a shale predominates, varying in colour from greyish-brown to purple, having a conchoidal fracture, and the features of Ecca Shale, as described by Dr. Molengraaf (Trans. Geol. Soc. South Africa, vol. iv, pt. 5, pp. 107–112).

The watercourses and dongas are too shallow to show the base of the Ecca series, and I have searched for the presence of Dwyka Conglomerate here without avail.[5] In a narrow gorge running into the Klip River near to this station is a level piece of ground covered with blocks, which, from the absence of a parent rock and from the

[1] Seward: ibid., p. 116.
[2] Royle: ibid., p. xxix*.
[3] Feistmantel: ibid., vol. iii, pl. xiii *a*, figs. 1, 2.
[4] For No. 1 see p. 509.
[5] Since Dr. Molengraaf's memoir on "The Origin of the Dwyka Conglomerate," describing the Ecca Beds as resultants of glacial action, much attention has been given to the subject. See the Trans. Geol. Soc. South Africa, 1898, vol. iv, pp. 103–115; and Nat. Science, 1899, pp. 199–202. In E. J. Dunn's Geological Map of South Africa (1887) the Ecca Beds range only up as far as the Tugela River in Northern Natal. The Ecca Beds described by Dr. Molengraaf are in the Vryheid district, just south of Utrecht and west of Zululand.

peculiarity of their disposition, appear to have been travelled blocks (Locality No. 1). Each one is more or less encased with a fine-grained sandstone, like the kernel of an almond in its shell, which to a certain extent takes the shape of the central mass.

These blocks, lying on the Ecca Shale, are well shown in the photographs Nos. 1 and 2, for which I am indebted to Captain Dalgleish, of the Newcastle Field Artillery.

"No. 2" shows an artificial pile of detached blocks, each partially exhibiting the crust or casing of sandstone. These stones have evidently been exposed, and possibly rolled from higher ground, and thus more or less fractured.

"No. 1" (see Fig. 1) shows a block still lying *in sitû*, partially embedded in the Ecca Shale, size 27 × 19 × 12 inches. The immediate foreground shows the cutting of a military road, and by this the portion facing the spectator has been exposed, whilst the base of the block and the further portion remain embedded in the shale, as when planted there by natural agencies.

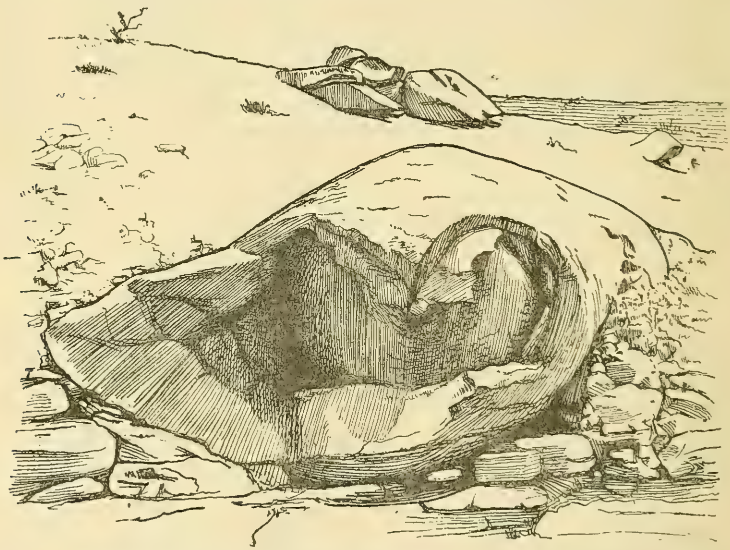


Fig. 1.—One of the encrusted blocks in the Ecca Shale near the Station Hospital, Ladysmith, Natal.

There is so much that to me is enigmatic in these stones that, with the stimulus your kindly interest in them has excited, I have extended my researches, with the result, as mentioned in mine of May 16th, that I found a similar specimen at Nicholson's Nek, four miles due north-east from this station (Locality No. 2), and on a second visit discovered others having the same characters. Since then I spent a satisfactory day at Bester's Farm (Locality No. 3), behind Waggon Hill, about five miles in a south-west direction from the Station Hospital (that is, *Stationary*, in contradistinction from *Field Hospital*). This Bester's Farm (occupied by a man of that name) must not be confounded with "Besters," a railway station on the Harrismith line, about 16 miles from Ladysmith.

Following the watercourse (at this season merely a dry donga) towards the hills a mile and a half away from Bester's house I found many of these Olifant Klip[1] blocks *in situ*, embedded in the blue shale. Some were embedded in the bed of the watercourse, but others were revealed by projecting from the almost perpendicular sides of the donga, having ten feet of shale between them and the surface of the ground. These are absolutely untouched by the hand of man. A casing of similar sandstone is here also evident; but, from moisture during the rainy season, more or less decomposition has ensued.

A blow with the hammer sufficient to break the crust generally detaches the same from its contained central mass; in order, therefore, that you may have the fullest opportunity of investigation I am having a small block sawn through by a local mason here, so as to give a section of the central portion still retaining its part of the crust above and below. This is from the site of my first find, on the declivity near the Klip River at this Station Hospital.

The thickness of the portion sliced off is 3 to 5 inches, and the diameters of its flat face are 16½ by 12 inches.

In the same package I have enclosed specimens from the centre of blocks found by me at Bester's Farm. These, as far as I can see, possess the same characters as the specimens sent you by post at first.

The enquiry as to the source of these blocks becomes more interesting, and their geological relations more important, since I am now enabled to prove their presence on or in the Ecca Shale at four different points widely apart.

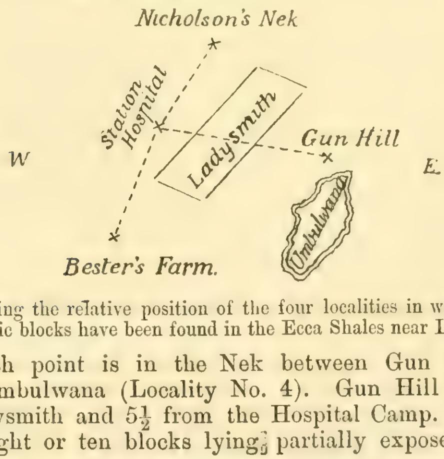


Fig. 2.—Showing the relative position of the four localities in which the travelled concentric blocks have been found in the Ecca Shales near Ladysmith.

The fourth point is in the Nek between Gun Hill and the mountain Umbulwana (Locality No. 4). Gun Hill is four miles east of Ladysmith and 5½ from the Hospital Camp. At this Nek there are eight or ten blocks lying partially exposed, *in situ*, on

[1] The kernel of these blocks resembles in microscopic structure the so-called 'Elephant Rock,' or 'Olifant Klip' of the Transvaal.

the Ecca Beds, with central mass and concentric coatings similar to the others already mentioned.

The occurrence of these peculiar blocks in large numbers, at places so far apart, points to some extensive physical operations under which their formation and deposition have taken place.

Mr. Fred. Chapman suggests that these blocks, with a more or less concentric structure, have been due to sigmoidal folds in crushed Palæozoic rocks. Their distribution was probably due to ice-action during the formation of the Ecca Shales.

The encrusted blocks and their association with the Ecca Shale are precisely the same in the four several localities in which I have now found them.

There can be no question about their being travelled blocks. I have been over the whole country within a radius of 15 miles round here, and have failed to find anything approaching the kind of stone of which the central portion consists. Therefore I am certain that I have not met with the rock from which these blocks were derived, nor, as far as I am aware, is there any previous mention of the occurrence in Natal of what I must perforce call 'dolomite,' such as the central mass of these encrusted blocks, which is a blue magnesian limestone, effervescing on application of a mineral acid.

[If the Ecca Beds are really extra-morainic deposits in connection with the Dwyka Conglomerate, it may be to the latter we have to look for the immediate source of the blocks, and to far-away southern regions for the earlier rocks from which they originally came.—T. R. J.]

V.—Notes on the Olifant Klip from Natal, the Transvaal, and Lydenburg.

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

(Appendix to Dr. Exton's paper on the Travelled Blocks in the Ecca Shales near Ladysmith.)

I.—Specimen from one of the blocks lying on the Ecca Shale on the declivity near the Klip River at the Station Hospital, Ladysmith. This is a bluish-grey rock of close texture, with a flaky and sometimes conchoidal fracture. The broken surface does not reveal the rock's internal structure; but on the weathered surface, which appears as a brown crust, the siliceous strings and bands passing through the rock stand out in high relief. The surface effervesces freely when touched with acid.

Under the microscope this rock appears to be a mylonized siliceous limestone. It was perhaps originally a calcareous sandstone; possibly having organic remains (as shell-fragments), more or less massive.

The arenaceous part of the rock now appears as brecciated fragments of sandstone, alternating with contorted and fibrous calcareous material. The whole structure shows an extraordinary amount of crushing, and exhibits various stages in the formation of a cleaved rock. The harder arenaceous portion occurs as strings of rifted quartzose fragments, once continuous, but now broken up and rippled, whilst between the folds, which are often sharp and V-shaped, the calcareous and other minerals lie in fibrous bands or intermingled with quartz-grains.

On the margins of the sandstone fragments some dolomite rhombs may be detected.

This 'Olifant Rock' is not a true dolomite, but a crushed limestone with much siliceous interstitial matter, and the crushing has given rise to a pretty 'rippling' of the granular portion, such as one often sees in the Skiddaw Slates and other rocks of a similar nature.

II.—The large block, from near the Hospital, is broken on one side, and has been sawn across carefully on the other to show its structure; and a large portion of the original surface exposed by weathering is seen on the rest of the specimen. It is evidently a portion of a sub-lenticular mass, consisting of an inner calcareo-siliceous material and an outer finer-grained siliceous and limonitic crust.

The whole block is strongly suggestive of its having been a lenticular mass, produced by intense folding, which has resulted in two contiguous, but differently constituted, layers being cut off in their continuity from the rest of the mass, as may be seen in certain of the folded Palæozoic rocks of the West of England, where a series of sigmoidal folds ultimately give rise to a band of separate lenticles. (See for instance Dr. H. Hicks' paper on "Folds and Faults in the North Devon Rocks," Geol. Mag., 1893, pp. 3–9, especially the woodcut at p. 5.)

Fig. 3.—Sigmoidal folding in Devonian Rocks, east side of Hele Bay, Ilfracombe. To illustrate the origin of the concentric Olifant Klip blocks.

A. Ordinary sigmoidal fold in limestone.
B. Dumb-bell shaped fold due to pressure and thrust.
C. Isolated fold with crust and core.
D. Crushed and contorted slaty beds.

From a photograph by F. Chapman, 1899.

In explanation of the formation of the travelled and broken blocks found in the Ecca Shale near Ladysmith, as lenticles, in contorted Palæozoic strata, which have subsequently been broken out and then shifted by water or ice-action, the above section is given.

The microscopic structure of the inner portion of this Ladysmith specimen is seen to be both minutely and coarsely crumpled; whilst at short intervals the rock is traversed in various directions by small and interrupted faults. The weathering has brought out this structure of the internal portion very distinctly; and therefore the harder parts, with more silica in their composition, stand in high relief.

The forces which have produced the structures of 'rippling,' shearing, thrusting, and faulting in the central part of the mass have resulted in the formation of coarser vertical faults in the stronger and more homogeneous siliceous layer which now, probably through the folding process, forms the outer crust.

III.—A specimen from one of the blocks found in the Ecca Shale at Bester's Farm behind Waggon Hill, four miles from Ladysmith. This is a dark-grey rock, weathering on the dull side to a light-brown crust, along which harder bands of quartz stand out in strong relief. These hard bands are thin and almost papery in structure; and they are not continuous now, but nipped and disconnected by the oblique lines of the dynamical compression to which they have been subjected. The remnants of the siliceous bands are thus converted into a string of small lenticles.

The microscopic characters are like those of another specimen (from Ladysmith) above mentioned; that is, a contorted and mylonized siliceous limestone with much limonite.

IV. *Note on a specimen of the Olifant Klip of the Lydenburg District, from the Collection of Nicol Brown, Esq., F.G.S.*—This specimen shows strong indications of bedding lines, some of which, in consequence of their being siliceous, stand out in rugged relief. The rock also shows lines of faulting in a V-shaped manner (trough-faults). The surface of the limestone is coarsely hollowed or pitted (like elephant hide), and is of a dull bluish colour. Cold acid has no effect on the rock.

In section this rock is seen to be a dolomitic limestone. The main mass is composed of tesseræ of dolomite crystals with a few idiomorphic ones; that is, with their faces developed, especially in the clear parts of the section.

Darker patches in the rock, more finely crystalline to granular in structure, seem to point to former organic inclusions.

V. *Note on Olifant Klip from the Sterkfontein Caves near Johannesburg, in the Transvaal, in Mr. Nicol Brown's Collection.*—(1) A greenish or slate-coloured argillaceous limestone rock. Decomposing externally into a brown ochreous crust. Under the microscope this specimen shows itself to be much crushed, rapidly on the way to become a micaceous calc-schist. Minute quartz-grains interspersed through the section. Much limonitic material present. The apparent lamination seen on the fractured surface is probably due to cleavage.

(2) A sub-translucent, pale grey rock with oolitic structure. Composition, a dolomite. Under the microscope the larger proportion of this rock is seen to consist of minute rhombohedra of

dolomite, whilst some of the oolitic grains have patches of polysynthetic quartz, as a mosaic, near their centres. The concentric layers of the oolite granules seem to be marked out by a thin coating of graphite.

VI. *On the Olifant Klip from Lydenburg and Ladysmith; by* F. Rutley, F.G.S.—I do not see any ground to doubt that the rock from the Lydenburg district (see above) is other than what the label on the section states, namely, a dolomitic limestone. The prevalent rhombohedral forms, and the absorption of light when the polarizer alone is turned, suffice, I think, to show that the opinion is a correct one. The section of the rock (Olifant Klip) from Ladysmith is labelled "Crushed calcareous and siliceous rock." Probably if you have immersed a chip of the rock in H Cl you found a certain, but I suppose not very large, residue of insoluble matter. The section looks like limestone and sandstone crushed together, or very fine grit. The sand-grains are very small, and cemented by what I take to be limonite.

The sand-grains do not give satisfactory interference figures, but in one or two cases they appeared to be positive.

I find that I can make out nothing satisfactory from the small grains in the darker patches in the Olifant Klip. They do not give any trustworthy figures in convergent light. I suppose they are fragments of a fine grit.

VI.—On the Physical History of the Norwegian Fjords.[1]

By Prof. Edward Hull, M.A., LL.D., F.R.S., F.G.S.

That the Norwegian fjords were originally river valleys is a statement which scarcely admits of controversy. In their form, outline, and topographical position they are simply prolongations of the valleys which descend into the sea partly submerged; and if the land were still further submerged, as it once was to the extent of 200 metres according to Andr. M. Hansen, the fjords would be prolonged beyond their present inland limits without much variation of form.

The process of valley erosion by rain and river action is nowhere in Europe more admirably exemplified than in Western Norway, and the process may be supposed to have been in operation in the early formation of the fjord channels themselves before the epoch of submergence. But when we come to examine the form of the channels, as shown by the soundings marked on the Admiralty charts, we find ourselves confronted by the remarkable fact that the beds of the channels descend to very great depths, far exceeding those of the outlets where the fjords open out upon the floor of the North Sea. Now as river valleys must necessarily increase in depth (in reference to the surface of the sea) from their sources to their outlets, we are here brought face to face with a physical problem which apparently is inconsistent with our view of the original character of these channels as stated above. To the solution of this problem we must now shortly apply ourselves.

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

2. *General form of the fjord-beds.* — The numerous soundings laid down on the Admiralty charts of 1865 and 1886 enable us to determine with accuracy the form of the submerged portions of the fjords. Using these soundings, and by their aid laying down the isobathic contours, we arrive at results sufficiently remarkable. In the case of the Hardanger, the Feris, the Sogne, the Nord, the Vartdals, and the Stor Fjords with their branches, we find that shortly after passing the entrance from the outer sea, and the chain of islands which fringes the coast of the mainland, they rapidly descend to great depths, which are continuous for long distances inland, and then gradually become shallower toward the upper limits, where they pass into river valleys characterized by terminal moraines of ancient glaciers, or old sea terraces. In carrying out the mapping of the contours the author has adopted the following soundings:—

(1)	Those	of the	100-fathom	contour		(600 feet).
(2)	,,	,,	200	,,	,,	(1,200 feet).
(3)	,,	,,	400	,,	,,	(2,400 feet).
(4)	,,	,,	600	,,	,,	(3,600 feet).

The floor of the Sogne Fjord descends to even greater depths than the last of these, viz. 661 fathoms (3,966 feet), which is reached in the case of this fjord at a distance of about 25 miles from the entrance. At the entrance itself the depth seldom exceeds 100 fathoms (600 feet), and is generally less; but once the deep water is reached there is little change of level for long distances. As regards the cross-section of the principal fjords, a glance at the charts shows that they retain the form of narrow channels with little variation in breadth, receiving tributaries on either hand and bounded by steep or precipitous walls of rock; as in the case of the valleys of which they are only prolongations under the surface of the sea.

3. When endeavouring to account for the peculiar form of the fjords and the depth of their floors over the central portions we must not forget that these old river valleys were the channels of great glaciers during the post-Pliocene or Glacial period, and that glacial erosion has contributed to the deepening process. Some Norwegian geologists, such as Hansen,[1] attribute the great disparity of the depth of the fjords at the inner and outer stages of their course to this deepening of the original channels by glacier erosion on the one hand, and to the piling up of enormous masses of moraine matter at the entrance on the other. To the latter cause the author fully assents; but he is doubtful whether glacier erosion has had the effect of adding many hundreds of feet to the depth of the original floor of the valleys. But leaving this question, we have to consider a second problem: namely, by what means did the original rivers empty themselves into the ocean before the Glacial period, when there was neither deepening of the floor by glacial erosion nor shallowing by moraine matter? Previous to the Glacial epoch the rivers must, in the

[1] "Norway," edited by Dr. Sten Konow and Karl Fischer, May, 1900. Translated by J. C. Christie and Miss Muir, and others.

author's view, have entered the Arctic Ocean through channels which cannot now be clearly traced by soundings over the shallow floor of the North Sea. At the same time it is certain that it was by such channels that they reached their ultimate destination in the Arctic Ocean, because rivers as they flow seawards must necessarily descend to lower levels. This being so, it follows that the channels do actually exist, though they may not be traceable by the soundings over the flow of the comparatively shallow North Sea; and we have now to consider why it is that they are untraceable.

The cause appears to be closely connected with the subsequent submergence in later or post-Glacial times, as indicated by the raised beaches and terraces.[1] During this epoch the glaciers had only partially disappeared or receded from the lower valleys. Great quantities of mud, sand, gravel, and boulders would thus be carried down by the streams and distributed by floating ice over the sea-bed. By such material the whole floor of the North Sea has been overspread to unknown depths, and owing to the agency of tides and currents may have been swept into the deep channels of the pre-existing rivers. The author is convinced that, were it possible to strip the floor of the North Sea of its sedimentary covering, these channels would be found traversing the floor of the continental platform, and ultimately opening out by cañon-like channels on the floor of the Arctic Ocean.

The phenomena here observed, or inferred, have their representatives along the coasts of the British Isles and Western Europe. In both cases there is the shallow continental platform, terminating in a deep and rapid descent to the floor of the abyssal ocean, and traversed by channels of ancient rivers traceable by the soundings in the case of Western Europe, or inferential in the case of Western Scandinavia. In a few cases these channels are for short distances clearly indicated on the charts; as, for example, in the case of the Bredsund Dybet, which is a prolongation of the Stor Fjord out to sea, between the islands of Godo and Harejdo in lat. 62° 30′, with a general depth of 100 fathoms below the adjoining floor of the sea; and there are a few other similar cases.

Outline of the physical history of the fjords.—As connected with the past history of the Norwegian fjords the following appear to be the most important stages:—

1st (Earliest) Period.—Continental conditions; Archæan rocks; river erosion begins.

2nd Period.—Partial submergence in early Silurian times.

3rd Period.—Elevation of land during Mesozoic and Tertiary periods; further deepening of river channels.

4th Period.—*Quaternary.* Early Glacial; great elevation of land and ultimate extension of snowfields and glaciers. Ice filling the valleys and moving out to sea.

[1] According to Professor Reusch the terraces with marine shells reach an elevation of about 200 metres (656 feet) in the Trondhjem district; but the author during a recent visit was unable to observe any higher than 250 feet south of this position.

5th Period.—*Quaternary.* Post-Glacial; subsidence and partial submergence of land; retreat of the glaciers. Icebergs and rafts of ice covering the adjoining sea. Amelioration of climate.

6th Period. — *Recent.* Re-elevation to approximately present position with regard to the outer ocean. Formation of raised beaches (strand linien) during the progress of emergence.

The paper concluded with a comparison between the above physical features as they occur in Norway with those of Scotland.

VII.—On the Circulation of Salt in its Relations to Geology.

By William Ackroyd, F.I.C., F.C.S., Public Analyst for Halifax.

A wrong impression is given by the question: "Why will Mr. Ackroyd not have the 19 rivers?" (Geol. Mag., November, 1901, p. 505). The data collected by Sir John Murray are admirable additions to our natural knowledge, and they are used in my last article (Geol. Mag., October, 1901, p. 448), but I contend that they are not available for use in the expression—

$$\frac{\text{Sodium in the sea.}}{\text{Sodium annually delivered into the sea by rivers.}} = \text{the age of the Earth;}$$

and I cannot accept either the minor or major limits of time arrived at in this way. Perhaps a few more lines are necessary to further amplify my reasons.

The 19 rivers contain the following compounds, among others, in tons per cubic mile of water: calcium and magnesium carbonates, 439,580; sodium sulphate, 31,805; sodium nitrate, 26,800; and common salt, 16,657. One may take the following views of these data and of river water generally in so far as they affect the denominator of the fraction:—

The Nitrate.—The succession of events in the process of nitrification is well known to chemists from the genesis of ammonia and carbonic acid to the final production of ammonium nitrate. The theory is further held that when the ammonium nitrate is changed to sodium nitrate it is by interaction with sodium chloride, and that the latter is of marine origin. This last idea is strongly supported by the composition of the *caliche* of the South American nitrate industry. The inference is plainly that the sodium in sodium nitrate is cyclic, and no more available in this calculation of the age of the Earth than Triassic salt. Professor Joly makes no allowance for it, nor indeed any mention of it.

The Common Salt.—I will not reiterate my arguments concerning the part of this compound which is cyclic of short period, as I have sufficiently indicated their nature in my last article. But under this heading the calcium and magnesium carbonates certainly demand attention. These carbonates carry with them on the average probably not less than ·01 per cent. of combined chlorine (p. 447), which, as anyone who knows anything of analysis will understand, is included under the head of chlorides, and calculated into common salt would furnish 43 per cent. of the 16,657 tons. It is cyclic of long period, and not available for Professor Joly's calculation.

Fluctuations.—An inverse relation undoubtedly exists between the soluble contents of a river (including, of course, sodium compounds) and the amount of water in it in Summer and Winter. In all the great rivers subject to flood the variation must be enormous; in the case of the Nile it amounts to 400 per cent. As far as I can learn, these fluctuations have not been taken into account.

Coming once more to the numerator: Mysteries hang over it. The composition of the sea is not what one would expect with the precise conditions of solvent denudation required by Professor Joly's speculations. For instance, one looks for huge proportions of nitrate in it; sea analyses show practically none. Again, the chlorine in it multiplied by a known factor is a measure of its sodium contents, but the same factor does not apply to average river water. These are not matters of opinion but of fact. What becomes, then, of Dr. Joly's "constancy in the *nature* and *rate* of solvent actions going on over the land surfaces" (Trans. Roy. Soc. Dublin, ser. II, vol. vii, p. 24)?

Too much space and time would be required for me to deal with the second half of Professor Joly's November article. I may, however, be permitted to observe that he appears to me to tilt at an irrefragable law of solution, and then only saves his lance from being utterly shattered by an adroit swerve.

NOTICES OF MEMOIRS.

I.—Note on the Cambrian Fossils of St. François County, Missouri. By Professor C. E. Beecher.[1]

THE small collection of fossils submitted to the writer by F. L. Nason, for identification, is interesting, especially as it determines the geological horizon of an extensive series of limestones, sandstones, conglomerates, etc., in south-eastern Missouri, the age of which has hitherto been somewhat in doubt. Also, since these strata are intimately associated with the lead-bearing rocks of this region, the identification has considerable economic value.

It is stated by Arthur Winslow, in a paper on "The Disseminated Lead Ores of South-Eastern Missouri"[2] (p. 11), that although these rocks are placed in the Lower Silurian "The possibility still remains that there may be a faunal break which will admit of some of the lower strata being classed as Cambrian, though there is nothing in

[1] Reprinted from Silliman's American Journal of Science for November, 1901, pp. 362–366.

[2] Bulletin No. 132 of the United States Geological Survey, 1896.

the stratigraphy to suggest it. This must, therefore, be left to the palæontologists, and owing to the dearth of fossils the problem is not an easy one for them to solve." In volume ix of the Missouri Geological Survey (pt. iv, p. 52, Keyes, 1895) the Fredericktown dolomite (=St. Joseph limestone) is referred to the Upper Cambrian on account of the presence of *Lingulella Lamborni* (Meek), but since this species is peculiar to the horizon, and the genus has a much wider range, this correlation is not established. A general statement is made by Keyes regarding this region (l.c., p. 44) that "No strata younger than the Cambrian are believed to be represented. But few fossils have been found in the rocks of the area, so that the faunal evidence as to geological age is somewhat meagre." The present collection of fossils, made by Mr. Nason, indicates that the entire series is older than the Lower Silurian (Ordovician), and that at least the upper portion probably belongs to the Upper Cambrian. All but one species of the fossils were obtained from the lower members of the Potosi limestones, and since this is the topmost formation of this region its correlation is of the first importance. The fossils occur abundantly in the limestone and conglomerate beds, and more sparsely in the sandstones. They consist chiefly of fragments of trilobites, with a few brachiopods and other forms. Lithologically, there is a very close resemblance between these fossil-bearing beds and those of a similar horizon in the Black Hills of South Dakota. Limestones, limestone conglomerates, and sandstones of the same appearance are found in both sections. Faunally, there is a suggestion of affinity with the Potsdam fauna of Wisconsin and Texas. A careful comparison, however, reveals that these resemblances are more general than specific, and that the species seem to be distinct. Nevertheless, the facies of this fauna seems to indicate Upper Cambrian, though further studies with additional material may show it to belong to the middle member.

Owing to the small number of specimens in the present collection, the number of species is necessarily limited. It will doubtless be considerably increased by future collections. Among the trilobites the genera *Ptychoparia*, *Ptychaspis*, *Chariocephalus*, and *Crepicephalus* are more or less clearly identifiable. A species of *Chariocephalus* closely agrees with the *C. onustus* of Whitfield.

The species of brachiopods seem to be fairly abundant, especially an orthoid shell resembling in some respects *Billingsella*. It occurs in the shaly partings between the layers of limestone. A species of *Acrotreta* and *Lingulella* are common both in the limestones and arenaceous beds.

Hyolithes primordialis, Hall, and a small species of *Platyceras* also occur in the limestones, together with segments of cystidean or crinoidal columns.

Abundant remains of a linguloid shell are found on the lower, or La Motte, sandstones constituting the basal member of the clastic rocks of the section. Making allowances for different conditions of preservation, this species may be identified with the *Lingulella Lamborni* of Meek, which occurs in some green shales of the same age in Madison County, a little further south. In the absence of other evidence the diagnostic value of this brachiopod is very slight, and it is impossible to say whether the Bonne Terre, or St. Joseph, limestones and the La Motte sandstones represent Lower Cambrian terranes or whether they with the Potosi all belong to the Middle or Upper Cambrian.

The important point of this correlation is that, upon palæontological evidence which has hitherto been largely wanting, an extensive area and thickness of sedimentary rocks are definitely placed in the Cambrian.

II.—Discovery of Eurypterid Remains in the Cambrian of Missouri. With an Illustration. By Prof. C. E. Beecher.

THE wonderful development of Merostomes in various parts of the world at about the close of the Silurian has long been recognized, and the suddenness of their appearance out of an apparently clear Palæozoic sky has been a matter of considerable speculation. Almost at the same instant of time there appeared on the geologic horizon a marvellous assemblage of these ancient arthropods. A very few scattering forerunners are known from older rocks, but most of them are small and strange creatures, little resembling the characteristic *Eurypterus* and *Pterygotus* of the Upper Silurian, and in fact belonging to other orders than the Merostomata.

In North America the known genera and species of the order Eurypterida belong almost exclusively to the Waterlime group (Rondout) above the Salina beds. Dr. John M. Clarke[1] has recently announced the discovery, by Mr. C. J. Sarle, of a new Eurypterid fauna at the base of the Salina, which carries this peculiar biologic facies one comparatively brief stage further back. Evidences of still older forms are very meagre. A single species of *Eurypterus* (*E. prominens*, Hall) is referred to the Clinton beds of the Silurian with considerable doubt. The next indication of a greater antiquity of this order consists of a fragment of an abdominal segment and a single jointed limb, from the Utica slate of New York, described by C. D. Walcott[2] as *Echinognathus Clevelandi.*

It is therefore of considerable interest and importance that a new and much older horizon for the Eurypterida can now be chronicled.

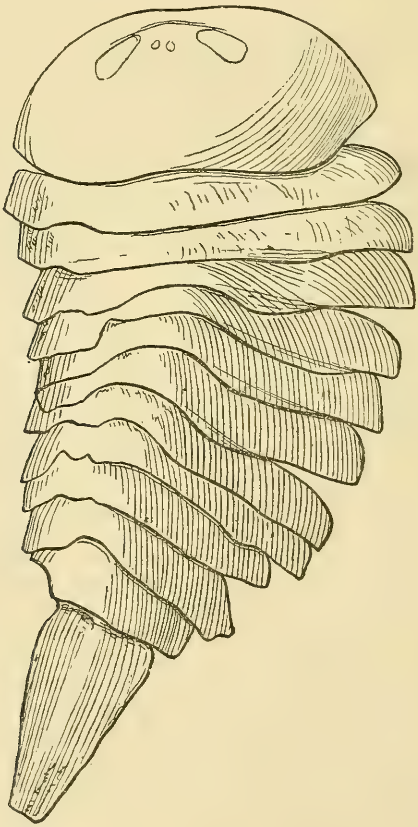
Mr. Arthur Thacher, President of the Central Lead Company of Missouri, formerly a professor in Washington University, found a nearly entire specimen of a new Eurypterid in the Potosi limestone of St. François County, and through his generosity and the kindly interest of Mr. Frank L. Nason the specimen was transmitted to the Yale University Museum. Owing to the supposed scarcity of fossils in the Potosi and St. Joseph terranes of Missouri, their

[1] Notes on Paleozoic Crustaceans. N.Y. State Museum, Report of the State Paleontologist for 1900. 1901.

[2] Description of a new genus of the Order Eurypterida from the Utica Slate. Silliman's Journal (3), vol. xxiii, 1882.

correlation was long a matter of uncertainty, until Mr. Nason described certain horizons bearing an abundant and characteristic Cambrian fauna.

The specimen here described at once suggests the familiar and well-known genus *Eurypterus*, and only when its characters are studied in connection with its geological occurrence is it apparent that its differences are of sufficient importance to warrant its generic separation. The specimen represents nearly the entire dorsal test of the animal, and consists of the cephalothorax with the abdominal segments, including the telson or tail-spine.



Strabops Thacheri, Beecher.—Dorsal aspect of type-specimen, $\frac{1}{1}$. Potosi Limestone (Cambrian): St. François County, Missouri. Original in Yale University Museum.

The cephalothorax is comparatively shorter and wider than in *Eurypterus*, the eyes are further forward, nearer together, and more oblique, and besides the telson but eleven abdominal somites can be determined on the dorsal side, instead of twelve as in *Eurypterus*.

These differences are considered as indicative of a new genus, and it is proposed to recognize this type under the name *Strabops*, nov. gen., with *Strabops Thacheri*, n.sp., as the type species. The generic name is in allusion to the inward turning or squinting of the eyes (*στραβός* 'squinting' and *ὄψις* 'face').

Doubtless many generic differences will appear when the appendages of this type are obtained. The differences in the characters available for comparison are quite as great as between *Eurypterus* and *Dolichopterus*, *Stylonurus*, *Anthraconectes*, or *Eusarcus*. This, taken with the fact that practically all the Cambrian genera, especially the more highly organized types, became extinct long before the Upper Silurian, lend support to the conclusion that *Strabops* is generically distinct from any hitherto known form.

STRABOPS THACHERI, gen. et sp. nov.

Body broadly ovate in general outline exclusive of the telson, slightly convex in the specimen, though probably quite arched both transversely and longitudinally in life, as indicated by the outline of the separate segments.

Cephalothorax short and broad, length less than one-half the width, anterior and lateral margins regularly rounded, posterior margin gently curved in the middle and turning obliquely forward toward the genal extremities, which are obtusely angular.

Eyes medium-sized, ovate, narrow ends pointing obliquely inward, situated in the middle of the anterior half of the cephalothorax, distant about the length of one eye, connected anteriorly by a distinct arched line or fold. The eye tubercles are mostly exfoliated, and their convexity and surface cannot be determined. *Ocelli* indicated by two spots midway between the eyes.

Abdomen. The dorsal side shows eleven segments exclusive of the telson. The axis in the specimen is slightly convex, and slopes off into the nearly flat pleural region without any line of demarkation. The greatest width is across the third segment. The extremities of the segments are rounded anteriorly and on the sides, and terminate behind as a simple angulation. The first six segments are quite uniform in length, while the three following are somewhat shorter, and the last two are a little longer.

Telson a broad flat spine, obtusely elevated along the middle.

Surface smooth, with an indication of a row of minute crenulations or scale-like markings near the posterior edge of each segment.

Dimensions.—Greatest length of specimen 110 mm., length exclusive of telson 82 mm.; greatest width, allowing for compression on left side, 60 mm.; length of cephalothorax 20 mm., width 49 mm.; greatest width of telson 17 mm.

Formation and locality.—From the lower members of the Potosi limestone, Flat River, St. François County, Missouri.

The only known genus of merostomes besides *Strabops* occurring in the Cambrian is *Aglaspis*, Hall, represented by two species (*A. Barrandi* and *E. Eatoni*, Whitf.). But since *Aglaspis* belongs to the order Synxiphosura, it leaves *Strabops* as the present sole representative of the Eurypterida.[1]

III.—On the Anatomy of *Todea*, with an Account of the Geological History of Osmundaceæ. By A. C. Seward, F.R.S., and Miss Sybille O. Ford.[2]

The anatomical structure of the genus *Osmunda* has been dealt with by several writers, and more particularly by Zanetti in an able paper published in the *Botanische Zeitung* for 1895, but the other genus of the Osmundaceæ has not received equal attention at the hands of anatomists. Our work, which was undertaken with a view to discover in what respects *Todea* differs from *Osmunda*, includes the examination of *Todea barbara* and *T. superba*, as well as the investigation of series of microtome sections of young plants. The family Osmundaceæ is usually regarded as to some extent intermediate between the Eusporangiate and Leptosporangiate ferns, and in many respects the two genera *Osmunda* and *Todea* are of interest in regard to the phylogeny of the various divisions of the Filicinæ.

The stem of *Todea barbara* is traversed by a single stele composed of xylem groups surrounding a central pith and separated from one another by medullary rays: these groups vary considerably in shape and number at different levels. There may be as few as two or as many as eight xylem strands in one transverse section of the stem, while in *Osmunda regalis* the number is considerably greater. The xylem strands are surrounded by parenchyma, and the sieve-tube zone occupies the same position as in *Osmunda*. This zone, which is continuous in *O. regalis*, is occasionally discontinuous in *Todea* opposite some of the xylem strands. The comparatively large sieve-tubes occur in triangular patches at the outer end of each medullary ray. A characteristic band of tangentially elongated elements succeeds the sieve-tube zone, and this is followed externally by a parenchymatous band, the outermost layer of which constitutes the endodermis. The paper deals with the phyllotaxis of *Todea barbara*, the origin of the leaf-traces, and the gradual alteration in structure which the collateral leaf-trace undergoes as it passes out from the stele of the stem as a horseshoe-shaped strand with one protoxylem group, and gradually assumes the form of the broadly U-shaped concentric stele of the petiole with its numerous protoxylem groups. The anatomy of 'seedling' plants of *Todea* is found to agree with that of *Osmunda regalis* plantlets as described by Leclerc du Sablon. As bearing on the questions of relative

[1] Although *Aglaspis* was compared with *Limulus* by Professor Hall, and its affinities were distinctly stated as with the Merostomata, yet most subsequent writers have overlooked its true relationships and have included it in their lists of trilobite genera. The family named Aglaspidæ was first employed in 1877 by S. A. Miller in "The American Palæozoic Fossils," p. 208, and the restoration of the family to the Merostomata was first made by the writer in a paper entitled "Outline of a Natural Classification of the Trilobites" (Silliman's Journal (4), vol. iii, p. 182, 1897).

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

antiquity and phylogeny of the members of the Filices, we have endeavoured to give an account of the geological history of the Osmundaceæ.

IV.—Plants and Coleoptera from a Deposit of Pleistocene Age at Wolvercote, Oxfordshire. By A. M. Bell, M.A., F.G.S.[1]

PLANT remains of Pleistocene time are of great rarity in England. The two most important series which have been described are from Hoxne, in Suffolk, obtained by Mr. Clement Reid, F.R.S., and Mr. H. N. Ridley (Geol. Mag., 1888, p. 441), and from North London by Mr. Worthington G. Smith.

There is in these remains a singular difference. Of twenty-eight plants obtained at Hoxne three are Arctic (*Salix polaris* and *myrsinites*, *Betula nana*); seventeen range to the Arctic Circle. At Stoke Newington, on the contrary, Mr. W. J. Smith obtained the elm, the chestnut, clematis, and perhaps the vine. Only three out of eleven plants reach the Arctic Circle. The pine, the alder, birch, and yew, with the royal fern, were more in harmony with the present and the past floras. In the author's opinion the Stoke Newington flora represents a much later age of Pleistocene time than the Hoxne flora. The conditions were continental, and the flora of the south was gaining, while the Arctic flora was disappearing.

The plants as yet identified, by the kindness of Mr. Clement Reid, from Wolvercote resemble those found at Stoke Newington more than those at Hoxne. This is in harmony with the writer's view that the Wolvercote deposit is of late Pleistocene age, nearer to the Stoke Newington than to the Hoxne deposit.

Eighteen plants obtained by the author are given. All of them are found in Oxfordshire to-day. Eight only have an extension to the Arctic Circle. Four mosses have been obtained, one of which is certainly recent. A considerable number of the wing-cases of beetles have also been found. These are difficult to identify, but the genus of one, remarkable by its rows of hairs, has been named by Mr. Waterhouse, of the Natural History Department of the British Museum. Only one of the genus is now found in England, and that is different from the Wolvercote species. On the other hand the genus is common on the Continent.

These facts, coupled with those from Stoke Newington, tend to the conclusion that in late Pleistocene time the climate of the Thames Valley was more continental than it is at present.

V.—Recent Discoveries in Arran Geology. By William Gunn, of H.M. Geological Survey of Scotland.[1]

(Communicated with the permission of the Director of the Geological Survey.)

IN the last ten years very important additions have been made to our knowledge of the geology of Arran both in the aqueous and in the igneous rocks of the island.

Among the older rocks a series of dark schists and cherts has been discovered in North Glen Sannox. They are probably of Arenig

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

age, though no organic remains have been found in them, are closely related to the rocks of Ballantrae in Ayrshire, and similar beds occur in various places along the Highland border, where they have been described by Messrs. Barrow and Clough. In the Isle of Arran these rocks are intimately connected with the Highland schists.

The Old Red Sandstone of Arran has been found to comprise two subdivisions, and in North Glen Sannox the upper division lies unconformably on the lower. This formation is not confined to the ground north of the String road, as generally supposed, but extends in places three miles to the south of that road, being well developed in the Clachan Glen, where it is much metamorphosed by intrusive igneous rocks. No fossils have been found in the Old Red Sandstone of Arran except *Psilophyton princeps*, specimens of which have been obtained from the lower division in Glen Shurig.

The Carboniferous formation, fine sections of which occur on the shore at Corrie and at Laggan, is now known to occupy but a small portion of the area of the island. Near Brodick Castle and in Glen Shurig its width of outcrop is not much more than 200 yards, and it does not reach the western shore, being overlapped in the interior by unconformable beds of New Red Sandstone. Beds probably of Coal-measure age with characteristic Upper Carboniferous fossils have been recognized at Sliddery Water Head, Corrie, The Cock, and in various other places, but these have no great thickness and contain no seams of coal. They represent apparently the basement beds of the Coal-measures.

The stratified rocks of the southern part of the island, consisting of red sandstones, conglomerates, and marls, have been proved to repose unconformably on the Carboniferous formation, and in places they contain derived pebbles with Carboniferous fossils. All the evidence points to their being of Triassic age, and they may easily be divided into two series, the lower of which probably represents the Bunter Sandstone and the upper the Keuper marls. These Triassic rocks occupy the whole of the coast from Corrie southwards, around the south end of the island, and the west coast up to Machrie Bay, where they appear to lie conformably on the Old Red Sandstone. They also form a small area in the north-eastern part of the island near The Cock.

That still more recent formations once existed in the island, whence they have been removed by denudation, is proved by the presence of fragments of Rhætic, Liassic, and Cretaceous rocks in a large volcanic vent which is probably of Tertiary age. These fragments occur on the western side of the island in the district of Shisken, on the slopes of Ard Bheinn, and they have yielded a considerable number of characteristic fossils which have been examined and determined by Mr. E. T. Newton.

Some of the most important of the discoveries are those connected with the old volcanic rocks of the island. A series of interbedded lavas and tuffs is found in North Glen Sannox associated with the schists and cherts previously mentioned. Like them they are probably of Arenig age, and closely related to similar rocks at

Ballantrae in Ayrshire. Two distinct volcanic platforms have been found in the Old Red Sandstone of the island. One set of basic lavas is intercalated in the lower division on the west side of the island, and another occurs in the upper division of the North Glen Sannox. In addition to the volcanic series previously known in the Lower Carboniferous rocks two others have been discovered in the upper part of the formation. That the island was the seat of volcanic activity in times still more recent is proved by the recognition of a large volcanic vent in the Shiskin district, which must be of post-Cretaceous age, as shown by some of the fragments it includes. From these facts we conclude that the island has been the scene of volcanic action at no less than seven different periods.

Much has also been learned with regard to the distribution and age of the various intrusive igneous rocks. Two masses of a somewhat intermediate character found in Glen Rosie and in Glen Sannox are probably of Old Red Sandstone age, but nearly the whole of the varied igneous rocks of the island must now be assigned to the Tertiary period, not excepting the well-known granite mass of the northern part of the island. The finer granite which occupies the interior of the nucleus has a tortuous boundary. It is clearly intrusive in the coarse granite which surrounds it, but both belong practically to the same period, as they have one and the same system of jointing.

The ring of granite, granophyre, and quartz diorite which surrounds the large volcanic vent was previously little known, and the other numerous and varied intrusive masses, both acid and basic, which occur in the island were but poorly represented on existing maps.

VI.—On the Crystalline Schists of the Southern Highlands; their Physical Structure and Probable Manner of Development. By Peter Macnair.[1]

THE area under notice is defined as that lying immediately to the north-west of the great boundary fault which crosses Scotland from the Firth of Clyde to Stonehaven. An account is then given of the various opinions that have been held concerning the structure of this region since the time of Macculloch up to the present day. The author then proceeds to show that the schist zones traverse this region in roughly parallel bands, and described a series of sections at right angles to the strike of the principal foliation of the area. The following is a summary of the author's conclusions regarding the stratigraphy, physical structure, and the manner of development in this part of the Scottish Highlands:—

1. The sedimentary schists of the Highlands proceeding from the margin inwards may be divided into the following zones:—Lower Argillaceous zone, Lower Arenaceous zone, Loch Tay Limestone zone, Garnetiferous Schist zone, Upper Argillaceous zone, Upper Arenaceous zone. Associated with these are schists of igneous

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

origin. It is probable that these zones are capable of still further subdivision, but this is not attempted as yet.

2. From an examination of the relationships of these different zones, the order as given above appears to be an ascending one, proceeding from the margin inwards, the well-marked zone known as the Loch Tay Limestone forming a sort of datum-line, from which one can recognize the positions of the lower and upper schists.

3. It is supposed that the movements which plicated the rocks of the Highlands were directed from the centre outwards, or from the north-west towards the south-east. This is shown by the fact that where the bedding can be traced the overfolding is generally towards the south-east. Also the foliation, where it has been observed, faces in the same direction.

4. In the eastern part of the region we suppose that the beds have been folded into a series of isoclines facing the south-east, and that foliation has been developed roughly parallel to the axes of the folds in the bedding, thus making the foliation appear to be roughly coincident with the original planes of stratification. At Comrie, in Perthshire, the axes of the isoclines in the bedding are nearly vertical, but with a slight hade towards the north-west. The axes of the isoclines get gradually lower and lower as we proceed towards Loch Tay. In the same way the foliation planes are nearly vertical along the frontier, but get flatter and flatter as we proceed northwards.

5. In tracing these rocks towards the south-west an increasing crumpling and folding of the foliation planes, accompanied by more intense metamorphism, is seen to take place: this is made evident in approaching the shores of Loch Katrine and Loch Lomond, but it seems to have reached its maximum in Cowal.

6. In Cowal, along the Firth of Clyde, the position of the foliation planes has been reversed, now dipping towards the south-east. Between the Firth of Clyde and Loch Fyne the foliation planes have been much crumpled, and still later divisional planes have been developed in them, this being a region of the most intense metamorphism.

VII.—The Source of Warp in the Humber. By W. H. Wheeler, M.Inst. C.E.[1]

IT has frequently been stated that the mud or warp in suspension in the Humber is derived from the erosion of the cliffs on the Yorkshire coast, and the object of the paper is to show that it is physically impossible for the detritus eroded from those cliffs to be carried into the Humber, and that the material in suspension in the water is derived from detritus washed off the land drained by the Humber and its tributaries or eroded from their banks. The drainage basin of the Humber covers 10,500 square miles, and embraces strata of various kinds of rocks, including estuarine deposits, glacial drifts, chalk, sandstone, and oolites.

The water in the zone extending around the junction of the Trent

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

and the Ouse with the Humber, extending over a length of thirty-five miles, is very highly charged with solid matter in suspension, the maximum quantity being attained in the Summer, when the downward flow of the fresh water is at a minimum, the quantity then in suspension amounting to as much as 2,240 grains, or nearly the third in a cubic foot of water. Above and below this zone the quantity diminishes to 262 grains up the river Trent and 202 grains near the Albert Dock at Hull, while off Spurn, at the entrance to the river, there is no mud in suspension, but only a few grains of clean sand. The floor of the North Sea at the entrance is covered with clean sand and shells, the beach up to Grimsby also being covered with sand.

The solid matter in suspension is derived from the detritus washed off the land and poured into the river when freshets occur, or from the erosion of the banks of the river and its tributaries. The greater quantity that prevails in the more turbid zone is due to the material being kept in a state of oscillation by the ebb and flow of the tides when the quantity of fresh water flowing down is not sufficient to carry it out to sea.

The average quantity of solid matter contained in thirteen other English rivers when in flood is 200 grains in a cubic foot. The average rainfall within the watershed of the Humber is 29·60 inches, of which 10 inches may be taken as the quantity due to such rains as produce freshets. With these figures the normal total quantity of solid matter placed in suspension in floods may be put at three million tons in a year. A portion of this is carried out to sea in heavy freshets, and the rest remains in the river in a state of oscillation.

The tendency in all rivers, whether fresh or tidal, is for material to work downward under the laws of gravity. The same quantity of tidal water that flows into the river has to flow out again, but its capacity for transporting material downwards is reinforced by the discharge of the fresh water.

The flood current in the Humber runs at the rate of four miles an hour, and its duration varies from six hours at Spurn to two and a half at Goole. It may be taken, therefore, that a particle of solid matter entering the Humber at Spurn Point would not be carried by the flood tide more than 20 miles up the river, or 25 miles below the point where the greatest amount of solid matter is held in suspension. On the turn of the tide it would be carried back again. Allowing for the greater time the ebb current is running above the junction of the rivers as compared with the flood, the material carried down on the ebb is 73 per cent. greater than that carried up on the flood.

Taking the length of the Holderness Cliffs as 34 miles, the average height at 12 yards, and the mean annual loss at $2\frac{1}{4}$ yards, the mean quantity falling on the beach is about $1\frac{3}{4}$ million cubic yards a year, of which about 40 per cent. consists of stones, gravel, and coarse sand, leaving less than a million cubic yards to be washed away. The foot of the cliffs is only reached for about four hours at high-water of springs, that is, by 260 tides in a year, the average quantity of alluvial matter for each tide being 3,728 cubic yards.

The drift of the tidal current towards the Humber lasts $3\frac{1}{2}$ hours, and runs at a velocity of $2\frac{1}{2}$ miles an hour; the greatest distance a particle of solid matter put in suspension at the point of mean distance, 20 miles from the Humber, could be carried southward is $8\frac{3}{4}$ miles; when this distance is reached the tide would turn and the particle would be carried northward for 16 miles, or 28 miles away from the Humber.

It is, however, quite improbable that a particle of matter placed in suspension at the foot of the cliffs could ever reach the main current going to the Humber. Owing to the Yorkshire coast being in an embayment the main tidal current does not approach nearer the coast than the 6-fathom line, or a mile away from the coast. The current of the flowing tide sets into the embayment towards the coast. Even if a particle from the cliffs could overcome this shoreward set and traverse the water contained in this mile of water in an opposite direction, so as to be brought into the main southerly-going current, the quantity of solid matter brought into suspension would only be sufficient to supply one grain to 14,000 cubic feet of water.

It is evident from the above facts that it is not possible for the detritus from the Yorkshire coast to reach, much more to be carried up, the Humber.

VIII.—The Artesian Water in the State of Queensland, Australia. By R. Logan Jack, LL.D., F.G.S.[1]

The western interior of Queensland is a vast area of magnificent pastoral country, but is not endowed with a sufficient rainfall. In 1881 the author had reason to suspect that the Cretaceous rocks of the Western Downs afforded conditions favourable for the discovery of artesian water. Subsequently, in 1885, the author (then Government Geologist) and Mr. J. B. Henderson, hydraulic engineer, made a study of the area, and an experimental bore was put down which proved a success.

From Mr. Henderson's annual report for 1899–1900 it appears that up to June, 1900, 185 miles of boring had been made in search of artesian water in the district, and a large proportion of the bores have been successful; and though the artesian water does not fully compensate for the lack of rain, still the bores have already produced an important change in the conditions of life in the interior.

The greater part of the western interior of Queensland is composed of soft strata of Lower Cretaceous age, consisting of clay-shales, limestones, and sandstones. These strata are so disposed that the lower members of the series crop out on the western flanks of the coast range, where not only is the elevation of the surface greater than in the downs to the west, but the rainfall is also comparatively abundant.

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

Along the eastern margin of the Cretaceous area there is a porous sandstone of great thickness, the 'Blythesdale Braystone,' and owing to low dip the outcrop of this permeable stratum occupies a belt from five to twenty-five miles wide; but the Braystone finally disappears beneath the argillaceous and calcareous upper members of the series which forms the surface of the downs to the west. Several rivers disappear while crossing the outcrop of the Braystone, and the water must be carried in it beneath the clay-shales of the downs.

The outcrop of the Braystone is concealed over part of the area by nearly horizontal tablelands of the 'Desert Sandstone,' an upper member of the Cretaceous formation lying unconformably on the lower divisions. It is, however, also of a permeable nature. The author gives an estimate of the water which should penetrate the Braystone, and suggests the probability that much of it finds an outlet under the sea in the Great Australian Bight and the Gulf of Carpentaria.

The artesian water basins are, in fact, broken basins, and the break gives rise to leakage either on land or beneath the sea. In places, therefore, the water rises in a bore, but does not reach the surface owing to the site of the bore being higher than the head of pressure. This is termed 'sub-artesian water,' and the author gives illustrations of both artesian and sub-artesian water in the district in question.

REVIEWS.

Les variations de longueur des Glaciers dans les Regions arctiques et boreales. Par Charles Rabot. (Extrait des Archives des sciences physiques et naturelles, 1899–1900.) pp. 230. (Geneva and Bale: Georg & Co.)

THIS is the latter part of a treatise of which the former was published in 1897. Since that date much additional information has appeared, of which a summary is given, together with the conclusions to which the author has been led. These are:—(1) Prior to the eighteenth century the glaciers, as proved by documentary evidence in Norway and Iceland, and made highly probable also in Jan Mayen and Spitzbergen, were much less extensive than they are at the present day, and this minimum condition had lasted for centuries. (2) During the eighteenth century, as well as in the earlier years of the nineteenth, a very great extension (*une crue enorme*) occurred, which was general throughout the Northern Hemisphere. In the course of this the glaciers invaded regions which had been free from ice during historic times. Of this. in Greenland, Jan Mayen, Iceland, Norway, and Alaska, in some cases there is documentary proof; in others it is made highly probable by less direct evidence. (3) The remainder of the nineteenth century has been a period of uncertain movements. In some places a considerable advance has been followed by a slight retreat; in others the latter set in after a pause at the maximum which had been reached in the earlier years. At the present day the Greenland glaciers appear to be stationary at a maximum. In Iceland almost all the glaciers are now retreating, though not to any great extent, and in some of them the previous advance continued till about the year 1880. From Spitzbergen the evidence is defective; so far as it goes some glaciers appear to be advancing, others retreating. In Norway the ice reached a maximum at the beginning of the century, and since then there has been a slow retreat, interrupted by slight advances. In none of these regions has there been a diminution comparable with that which has been observed in the Alps during the last half-century. M. Rabot has drawn up a table to show the advances of the glaciers for Greenland, Iceland, Jan Mayen, Spitzbergen, Scandinavia (north and south), and the Alps. Though the information is not equally full and precise in all cases, it suffices to show that while the movements of the glaciers in the northern region exhibit a general correspondence, they afford signs of a local individuality, and those of the Alpine glaciers appear to be in most cases independent. The results from the northern region are then used by M. Rabot to test the three laws of the variation of glaciers which were tentatively advanced by Professor Forel. (*a*) The law of periodicity. In the north this apparently does not hold good, the duration of the advances and retreats being irregular. (*b*) Law of simultaneousness. This holds good. (*c*) Law of variation of volume; namely, that any change affects the length, breadth, and thickness of the glacier. This apparently is not valid in the north, for there the end of a glacier may be stationary or even advancing, while its thickness higher up is diminishing. For this apparent anomaly the author offers an explanation. Lastly, he discusses the question whether the results of the more minute observations which have been carried on in the Alps during the last twenty years establish a relation between the variations of the climate and the length of the glacier; such a relation appears to be suggested, but more evidence is needed before it can be regarded as established.

The rule "Always verify your references" holds good, as commonly, in M. Rabot's book, for names are often misspelt. We leave Germans to deal with Pettermanus, but object to Professor Garwood being persistently transformed into Garnwood. This, however, is a superficial blemish. The memoir itself embodies a mass of information, accumulated by patient and laborious study, and cannot fail to be very valuable for purposes of reference to all who take an interest in glacial questions. T. G. BONNEY.

REPORTS AND PROCEEDINGS.

I.—GEOLOGICAL SOCIETY OF LONDON.

November 6th, 1901.—J. J. H. Teall, Esq., M.A., V.P.R.S., President, in the Chair. The following communications were read:—

1. "Note on a Submerged and Glaciated Rock-Valley recently exposed to view in Caermarthenshire." By Thomas Codrington, Esq., M.Inst. C.E., F.G.S.

This valley was brought to light in building a bridge across the River Towy at Dryslwyn, 9 miles from Caermarthen, to which the tide now flows. At the bridge the valley is narrowed to about half a mile. Near the water-edge the rock sloped down gradually to 23 feet below summer water-level, and was glaciated in large furrows a foot or more across, and striated blocks of grit rested upon it. About 60 feet farther out into the river, rock was not met with till depths of from 34 to 42 feet below summer level were reached, and the rock-surface was found to be sloping towards the south at an angle of from 28° to 18° with a vertical line; it was followed down to between 45 and 56 feet below summer water-level. Scratched stones were again met with in the clay near the rock. The glaciated surface on the northern bank is only 25 feet above sea-level; and the rock-surface is sloping down at a precipitous angle at 8 feet below sea-level at a distance of 18 miles from the mouth of the river.

2. "On the Clarke Collection of Fossil Plants from New South Wales." By Edward Alexander Newell Arber, Esq., B.A. (Communicated by Professor T. McKenny Hughes, B.A., F.R.S., F.G.S.)

This collection, numbering nearly 2,600 specimens of all kinds, including some 80 fossil plant-remains, was presented to the Woodwardian Museum, Cambridge, in November, 1844.

The following is the stratigraphical succession in New South Wales:—

4. Wianamatta and Hawkesbury Beds.
3. Newcastle Beds.
2. Marine or Muree Beds.
   - *c.* Upper Marine Beds.
   - *b.* Lower Coal-measures.
   - *a.* Lower Marine Beds.
1. *Lepidodendron*-beds (Arowa, etc.).

Four species from the Wianamatta Series are described, fourteen species (including one new one) from the Newcastle Series, and two from the Arowa Beds. Of the twelve new types described by McCoy,[1] five (namely, *Odontopteris microphylla*, *Sphenopteris plumosa*, *Glossopteris linearis*, *Phyllotheca ramosa*, and *Ph. Hookeri*) are no longer considered as such. One new type has been added.

The age of the beds is then discussed. Such evidence as the few plants in the Clarke Collection afford supports Feistmantel's conclusion that the Wianamatta Beds are of Triassic age. *Thinnfeldia odontopteroides* occurs in Rhætic beds in South America, and the identification of Rattee's *Salisburia palmata* with the American *Baiera multifida*, and a comparison with the Rhætic *Baiera Steinmanni* of Chile, is a new point in favour of this conclusion. The plants also support Feistmantel's opinion that the Newcastle Beds are equivalent to the Permian of Europe. The exact horizon and age of the Arowa Beds must for the present remain doubtful.

3. "On an Altered Siliceous Sinter from Builth (Brecknockshire)." By Frank Rutley, Esq., F.G.S.

[1] Ann. Mag. Nat. Hist., 1847, vol. xx.

A rock-specimen, given to the author many years ago by the late H. W. Bristow, forms the main subject of this paper. It shows no trace of original sand-grains; it is compact, and with a fracture platy to conchoidal; small splinters of it can be fused on their edges to a white, frothy glass. Under the microscope the rock is decidedly tufaceous, containing small fragments chiefly of pumice, less often of crystals which are apparently epidote. In the slides of this rock and in some of the siliceous sinters from New Zealand used for comparison, there are small patches of a brown substance which may possibly be of organic origin; in connection with it, Professor Weed's discovery of algous growths in some of the New Zealand sinters is mentioned. A specimen of hard breccia, also from the vicinity of Builth, is described. The cement of this rock is also possibly siliceous sinter, as well as some of the fragments, which latter show faint evidence of the inclusion of little shreds of pumice.

II.—Manchester Literary and Philosophical Society.

October 15th, 1901.—Mr. Charles Bailey, President, in the Chair.

Mr. R. D. Darbishire, F.S.A., exhibited a large collection of the Eolithic implements of the Kentish plateau, and illustrated with map and section the outline of the denudation of the valley of the Weald, leaving a drift-deposit on the remaining Chalk of the north and south escarpments.

In the process many levels of river-gravels had been fixed, and partly occupied by stone implements of successive ages, mostly much mixed up in the redeposition of the gravels by succeeding movements. He described the general facies of the so-called Palæolithic implements from river deposits in France and England, and their peculiar modes of manufacture by 'chipping' or flaking, and shapes; and confessed inability to determine the uses of such tools or any characteristics of the men who made them. They were fossil indications of man with mind, skill, and purpose, and that was all. He then referred to the late Sir Joseph Prestwich's announcement of Mr. B. Harrison's great discovery of stone implements in the drift covering the remaining chalk plateau, quoted important adhesions, and referred to the expressions of scepticism by Sir J. Evans, Professor Boyd Dawkins, Sir H. H. Howorth, and others.

Exhibiting a very complete and well-arranged series of the plateau remains, Mr. Darbishire, after claiming large personal familiarity with stone implements, proceeded to vindicate the primeval and distinctive character of the same by reference to :—(1) The peculiar character of (*a*) the material used, and (*b*) the uniform and extreme 'patination' of most specimens. (2) The peculiar shapes of the same, showing several separate designs (*c*) in lateral curves (like bites out of a cake), sometimes duplicated with a point left between; (*d*) in instruments with bold lateral curves on each side of a strong, sometimes sharp, sometimes obtuse point; (*e*) in flat flints, with chipped edges more or less all round; and (*f*) in repudiation of a vague dismissal of the remains in question as 'wastrels.'

(3) The peculiar and original fashion of chipping the flint *perpendicularly through the thickness* so as to remove the natural edge (sharp and rough) of the stone, and the general absence of work on the sides of the tool. (4) The collective facies of the mass, unembarrassed by admixture of forms known as Palæolithic. And lastly to (5) a very decided declaration that after many years' study of stone implements from various countries and ages, he had never seen an eolith amongst palæoliths, or a palæolith amongst eoliths.

In conclusion, he declared his unhesitating concurrence with those more learned and skilful observers who believed that in the so-called Eolithic remains Mr. Harrison had revealed the fossil indications of the mind and purpose of a race of men long anterior to that of the Palæolithic record, and confirmed a precedent geological era for the habitation in this country of Man, actually qualified by invention, design, skill, purpose, and perseverance—still the fundamental characteristics of the race—which with the great development and inheritance of civilization, the arts, and literature, is now possessing the earth.

CORRESPONDENCE.

FAXE OR FAXOE.

Sir,—I recently saw it stated in the Geological Magazine that Faxe is the correct name of the well-known locality for fossils in Zealand, and that the name Faxoe used by Darwin and others is impossible, as the place is not an island. This is not conclusive. May not the place have formerly been an island, and may not Faxe be a modern corruption of an older name Faxoe? It is well known to philologists, and to all who have paid any attention to place-names, that there are many places which are proved by their names to have once been islands, though they are no longer so. The late Isaac Taylor, in his interesting book, "Words and Places," mentions several such names in the Valley of the Thames and in the Eastern Counties, as well as elsewhere. J. R. Dakyns.

Snowdon View, Gwynant, Beddgelert.

FOSSILS WITH GARNETS.

Sir,—*Verbum sapientibus* contains in itself no proposition: it may equally be either *sat sap.* or sat upon *insip.*; in this style, "Words are worth nothing, therefore take mine." But certainly, in a case like the present, where statements of opposite import are both alike quotations from the "traditions of the elders," the old motto of the Royal Society, for those in a position to adopt it, *Nullius per verba*, is the best Verbum Sap.

THE CIRCULATION OF SALT.

Sir,—In connection with recent questions concerning the circulation of salt I would like to call attention to a curious phenomenon described by Messrs. F. W. and W. O. Crosby in the *Technology Quarterly* (U.S.A.), vol. ix, No. 1, March, 1896. I refer to the

"*Sea mills of Cephalonia*" (Greece). "The mills are driven by a current of sea-water which flows into the land for about fifty yards through an artificial channel, finally disappearing amid clefts and fissures in the limestone rock" (Baedeker). "The boundaries of this influx have never been definitely determined, but it certainly extends along the coast for nearly half a mile" (loc. cit.). Messrs. Crosby estimate the daily consumption of sea-water at 6,000,000 cubic feet. H. E. Strickland has also described these sea-mills (Proc. Geol. Soc., xi, pp. 220, 221).

A. K. Coomara-Swamy.

Worplesdon.

SALTER'S UNDESCRIBED SPECIES.

Sir,—In my first paper on some of Salter's Undescribed Species (Geol. Mag., 1900, Dec. IV, Vol. VII, p. 303, Pl. XII) there is an unaccountable omission, which has only within the last few days been brought to my notice. There is an absence of any reference to the specimen represented in Fig. 7 on the accompanying plate. In what manner the oversight occurred I am unable to discover, as a description was ready for publication with the rest of the paper. The specimen figured, which is referable to the species *Niobe solvensis* (Hicks), is of not a little interest, because it is the one mentioned by Salter (Cat. Camb. Sil. Foss. Woodw. Mus., 1873, p. 23, *a* 469) under the name *Asaphus Menapiæ.* The following description is given by him (*loc. cit.*) : "*Asaphus Menapiæ*, Hicks (undescribed). A large species with smooth tail-piece." It comes from the Tremadoc rocks of Ramsey Island, and was presented to the Woodwardian Museum by Dr. Hicks. It occurs on the same piece of rock as the type-specimens of *Calymene vexata* (Salter) (? = *Neseuretus recurvatus*, Hicks) and *Calymene ultima* (Salter) (? = *Neseuretus quadratus*, Hicks), which I have described and figured in the paper above mentioned. The piece of rock bears Salter's label with these names; also a later label in Tawney's handwriting, with the inscription "Salter's MSS. names not adopted exactly by Hicks when he described the fossils." This remark is borne out also by the fact that this pygidium of *Asaphus Menapiæ* does not agree with that of *Niobe menapiensis* (Hicks), as figured and described by Hicks (Q.J.G.S., vol. xxix, 1873, p. 46, pl. iv, figs. 1–9), but with that of *Niobe solvensis* (Hicks), described and illustrated at the same time. Hicks makes here no mention of the name *Asaphus Menapiæ*, and was apparently ignorant of its retention in the Cambridge Catalogue, which was then on the eve of being published. The specimen of *A. Menapiæ* is a slightly distorted internal cast of the pygidium, measuring 26 mm. wide and 16 mm. long, and it agrees in all its visible characters with Hicks' *Niobe solvensis.*

In my paper there is also an obvious misprint in the numbering of the figures on the plate (Pl. XII). *Neseuretus quadratus* is represented by Fig. 6, not by Fig. 5, which represents *Neseuretus*, sp.

F. R. Cowper Reed.

Woodwardian Museum, Cambridge.

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