THE

GEOLOGICAL MAGAZINE:

OR,

Monthly Journal of Geology:

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

NOS. CCXCV. TO CCCVI.

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NEW SERIES. DECADE III. VOL. VI.

JANUARY—DECEMBER, 1889.

LONDON:

TRÜBNER & Co., 57 AND 59, LUDGATE HILL.

F. SAVY, 77, BOULEVART ST.-GERMAIN, PARIS.

1889.

HERTFORD:
PRINTED BY STEPHEN AUSTIN AND SONS.

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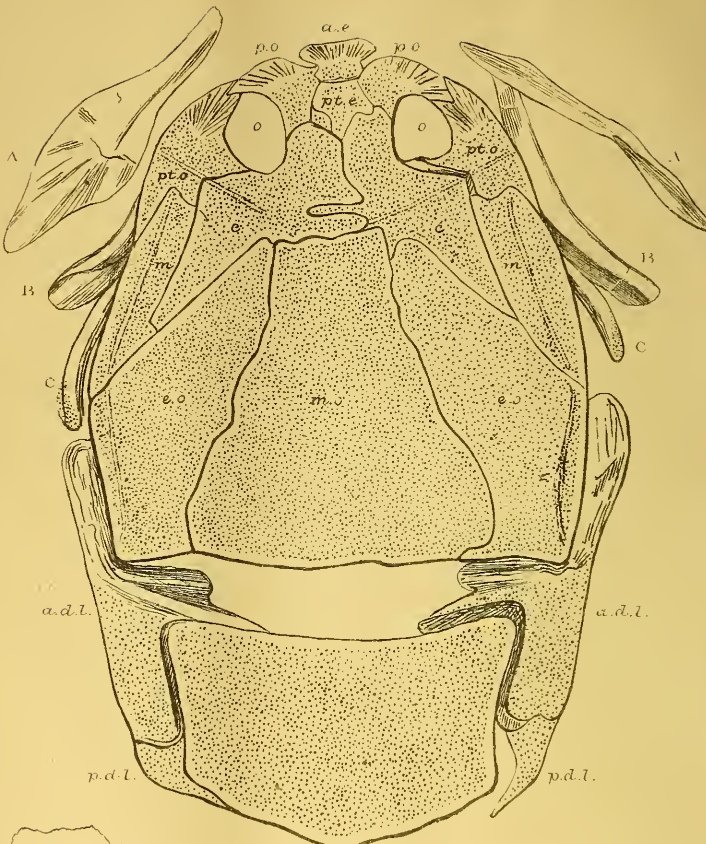
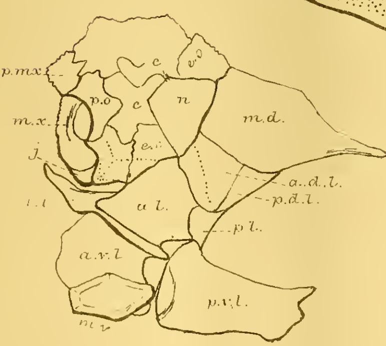
LIST OF WOODCUTS.

LIST OF PLATES.

1





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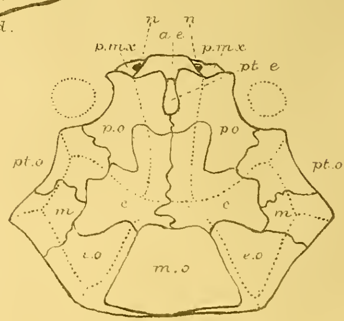


2

R. H. Traquair del.
E. C. Woodward lith.
West Newman & Co imp.

1. Homosteus. 2., 3. Coccosteus.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VI.

No. I.—JANUARY, 1889.

ORIGINAL ARTICLES.

I.—*Homosteus*, Asmuss, compared with *Coccosteus*, Agassiz.

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

(PLATE I.)

THE creature which forms the subject of the present communication is the same as that which was described as *Asterolepis* by Hugh Miller in his "Footprints of the Creator," and consequently its remains are at present better known to British geologists and palæontologists under that name. Why, then, alter a name which we have used so long? is a question likely to be asked by those who have not critically studied the complicated mesh in which the synonymy of the name "*Asterolepis*" is entangled.

The genus *Asterolepis* was proposed by Eichwald in 1840[1] for fragmentary remains of the exoskeleton of a vertebrate organism, from the Russian Devonian rocks, allied to *Pterichthys*, Ag. To these remains Agassiz also applied the name *Chelonichthys*, which he subsequently withdrew in favour of *Asterolepis* as having priority; and with them he also identified generically certain large bones and plates from the Lower Old Red of Dorpat, some of which were first figured by Kutorga[2] as "*Trionyx*" and "*Ichthyosauroides*," and of which a considerable number, collected by Asmuss, were reproduced in plaster and copies sent to Agassiz. A number of these casts were figured by Agassiz,[3] as of bones of "*Asterolepis*," some of which are generically identical with the creature of whose bones and cranial buckler many fine specimens from Thurso, largely collected by Robert Dick, came into the possession of Hugh Miller. And thus it was that these remains came to be figured by Hugh Miller as belonging to *Asterolepis*, although they had no affinity to the creature to which Eichwald originally gave that name, their identification with which being entirely due to a mistake of Agassiz, misled as he was by their mere external sculpture, consisting of small tubercles with stellate bases.

For, that "*Asterolepis*" cannot be applied to any of the remains from Dorpat represented by these casts, is unconsciously shown by

[1] Die Thier- und Pflanzenreste den alter rothen Sandsteins und Bergkalks in Nowgorodschen Gouvernement," Bull. Acad. Imp. St. Pétersburg, tome vii. p. 78.

[2] Beiträge zur Geognosie und Palaeontologie Dorpats, 1835–37.

[3] Poiss. Foss. du vieux Grès rouge, tab. xxxii.

Agassiz himself, isasmuch as he figured as "*Asterolepis ornata*," Eichwald, a nuchal or median occipital plate of unmistakeable Pterichthyan character,[1] apparently quite unaware of the significance of its shape. Nevertheless Agassiz in some controversial remarks on the subject insisted that his *Chelonichthys* (= *Asterolepis*) had nothing to do with *Pterichthys!*[2]

Now, in 1856, Asmuss published a thesis[3] in which he minutely described the Dorpat fossil bones, including the subjects of the aforesaid casts, and made out of them two genera, *Homosteus* and *Heterosteus*, with many species. In the former of these two, namely *Homosteus*, Hugh Miller's fish, the so-called "*Asterolepis* of Stromness," is clearly to be recognized.

Upon these facts Pander insists in his "Placodermen," and not only did he propose to replace "*Asterolepis*" by *Homosteus* in the case of Hugh Miller's fish, but believing *Asterolepis*, Eichw., to be altogether identical with *Pterichthys*, Agassiz, as the name is undoubtedly prior, he proceeded to cancel the latter name altogether.

Naturally Pander's views excited opposition in this country, where the names brought into use by Agassiz and Hugh Miller had become classic through the writings of these distinguished men. Sir Philip Egerton, who does not seem to me to have thoroughly understood the situation, fiercely combated the proposals of Pander in the following words: "Having read both sides of the question with great care, my own impression is that Prof. Eichwald may perhaps have included in his genus *Asterolepis* some fragments which he subsequently ascertained (through the more perfect Scotch specimens sent to Russia by Dr. Hamel) to belong to the genus *Pterichthys* of Agassiz, and hence discarding the majority, namely, *Asterolepis* proper, assigns this name to the minority, to the exclusion of the Agassizian name. In the mean time Prof. Agassiz, then engaged upon his 'Poissons Fossiles du vieux Grès Rouge,' received through Prof. Brown, from Eichwald himself, specimens of his *Asterolepis*, which had no reference to *Pterichthys*, but were identical with the genus *Chelonichthys* established upon specimens brought over from Russia by Sir Roderick Murchison, and of which other specimens were found in the Orkney beds. On making this discovery he at once relinquished his own name, *Chelonichthys*, and adopted *Asterolepis* of Eichwald. If now it is sought to supersede *Pterichthys* of Agassiz by *Asterolepis* of Eichwald, it is surely just that the term *Chelonichthys* should be retained for Eichwald's *rejectamenta*, rather than *Homosteus* of Asmuss, a name of much later date than that of Agassiz."[4]

But whatever the specimens from the Orkney beds may have been, if any one will only compare Agassiz's own figure of *Asterolepis ornata*, Eichwald ("Old Red," tab. 30, fig. 5), with the plate No. 10 in Pander's restoration of the same species ("Placodermen," tab. 6,

[1] *Op. cit.* tab. xxx. figs. 5, 6.
[2] *Op. cit.* appendix, p. 152.
[3] Das vollkommenste Hautskelet der bisher bekannten Thierreiche, Dorpat, 1856.
[4] Quart. Journ. Geol. Soc. vol. xvi. 1859, p. 122.

fig. 1), he will see that this specimen at least, far from having "no reference to *Pterichthys*," is the median occipital plate of a very closely allied form indeed. Without injustice to the memory of Sir Philip Egerton, to whom palæichthyological science is indebted for so much valuable work, it is clear that he had not sufficiently gone into this question at least, as the fact above noted was dwelt upon by Pander himself (*op. cit.* p. 16).

On the Continent, however, the name *Homosteus*, Asm., has been adopted for Hugh Miller's fish, and reasons have also been found for maintaining *Pterichthys* and *Asterolepis* as distinct genera, in a supposed difference in the articulation of the arms. In the previous volume of this MAGAZINE[1] I have shown that this supposed diagnostic mark is untenable, at the same time that I have sought to establish another on the mode of articulation of the anterior median dorsal plate.

But Agassiz's work, in which he classified "Asterolepis" among his "Cœlacanthi," a group generally equal to the Cycliferous Crossopterygii of more recent times, was the means of drawing Hugh Miller into mistakes of much greater importance than mere nomenclature. Accordingly, as Pander pointed out, Miller attributed to his *Asterolepis* "the teeth of *Dendrodus* and the scales of *Glyptolepis*," and made a very formidable creature out of it, ten to thirteen feet in length; indeed, referring one of the large Russian plates (*Heterosteus*, Asmuss) to the same genus, he calculated a length of eighteen to twenty-three feet for the entire fish. And his non-recognition of the true affinities of the creature led also to other mistakes in the identification of bones, to which allusion will be made in due course.

By Asmuss *Homosteus* and *Heterosteus* were placed in a family by themselves, *Chelonichthyda*, in a somewhat heterogeneous group of "Ganoidea loricata," the other families herein included being Spatularida, Acipenserida, Coccosteida, Pterichthyda, and Cephalaspida. As regards *Homosteus*, though, as Pander remarks, it is wonderful how, without knowledge of Hugh Miller's drawings or description, he was able to fit together the isolated plates at his disposal, yet, unacquainted with the orbits, he supposed the cuirass to belong exclusively to the body, and also entirely reversed its position on the animal.

Pander, however, classified *Homosteus* in McCoy's group of Placodermata and rightly gave it a place immediately after *Coccosteus*, interpreting as its median dorsal plate the one considered by Hugh Miller to be a "hyoid," and supposed by him to occupy a place between the rami of the jaws. This supposed hyoid plate was known to Hugh Miller only in an isolated form, but it fell to the lot of the late Mr. John Miller, of Thurso, to record a specimen in which it occurred in its natural position on the back behind the head, and so with absolute certainly to confirm Pander's view of the case. Mr. John Miller's collection having some years ago passed

[1] Notes on the Nomenclature of the Fishes of the Old Red Sandstone, GEOL. MAG. Dec. III. Vol. V. 1888, p. 508.

into the possession of the Museum of Science and Art, Edinburgh, I propose to make this, the most perfect specimen of *Homosteus* which has ever been found, the text of the following remarks on the genus.

Along with *Homosteus* it may, however, be as well to re-examine the structure of *Coccosteus* itself as a basis of comparison.

The reading of the cranial buckler of *Coccosteus* is much complicated by the fact that certain superficial grooves belonging to the lateral-line system are very conspicuous and apt to be mistaken for sutures, while the true sutures are visible with difficulty, and can only be made out in exceptionally well-preserved examples. They seem, indeed, to have almost entirely escaped the observation of Agassiz, as the lines on the head indicated on his restoration of *Coccosteus* ("Old Red," tab. 6, fig. 4) belong almost without exception to the lateral-line system. The figures given by Hugh Miller (Quart. Journ. Geol. Soc. 1859, p. 129, and "Footprints," 1st ed. fig. 11), in which he attempts to reduce the plates of the cephalic shield of *Coccosteus* to the same plan as that of the bones of the top of the head in the Cod, are much better, inasmuch as many of the true sutures are given; but it is also too plain that he also looked upon the superficial grooves as indicating the real boundaries of the plates which he considered as the homologues of the cranial roof-bones in osseous fishes. Pander's interpretation, although his figures give both sets of lines on the upper surface with considerable though not perfect accuracy, is correct only as regards the hinder part of the buckler, his reading of the anterior half being hopelessly wrong, and consequently his elaborate comparison with the arrangement in *Asterolepis* falls to the ground. By far the most correct restoration of the cranial shield of *Coccosteus* is that of Huxley,[1] in which he omits the superficial grooves altogether, and in which the only faults I can find are of omission, viz. the non-recognition of the median suture between the two central plates which he letters as "frontal," and of the *pair* of premaxillary bones on each side of that median bone in front, to which he applies the name "premaxilla."

In Pl. I. Fig. 2 I have given a sketch of the head of *Coccosteus decipiens*, Ag., the superficial grooves being given in dotted, the sutures in continuous lines, and as regards the names I have applied to the bony plates, I have thought it best to use as few as possible which might lead the reader to infer that I considered them the morphological equivalents of the cranial bones of ordinary fishes.

Posteriorly we have the trapezoidal *median occipital* plate (*m. o.*), flanked on each side by the triangular *external occipital* (*e. o.*). In front of these are the two *central* plates (*c.*), external to which and forming the antero-external margin of the buckler are three plates, *marginal* (*m.*), *post-orbital* (*pt. o.*), and *pre-orbital* (*p. o.*), the two latter forming the upper margin of the orbit. The two pre-orbitals come together in the middle line posteriorly only for a very short distance, in front of which they are separated by a narrow oval

[1] Dec. Geol. Survey, x. p. 30.

space open anteriorly, and in this space is lodged, first a small elliptical plate, the *posterior ethmoidal* (*p. e.*) and the median limb or stalk of the *anterior ethmoidal* (*a. e.*). This latter bone, the "premaxilla" of Huxley, is like a nail-head with a broken off stalk attached, the head forming the anterior point of the buckler, the stalk passing back between the pre-orbitals. On each side of it in front are the small nasal openings (*n.*), each being bounded externally by a small separate bone, the *premaxilla* (*p. mx.*). The orbit is bounded below by the "paddle-shaped" bone (*mx.* Fig. 3) representing the *maxilla*, which has a sort of resemblance to that in *Palæoniscus*, and to the posterior extremity of which is appended a small triangular plate (*j.*), the *jugal* or post-maxillary.

Turning now to *Homosteus*, we shall find that Hugh Miller's comparison of its cranial plates with those of *Coccosteus* is not so far amiss, of course, taking into account the faults of his reading of the buckler of the latter genus. In Fig. 1 I have sketched the configuration of the specimen of *Homosteus*, referred to by John Miller as having the dorsal plate *in situ*. Much of the bony substance having splintered off from the "specimen" itself, I have had a plaster impression taken from the "counterpart," which consequently reproduces the details of the original in a very much more perfect manner, and from this model the drawing has been taken. And I may add that every detail of the buckler here given is corroborated by another splendid specimen, also from the collection of John Miller, in which, however, the dorsal plate has got displaced to one side.

We find a wonderful correspondence in the arrangement of the bony plates, the differences appearing almost entirely due to the altered position of the eyes, and the assumption by the cranial shield of an antero-posteriorly elongated, instead of a broadly hexagonal figure.

The *median occipital* (*m. o.*), preserving its trapezoidal shape, has become much elongated, as have also the *external occipitals* (*e. o.*), while the *centrals* (*c.*) have become much smaller in proportion, and have come to take part in the inner boundary of the orbit, more, however, on the upper than on the under aspect; they are also in contact in front with the *posterior ethmoidal* (*pt. e.*), the hinder angle of which is inserted in a notch between their anterior extremities. The *marginal* (*m.*), also much elongated, is easily recognized; but it is now alongside of, instead of in front of, the external occipital, and the *post-orbital* (*pt. o.*) and *pre-orbital* (*p. o.*) have altered their relation to the orbit in a strange fashion. Separating internally, so as to allow the central to come into the boundary of that opening, they have thrown out processes which unite externally, and so in *Homosteus* the orbits come to be entirely enclosed *within* the buckler, instead of being *outside* it, as in *Coccosteus*. The last plate to be noticed is the *anterior ethmoidal* (*a. e.*), which occupies a position at the front of the snout exactly as in *Coccosteus*, but no trace is seen either of the small premaxillary, or of the nasal openings of that genus.

The lateral-line system of grooves is sparingly developed on the cranial shield of *Homosteus*. On each side the lateral groove passes along the external occipital and the marginal on to the post-orbital, where it divides into two branches, one of which passes outwards and forwards to the margin of the shield, while the other passes backwards and inwards to be lost near the middle of the central plate. If we compare this arrangement with that in *Coccosteus* (Fig. 2), we shall see that the plan is quite the same, although the extent of the groove-system is considerably diminished.

The facial bones of *Homosteus* are extremely difficult of determination, and I must frankly confess that I have come to no certain conclusions regarding them. In the specimen represented in Pl. I. Fig. 1 are three detached bones, A, B, and C, on each side of the anterior part of the cranium, by which B and C are also partly concealed, while on the right side the bone A is seen only in longitudinal section, having stood on edge to the bedding of the rock. When those bones are seen in connection with examples of the buckler, they alway occur in the same order, and isolated specimens of all of them are also in the collection of the Edinburgh Museum.

The bone A is broadest behind the middle, narrowest at each end, especially the anterior one. In the specimen here figured it is seen from the internal aspect, having apparently got turned over; but other specimens show that on the external aspect near the middle it had a patch of the usual tuberculation, with a short lateral-line system groove. This bone is figured by Hugh Miller as "lateral cerebral plate," but as many specimens in the collection show that its position was immediately below the edge of the antero-lateral portion of the buckler external to the orbit, the groove on its surface being a continuation of the transverse branch on the post-orbital, it is clearly the homologue of the paddle-shaped bone or *maxilla* in *Coccosteus* (Fig. 3). If this be the case then, we may assume that the bone B, following and parallel to it, is the mandible; but no traces of teeth can be found on either, or, indeed, on any bone which it is safe to refer to *Homosteus*. Like the Sturgeon it must have been edentulous.

The bone C is figured by Hugh Miller (Footprints, fig. 45*a*) as a clavical (here he meant what we now call post-clavicle); but, of course, such an interpretation founded on its superficial resemblance to the post-clavical of a modern Teleostean is here negatived by its position. Hugh Miller noticed the tuberculation of the outer side of one of its extremities, but in accordance with his theory of its position in the animal, he assumed this tuberculated portion to be its "head," or anterior extremity. The present specimen shows, however, that this extremity was posterior.

The last and crowning point of interest in the specimen represented in Pl. I. Fig. 1, is the exhibition of the dorsal cuirass *in situ*. Five plates are here seen, one median and two lateral, corresponding exactly to plates occupying a similar position in *Coccosteus*.

The central dorsal plate (*m. d.*) is so well known as Hugh Miller's supposed "hyoid," that it requires no further description, beyond the remark that its resemblance to that of *Coccosteus*, except in its short broad shape and the want of the posterior elongated peak, must be evident at the first glance. It is here shown in position, its broad margin being directed forwards, and lying parallel to the posterior margin of the cranium, from which it is here separated by a narrow gap, its obtuse point being free and posterior. Its lateral margins overlap on each side two other bones, of which the anterior one (*a. d. l.*) was figured by Hugh Miller as "non-descript latero-hyoidal plate," he being well aware of its relation to the median bone, though, in accordance with his theory of the latter, he reversed its position. Its relation to the skull was, however, correctly represented by Pander ("Placodermen," tab. 8, fig. 2*a*.). It consists of two parts, one flattened above, and applied anteriorly to the outer part of the posterior margin of the skull, by which as well as by the median plate it is overlapped, and another, narrower, forming a right angle to the flattened portion and running forwards a little way along the posterior part of the outer margin of the cranial buckler; in the angle between the two parts is a socket for articulation with a corresponding projection of the postero-external angle of the external occipital. Naturally Hugh Miller found himself at a loss to account for the presence of this socket. Different as the two bones are in shape, it is impossible not to recognize in this bone the homologue of the *anterior dorso-lateral* in *Coccosteus* (Fig. 3), though here the socket and peg have changed their positions on the bones concerned.

Behind this anterior dorso-lateral there exists in the specimen figured in Pl. I. Fig. 1, another and much smaller plate (*p. d. l.*) on each side, which has not previously been noticed. It needs no reasoning to perceive at once that this is the *posterior dorso-lateral* of *Coccosteus* (*p. d. l.*, Fig. 3).

It is curious that no undoubted remains of a ventral body-carapace like that of *Coccosteus* have occurred in connection with *Homosteus*; but, at the same time, I might mention that the plate (Footprints, fig. 37) designated "palatal plate" by Hugh Miller, looks to me as if it might well be the anterior median ventral, so far as its shape is concerned, though its great size may be considered as somewhat against the supposition. At all events there is no evidence for referring it to the palate.

There are also several other bones figured by Hugh Miller and contained in the Edinburgh Museum, which from the way in which they occur, associated with other undoubted remains of *Homosteus*, clearly belong to the same fish, but whose position in the body I cannot speculate upon. These are the "operculum" (Footprints, 5th edition, fig. 39), the very curious bone (*ib.* fig. 43) spoken of by Hugh Miller, as "shoulder (*i.e.* coracoid?) plate"; his so-called "dermal bones" (*ib.* fig. 44). What the bones *c* and *e* in fig. 46 of the "Footprints" are I am also unable to determine.

But a number of the other remains figured in the "Footprints" as "*Asterolepis*" belong not to *Homosteus*, but to *Glyptolepis* *paucidens*, Ag. sp. These are the scales (figs. 26 and 27), the mandibles (figs. 32, 33, and 36), the sections of teeth (figs. 34 and 35); the bone *d* (fig. 46), which I look upon as the lower end of the clavicle; and the interspinous piece (fig. 48), which Hugh Miller figured as the "ischium of *Asterolepis*." The latter is indeed a very curious bone, and it is not at all remarkable that the author of the "Footprints" should have sought to identify it with the basal bone of a ventral fin constructed in teleostean fashion. Knowing that such a pelvic fin-element could hardly have existed in either *Homosteus* or *Glyptolepis*, the bone was long a puzzle to me, until one day I observed a very similar bone supporting the distal set of interspinous bones of the second dorsal fin in a specimen of *Glyptolepis leptopterus*, also in the Hugh Miller Collection. A similar bone supporting three smaller interspinous elements was described and figured by Sir Philip Egerton in *Tristichopterus*.[1]

As regards the *species* of *Homosteus*, which has been under consideration, no specific name was given to it by Hugh Miller. By Morris[2] it was catalogued as the "*Asterolepis Asmusii*" of Agassiz, but I know not on what ground. Certainly I can find no resemblance between the sculpture of the surface of the plates of *A. Asmusii*, as given in Agassiz's figures, and that which characterizes the present fish in which the tubercles are small, sharply defined, with prominently stellate bases, and for the most part closely placed. Nor can it be identified with the species of *Homosteus* described by Asmuss from Dorpat, and so I would propose that for the future it be known as *Homosteus Milleri*.

EXPLANATION OF PLATE I.

(In all the figures the same letters refer to the same things.)

m. o. median occipital. *e. o.* external occipital.[3] *m.* marginal. *c.* central. *pt. o.* post-orbital. *p. o.* pre-orbital. *pt. e.* posterior ethmoidal. *a. e.* anterior ethmoidal. *p. mx.* premaxillary. *n.* nasal opening. *m. d.* median dorsal. *a. d. l.* anterior dorso-lateral. *p. d. l.* posterior dorso-lateral. *a. l.* anterior lateral. *p. l.* posterior lateral. *i. l.* interlateral. *a. v. l.* anterior ventro-lateral. *p. v. l.* posterior ventro-lateral. *m. v.* posterior median ventral. A, B, C, three facial plates lying below the margin, anteriorly of the cranial shield of *Homosteus*.

Fig. 1. Sketch of a specimen of *Homosteus Milleri*, Traq., in the John Miller Collection, Museum of Science and Art, Edinburgh.

Fig. 2. Restoration of the top of the head in *Coccosteus decipiens*, Ag. The dotted lines indicate the distribution of the grooves of the lateral-line system.

Fig. 3. Sketch of a specimen of *Coccosteus minor*, H. Miller, from Thurso, the vertebral column omitted. Hugh Miller Collection.

II.—Note on the Lower Cambrian of Bethesda, North Wales.

By Professor T. McKenny Hughes, M.A., F.G.S.

Until quite lately no fossils had been found in the Lower Cambrian of Bethesda. Indeed we had almost given up the hope of obtaining any evidence of the life of the period represented by them, because of the great alteration in the character of the rock resulting from the severe mechanical action to which it had been

[1] Dec. Geol. Survey, vol. x. p. 52, plate 5. [2] Catalogue British Fossils, p. 318.
[3] On Plate I. in Fig. 2, for *p.e.* read *pt.e.* In Fig. 3, for *e.n.* read *e.o.*

subjected. The announcement that Mr. Robert Lloyd had discovered fossils in the uppermost slate beds of the Penrhyn Quarries was therefore received with great interest, which was increased when it was found that some of these were in a sufficiently perfect state for determination, and that they were referred by Dr. Woodward[1] to a new species of a well-known Lower Cambrian genus of Trilobite.

I have since found fragments of another smaller species in the same beds not far below the Bronllwyd grit.

The zeal of Mr. Robert Lloyd, to whom I am indebted for much valuable information, especially with reference to the subdivisions and measurements of the Penrhyn Slates, has recently been rewarded by the discovery of traces of fossils in the part of the quarry known as Sebastopol, some 1200 feet lower in the quarry than the *Conocoryphe viola* zone.

Unfortunately these specimens also are too obscure for determination. They appear to be the casts of the carapace of a Trilobite filled with radiating mineral matter, and are of somewhat the same size and outline as those of *Conocoryphe viola*.

I have thought it might be of interest to offer a few notes on the rocks seen in a traverse from a point a little west of Bethesda across the Penrhyn Quarries over Moel Perfedd to Cwmbual on the south, with a view to fixing the position of the only fossil zones yet known in that area, and pointing out the localities where it seems most probable that fossils may yet be found. The accompanying diagram section will facilitate reference :—

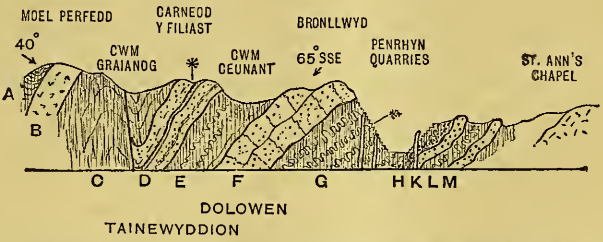


Fig. I.—Diagram Section N.N.W. and S.S.E. from St. Ann's Chapel to Moel Perfedd. Length of Section 2¼ miles. The cleavage is nearly vertical N.N.E. and S.S.W.

* Indicates horizons at which fossils have been found.

A. The slates south of Moel Perfedd are dark grey irregularly cleaved lumpy sandy beds which at one place dip at an angle of about 40° to the north, that is, towards the felspathic rock.

B. This felspathic rock behaves as an intrusive mass. It is not seen down the hill side to the bottom of the valley.

C. Black and grey slaty rock fills up the interval between Moel Perfedd and Carnedd Filiast. In this Cwm Graianog has its origin.

D. The grit of Carnedd Filiast is inclined at a high angle and runs down the north side of Cwm Graianog protruding in rough bosses near Tainewyddion. Here it is split up by finer beds upon the face of which *Cruziana semiplicata* is abundant.

[1] Quart. Journ. Geol. Soc. vol. xliv. pp. 74–78, pl. iv. 1888.

In the talus under the cliff above Tainewyddion I found several specimens of *Lingulella Davisii* in a grey or yellow flag similar to that which occurs subordinate to the Carnedd Filiast grit. We are here evidently in the Middle Lingula Flags, which is represented chiefly by massive coarse grit. When we wander south into the district west of Arenig, there are still beds of strong grit at this horizon, but they are thin and quite subordinate to the flags and slates. The shore line was further north, and therefore in that direction we may expect to find the rocks of this age either represented entirely by shore deposits or overlapped against the rising ground by the newer part of the series.

Below the Filiast grit we should search for Lower Lingula and Menevian, and we shall see that there are black slates about that horizon from which as yet no fossils have been recorded.

E. Between Carnedd Filiast and Bronllwyd there is a depression which, further east, forms the head of Cwm Ceunant. This hollow is due to the occurrence here of a soft pale grey and white irregularly cleaved sandy slate. It seems to be in the line of the softer rock which runs through the gap between Elidrfawr and the rocky hill which rises from Marchlyn Bach on the west. These slaty beds pass up into the sandstone and grit of Carnedd Filiast and down into the grit of Bronllwyd. A soft black slate is seen in this division above Pengareg; any part of this series might be expected to yield fossils and it is here we should search for Lower Lingula Flags and Menevian.

F. The grit of Bronllwyd, which comes next in descending order, and rests immediately upon the Penrhyn slate, consists chiefly of a quartz grit and conglomerate, containing fragments, generally about the size of a pea. It passes into banded grit and sandstone, with beds conspicuously mottled black and grey, the black being due to large mudpans, and included masses of shale pinched up in it, so as to occur very irregularly through what otherwise appear to be somewhat evenly lying beds. This proves that a considerable amount of deformation often takes place even in a massive grit. The alteration of a grit by cleavage into a schistose quartz rock is well known, but this fold and fault deformation is also clearly a common phenomenon.

The Bronllwyd grit is of great thickness, and rolls over rapidly to the south-east, a dip of 55° being observed in one place above the Penrhyn Quarry.

G. The Penrhyn slates, which next succeed in descending order, are wonderfully uniform in character throughout, but yet a close observation of those small differences which affect the quality of the slate has called attention to slight variations of texture, as well as the more marked difference of colour, and enable us to make out the fallowing subdivisions:—

a. Immediately below the Bronllwyd grit is a glossy light apple-green slate, somewhat like a hone stone in character. It is a useful slate, and was used for the roof of the new church at Bethesda. It has not been much worked, except in one quarry, known as Crimea, a name much in people's minds at the time it was opened. In this quarry the new Trilobite, *Conocoryphe viola*, Woodward, was found by Mr. Lloyd. I verified its occurrence by finding several specimens myself. I have been able to add also another smaller species of Trilobite, but my specimens are too fragmentary for determination. There is also not uncommon in these beds a rounded pear-shaped body, with a granular texture and banded structure, perhaps some form of sponge. There are hardly any indications of bedding, except the regular roof of grit and the constant but less regularly occurring purple slates below. There are a few sandy lines and bands, which, however, can rarely be followed for more than a foot or so. The fossils appear on distorted bed faces, generally lying within 5° or 10° of the cleavage planes.

These beds are locally known as the Upper Green Slate, Maenty-gwyrdd uchaf, or Cerrig llwydion, and the estimated thickness is 120 feet.

The Upper Green Slate passes down into the next subdivision.

b. Purple Slate. The way in which this comes on shows that the colour does no go for much, as it occurs in a blotchy irregular manner, suggestive rather of local circumstances affecting the iron in the rock at any time subsequent to its deposition. It has often a silky texture; this character being seized upon by the workmen, who called it the Silky Vein, or Cerig Rhiwiog, as distinguishing it from the more sandy and irregular mass of slate below. It is of about the same thickness as the Upper Green Slate, viz. some 120 feet.

c. A coarser and less evenly cleaved rock which is called Bastard slate, and is said to be in thickness about 850 feet.

d. The old blue slate, so called first because it was one of the earliest quarried, and next because of its colour. The colour is, however, more green than what we should understand by blue when applied to a slate. This difference is lost in the Welsh name Careglas. It is in the upper part of this band that the traces of fossils have been recently found in the working known as Sebastopol, according to Mr. Lloyd's estimate, some 1200 feet lower than the Crimea quarry, or zone of *Conocoryphe viola*.

e. A bed of red gritty rock, known as Gwenithfaengoch, about 15 feet in thickness, separates this slate from

f. The Lower Purple Slate, Cerig Cochion, which attains a thickness of 300 feet, and passes down through

g. About 240 feet of veined slate, known as Cerig gleision gwythienog, into

h. The Lower Green Slate, Gwyrdd isaf, in which there is some 300 feet of workable slate.

H. Greenish sandy beds, with included fragments of older rock, are just touched at the bottom of the quarry. These are probably the top of the passage beds into the schistose fragmental rock, which is associated with

K. The cleaved grit and conglomerate, seen near the bridge, south of Bethesda.

L. Below these come the slates of the Tramway cutting, to be more fully described in illustration of the chief point of this communication, viz. the nature of the deformations which have taken place in the Penrhyn slates, and their bearing upon the manner of occurrence of fossils in different parts of the series.

M. To the north of these the St. Anns Grit crops out. It was touched in breaking ground for the new brickworks near St. Anns, and was quarried for use in some of the buildings connected with them. It contains numerous and conspicuous grains of hyaline quartz, as well as of pink quartz and jasper, in this resembling the Cambrian grits of the Bangor-Carnarvon area.

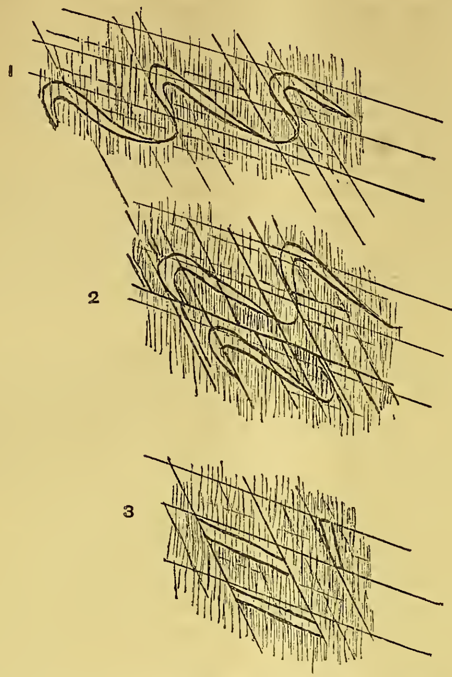
Such is the succession of rocks seen south of Bethesda. There is no proof here of a repetition by complete inversion of any large portion—though the rocks have been much crushed up in detail.

One of the various difficult questions raised by the examination of this district is, What were the conditions which favoured the preservation of fossils only here and there in this great thickness of rock? The first and most obvious reason which suggested itself was that the great unyielding mass of the Bronllwyd Grit, immediately below which the fossils occurred, saved the underlying bed from the severity of the crush, and that the finer rock therefore split along bedding planes parallel to the base of the grit. An examination of the section, however, soon showed that this explanation would not hold: for the fine green rock is strongly cleaved right up to the base of the grit, and the grit itself has evidently suffered much in the crush, as shown by the squeezed-up mudpans and the contortions of the finer parts. Moreover, if the occurrence of fossils 1200 feet lower down in the quarry and far from any unyielding mass of grit be verified, we must seek some other reason for the exceptional preservation of such traces.

When in the quarry we endeavour to seek an explanation, we notice first that the fossils do not occur in the planes of bedding as inferred from the lie of the large consecutive masses of rock of different lithological character. Yet the fossils can never have been of such rigidity as to have been thrust into approximate coincidence with the planes of cleavage during the crush which produced it. Further we observe that there are no bands or lines suggestive of stratification running parallel to the dip inferred from the alternating beds of grits and slates. Any such bands and lines are irregular, interrupted, of small extent, and at all angles to the constant cleavage.

In rocks of such a uniform character as the Penrhyn Slates the relative displacement of parts is never easy of detection. If, however, we follow them to where some of the beds are picked out by differences of colour and texture, so that we can disentangle the complications, we get a clue to the processes by which the rock has been reduced to its present state, and an explanation of the irregular manner of occurrence of the fossils. In the Tramway cutting for instance, between the St. Ann's Road and the Quarries, we see that the bands which here mark bedding are twisted, drawn out, doubled back, interrupted, and repeated, in every variety of fold and break—of which examples are given in the subjoined woodcut, Fig. II.

Fig. II.



The selection shows three stages of the same class of movements, where the folds are more conspicuous in the first and the faults in the last, so that in it portions of the folds are faulted out of the field of view altogether. This is not cleavage, nor necessarily connected with cleavage, and on this distinction I would lay particular stress. Many rocks, such as the gnarled series of Anglesea and parts of the Devonian of Devonshire, show the fault and fold structure with inconspicuous cleavage. This is the action which produces schistosity in all sorts of rock, modified, of course, by its original character, whether, for instance, it is a soft rock with subordinate hard beds, or a somewhat uniform mass with veins. The essential character of the fold and fault structure being that there is a relative displacement of considerable portions of the mass, producing what I have elsewhere called a universal slickenside. The essential character of cleavage being that there is no such displacement of considerable portions of the rock, but only a molecular rearrangement producing a tendency to split along an indefinite number of parallel planes.

Cleavage may affect a rock in which the bedding planes are not contorted, so that fossils are often found along an even line on the edges of the cleavage planes.

Cleavage may be superinduced upon a rock already affected by fault and fold structure, especially in a rock of a fine and homogeneous character, and this is what seems to have taken place in the case of the Penrhyn Slates.

Doubts as to the nature of cleavage may often be traced to the want of a clear distinction between these two superinduced structures—the molecular rearrangement due to cleavage and the kneading of the mass with *fault and fold schism.*

Why pressure should in one case crumple up the beds and in another make them yield as a plastic body, is a separate question probably capable of receiving different correct answers in different cases. What we are aiming at now is the establishment of the fact that there is this two-fold action, and resulting different structure, and the application of it to the explanation of some stratigraphical difficulties.

In these lower Penrhyn Slates the direction of displacement of well-marked beds is not even generally coincident with cleavage. We see here evidence that there is not only a thickening of homogeneous masses by molecular movement approximately at right angles to the direction of pressure as indicated by the cleavage, but also a folding and crumpling of the beds, so that one layer is repeated three or four times in the same vertical section.

Thus we get a suggestion of the reason why fossils may be found only here and there in a rock-mass which appears to be throughout of a similar character and to have been subjected to similar conditions. The cleavage often leaves the fossils on planes along which the rock will not split, at the same time distorting them beyond the possibility of recognition in small fragments. But when the rock has been crumpled and folded previous to or coincidently with the cleavage, some specimens here and there will lie on faces which have suffered less deformation or coincide with easy divisional planes.

The great rock-masses near Bethesda roll away in great undulations, having a general dip to the south and east; but subordinate masses are puckered, behaving under this enormous pressure as if plastic, the greater surface extension being compensated by diminished thickness and *vice versâ.*

Ramsay[1] pointed out that the vertical extent of some of these beds was probably greatly in excess of their original thickness.

This kind of thing is, of course, most likely to occur in such cases as that which we are considering, where the newer beds abut against an axis of older rocks which have been already squeezed and shrunk beyond the possibility of much further compression, just as in a crowd the man who is jammed against the wall or post gets most hurt.

We further notice that along the old Archæan axes two things happen which account for a very rapid disappearance of beds which are seen to be of great thickness in a closely adjoining area.

[1] Mem. Geol. Survey, vol. iii. pp. 190–196.

There is first the accumulation in the hollows and an overlap of the later over the younger part of the same series as the successive deposits creep up the flanks of the submerged land.

And, secondly, there is the exaggeration of the thickness of the mud accumulated in the hollows when pressure supervenes and squeezes it up against the base of the cliffs and steep mountain chains of the ancient submerged land.

Thus the manner of occurrence of the fossils in the Penrhyn quarry throws some additional light on the processes which have modified the older rocks even to the exaggeration of thickness.

There is not such a great difference in the thickness of the lowest part of the series at Bethesda and Bangor, and even that difference can be much reduced by allowing for the increase in the apparent thickness of the Penrhyn slates by squeeze.

The still greater missing series at Carnarvon may be accounted for by the overlap of higher over lower Cambrian against an important sea-bordering Archæan mountain range. The lowest Cambrian beds at Carnarvon were thus a higher and newer part of the system, and being nearer the tops of the mountain ridges escaped the great crush that caught the older and deeper beds thrown down nearer the base of the ancient range.

III.—Notes on the Physics of Metamorphism.

By Alfred Harker, M.A., F.G.S.,
Fellow of St. John's College, Cambridge.

THE problem of the metamorphism of rock-masses is one in which increased study has not led to unanimity of opinion. The literature of the recent Geological Congress in London suffices to remind us, how widely divergent are the conclusions to which various geologists have been led by researches in the field. Since, then, the *a posteriori* line gives such very different results in different hands, it may be worth while to revert for a moment to the deductive method, and try to trace the consequences, in this connexion, of admitted physical principles.

Since some definition of our subject is necessary, we will, for the present purpose, group together under the name metamorphism all processes which result in a partial or complete crystallization or re-crystallization of solid masses of rocks. Such changes are usually effected through chemical re-arrangements, and are often attended by the development or creation of special structural planes in the rock-masses. Those processes which do not appear to demand either a high temperature or a high pressure, such as the conversion of sandstone into quartzite by deposition of interstitial quartz, although logically included here, will not be discussed. We may conveniently distinguish them as *hydro-metamorphism*, recognizing the important part played by water in changes of this kind.

The geological manuals lay down a fundamental distinction between *contact*- and *regional*-metamorphism; but from our present starting-point we arrive at a somewhat different division. It is indeed evident that what is essential to contact-metamorphism is not the proximity of an eruptive mass, but simply an elevation of temperature; and, so far as chemical and mineralogical changes are concerned, it is immaterial whether the heat be conducted from some neighbouring source or generated in situ by mechanical or other means. It appears, again, from the writings of many geologists who invoke the operation of mechanical force in explanation of metamorphism, that they require nothing of that agent beyond the generation of heat by the crushing of the rocks operated upon. A theory based on these lines fails to show any cause for difference between the results of dynamical and of contact-metamorphism. That differences of kind exist, is, however, generally admitted. Certain minerals, such as andalusite, tourmaline, garnet, and idocrase, are known to be especially associated with the alteration of stratified rocks at high temperatures. On the other hand, there are changes, such as the amphibolisation of pyroxene, the saussuritisation of plagioclase, the conversion of potash-felspar into white mica and quartz, and the production of sphene at the expense of titaniferous iron ores, which are characteristic of altered rocks showing clear evidence of mechanical stress. These two phases of metamorphism by no means exhaust the possibilities, but they apparently compel us at the outset to recognize as distinct from one another a *thermo-* and a *dynamo-metamorphism*, the pressure in the latter case operating not through the medium of heat generated, but immediately. In short, we must admit the *direct* correlation between mechanical and chemical energy, to which experimental results unmistakably point.

While allowing the potency of pressure as a factor in geological transformations, many writers seem reluctant to admit it to a rank co-ordinate with temperature, as one of the conditions governing all chemical processes. They quote the experiments of Mallet, but overlook those of Cailletet and Spring. But if the chemist can, for the most, neglect in practice the effects of variations of pressure on solid bodies, it is only because the range of pressure in his experiments is comparatively small: the laboratory of nature knows no such restrictions. In parts of the earth's crust with which geological research is concerned, there must be enormous pressure, as well as extreme temperature; and these two, though often locally coinciding, must be physically independent. For rough purposes we may separate four sets of conditions, which may exist in various places, and which may be expected to govern the atomic forces in different manners, giving rise in their several provinces to different chemical combinations:

(i). Low temperature and low pressure (*hydro-metamorphism*).
(ii). High temperature and low pressure (*thermo-metamorphism*).
(iii). Low temperature and high pressure (*dynamo-metamorphism*).
(iv). High temperature and high pressure (*plutono-metamorphism*).

The first, in the widest sense, will embrace various chemical changes which go on chiefly near the surface of the earth. The second will be typically represented by 'contact-metamorphism,' but will also include cases in which the crushing of rocks under a moderate pressure gives rise to the generation of heat sufficient to produce a considerable rise of temperature. The third set of conditions will be best exemplified when pressure acts on a rock-mass not rigid enough to offer great resistance to crushing. A good illustration of its effects is seen in satiny slates or *phyllades*, such as those of Fumay, and perhaps of Llanberis and Michigan. These rocks, distinguished from mere clay-slates, must in some cases be classed as highly metamorphic. They appear to consist largely of authigenic minerals, and their highly-developed cleavage-structure is in fact a micro-foliation.

By applying to various districts of altered rocks this distinction of thermo- and dynamo-metamorphism, that is, by considering the proximate instead of the mediate causes of the chemical transformations, we may possibly find a clue to some apparent anomalies. One of these is the interpolation of thermo-metamorphic rocks in the midst of a region of dynamo-metamorphism. Such are the puzzling *cornéites* (composed of biotite and quartz), the garnetiferous and other special rocks of the Remagne and Bastogne district in the Belgian Ardenne. Their peculiarity seems readily to connect itself with the facts that they occur in the cores of anticlinal folds, where they must have been crushed upon themselves, and that the rocks thus affected, unlike their neighbours, are hard beds which would offer resistance to the deformation, and so give rise to the generation of heat.

It is not to be expected, however, that the varied mineralogical phenomena of a great metamorphic region will in general divide themselves into those due to high temperature and those due to high pressure. We have still to reckon with the case of great heat produced by the crushing of large masses of hard rocks under a pressure itself sufficient to modify materially the chemical affinities. The results produced by the superposition of thermo- and dynamo-metamorphism must be very complex: but we have no reason to suppose that these are comparable in any special way with the effects of a very high temperature and an intense pressure operating simultaneously. Indeed we must recognize in this latter a problem to which we can bring no direct experimental knowledge. Rocks which have been subjected to such conditions may presumably assimilate in some respects to those solidified from fusion under similar circumstances, although we should expect differences of textural and structural characters between the two. Failing a better name, we may accordingly use the term *plutono-metamorphism* to describe the profound changes in rocks implied in the joint influence of very elevated temperature and enormous pressure.

Experiments in the artificial reproduction of minerals have led geologists to lay stress on the presence of water during the transformation of rocks. This question does not touch the fourfold division suggested above. The temperature and the pressure must in general[1] completely define the conditions of the chemical pro-

[1] The exceptions being fusion and solidification, which cannot fairly be classed with metamorphism.

cesses involved (local solution, crystallization, etc., being included as chemical changes): water, if present, is one of the substances in which the recombinations are induced; in other words, a part of the rock. In pure thermo-metamorphism it is probable that the expulsion of contained water is the first effect of the rise of temperature, and observations show that this is true even of the liquid enclosed in the minute pores of crystals. High pressure acting upon rocks containing water will, as appears from theory and experiment, assist solution, but retard the complementary process of crystallization from solution. An important case will be that of a heterogeneous rock-mass in which the pressure varies from point to point. Here the solution of minerals at the points of maximum pressure, and their deposition where the pressure is least, must be a factor of great potency in the transformation of the rocks. Indeed this action, first pointed out by Sorby, may have a very important application to the separation of the several constituent minerals, and their segregation into lenticular streaks, which mark a common type of crystalline schists.

As is indicated by the last suggestion, the structural cannot be strictly separated from the chemical effects of pressure. Such separate consideration is to some extent possible only with comparatively soft rocks, which do not offer great resistance to deformation. In such cases it is useful to remember that a pressure in a definite direction is mathematically equivalent to a uniform pressure together with certain shearing stresses. Of these the former tends to produce a change of volume without change of shape, *i.e.* a uniform compression, the latter a change of shape without change of volume, *i.e.* a shear. Both these changes involve an expenditure of mechanical energy, but the energy expended in shearing will be small in the case of a soft rock. The term *shear* is here used to describe a continuous deformation, not a disruption. This seems a legitimate adaptation of the mathematical word, although since rocks are heterogeneous bodies, their "shearing" presents only a geometrical, not a physical, analogy to the shearing of elastic and viscous substances. In this useful sense the expression was introduced into geological literature by Mr. Fisher only four years ago, and it is to be regretted that it has been so soon perverted by those who apply it to discontinuous sliding or faulting.

We frequently find it stated, or assumed, that when structures such as cleavage or foliation are set up in a rock-mass by shearing, they are parallel to the direction of shearing; although, as has often been pointed out, they must really be perpendicular to the maximum linear compression. In other words, these structural planes are parallel to the chief diametral plane of the strain-ellipsoid, while the shearing-planes, if they remain constant in direction, are parallel to cyclic sections of the ellipsoid. Only for a large amount of shearing will the shearing-planes and the induced structural-planes become nearly parallel.

In a rock of considerable rigidity, shearing as well as compression involves the expenditure of mechanical energy, which must be converted into heat or chemical energy or both, and so contribute to the chemical part of the metamorphism.

There is another case which must be to a certain extent realized by some rocks, and which we may picture as that of a mass consisting of grains individually rigid, but capable of sliding upon one another. This is the "granular medium" investigated by Professor O. Reynolds.[1] Here a pure shear is impossible, since any change of shape in the whole, effected by rearrangement among the grains, involves a change of total bulk. If such a mass has already been "packed" into a state of minimum volume (not necessarily the least possible volume), any deformation will increase its bulk, and so will be resisted by the pressure. Such a condition could be permanently relieved only by chemical action, beginning perhaps by the solution of the grains at their points of contact. It appears too that the intercalation among more yielding materials of a granular rock, which becomes in places "packed" to a minimum volume, will often determine internal disruption and faulting of the mass.

The relation between foliation and the banded or gneissic structure is a question which need only be referred to briefly. When the latter is produced by the same prime agent as the former, as for example in the manner described by Mr. Teall,[2] the two structures will necessarily be parallel to one another. But when foliation is set up by dynamical agency in rock-masses possessing a previous banded structure, whether from stratification, or earlier metamorphism, or any other cause, the former will not of necessity be parallel to the latter, although it will tend to become so with increasing deformation. Numerous examples of foliation oblique to gneissic structure have been described and figured.[3] For the sake of clearness, it does not seem advisable to name this peculiarity "double foliation." If we use the term foliation strictly with reference to the intimate structure of the rock, and not to alternations of different petrological types, a rock-mass cannot present two foliations in the same place: the second will destroy the first as a direction of true schistosity. The same is true of slaty cleavage, notwithstanding various statements to the contrary. I have examined numerous examples of the local phenomenon styled "double cleavage" in the Ardennes, and in all cases resolved the second set of structural planes into a false (or *ausweichungs*-)cleavage, consisting in a succession of minute folds or faults of the kind figured by Heim, Reusch, and others.[4] The "cross-cleavage" of Wales and the Lake District appears to be merely a fine jointing.

In conclusion, it may be well to remark that the analysis of internal forces into uniform pressure and shearing stresses is quite general. Such ideas as torsion or wrench on a screw do not import

[1] Phil. Mag. ser. 5, vol. xx. p. 469, 1885.

[2] Geol. Mag. 1887, p. 484.

[3] Q.J.G.S. vol. xliv. p. 398; 1888: Reusch, *Krystallinischen Schiefer*, pp. 74 and 115; 1883.

[4] *Mecanismus der Gebirgsbildung*, plate xv. figs. 8 and 11; 1878: *Krystallinischen Schiefer*, p. 51; 1883: *Bömmelöen og Karmöen*, p. 196; 1888: Report Brit. Assoc. for 1885, pp. 838 and 840.

anything new with respect to the conditions of rock-transformation. They express usefully theories as to the distribution of mechanical stress and its induced metamorphism, but do not give rise to any new *kind* of metamorphic processes.

IV.—On the Ballantrae Rocks of South Scotland and their Place in the Upland Sequence.

By Prof. Charles Lapworth, LLD., F.R.S., F.G.S.

Part I.—The Ballantrae Rocks.

On the extreme north-west flank of the Lower Palæozoic region of the Southern Uplands of Scotland there occurs a remarkable coastal area of stratified, igneous and altered rocks, known to geologists as the "Ballantrae Rocks," from the little fishing town of Ballantrae, which is built upon them. They range along the shores of the Firth of Clyde for a distance of about 12 miles, and are well displayed in section in a series of rugged cliffs cut through by the picturesque coast road between Ballantrae and Girvan. The area they occupy nowhere exceeds five miles in width, and is limited inland by the smoother regions floored by the barren greywackés of the Uplands and the fossiliferous strata of the Girvan district, but this inland boundary is everywhere curiously broken and irregular.

The rocks occurring within the limits of the Ballantrae district consist of—(*a*) conglomerates, limestones, shales, quartzose flagstones, and volcanic grits and tuffs; (*b*) broad sheets of serpentine, porphyrite, and various crystalline rocks; and (*c*) irregular masses of gabbro, diabase, and dolerite. Of the mutual relationships and true systematic position of these rocks, very diverse views have been advocated by geologists. Some of the unaltered limestones within the Ballantrae area were proved by Mr. Carrick Moore,[1] as early as 1848, to contain the same fossils as the well-known limestones of the Stinchar valley (and consequently to be of Llandeilo-Bala age). Since that date a few additional fossils have been recorded from the rocks of the area,[2] but these have all been procured from the same well-marked limestone zone.

The presence of these Llandeilo-Bala fossils in the limestones of the Ballantrae district has been very naturally held by most geologists as fixing generally the geological date of the associated stratified, igneous, and altered rocks. By some this deduction has been carried out fully, and the whole of the Ballantrae rocks have been described as Bala beds in various stages of metamorphism.[3] By others, however, while the Ballantrae rocks were placed, as a whole, with the Stinchar Limestones at the base of the fossiliferous Girvan sequence, some of their crystalline members were regarded as of igneous and eruptive origin.[4] Finally, others, who were aware of the faulted and convoluted character of the region, have suggested that some of its included rocks may be even of Pre-Cambrian age.[5]

By myself the Ballantrae rocks have been looked upon as a

[1] Q.J.G S. 1849, vol. v. pp. 7-17. [2] Explan. Geol. Surv. Scot. Sheet vii., p. 9.
[3] J. Geikie, Q.J.G.S. 1866, vol. xxii. p. 513-534.
[4] Murchison, Siluria. 5th ed. p. 155, note.
[5] Hicks, Q.J.G.S. 1882, vol. xxxviii. p. 665.

complex formed of—(*a*) the Stinchar limestone and conglomerate series; (*b*) a stratiform series of sedimentary and volcanic rocks of much earlier date; and (*c*) intruded igneous masses of subsequent but unknown geological age. When the first and last of these sections had been satisfactorily eliminated, I believed that the remainder—or Ballantrae series proper—would prove to be of higher antiquity than any of the fossiliferous strata hitherto recognized in the Southern Uplands.[1]

In my paper[2] upon the Girvan succession the rocks of the Ballantrae complex are thus referred to:—"These Girvan rocks (Llandeilo-Bala to Wenlock) appear to repose at their base upon the generally older igneous and altered rocks of Ballantrae. The Ballantrae rocks have as yet been too imperfectly studied to allow us to hazard any conclusion respecting their true geological age. That many of the rocks grouped together under this title are of far greater antiquity than the basement beds of the Girvan succession may be regarded as established by the fact that fragments of the Ballantrae rocks occur in the Kirkland or Purple conglomerate at the base of the Girvan succession. These (their) Pre-Girvan traps and ashes must either represent the Arenig and Llandeilo (Lower) volcanic rocks of Wales and Cumberland, or must be of more ancient date. On the other hand, rocks which are unquestionably of true Girvan age occur at many localities within the typical Ballantrae region itself, while the patches of altered or so-called Ballantrae rocks (of that memoir) found outside that area, as at Shallock Hill, Laggan Hill, and elsewhere, almost certainly include some greatly altered Girvan rocks."

The time at my disposal for working out the main object of my Girvan paper—namely, the determination of the natural order of succession among the fossiliferous rocks of the Girvan district—did not admit of my devoting more attention to the rocks of the Ballantrae complex than was sufficient to establish their inferiority as a whole to the fossiliferous Girvan series. Hence all the rocks (sedimentary, igneous, and altered alike), whose position and characters showed that they formed a part of the heterogeneous Ballantrae complex, were provisionally grouped in that paper under the title of "Ballantrae rocks." It was perfectly clear however that before the Girvan stratigraphy should be regarded as even fairly complete it would be absolutely necessary to—(1) study in greater detail the rocks of the altered or so-called "Ballantrae patches" within the limits of the Girvan area, and separate off their included post-Girvan igneous intrusions and the Girvan rocks these had hardened and altered, from the truly older stratiform rocks of pre-Girvan date; and (2), to establish on the same palæontological evidences as those relied upon in determining the systematic position of the various members of the Girvan succession, the pre-Girvan age of those members of the Ballantrae complex which were held by myself to be of higher antiquity than the basement beds of the (Upper Llandeilo) Girvan succession.

[1] Compare Lapworth, Q.J.G.S. 1878, p. 341; *ibid.* 1882, p. 663; and Trans. Geol. Soc. Glasgow, 1878, p. 83.

[2] Lapworth, Q.J.G.S. 1882, vol. xxxviii. p. 663.

With these especial aims I paid a visit to the Girvan district in 1885, and was then able to satisfy myself upon the following points:—

1. The diabases, syenites, gabbros and serpentines occurring in the altered patches within the limits of the Girvan district proper are many (if not all) of post-Girvan (post-Silurian ?) age. They occasionally traverse, and usually harden and alter, such of the Lower Girvan rocks as they are locally associated with (as at Shallock Hill, Meadowhead, Byne Hill, Laggan Hill, Craighead Hill, and the slopes of the valley of the Stinchar) ; so that (exception being made of some of the strata of the last three areas named) the igneous and altered rocks of these patches have no claim to be ranked as of Ballantrae age. These post-Girvan igneous rocks have intruded themselves mainly in sheets along the many anticlinal arches into which the Girvan rocks are thrown, either between the Girvan rocks and the Ballantrae rocks proper, or among the limestones and conglomerates. etc., which make up the basal members (Barr or Stinchar Series) of the Girvan succession.

2. Similar igneous rocks (apparently of corresponding age) are met with in mass within the limits of the Ballantrae region itself, and have been equally operative in hardening and altering the enveloping strata. But in addition to these post-Girvan masses and the infolded Girvan (Stinchar) limestones and conglomerates of the region already referred to, the Ballantrae rock complex actually includes great thicknesses of stratiform rock—volcanic (contemporaneous), sedimentary, altered and unaltered; some of the last of which are distinctly of pre-Girvan date (and consequently of higher antiquity than any fossiliferous stratum yet recognized in the Southern Uplands)—for they contain locally a well-marked Graptolitic fauna of *Arenig* age.

The Arenig fossils occur in certain hardened black shales on the sea-shore at Bennane Head, about the centre of the Ballantrae area. These shales are associated with siliceous and felspathic grits and flagstones, purple shales, conglomerates and various igneous and altered rocks. Similar black shales occur near Lendalfoot, on the north-western slopes of Craighead Hill and elsewhere, but hitherto they have afforded no determinable fossils.

The recognizable forms collected by myself from the Bennane shales include :

Phyllograptus typus, Hall.
Tetragraptus quadribrachiatus, Hall.
,, *bryonoides*, Hall.
,, *fruticosus*, Hall.
,, *Bigsbyi* (*caduceus*) ?, Hall.

Didymograptus extensus, Hall.
,, *bifidus*, Hall.
Caryocaris Wrightii, Salter.
Associated with forms of *Dictyonema*, *Lingula* and *Obolella*.

It is almost unnecessary perhaps to point out that we have here a Scottish representative of the well-marked fauna of the middle zones of the Arenig Quebec or first Ordovician fauna of South Britain, Northern Europe, and Eastern America. Not only is the general facies of the fauna of the well-known Arenig Point Levis, or Skiddaw type, but the Bennane forms occur—as will be apparent from a study of the following table—always in the same association.

TABLE SHOWING THE RANGE OF THE BALLANTRAE GRAPTOLITHINA.

SPECIES.	Skiddaw Slates.[1]	Arenig of St. Davids.[2]	Point Levis.[3] Quebec Group.	Quebec Group. Newfoundland.[4]	Phyllograptus Schists. Sweden.[5]	Phyllograptus Schists. Norway.[6]	Australia.[7]
Phyllograptus typus, Hall	x	...	x	x	x	x	x
Tetragraptus bryonoides, H.	x	x	x	x	x	x	x
,, *quadribrachiatus*, H. ..	x	x	x	x	x	x	x
,, *fruticosus*, Hall	x	...	x	x	x	x	x
,, *Bigsbyi*, Hall	x	...	x	x	x	x	
Didymograptus extensus H.	...	x	x	x	x	x	
,, *bifidus*, H., *Murchisoni*, Beck.	x	x	x	x	...	x	
Caryocaris Wrightii, Salt.	x						

We have therefore in the foregoing facts a complete palæontological demonstration of the theory that the local series of rocks to which the title of Ballantrae Series or "Ballantrae rocks" has been applied, is in reality a complex of stratified, altered, and igneous rocks of very different geological ages: Arenig, Llandeilo, and post-Ordovician: the common facies of the pseudo-series being mainly the result of the common interfolding, alteration, and intrusion its rocks have undergone. The development of the natural order, inter-relationships and mode of alteration of this complex has yet to be worked out, and can only be satisfactorily accomplished by a mapping of the entire district, zone by zone, and band by band. When that work has been completed, it is by no means unlikely that fossiliferous zones of a yet higher antiquity may be detected; and that here it will be shown that, as elsewhere, the most extreme views held regarding the collective rock series may each have contained a certain proportion of the actual truth.

Although the simple fact of this discovery of an Arenig fauna in the Ballantrae rocks has long been made known,[8] I have hitherto withheld the foregoing details, because of their vital bearing upon the general question of the true sequence of the Lower Palæozoic rocks of the Scottish Uplands. The present, however, appears to be the most natural time for their publication. The epoch-making memoir by Messrs. Peach and Horne on the structure of the N.W. Highlands in the Quarterly Journal of the Geological Society for August, 1888, p. 378, has given the finishing-stroke in Britain to the antiquated ideas of the reliability of apparent stratigraphy in areas subjected

[1] Nicholson, 1872, Brit. Mon. Grapt. p. 97, etc.
[2] Hopkinson and Lapworth, Q.J.G.S. 1875, p. 635.
[3] Hall, Grapt. Quebec, 1865, pp. 56-57.
[4] Coll Canadian Geol. Survey.
[5] Tullberg, Skånes Grapt. pt. i. 1882, p. 22, etc.
[6] Brögger, Die Silurischen Etagen 2 und 3, 1882, pp. 38-41.
[7] Lapworth, Geol. Dist. Rhabdophora, 1879, p. 23.
[8] Jukes-Browne, Historical Geology, 1886, p. 98.

to intense lateral pressure. The conscientious and detailed paper by Messrs. Marr and Nicholson[1] on the Stockdale Shales of the Lake District, in the November Number of the same publication, has brought home to British geologists, in an equally convincing manner, the untenability of the views of those few surviving stratigraphists who still hesitate to acknowledge the paramount value of the Graptolites in the elucidation of complicated questions of stratigraphy and correlation among the Lower Palæozoic rocks.

In these two typical papers the *zonal* and detailed method of stratigraphy, as opposed to the *regional* and generalized method, has been consistently followed throughout, and it is to the adoption of this method I believe that they owe their reliability and their success. This zonal method, which has always been employed by myself in my work among the convoluted rocks of the Scottish Uplands, has thus quietly entered upon what may be regarded as the accepted or orthodox stage. With the new interest springing up among British geologists respecting the natural sequence and the proper classification of the Lower Palæozoic rocks, it may be regarded as certain that the complicated region of the Scottish Uplands will now be studied in fuller detail by geologists acquainted with the new methods, and that such differences of opinion as still exist among geologists respecting these rocks will soon find their natural solution and harmony, as in the cases of the Lake District and the N.W. Highlands, in a careful and detailed investigation of all the actual facts.

(To be concluded.)

V.—On a New Species of the Genus *Protaster* (*P. brisingoides*), from the Upper Silurian of Victoria, Australia.

By J. Walter Gregory, F.G.S., F.Z S.,
of the British Museum (Natural History).

So little is as yet known of the Palæozoic Ophiuroidea, that the discovery of some specimens that represent a new species of *Protaster* in the Upper Silurian rocks of Victoria is of interest. Some of the specimens were forwarded to Dr. Woodward by Mr. Frederick McKnight, of 60, Hawke Street, West, Melbourne, Victoria, some time ago, but they were too fragmentary to be of much service; several better examples having been received from the same source, Dr. Woodward has kindly entrusted them to me for description.

Protaster brisingoides, n.sp.

Disk obscurely indicated: apparently of medium size and pentagonal in shape, each face being concave owing to the disk extending slightly along the arms. It is seen only in one specimen, and in this but faintly.

The arms are at least twice as long as the diameter of the disk, and probably considerably more, the full length not being known.

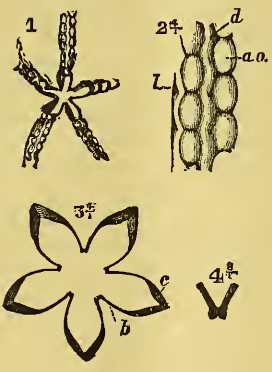
The mouth-frames are homologous with the ambulacral ossicles of

[1] Quart. Journ. Geol. Soc. (read May 9), 1888, vol. xliv.

the arms; they are about three times as long as broad and somewhat spindle-shaped, being more bulging in the middle than in *P. leptosoma*, which is the nearest ally of this species; the margins are entire and not notched as in that species. The adambulacral elements in the "oral pentagons" probably represent the jaw and jaw-plate; the former is long and narrow, about four times as long as broad, and slightly curved at the inner end (Fig. 3, *b*); the jaw-plate, which unites the jaw to that of the adjoining radius, is short and thick; its inner surface is concave, as the two free corners extend somewhat towards the centre of the disk (Fig. 4, *c*). Neither buccal nor dental papillæ nor teeth are shown.

Each arm consists of a series of pairs of ambulacral ossicles (Fig. 2, *ao*) and adambulacral plates (Fig. 2, *l*) on each side of a median ridge, seen on the abactinal surface (Fig. 2, *d*): the first apparently represent the unfused halves of the ambulacral or vertebral ossicles of Ophiuroids; the second, the lateral or adambulacral shields: the nature of the median ridge is doubtful; it may possibly represent upgrowths from the ambulacral ossicles comparable to those in *Brisinga*, or it may have some connection with the dorsal shields, which are not otherwise indicated. Seen from the abactinal aspect, the ambulacral ossicles appear thick and bluntly oval, with the longer axis in the direction of the arm, and placed alternately in the concavities of the sinuous median ridge; they are distinctly

Dimensions.—	Diameter of disk	12 mm.
	Diameter to the extremities of the oral pentagons ...	7 mm.
	Width of arm	2 mm.
	Length of ambulacral ossicles	1 mm.



Explanation of the Figures.

Fig. 1. Specimen of *Protaster brisingoides*, abactinal aspect; nat. size.[1] Fig. 2. Part of an arm from the same specimen, that which is uppermost in Fig. 1; *d*. median ridge; *a o* ambulacral ossicle, *l*. adambulacral plate; ×4 diam. Fig. 3. The oral apparatus from another specimen in which the disk is not shown; *b*. jaw, *c*. mouth-frame; ×4 diam. Fig. 4. A jaw-plate and distal ends of a pair of jaws; ×8 diam.

[1] The faint indication of a disk is not shown in the figure, but can be detected in one or two of the interradii.

alternate in the arms, but in the disk, which includes the first three pairs, they are merely subalternate. The ambulacral ossicles are much thicker than those of other species of *Protaster*, and they are consequently less numerous. They are separated by double concave spaces, which served for the passage of the tube feet (or of the ampullæ, if, as is not improbable, the tube feet were arranged on the Asteroid type). The adambulacral plates are long and quadrangular, running parallel to the arms, each slightly longer than the corresponding ambulacral ossicle.

The actinal aspect of the arms is not well exposed in any of the specimens; in one, however, the end faces of the adambulacral plates are seen, as at their aboral extremities they curve actinally.

Neither the articular facets of the ambulacral ossicles nor the arm spines are shown.

Locality and stratigraphical position.—The specimens were found in the so-called "Mayhill Sandstone" of Moonee Ponds, Flemington, near Melbourne; they are Upper Silurian in age, but there seems no sufficient reason for regarding the beds from which they have been derived as in any way the equivalent of our Mayhill Sandstone.

The rock is a yellowish, fine-grained, micaceous sandstone, from which all calcareous matter has been dissolved, so that the fossils occur only as casts and impressions coloured by iron oxide.

Affinities of the species.—The only species of *Protaster* for which this could be mistaken is *P. leptosoma*, Salter, from the Leintwardine Flags of Ludlow; from this, however, it may be readily distinguished by the shape of the mouth-frames and of the ambulacral ossicles.

In a list of fossils from the Upper Silurian rocks of Victoria, published by F. M'Coy in 1874,[1] the MS. name of *Tæniaster australis* is recorded from the Upper Yarra. This may refer to the species here described, which at first sight, in specimens that do not show the disk, is not unlike a *Tæniaster*; in the absence of any description of M'Coy's species, it is quite impossible to say whether such is the case, and as the specimens do not come from the same locality, though some of the Asteroids recorded are from Moonee Ponds, it would not be safe to adopt M'Coy's manuscript name. It serves, however, to remind us of the differences of opinion as to the relations of *Tæniaster* and *Protaster*, which Hall[2] maintained were very closely allied, if not identical, attributing the supposed differences between them to errors in description by Salter.[3] According to the original description by Billings,[4] *Tæniaster* differed from *Protaster* in the absence of a disk, in the development of the oral plates from the adambulacral plates and not from the ambulacral elements, and in that the pores pass through the spaces between the

[1] R. B. Smyth, Progress Reports, Geol. Survey, Victoria, No. 1, Melbourne, 1874, p. 34.

[2] J. Hall, 20th Regents Report, Albany, 1867, pp. 293–4 and 300–1.

[3] J. W. Salter, On some new Palæozoic Starfishes, Ann. and Mag. Nat. Hist. ser. 2, vol. xx. 1857, pp. 330–2, pl. ix. figs. 4 and 5; and Additional Notes on some new Palæozoic Starfishes, ser. 3, vol. viii. 1861, pp. 484–6, pl. xviii. figs. 9, 10, and 11.

[4] E. Billings, On the Asteriadæ of the Lower Silurian Rocks of Canada, Canadian Org. Remains, dec. iii. Montreal, 1858, p. 80–1, pl. x. figs. 3 and 4.

ambulacral ossicles and the two adjoining adambulacral plates, and not through the body of the ambulacral ossicle itself. Hall has claimed to have discovered traces of a disc in Billings's type specimens of *Tæniaster,* and if so, this distinction falls to the ground; but, in regard to the two other points, the collection of specimens of *P. Miltoni* in the British Museum Collection confirm the correctness of Salter's views. The differences are, therefore, valid ones, and both genera must be retained, as has been done by Zittel. This new species differs from *Tæniaster* in the presence of the disk, though, as we have seen, this distinction may possibly not hold good, and in the structure of both arms and oral pentagon. It undoubtedly differs from the other species of *Protaster* in many important points of structure, and herein agrees more closely with *Brisinga* than does any Protophiuroid yet described; to mark this resemblance the specific name has been given. But the other species of *Protaster* differ among themselves in equally important points, and the genus is apparently constituted by a group of species which careful revision and further knowledge of their structure would probably relegate to more than two distinct genera. The necessity for such a revision has been recently urged by Sturtz,[1] and to this with a discussion of some questions in their anatomy and the significance of some points in the structure of *P. brisingoides*, I hope subsequently to return. Till such has been done, it seems advisable to include this species in the comprehensive genus *Protaster.*

VI.—Note on the Genera *Tristychius* and *Ptychacanthus*, Agassiz.

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

Some years ago,[2] in showing that the spines supposed by Hancock and Atthey to be dorsal spines of *Gyracanthus* were merely young and unworn specimens of lateral spines of the same genus, I called attention to the general fact that young examples of Selachian spines could not be expected to represent the older ones in miniature, and *vice versa.*

For as the spine increases in size by growth at the base, the young one is consequently represented only by the distal portion of the adult. And as in the process of growth, differences in sculpture and proportions may supervene, the general characters may be so altered, that if the distal portion be lost by attrition, the old and young individuals may be with difficulty recognizable even as belonging to the same genus.

Such an instance may, I think, be found in the spines named by Agassiz respectively *Tristychius arcuatus* and *Ptychacanthus sublævis*, both from the Lower Carboniferous rocks of Central Scotland.

In very young specimens of the former the surface of the exserted portion is entirely covered with longitudinal ridges and sulci, and

[1] B. Sturtz, Beitrag zur Kenntniss palæozoischer Seesterne, Palaeontographica, vol. xxxii. Stuttgart, 1886, p. 79.

[2] Ann. and Mag. Nat. Hist. ser. 5, vol. xiii. 1884, p. 37.

there is scarcely any posterior area, the two rows of marginal denticles being placed close to each other and alternating. As the spine increases in length, the ridges begin to drop off behind, so that in examples of from three to four inches in length, like Agassiz's type,[1] only the tip is ridged all round, while three ridges, one median and two lateral, persist beyond the other along the front, whence the name *Tristychius.* Along with this change in sculpture, the two posterior rows of denticles diverge from each other, and a well-marked *area* is formed between them as in *Ctenacanthus.*

In still larger spines the sulcated tips become entirely worn off, leaving only the three anterior ridges, which in turn also finally disappear in examples which have been subjected to any considerable amount of wearing. A somewhat short, gently-curved, bluntly-pointed spine now confronts us, destitute of ridges or sulci, and with the surface covered only by very close and delicate striæ. Such spines are indistinguishable from Agassiz's description and figure of *Ptychacanthus sublævis*,[2] of which the original seems unfortunately to be lost, for although Agassiz states that it belonged to Professor Jameson, I have never been able to find it in the Edinburgh Museum.

Ptychacanthus sublævis then represents to my mind nothing but an adult *Tristychius arcuatus*, with the point broken off, and the general surface a little worn, and this view is, I consider, not only corroborated, but proved by a series of specimens of undoubted *Tristychius* in the Edinburgh Museum.

NOTICES OF MEMOIRS.

I.—*Amblypristis Cheops*, nov. gen. et. sp., aus dem Eocaen Aegyptens. By Prof. Dr. W. Dames. Sitzungsb. Ges. naturf. Fr. Berlin, 1888, No. 6.

THIS paper forms an interesting contribution to our knowledge of the fossil vertebrate fauna of Birket-el-Qurūn, in Fajum, for which we are already indebted to Dr. Dames (Sitzungsb. königl. Akad. Wiss. Berlin, 1883, pt. i.). The evidence of the new Saw-fish (*Amblypristis Cheops*) consists in some detached rostral teeth, differing from those of the existing *Pristis* in their shortness and great relative breadth. One example is figured; and Dr. Hilgendorf adds a brief note on the structure of the rostral teeth of the living genus, as compared with the fossil.

II.—On some Devonian Crustacea. By Rev. G. F. Whidborne, M.A., F.G.S.[3]

BESIDE species of Crustaceans already described from Woulborough and Lummaton, several new species are found there, as the following: *Phacops batracheus*, which differs from *P. fecundus*, Barr., in the rearward position of the eye and more overhanging glabella; *Proetus batillus*, which has a flatter glabella than *P.*

[1] Poiss. Foss. tome iii. tab. 1*a*, fig. 9–11.
[2] Op. cit. tome iii. tab. 5, fig. 1-3.
[3] Revised abstract of paper read at the British Association.

bohemicus, Barr., more anterior eyes, and longer cheek spines; *P. subfrontalis*, which approaches *P. frontalis*, Barr., but has a much squarer glabella; *P. audax*, which is like *P. granulosus*, Goldf., but has tuberculated cheeks; *Cyphaspis ocellata*, like *C. ceratophthalmus*, Sandb., but with long sharp cheek spines; *Lichas devonianus*, having a wider head than *L. Haueri*, Barr., larger eyes surrounded by tubercles, and a more arched neck; *Acidaspis Robertsii*, with narrower cheeks than *A. lacerata*, Barr.; *A. Hughesii*, with a bilobed tail surrounded by a flat border bearing aciculate spines; *Bronteus delicatus*, having its glabella marked with transverse lines, and smaller spots than in *B. flabellifer*, Goldf.; *B. pardalios*, which is more coarsely tuberculated than *B. granulatus*, Goldf.; *Entomis peregrina*, distinguishable from *E. tuberosa*, Jones, by the indistinctness of its nodule; and *Bactropus decoratus*, dissimilar from *B. longipes*, Barr., in being much smaller and more coarsely striated.

The *Cheirurus* of these beds is not *Ch. articulatus*, Münst., but a new species, *C. Pengellii*, differing from it in the shorter front lobe of its glabella. The true *B. flabellifer*, Goldf., occurs, not at Woulborough, but at Chircombe Bridge, where it is accompanied by *Dechenella setosa*, n.sp., differing from *D. Verneuili*, Barr., in having nineteen segments on the tail.

III.—On some Devonian Cephalopods and Gasteropods. By Rev. G. F. Whidborne, M.A., F.G.S.

The following new species occur at Woulborough or Lummaton, or in the case of some of the Gasteropods at Chudleigh: *Goniatites obliquus*, a large shell with open umbilicus, flat sloping sides and narrow flat back; *G. psittacinus*, a small tumid shell with closed umbilicus, rounded whorls, slightly curved sutures; *G. nuciformis*, with minute umbilicus and much broader back than the preceding; *G. aratus*, a flatter shell with small umbilicus, and marked with four angulated sulci; *G. pentangularis*, with open spire, inner whorls ribbed, and section of whorls pentagonal; *G. Hughesii*, large and flat with closed umbilicus, evenly rounded back and minutely striated surface; *Cyrtoceras Leei*, a large curved conoidal form with more irregular and dilate lamellæ than *C. fimbriatum*, Ph.; *C. pulcherrimum*, unlike *C. reticulatum*, Ph., in having tubercles on the shoulder instead of ribs; *C. Vicarii*, having a broader section, and much fewer tubercles than the last; *C. præclarum*, more involute and elliptical than the last, with wider mouth and oblique ridges crossed by distant striæ; *C. majesticum*, large and smooth, with oval mouth, narrow chambers and imperfect spire; *Hercoceras inornatum*, differing from *H. subtuberculatum*, Sandb., in being smooth; *Orthoceras hastatum*, more conical and with fewer annulæ than *O. tubicinella*, Ph.; *O. Vicarii*, differing from *O. pulchellun*, F. A. Röm., in being round and not oval in section; *O. comatum*, which is *O. tubicinella*, Sandb., not Ph.; *Phragmoceras vasiforme*, which is rather less convex than *Ph. subpyriforme*, Mü.; *Ph. ungulatum*, small and more arched than *C. cornucopia*, Sandb.; *Ph. Marri*, conical and transversely flattened, approaching *G. Conradi*, Barr.; *B. mundus*, with broad grooved keel, and very transverse kidney-shaped mouth; *Euomphalus fenestralis*, with a depressed spire and three ridges cancellated by numerous rings; *Pleurotomaria perversa*, a large sinistral shell, unlike *Pl. expansa*, Ph., in having spiral striæ, a deeper suture, whorls more convex; *Pl. victrix*, which has an elevated spire, angulated whorls, central sinus band, and a few spiral striæ; *Pl. Chudleighensis*, separated from the preceding in having its spiral ridges crenulated, and the sinus band much higher; *Littorina devonaic*, having the general shape of *Purpura lapillus*, with eight spiral rows of tubercles which are largest near the suture; *Monodonta archon*, very large and trochiform, with flat base and sides, linear suture and oblique growth-lines; *Phorus philosophus*, with a low spire, wide umbilicus and convex whorls bearing fragments of broken shells; *Macrocheilus tumescens*, a much more globular form than *M. subcostatus*, Schlot.; *Turbo Pengellii*, unlike *T. subangulosus*, d'A. and de V., in its wider flatness above the shoulder; *Loxonema scalaroides*, very elongate, with its convex whorls crossed by discontinuous varices; *H. duplisulcata*, differing from *H. tenuisulcata* in possessing a series of subsidiary striæ; *Acroculia columbina*, a wide depressed form with fine waving longitudinal markings; *Metoptoma cordata*, like *M. pileus*, Ph., but with loftier umbo and more angulated mouth; and *Chiton papilio*, which comes midway between *Ch. corrugatus*, Sandb., and *Ch. sagittalis*, Sandb.

The above are accompanied by *Orthoceras Oceani*, d'Orb. (= *O. cinctum*, Ph.), *O. tenuistriatus*, Mü., *O. subfusiforme*, d'A. and de V., *O. regularis*, Mü., *O. subarmularis*, Mü., *B. lineatus*, Goldf. (= *B. striatus*, Ph.), *P. bifida*, Sandb. (=*B. Woodwardii*, Ph.), *Eu. serpula*, de Kon., *Eu. planorbis*, d'A. and de V., *Eu. lævis*, d'A. and de V., *Eu. rota*, Sandb., *Eu. decussatus*, Sandb., *Eu. germanus*, Ph. sp., *Eu. catenulatus* (=*Eu. serpens*, Ph., Pal. Foss. fig. 172, *f.* and *g.* only), *Pl. D'Orbigniana*, d'A. and de V., *Pl. subclathrata*, Sandb., *Pl. Lonsdalii*, d'A. and de V., *Pl. delphinuloides*, Schlot., *Pl. calculiformis*, Sandb., *Pl. trochoides* (=*Pl. monilifera*, Ph. Pal. Foss.), *Pl. distinguenda* (=*Pl. aspera*, Ph. Pal. Foss.), *N. deformis*, Sow., *N. piligera*, Sandb., *T. multispira*, Sandb.? *L. purpura*, d'A. and de V., *L. subcostata*, d'A. and de V., *Scalaria antiqua*, Mü., *M. subcostatus*, Schlot. (=*M. arculatus*, Ph., and *M. elongatus*, Ph.), *Scoliostoma texatum*, Ph. sp., *Sc. gracile*, Sandb., *Holopella tenuicostata*, Sandb., *H. tenuisulcata*, Sandb., *H. piligera*, Sandb., *Acroculia multiplicata*, Giebel, and *A. proæva*, Eichw.

IV.—Note on Graptolites from Dease River, B.C.[1] By Prof. Charles Lapworth, LL.D., F.R.S., F.G.S.

In June, 1887, a small collection of Graptolites was obtained by Dr. G. M. Dawson on Dease River, in the extreme northern and inland portion of British Columbia, about lat. 59° 45′, long. 129°. These fossils were derived from certain dark-coloured, carbonaceous and often calcareous shales, which in association with quartzites and

[1] Reprinted from the "Canadian Record of Science."

other rocks, characterize a considerable area on the lower part of the Dease, as well as on the Lizard River, above the confluence. The collection referred to was transmitted by Mr. J. F. Whiteaves to Prof. Lapworth, whose special studies on Graptolites are well known. It is believed that the following preliminary note by Prof. Lapworth will be of interest, as the occurrence of Graptolites on the Dease River extends very far to the north-westward of our previous knowledge of the occurrence of these forms in North America. In 1886 a similar small collection was obtained by Mr. R. G. McConnell near the line of the Canadian Pacific Railway, in the Kicking Horse (Wapta) Pass. This and the new locality here described are the only ones which have yet been found to yield Graptolites in the entire western portion of the Dominion.

Prof. Lapworth, under date December 13th, writes as follows:—

I have, to-day, gone over the specimens of Graptolites, collected by Dr. Dawson, from the rocks of the Dease River, British Columbia. I find that they are identical with those examined by me from the rocks of the Kicking Horse Pass, some time last year. The species I notice in the Dease River collection are:

Diplograptus euglyphus, Lapworth.
Climacograptus comp. *antiquus*, Lapw.
Cryptograptus tricornis, Carruthers.
Glossograptus ciliatus, Emmons.
Didymograptus comp. *sagittarius*, Hall.
New form allied to *Cœnograptus*.

These Graptolite-bearing rocks are clearly of about Middle Ordovician age. They contain forms I would refer to the second or Black River Trenton period: i.e. they are newer than the Point Lévis series, and older than the Hudson and Utica groups. The association of forms is such as we find in Britain and Western Europe, in the passage-beds between the Llandeilo and Caradoc Limestones. The rocks in Canada and New York, with which these Dease River beds may be best compared, are the Marsouin beds of the St. Lawrence Valley, and the Norman's Kill beds of New York. The Dease River beds may perhaps be a little older than these.

Mr. C. White described some Graptolites from beds in the mountain region of the West, several years ago, which may belong to the same horizon as the Dease River zones, though they have a somewhat more recent aspect.

The specific identification of the Dease River fossils, I regard as provisional. While the species correspond broadly with those found in their eastern equivalents, they have certain peculiarities which may, after further study, or on the discovery of better and more perfect specimens, lead to their separation as distinct species or varieties.

It is exceedingly interesting to find Graptolites in a region so far removed from the Atlantic basin, and also to note that the typical association of Llandeilo-Bala genera and species is still retained practically unmodified.—G. M. D.

REVIEWS.

I.—The History of Volcanic Action during the Tertiary Period in the British Isles. By Archibald Geikie, LL.D., F.R.S., Director-General of the Geological Survey of the United Kingdom. (Transactions of the Royal Society of Edinburgh, vol. xxxv. 1888, pp. 21-184, with 2 Maps and 53 Woodcuts. Reprinted, 4to. Edinburgh, R. Grant & Son. Price 18*s*.)

THE work before us, probably the most important of the original papers by the author, must be read by every one devoted to the special study of volcanic action; at the same time it contains results of such high interest to all geologists, that in due course it will doubtless be regarded as one of the 'classic' memoirs of this prolific age.

At the outset the author gives a brief sketch of the labours of previous observers. Foremost among these was Macculloch, and of his great work on the Western Islands of Scotland, Dr. Geikie says, "Few single works of descriptive geology have ever done so much to advance the progress of the science in this country." It is pleasant to see the labours of the pioneers so fully acknowledged, and in reference to Ami Boué, who published in 1820 his *Essai géologique sur l'Ecosse*, it is remarked that "the value of this work as an original contribution to the geology of the British Isles has probably never been adequately acknowledged."

From time to time during the past 30 years Dr. Geikie has published the results of his own observations on the volcanic rocks of Scotland, but it was not until 1879 that he "appreciated for the first time the significance of Richthofen's views regarding 'massive' or 'fissure-eruptions,' as contradistinguished from those of central volcanoes like Etna or Vesuvius;" then, however, when traversing some portions of the volcanic region of Wyoming, Montana, and Utah, he "saw how completely the structure and history of these tracts of Western America explain those of the basalt-plateaux of Britain."

In the mean time an elaborate Memoir by Prof. Judd on the Ancient Volcanoes of the Highlands was read before the Geological Society of London; and it is important to notice that the conclusions of Dr. Geikie are to a very large extent at variance with those of Prof. Judd. The latter had recognized the basal wrecks of five great central volcanoes in the Western Islands; whereas Dr. Geikie has not been able to discover evidence of any great central volcanoes, and has found the order of outflow of the successive groups of rocks to have been the reverse of what Prof. Judd believed it to be.

In the present memoir Dr. Geikie commences his history of volcanic action with an account of the basic dykes, which traverse so large a part of Scotland, and extend also into the North of Ireland, the Isle of Man, and the North of England. Of these dykes, that in Cleveland is one of the best-known English examples. The author then describes the great volcanic plateaux, which, in spite of vast denudation, still survive in extensive fragments in Antrim and the Inner Hebrides. The eruptive bosses of basic rocks that have broken through the plateaux are next discussed, and then an account is given of the protrusions of acid rocks that mark the latest phase of eruption in the region.

Finally, the leading features in the history of Tertiary volcanic action in the British Isles are summarized by Dr. Geikie, whose words we quote as far as possible in our condensed account of his views.

The earliest beginnings of the volcanic disturbances may possibly go back into the Eocene period, and the final manifestations may not have ceased until Miocene times, or perhaps later.

These disturbances originated from a vast subterranean lake or sea of molten rock, which appeared beneath the volcanic region as it underwent elevation. Enormous horizontal tension arose, and a system of approximately parallel fissures opened in the terrestrial crust, having a general direction towards N.W. The majority of the fractures did not reach to the surface of the ground, though probably not a few did so. No sooner were the fissures formed than the molten lava underneath was forced upward into them for many hundred or even thousands of feet above the surface of the subterranean lava-sea. Solidifying between the fissure-walls, the lava formed the numerous basic dykes that constitute the widespread and distinctive feature of the volcanic region.

Where the fissures reached the surface or near to it, the molten rock sought relief by egress in streams of lava, of which abundant remains are still left in the basalt-plateaux of Antrim and the Inner Hebrides.

In some places, the accumulated pile of such ejections, which include layers of fine tuff, etc., even now exceeds 3000 feet. The surface over which the lava flowed seemed to have been mainly terrestrial, for here and there, between the successive sheets of basalt, the remains of land-plants and also of insects have been discovered.

Subsequently there uprose at certain points, coarsely crystalline basic rocks, which solidified as dolerites, gabbros, etc.

Probably long after the eruption of the gabbros, a renewed outbreak of subterranean activity gave rise to the protrusion of rocks of a markedly acid type. They include varieties that range from felsites through porphyries and granophyres into granite.

Around the bosses of gabbro and granophyre, the bedded basalts have undergone considerable contact-metamorphism ; and it is interesting to learn that the former precisely resemble rocks of similar kinds in Palæozoic and Archæan formations.

Ultimately another system of basic dykes was formed; dykes which cross those of earlier date, and rise through the other volcanic rocks.

We have passed over the more detailed portions of this work, contenting ourselves with pointing out the leading conclusions of the author. These are indeed based on extensive microscopic investigations of the rocks, as well as on the more important fieldwork. Further particulars, however, of the microscopic petrography are promised in a future memoir on the subject, by Dr. F. H. Hatch, whose assistance is cordially acknowledged by the author.

II.—A Bibliography of the Foraminifera, Recent and Fossil, from 1565 to 1888. By C. D. Sherborn, F.G.S. 8vo. pp. vi. and 152. (London, Dulau & Co., 1888.)

In the July Number, 1887, of the Geol. Mag., at p. 324, we briefly criticized a "Bibliography of the Foraminifera," by Prof. Anthony Woodward; and we regretted to point out some of its errors and shortcomings. We can now congratulate Rhizopodists on the publication of a good catalogue of all the books and memoirs treating of Foraminifera that have appeared during more than the last three centuries. The little shelled Protozoans under notice, always either quaint or elegant in form, and offering an interminable series of varied shapes to the microscopist, and highly interesting subjects of research to the biologist, have been treated of in hundreds of works with more or less exactness, and illustrated by thousands of plates of very different values. The bibliographies hitherto given to the public, within the last forty years, have been more or less useful as clues in the finding of some desiderata; but have often disappointed the student, or left him vaguely conscious that more or better work had been done in his line of research. If really desirous of learning what others have worked out, and of comparing the results of those who have preceded him, he now has good aid in his search, and has no excuse should he ignore earlier workers.

Having entered on the study of Foraminifera, and finding it necessary to master their bibliographic history, in making tables and catalogues of the multitudinous genera and species already recorded, Mr. C. D. Sherborn evidently found existing bibliographies too imperfect for the purpose, and therefore consolidated and augmented the several lists, which books and friends supplied, as fully explained in his Preface. The result is this excellent Bibliography before us, which has been earnestly and conscientiously carried out, with scrupulous exactness as to dates and titles of books and memoirs, the places of publication, the life-dates of the authors (when obtainable), and a definite uniformity in quoting periodicals and transactions, which especially is as valuable as it is rare. The frequent notes relative to some rare and other publications are of great value: and the enumeration of, or remarks on, the illustrations seem to intimate that the author of this "Bibliography" could supply an index of genera and species, very many of which are notoriously synonymous, having been determined and published without due regard to previous publications.

Mr. Sherborn has adopted the plan of enumerating the authors (about 700) in alphabetical order, and the works of each in order of date (about 2000), with cross-references. Of the books and papers thus mentioned only about 20 are noted as not having been seen, with such care and exactness has the work been carried out. There is a very short list of *errata* in the book, and scarcely any others can be found even after a considerable use of this valuable Bibliography. Strata of various ages have yielded so many Foraminifera that the geological formations are frequently mentioned in connection with them in the titles and pages of the books and memoirs here enumerated;

hence the Geologist, as well as the Biologist, has an interest in this Bibliography, which we cordially recommend to both as highly necessary in their researches.

III.—Tabular Index to the Upper Cretaceous Fossils of England and Ireland, cited by Dr. Charles Barrois in his "Description Géologique de la Craie de l'Ile de Wight," Paris, 1875, and "Recherches sur le Terrain Crétacé Supérieur de l'Angleterre et de l'Irlande," Lille, 1876. By E. Westlake, F.G.S. 4to. pp. 24 (Fordingbridge, Mitchell, 1888.)

THIS tabular list gives the geological distribution in the different zones of the Cenomanian, Turonian and Senonian divisions, of 405 species of Cretaceous fossils, referred to in the above-named works of Dr. Barrois; and also references to the localities where they occur. It appears to have been very carefully compiled, and should prove of very material assistance to all workers in the Cretaceous rocks of this and other countries.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—November 7, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read :—

1. "The Permian Rocks of the Leicestershire Coal-field." By Horace T. Brown, Esq., F.G.S.

The author considers that whilst rocks belonging to the Carboniferous and Trias have been mapped as Permian, true representatives of the Permian do exist in the district to a considerable extent. The Bunter conglomerates rest for the most part upon the truncated edges of Carboniferous strata; but intercalated between them and the Carboniferous, at various points, are thin beds of purple marly breccias and sandstones seldom exceeding from 30 to 40 ft., but differing in lithological character from the overlying and underlying rocks. The brecciated series rests with striking unconformity upon the Carboniferous. Moreover, the Boothorpe fault, which throws the Coal-measures 1000 ft., affects the overlying brecciated series to an extent of not more than from 20 to 30 ft. The unconformity between the brecciated series and the Bunter is less obvious. Sections establishing the double unconformity were described in considerable detail. Attention was also called to other localities within the Coal-field where Permian rocks exist, the author having in many cases mapped their boundaries.

He further called attention to certain beds which have been erroneously classed as Permian by the Survey. The first of these is a patch at Knowle Hills. Making extensive use of the hand-borer, he found that the greater part of the so-called Permian consists of a wedge-shaped piece of Lower Keuper let down by a trough fault. The so-called Moira grits belong to and are conformable with the ordinary Coal-measures of the district.

The lithological characters of the Leicestershire Permians is sufficient to differentiate them from the Trias and Carboniferous. They consist of red and variegated marls, bands of breccia, and beds of fine-grained yellowish sandstone; the breccia fragments are of great variety and little waterworn. These are imbedded in a bluish-grey matrix, hard or soft, which consists of insoluble matter united by the carbonates of lime and magnesia with some hydrated ferrous oxide, which on exposure becomes oxidized.

The breccias have a tendency to die out northwards. The most abundant materials are quartzo-felspathic grits with associated grey flinty slates (Older Palæozoic), with in addition vein-quartz, volcanic ash, and igneous rocks. The Carboniferous rocks afford argillaceous limestone, Mountain Limestone, grits, and hæmatite. At Boothorpe nearly 90 per cent. is made up of the old Palæozoic material, whilst at Newhall Park 28·8 per cent. consists of Carboniferous grits and hæmatite. The quartzite fragments resemble those of the lower part of the Hartshill series, but the existence of "strain shadows" indicates a difference subsequently explained. A very few fragments may be referred to the Charnwood rocks.

The bulk of the material has a southern origin, and the irregularity of the fragments proves that they cannot have come from a distance. Evidence is given of the probable existence of a ridge of older Palæozoics, from which the Carboniferous rocks had been stripped, beneath the Trias of Bosworth. (There is an actual outcrop of Stockingford shales at Elmesthorpe.) The direction of this line is parallel with the Nuneaton-Hartshill and Charnwood axes of elevation, and also with the general direction of the major folds and faults of the Leicestershire Coal-field. The northern part of this ridge, which is apparently a faulted anticlinal, is a very probable source of the angular fragments occurring in the Permian breccias 5 or 6 miles to the north-west.

The author concluded that the Permian rocks of the Leicestershire Coal-field belong to the same area of deposition as those of Warwickshire and South Staffordshire, all having formed part of the detrital deposits of the Permian Lake which extended northwards from Warwickshire and Worcestershire, and which had the Pennine chain on its eastern margin. He pointed out the dissimilar nature of these deposits to those of the eastern side of the Pennine chain from Nottingham to the coast of Durham. There were proofs of the existence of a land barrier, owing to the uprising of the Carboniferous, between the district round Nottingham and the Leicestershire Coal-field. The most northerly exposure of the Leicestershire Permians is 13 miles S.W. of those of South Notts. He indicated the probable course of the old coast-line of the western Permian Lake. Denudation had bared some of the older Palæozoics of their overlying Coal-measures, and it is the rearranged talus from the harder portions of these older rocks which now form the brecciated bands in the Leicestershire Permian.

In an Appendix some igneous rocks found in the Bosworth borings were described.

2. "On the Superficial Geology of the Central Plateau of North-western Canada." By J. B. Tyrrell, Esq., B.A., F.G.S., Field Geologist of the Geological and Natural History Survey of Canada.

The Drift-covered prairie extends from the west side of the Lake of the Woods to the region at the foot of the Rocky Mountains, rising from a height of 800 feet on the east to 4500 feet on the west, the gentle slope being broken by two sharp inclines known as the Pembina Escarpment and the Missouri Coteau, giving rise to the First, Second, and Third Prairie Steppes.

The author described the older rocks of this region, referring especially to his subdivision of the Laramie Formation into an Edmonton Series of Cretaceous age, and a Pascapoo Series forming the base of the Eocene, and then discussed the Superficial Deposits in the following order:—

1. *Preglacial gravels* occurring along the foot of the Rocky Mountains, composed of waterworn quartzite pebbles, similar to those now forming and, like them, produced by streams flowing from the mountains.

2. *Boulder-clay* or *Till*, having an average thickness of 50–100 feet, and filling up pre-existing inequalities. The clay is essentially derived from the material of the underlying rocks. The smoothed and striated boulders of the western region are largely quartzites derived from the Rocky Mountains; these gradually disappear towards the east, and are replaced by gneisses and other rocks transported from the east and north-west. Towards the north-west several driftless hills over 4000 feet high appear to have stood as islands above the sheet of ice. Some of the surface erratics of gneissose rock have doubtless been derived from the Till, whilst others are connected with moraine deposits, and others, again, appear to have been dropped from bergs floating in seas along the ice-front. The Till is sometimes divisible into a lower massive and upper rather stratified deposit, separated occasionally by

3. *Interglacial Deposits* of stratified material, with seams of impure lignite, and shells of *Pisidium, Limnæa, Planorbis*, etc.

4. *Moraines*, which are intimately associated with the Boulder-clay, and represent terminal moraines of ancient glaciers which originated upon or crossed the Archæan belt. One of these is the well-known Missouri Coteau.

After pointing out the derivation of quartzite pebbles in the drifts of the eastern region from Miocene conglomerates, and not directly from the Rocky Mountains, the author described

5. The *Kames* or *Åsars* generally occurring at the bottoms of wide valleys, and which resemble in structure those of Scandinavia.

6. *Stratified Deposits* and Beach-ridges which have been formed at the bottoms and along the margins of freshwater-lakes lying along the foot of the ice-sheet. The principal of these occupied the valley of the Red River, and has been called Lake Agassiz; it had a length of 600 miles and a width of 170 miles. The author described in detail the gravel terraces formed around this lake, and showed that a slow elevation had taken place towards the north and east

since their formation. He favoured the view that the waters of the lake were dammed by the ice towards the north. An account was given of some quartzite flakes, apparently chipped by human agency, in one of the terraces of this lake. On the recession of the ice the southern drainage-channel was abandoned, and a northerly one opened out.

7. *Old Drainage-channels.*—Throughout the whole region old drainage-channels appear to have been occupied by southerly running rivers (where the present drainage is northerly), and are considered to have carried away the waters draining from the foot of the ice. Some of these valleys have been blocked by moraines in the Duck Mountains, the result of local glaciers.

II.—November, 21, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.

W. Whitaker, Esq., B.A., F.R.S., F.G.S., who exhibited a series of specimens from the deep boring at Streatham, made some remarks upon the results obtained, of which the following is an abstract :—

After passing through 10 feet of gravel, etc., 153 of London Clay, $88\frac{1}{2}$ of Lower London Tertiaries, 623 of Chalk (the least thickness in any of the deep borings in and near London), $28\frac{1}{2}$ of Upper Greensand, and $188\frac{1}{2}$ of Gault, at the depth of $1081\frac{1}{2}$ feet hard limestone, mostly with rather large oolitic grains, was met with. This, with alternations of a finer character, sandy and clayey, lasted for only $38\frac{1}{2}$ feet, being much less than the thickness of the Jurassic beds, either at Richmond or at Meux's Boring. The general character of the cores showed a likeness to the Forest Marble, and the occurrence of *Ostrea acuminata* agreed therewith.

At the depth of 1120 feet the tools entered a set of beds of much the same character as those that had been found beneath Jurassic beds at Richmond, and beneath Gault at Kentish Town and at Crossness. The softer and more clayey components were not brought up; the harder consist of fine-grained compact sandstones, greenish-grey, sometimes with purplish mottlings or bandings, and here and there wholly of a dull reddish tint. With these there occur hard, clayey, and somewhat sandy beds, which are not calcareous, whilst most of the sandstones are. Thin veins of calcite are sometimes to be seen, and at others small concretionary calcareous nodules; but no trace of a fossil has been found.

The bedding is shown, both by the bands of colour, and by the tendency of the stone to fracture, to vary generally from about 20° to 30°.

In the absence of evidence it is hard to say what these beds are, and the possibilities of their age seem to range from Trias to Devonian. It is to be hoped that this question may be solved, as on it depends that of the possibility of the presence of Coal-measures in the district; and Messrs. Docwra, the contractors of the works, have with great liberality undertaken to continue the boring operations at their own expense for at least another week.

Details of the section will be given in a forthcoming Geological

Survey Memoir, in which, moreover, the subject of the old rocks under London will be treated somewhat fully.

The following communications were read :—

1. "Notes on the Remains and Affinities of five Genera of Mesozoic Reptiles." By R. Lydekker, Esq., B.A., F.G.S.

This paper was divided into five sections. In the first the author described the dorsal vertebra of a small Dinosaur from the Cambridge Greensand, which he regarded as probably identical with the genus *Syngonosaurus*, Seeley. Reasons were then given for regarding this form as being a member of the Scelidosauridæ, stress being laid on the absence of a costal facet on the centrum.

The second section described an axis vertebra from the Wealden of the Isle of Wight, which is evidently Dinosaurian, and may possibly belong to *Megalosaurus*. It is remarkable for exhibiting an intercentrum on its anterior aspect, and also for the absence of anchylosis between its centrum and that of the atlas.

In the third section the femur of a small Iguanodont from the Oxford Clay, in the possession of A. R. Leeds, Esq., was described. This specimen agrees with *Hypsilophodon* and *Camptosaurus* in its pendent inner trochanter, and it was referred to the latter genus as *C. Leedsi*. It is also considered to be closely allied to *Iguanodon Prestwichi*—the type of *Cumnoria* of Seeley—which is also considered to belong to the American genus. The name *Camptosaurus valdensis* was applied to an allied form from the Wealden; and the name *Cryptodraco* proposed to replace *Cryptosaurus*.

The imperfect skeleton of a Sauropterygian from the Oxford Clay near Bedford, which formed the subject of a previous communication, was redescribed. This specimen was identified with *Plesiosaurus philarchus*, Seeley, which it was proposed to refer to a new genus under the name of *Peloneustus*. This genus was shown to be allied to *Pliosaurus*, and to be represented by forms in the Kimmeridge Clay which have been described as *Plesiosaurus æqualis* and *P. stenodirus*. It was also compared with the genus *Thaumatosaurus*, Meyer, from which *Rhomaleosaurus* of Seeley was considered inseparable. Some remarks are added on other Sauropterygians; and it was proposed to adopt the name *Cimoliosaurus* for all the forms having a pectoral girdle of the type described under the names of *Elasmosaurus* and *Colymbosaurus*, and with single costal facets to the cervical vertebræ.

The paper concluded with a notice of the affinities of the Crocodilian genus *Geosaurus*. This form was shown to be closely allied to *Metriorhynchus*, both being characterized by the absence of dermal scutes and the presence of bony plates in the sclerotic. It was also shown that some of the species of *Cricosaurus* belong to the former genus; while there appear to be no grounds by which *Dacosaurus* (*Plesiosuchus*) can be separated from the same.

2. "Notes on the Radiolaria of the London Clay." By W. H. Shrubsole, Esq., F.G.S.

Microscopical examination of the London Clay of Sheppey and elsewhere has afforded proof of the existence of a Diatomaceous zone near the base of the formation. The formation of a well for the Queenborough Cement Company in 1885 was the means of furnishing a laminated clay with glittering patches of Diatoms from a depth of 225 feet. In this were also found fairly good pyritized specimens of Radiolaria, some of which were submitted to Prof. Ernst Häckel, who found a large number of fragments of Tertiary Radiolaria, but few well-preserved specimens appertaining to the families Sphæroidea, Discoidea, and Cyrtoidea, and apparently identical with those described from the Tertiary Tripoli beds of Grotte. No new species occurred among the recognized forms.

Sketches made by Mr. A. L. Hammond were also submitted to Prof. Häckel, who stated that these forms were not identical with any known species, recent or fossil.

The author described the following new species:—*Cornutella Hammondi*, *Spongodiscus asper*, and *Monosphæra toliapica*.

The specimens were preserved in iron-pyrites.

Some Tetractinellid sponge-spicules from the washings were recognized by Prof. Sollas.

3. "Description of a New Species of *Clupea* (*C. vectensis*) from Oligocene Strata in the Isle of Wight." By E. T. Newton, Esq., F.G.S.

A number of small fishes found by Mr. G. W. Colenutt, of Ryde, during his investigations of the Oligocene strata of the Isle of Wight, in beds belonging to the "Osborne Series," were described as belonging to a new species of *Clupea*. The specimens vary in length from 20 to nearly 60 millim. In all of them the head is much broken; but the rest of the body is beautifully preserved, showing most distinctly the vertebral column, ribs, fins, tail, and ventral spines. The single dorsal fin has its front rays about midway between the tip of the snout and the base of the tail, the ventral fins being immediately under the front of the dorsal and about midway between the pectoral and anal fins. The anal fin commences about halfway between the ventral fins and the base of the tail, occupying about two-thirds of that distance, and the tail is deeply forked. The scales are thin and in most cases much broken; while the ventral region of the body is armed with a row of strong spines. The spinal column contains about 40 vertebræ, of which 14 or 15 are caudal. The bones of the head are mostly broken, but those of which the outline can be traced agree with the corresponding parts of the Sprat.

These fishes are referred to the genus *Clupea*; but although very closely allied to the Common Herring and Sprat, the relative positions of the dorsal and ventral fins, as well as the number of vertebræ, prevent their being placed in any known species, either recent or fossil, and they are therefore regarded as a new form and named *Clupea vectensis*.

III.—December 5, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. "Notes on two Traverses of the Crystalline Rocks of the Alps." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

These journeys were undertaken in the summer of 1887 in the company of the Rev. E. Hill, F.G.S., in order to ascertain whether the apparent stratigraphical succession among the gneisses and crystalline schists which the author had observed in the more central region of the Alps, held good also in the Western and Eastern Alps. At the same time all circumstances which seemed to throw any light on the origin of the schists were carefully noted. The author examined the rocks along two lines of section:—(1) By the road of the Col du Lautaret from Grenoble to Briançon, and thence by the Mont Genèvre and the Col de Sestrières to Pinerolo, on the margin of the plain of Piedmont. (2) From Lienz, on the upper waters of the Drave, to Kitzbuhel; besides examining other parts of the central range, east of the Brenner Pass. The specimens collected have subsequently been examined microscopically.

The results of the author's investigations may be briefly summarized as follows:—

(1) While rocks of igneous origin occur at all horizons among the crystalline series of the Alps, these, as a rule, can be distinguished; or, at any rate, even if the crystalline schists in some cases are only modified igneous rocks, these are associated with recognizable igneous rocks of later date.

(2) There are, speaking in general terms, three great rock-groups in the Alps which simulate curiously, if they do not indicate stratigraphical sequence. The lowest and oldest resemble the gneisses of the Laurentian series; the next, those rather "friable" gneisses and schists called by Dr. Sterry Hunt the Montalban series; the third and uppermost is a great group of schists, generally rather fine-grained, micaceous, chloritic, epidotic, calcareous and quartzose, passing occasionally into crystalline limestones, and (more rarely) into schistose quartzites.

(3) The Pietra Verde group of Dr. Sterry Hunt, so far as the author has been able to ascertain, consists mainly of modified igneous rocks, of indeterminable date, and is at most only of local, if, indeed, it be of any classificatory value.

(4) Of the above three groups the uppermost has an immense development in the Italian Alps and in the Tyrol, north and south of the central range. It can, in fact, be traced, apparently at the top of the crystalline succession, from one end of the Alpine chain to the other.

(5) The middle group is not seldom either imperfectly developed or even wanting, appearing as if cut out by denudation. It was not seen in the traverse of the Franco-Italian Alps, except perhaps for a comparatively short distance on the eastern side, being probably concealed by Palæozoic and Mesozoic rocks on the western side. It is not very completely developed in the Eastern Tyrol, and seems to prevail especially in the Lepontine Alps, and on the southern side of the watershed.

(6) The lowest group is fairly well exposed, both in the French Alps and in the Central Tyrol.

(7) As a rule, the schists of the uppermost group had a sedimen-

tary origin. The schists and gneisses of the middle group very probably, in part at least, had a similar origin. In regard to the lowest group it is difficult, in the present state of our knowledge, to come to any conclusion.

(8) The slates and other rocks of clastic origin in the Alps, whether of Mesozoic or of Palæozoic age, though somewhat modified by pressure, are totally distinct from the true schists above mentioned, and it is only under very exceptional circumstances, and in very restricted areas, that there is the slightest difficulty in distinguishing between them. The evidence of the coarser fragmental material in these Palæozoic and later rocks indicates that the gneisses and crystalline schists of the Alps are very much more ancient than even the oldest of them.

(9) The remarks made by the author in his Presidential Address, 1886, as to the existence of a "cleavage-foliation" due to pressure, and a "stratification-foliation" of earlier date, which seemingly is the result of an original bedding, and as to the importance of distinguishing these structures (generally not a difficult thing), have been most fully confirmed. He is convinced that many of the contradictory statements and much of the confusion in regard to the origin and significance of foliation are due to the failure to recognize the distinctness of these two structures. In regard to them it may be admitted that sometimes "extremes meet," and a crystalline rock pulverized *in situ* is very difficult to separate from a greatly squeezed fine-grained sediment; but he believes these difficulties to be very local, probably only of a temporary character, and of little value for inductive purposes.

2. "On Fulgurites from Monte Viso." By Frank Rutley, Esq., F.G.S., Lecturer on Mineralogy in the Royal School of Mines.

The specimens described in this paper were collected by Mr. James Eccles, F.G.S., close to the summit of Monte Viso (12,680 feet above sea-level). They are fragments of a glaucophane-epidote schist, in which garnet, sphene, and occasionally diallage are present. Prof. Judd considers that the rock somewhat closely resembles the glaucophane schists and eclogites of the Ile de Groix.

The fragments are bounded by joint-planes or surfaces of easy fission, which are incrusted with minute pellets and thin films of fulgurite-glass forming the walls of lightning tubes. The glass was examined under the microscope (great care being taken to insure perfect isolation of the glass from the rest of the rock), and found to be, as a rule, remarkably pure, but in places not only gas-bubbles but also globulites occur, and the latter occasionally form longulites, and more rarely margarites. Microliths also are observable in some of the sections. In one section a minute rounded grain of schist containing a fragment of a strongly depolarizing crystal, probably epidote, appears to have been taken up in the glass.

Where the glass comes in contact with the rock the latter appears to have undergone no alteration beyond the development of a very narrow band of opaque white matter, which the author gave reason for supposing to be due, not to the action of the lightning, but to a pre-existent segregation of sphene.

The occurrence of globulites, margarites, longulites, and microliths in the glass would seem to indicate a less sudden cooling than is assumed to be usual in such cases; for the glass presents no signs which would characterize a subsequent devitrification or secondary change, and the bodies just enumerated appear, unquestionably, to have been formed during the refrigeration of the fulgurite.

3. "On the Occurrence of a New Form of Tachylyte in Association with the Gabbro of Carrock Fell, in the Lake District." By T. T. Groom, Esq. Communicated by Prof. T. McKenny Hughes, M.A., F.G.S.

In this paper the author described an ancient but well-preserved glassy rock of basic composition which he had found as a vein associated with the gabbro of Carrock Fell. The rock was described macroscopically and microscopically, and a complete chemical analysis was given. The chemical composition resembled that of the more acid basalts and the augite-andesites, and approached especially closely to some continental basalts, analyses of which were added for comparison. Examined microscopically, the rock consisted of a globulitic and crystallitic glass-basis of green colour, containing spherules of quartz, spherulitic felspars, and an interesting series of granules and granular aggregates of augite, which likewise frequently assumed a spherulitic form. The rock was rendered microporphyritic by the sparing development of crystals (or skeleton-crystals) of plagioclase felspar, augite and quartz. The optical characters of each of the minerals were given. Owing to the mode of development and to the variety of its constituents, the rock possessed an exceedingly complicated structure. The order of crystallization was worked out, and it was pointed out that a second generation of each of the important constituents had arisen. The second generation of felspar was of a more acid type, and that of the quartz was devoid of fluid vesicles, and had crystallized out after the rest of the rock had solidified sufficiently to form cracks. Close physical and mineralogical relations with the gabbro were indicated, and the author had no doubt that the two were in actual connection with one another. The age was put down as probably Ordovician. A comparison of the rock with other basic rocks showed that it had affinities both with the glassy forms connected with the more volcanic members, and with the variolites of Durance found associated with diabase. The relation with the latter rock was especially marked, but important points of difference rendered a separation of the two necessary, and for the new type of rock thus recognized the name *Garrockite* was suggested. This rock might be looked upon as a *Quartz-Gabbro-Vitrophyre*.

CORRESPONDENCE.

ICHTHYOSAURUS ACUTIROSTRIS, ZETLANDICUS, & LONGIFRONS.

SIR,—On page 313 of the GEOLOGICAL MAGAZINE, Dec. III. Vol. V. 1888, I stated that I was "disposed to unite both *Ichthyosaurus Zetlandicus* and *I. longifrons* with *I. acutirostris.* Since that passage was written Prof. Karl von Zittel has been good enough to send me a figure of an entire skull of an *Ichthyosaurus* from the Upper Lias of Curcy, evidently belonging to *I. longifrons,* which I consider inseparable from *I. Zetlandicus.* This specimen differs, however, from *I. acutirostris* in its perfectly straight rostrum; and we have, therefore, a character which (if not merely sexual) will afford a valid distinction between the two forms. If *I. quadriscissus* of Quenstedt be identical with *I. acutirostris,* the name *I. Zetlandicus,* as earlier than *I. longifrons,* should be adopted for the straight-beaked form.

November 17*th,* 1888. R. LYDEKKER.

THE SERPENTINE OF THE LIZARD.

SIR,—There are two slight errors in Mr. Somervail's paper "On a Remarkable Dyke in the Serpentine of the Lizard" (p. 553 of last volume), which may mislead readers. They are contained in one sentence, "The dyke forms a portion of the 'granulitic group' of Prof. Bonney, which is now known to be of igneous origin." (1) I have never placed any of the rocks near Pentreath Beach in my "granulitic group," but speak of them more than once as belonging to the "hornblende schists." (2) For "which is now known to be" read "which is now known to include some rocks." The origin of the distinctly "banded gneissic" portion, like that of the banded hornblende schists, cannot be said to be yet known to any one, unless Mr. Somervail has been honoured with a special revelation on the subject. Most persons who have particularly worked at questions of this kind consider the origin of these rocks a very difficult and as yet unsolved problem. The speculations as to the origin and relations of the Lizard rocks, with which Mr. Somervail has favoured us, will no doubt meet with the attention which they deserve, regard being had to the wide experience of their author and his intimate knowledge of rock-structures. T. G. BONNEY.

THE GENUS *ASCOCERAS.*

SIR,—The figure which Prof. Lindström gives in the December Number,[1] of an *Ascoceras* from the Island of Gothland is a very instructive one—as it supplies some of the earlier septa which have hitherto been wanting and gives a final proof of their existence. It is thus completely confirmatory of the description of the genus which I gave on p. 61 of my British Fossil Cephalopoda. At the time of writing I was obliged to say "the earlier part is unknown"—which still remains partially true—since only three chambers of

[1] GEOL. MAG. 1888, Dec. III. Vol. V. p. 533, Woodcut.

the ordinary type are seen in the new specimen; but I had to add "the body chamber and the last few septal chambers only [those which are distorted] being preserved in association." This is now no longer true, but the remainder of my description was entirely based on the probability, not to say the certainty, of such a specimen being ultimately found. It runs, "The earlier septa are of the ordinary kind, with very little convexity and the siphuncle is excentric, in some of large size . . . The last few chambers are distorted and their dorsal portions are seldom seen." These dorsal portions, as in the specimen figured by Barrande (Syst. Sil. de la Bohême, vol. ii. p. 513), are well shown in the new specimen. I arrived at the same conclusion as Professor Lindström—that the *Ascoceras* "is by no means the simplest form of Cephalopod, but the most abnormal," and included it with *Poterioceras* and others in the group *Inflati*, the genus being characterized by having its "later septa distorted." The group is said to *diverge* from the *Conici*, *i.e.* the *Orthocerata*, etc., and to be remarkable for the loss of the early septa.

It is satisfactory that in all these points the new specimens from Gothland confirm the previous observations. J. F. Blake.

THE MONIAN SYSTEM.

Sir,—I feel greatly indebted to Dr. Callaway for introducing the Monian System to the notice of your readers. It was through his advice I went to Anglesey, and he naturally takes a fatherly interest in the result.

There are, however, certain points in his "Notes" which call for explanation or reply.

1. I am happy to recognize that Dr. Callaway, in 1887, quite independently of my observations, came to the conclusion that the hornblende-schists were of igneous origin, notwithstanding that such a conclusion entirely overthrew his reading of the succession in the "gneissic series." I must even confess that he is bolder than I am, for my statement that these schists are igneous, is made in fear and trembling; for though I am forced to it by the stratigraphy, I know it would have been laughed at a few years ago. Nor can I get as far as "foliated felsites," those so considered by Dr. Callaway being compressed and indurated examples of the ordinary mica-schists of the district.

2. As to Parys Mountain, there are two other writers' opinions to consider besides Dr. Callaway's.

3. As to the Llanfechell Grit. I acknowledge it would be of some importance if it could be shown that any large part of the upper portion of the series was made up of fragments of the lower; but after all the Llanfechell Grits are merely subordinate bands in a long series, and there are no conglomerates in association with them, so that at best any included fragments would be poor evidence. Moreover, it seems quite common in these old rocks, for the earlier deposits to be rapidly altered and to contribute to the later. Thus the con-

glomerate of Bull Bay is made of the underlying quartz rock. The fragments in the "agglomerates" or "conglomerates" of Llangefni are like some of the neighbouring rocks, the Bangor beds are full of fragments of rocks very similar to other parts of the same series, and the conglomerate of Moel Tryfaen is largely composed of the immediately preceding Cambrian slates. I do not, therefore, give much weight to any argument from such a grit. I only dealt with it because it was confessedly at first the *only* argument for there being two groups of Precambrian rocks in Anglesey. If the rock is discussed, I have to say that of course Prof. Bonney's *description* is accurate. The fragments do "much resemble some of the finer-grained schists of Anglesey;" but they resemble those parts which have been *entirely re-formed;* such entire re-formation occurs sometimes in bands parallel to the lamination, sometimes in veins crossing it, and is not confined to the older part of the series, but affects many other parts. The veins, like the rest of the rock, have formed under a pressure that has induced an orientation of the micaceous ingredient. We cannot, therefore, identify the fragments with any definite rock.

4. The rocks near Llyn Irefwll. In this case, again, I should have said nothing except for the stress Dr. Callaway lays upon the locality. I twice failed to find the exact spot referred to, though the whole structure of the surrounding rocks seemed clear. Only by the minutest directions was I able to find a spot where some slaty-looking rock contained fragments of granite, and seems continuous with the diabase which forms part of several bosses. All these figure as "slate" in Dr. Callaway's paper. Several slides have been examined and prove to be diabase—hence "some of the slates of Dr. Callaway are diabase." Where the granitic fragments are found, this diabase has become more or less hornblendic, or dioritic—or it may be that the containing rock is a distinct one. In any case, fragments of granite are contained in a slaty-looking rock which is not a slate. They must also be contained in a true slate, since such is their matrix as described by Prof. Bonney; but this slate is certainly not the diabase ridge figured as Pebidian by Dr. Callaway. It is really not worth while pursuing the question any further.

5. With regard to the areas where there is a passage between Dr. Callaway's lower and upper groups, his observations are rather special pleading, because he selects two places, nearly the only two, where the succession is confessedly broken by faults, and gives these as examples; whereas in both these places the supposed succession is stated to be entirely made out from what is *observed* abundantly elsewhere.

6. As to the applicability of the Monian system to other regions, it is obvious that our first business is to thoroughly understand the development of a series of rocks in the place where the connection of one part with another is most fully displayed, and such a place is Anglesey, where the succession and stratigraphy in many places is comparatively clear. It is a later work to correlate other regions with the type, the probable result only being briefly indicated in my

paper. The reason for correlating the Longmynd rocks with the Upper Monian are, first, that they are certainly pre-Cambrian, especially since the discovery by Prof. Lapworth of the lowest Cambrian fauna in other rocks in the immediate neighbourhood, and, secondly, that the only certain fossils recorded from the Longmynd, *Arenicolites didyma*, are also recorded from the rocks of Bray Head. It is also to be noted that as the "Uriconian" is to a large extent volcanic, there need not be much of a gap between it and the "Longmyndian." By some curious effort of the imagination Dr. Callaway says "Uriconian and Malvernian are lumped together as Middle Monian," but I cannot find that I have anywhere mentioned the "Malvernian," as I know too little of that district and the descriptions are too discordant to make it safe even to venture upon a probability. It may not be Monian at all.

If Dr. Callaway has a fancy to call the different divisions of the Monian by names derived from other districts, there can be no objection, provided we first make sure of the correlation. I am perfectly satisfied with their all forming parts of a larger group or system—the Monian.

I may add that as these rocks have a quite distinct character from the true Hebridean, or the general type of gneisses, I was much delighted to find that so many foreign geologists, who visited Anglesey in September last, recognized their resemblance to rocks of their several districts which occur immediately beneath their lowest fossiliferous horizons. J. F. Blake.

Dec., 1888.

UNIFORMITY IN SCIENTIFIC BIBLIOGRAPHY.

Sir,—Having been for some time engaged in preparing a bibliography of earthquake-literature, I can fully endorse the necessity of Mr. C. D. Sherborn's plea for uniformity in the quotation of abbreviated titles of scientific journals. The increasing number and importance of works of this class render this and other unsettled points in bibliography worthy of attention and discussion; and I would venture to suggest that the British Association Committee on Zoological Nomenclature could find a useful successor in a Committee for securing Uniformity in Scientific Bibliography.

May I be allowed to offer here a few remarks on this subject?

Abbreviated Titles.—Besides a mere hap-hazard choice two courses are open in the selection of abbreviated titles.

(1) We may adopt that in use amongst the members of the Society issuing the journal, as "Phil. Trans." or "Comptes Rendus." Familiarity in a few cases and established custom are in favour of the retention of this system, but it has the obvious disadvantage of not representing at a glance the complete title of an unknown journal, for it omits the name of the society. Moreover, contractions founded on such words as "Transactions" or "Proceedings," common to a great number of societies, are objectionable.

(2) The abbreviations may be formed on a uniform plan from the full title of the journal. That adopted in the Geological Record

seems to me to fail in putting to the front a word like "Trans.," a comparatively unimportant part of the title, and also a word common, as just pointed out, to many different Societies.

A better method would, I think, be to put the most important, and at the same time least-frequently used, word first, and the others in descending order, as follows: 1. Place of meeting: 2. Name of society: 3. Name of journal: *e.g. Glasgow, Geol. Soc., Trans.*

I may remark, in passing, that this system is used in the library of the Birmingham Philosophical Society. It possesses the advantage that the book-shelves form an alphabetical index to their contents.

Obvious exceptions to the rule will occur at once, some as necessary, others as desirable. The British Association Reports cannot be classed under the name of any town; and it would hardly be advisable, for instance, to subordinate the well-known Transactions of the Seismological Society of Japan under the less-known heading "Tokio." The name of the country should clearly be used when it occupies the leading place in the title.

Date of papers.—The date of a paper contributed to a society may be taken as that of its reading, or as that of the publication of the volume in which it appears: these dates often differing considerably. The latter, I believe, is the method usually adopted. But, in a case of priority, this rule would not be followed; and a paper may also become widely known by means of "authors' copies" printed off before the complete volume is published. On these accounts, it seems to me desirable that the day on which a paper is read should be accepted as its date in bibliographies.

Charles Davison.

King Edward's High School, Birmingham,
Dec. 7, 1888.

THE BEDS OF THE LONDON AREA.

Sir,—In the short abstract of Mr. Whitaker's paper on the Streatham boring, read before the Geological Society on the 21st November, the question is raised as to the horizon which the generally red beds met with beneath the Mesozoic in many of the deep borings around London occupy between the Trias and the Devonian. It has appeared to me that they probably belong to the former, because the rocks met with at Meux's Brewery in Tottenham Court Road, and at Turnford, are distinctly of the *Devonshire* type. Now, so far as I know, the "Devonian" does not assume the Red Sandstone type in Devonshire. If this is so, then it offers a presumption that, where these older beds are found of the Devonshire type, as is the case under London, they are not likely to be found also of the arenaceous type, which belongs to those in the Mendip and South Wales district. In fact the two types are not likely to be found together in the same area, unless it happens to have the exceptional position of being situated where two distinct conditions of deposition succeeded one another during one and the same geological period. For these reasons I think these red beds newer than the Carboniferous.

Harlton, Cambridge, *Dec.* 11, 1888. O. Fisher.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VI.

No. II.—FEBRUARY, 1889.

ORIGINAL ARTICLES.

I.—On some Physical Changes in the Earth's Crust.

(*Part I.*)

By Charles Ricketts, M.D., F.G.S.

THERE always appears an objection to the agencies by which mountains and hills are formed being designated by such terms as "mountain architecture," "mountain building," etc., leading to the inference that to the deposition of the materials which enter into their composition these elevated regions owe their form and structure. There certainly are mountains which have been built, and some such are at the present time in process of building; but these instances refer only to elevated masses of volcanic origin: they have been constructed as the railway engineer builds his embankments, or, with greater preciseness, as the miner forms the bank at the pit's mouth, by tipping over the rubbish brought from below. To hills and mountains forming volcanic cones the term *mountain building* is quite correct; the volcano in eruption pouring over its lava, and belching forth scoriæ and ashes, which fall and accumulate around its vent.

The term building may also be applied to the formation of the miniature mountain-ranges which, in certain localities, fringe our coast; sand-hills and -dunes being due to the accumulations which the wind has carried landward when the sandy shores are exposed and dry. The term is likewise applicable where receding glaciers have brought down, and discharged as moraines, their burden of stones and rubbish, forming not only small mounds but hills and ridges of considerable size.

With respect to elevated masses such as these, whether great or small, the process of their formation may be correctly termed building; otherwise the formation of mountains is due to sculpture, —to erosion, disintegration, denudation,—and may be compared to the work of the quarryman, rather than that of the builder; to the art of the sculptor and not of the architect. Playfair, in his "Illustrations of the Huttonian Theory of the Earth," considered that "mountains as they now stand may not inaptly be compared to the pillars of earth which workmen leave behind them, to afford a measure of the whole quantity of earth which they have removed."[1]

[1] § 113, p. 127.

Excepting by very few it was formerly assumed that the sculpturing of mountains, and the formation of valleys, etc., were due to the action of the sea. Again, that "the excavation of valleys could be ascribed to no other cause than a great flood of water, which overtopped the hills from whose summits these valleys descend." It has been considered "they are due to cracks, rents and gorges of fissure in the rock-masses, in some of which rivers flow; that these fissures have been caused by upheaval, by ruptures, and denudation," and "that mountain valleys lie in lines of curvature, dislocation and fracture." No endeavour was made to demonstrate how any of these various causes could have excavated valleys, and it is very remarkable that there was no attempt to account for the redistribution of the materials which had been removed. It is probable that the difficulty of making the present conformation of the Earth's surface coincide with a preconceived chronology, may have had great influence in the formation of such opinions, even by those who are justly considered fathers in geological science. We are constantly reminded how greatly this feeling is impressed on the popular mind in expressions made by persons unacquainted with geological science; with those who may be considered educated, "I presume it is antediluvian;" with the workman or labourer, "It was there afore th' flood!" Walking through one of the minor gorges in the Carboniferous Limestone of North Derbyshire, and conversing with an intelligent man native to the district; on the remark being made, that some persons think these dales have been formed by the streams that run through them, the immediate and emphatic reply was, "No! that could never be;" and, pointing to the rivulet, "Why there is not water enough to drown a mouse. You may depend upon it all these places were cut out when the world was drowned."

Hutton (1795) and Playfair (1802) demonstrated that the formation of valleys was due to the effects of atmospheric agencies. Playfair says, "Water in every state from transparent vapour to solid ice, from the smallest rill to the greatest river, attacks whatever has emerged above the level of the sea, and labours incessantly to restore it to the deep. The parts loosened and disengaged by the physical agents are carried down by the rains, and, in their descent, rub and grind the superficies of other bodies; and, when rain descends in torrents, carrying with it sand, gravel, and fragments of rock, it may be truly said to turn the forces of the mineral kingdom against itself. Every separation which it makes is necessarily permanent, and the parts once detached can never be united save at the bottom of the ocean."[1] "All river channels have been cut by the waters themselves; they have been slowly dug out by the washing and erosion of the land."[2]

A long time elapsed before this explanation was accepted, not until there occurred in the early volumes of the GEOLOGICAL MAGAZINE a prolonged discussion on the subject, which proved that a great

[1] Playfair's Illustrations, etc., § 95, p. 111.
[2] Illustrations, § 99, p. 115.

change of opinion had taken place; very many of those who had been led to consider that, in the words of Hutton, "the rivers themselves had hollowed out their valleys," being on the staff of the Geological Survey, whose occupation affords special opportunities for determining such questions; not that they ignored the effects of the waves and tide, but did not attribute to them results which the sea could not produce, occurring where the sea had not been. The author of "Rain and Rivers" (the late Colonel George Greenwood), was the most persistent advocate of the views of Hutton and Playfair. This dashing cavalry officer renewed the assault again and again, never failing to attack any weak point exposed by his opponents.

This discussion was decisive in determining that valleys are formed by rain and rivers, and that the materials, which once filled up the excavations made, had been carried down and deposited in the sea near their mouths; but there still remained to be considered the methods by which this is accomplished. If the crust of the earth were rigid, rivers, by bringing down the disintegrated materials, would simply fill up the sea near their mouths, and, judging from the vast amount which must, during prolonged periods, have been removed in the excavation of valleys, there would be formed level plains or deltas extending over an immense number of square miles, through which the streams would flow. At the mouths of large rivers. and where the sediment derived from the excavation of the land is brought down by them, there is evidence in all cases that the weight of these accumulations in the bed of the sea, on deltas, and in bays, presses down the crust of the earth, and thus accommodates the subsequent accretion of materials. This result may be considered universal and capable of demonstration in strata of all ages, from the earliest Geological epoch to the present time.[1] No expression is in more frequent use than that different formations have been laid down during a period of subsidence. "Everywhere throughout the world," says Prof. James Geikie, "we read the same tale of subsidence and accumulation, of upheaval and denudation.[2] It has only very lately been generally recognized that the weight of the accumulation is the cause of subsidence; at all events when, in a consideration of the subject,[3] opportunity was afforded, there was no attempt to controvert this opinion. The subject is a most important one, and, with its converse, that denudation, by lessening the pressure on the earth's crust, causes the land to rise, may justly be considered the *Alpha* and the *Omega* of physical geology, for to it must be attributed the great movements and changes that take place on the earth.

These areas of deposition may subsequently enter into the structure of mountain-masses and form elevated ground, but, so far as *building*

[1] On Subsidence as the Effect of Accumulation, by C. Ricketts; Geol. Mag. Vol. IX. p. 119, 1872.

[2] Mountains: their Origin, Growth, and Decay.

[3] "Nature" for August 2nd, 1883, and subsequent numbers. In the number for August 30th, 1883, page 413, and October 4th, 1883. page 539, reference is directed to those who have taken the subject into consideration so far as known to myself.

is concerned, the result is the formation of alluvial and marine plains, occurring about or below the level of the sea; it is only on the conditions being altogether changed they become raised, chiefly in consequence of the removal of weight, consequent on the great denudation they have undergone, and thus help to form mountains.

The flanks of mountains are frequently composed of rocks whose strata have undergone disturbance and contortion, and are oftentimes affected by cleavage. These foldings have been referred to as essential features in the formation and "building" of mountains; but they extend as frequently to low ground, and pass beneath deltas and estuaries, and form the base upon which the strata constituting the bed of the sea rest. Geological inquiry shows that after having been raised above the sea-level and become weathered and eroded, the valleys and channels formed may again be submerged, and have their weathered surfaces buried beneath sediments to a depth of several thousand feet.

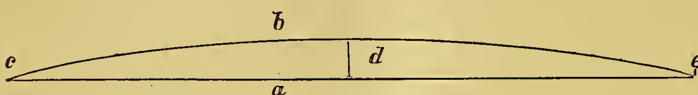
Contortions have been attributed to the forcing of wedge-shaped masses of metamorphic rock upwards so as to penetrate and protrude through sedimentary strata; but in a general elevation affecting a district the whole thickness of the earth's crust must be lifted together, and from a depth which would render such an occurrence impossible. In no instance would it appear more probable that such has taken place than on the flanks of the Malvern Range, had not Miss Annie Phillips[1] (sister to the Oxford Professor) found Silurian organisms embedded in a breccia derived from the disintegration of the metamorphic rock. Her discovery was most important, more so than is generally recognized; proving that during the deposition of the Upper Silurians the Malvern Hills formed an Island, in all probability the summit of a former mountain, buried beneath a great accumulation of strata then in process of deposition, the margins of which consisted of fragments of the metamorphic rock which had fallen down from its sides into the Silurian sea.[2] The contortions in these Silurian strata, or the power that caused them, could not have given origin to the mountain, for its summit was situated above the sea-level during the time of their deposition; on the contrary, its presence may have influenced but not caused, that action by which they are thrown into extensive folds. The rudder does not cause the ship to sail, but determines the direction of its course.

Any movement by which the crust of the earth is compressed into a less lateral space must, to an extent commensurate with the size of the area effected, have a tendency to cause the strata to become bent and contorted. This may result in some degree from the weight of accumulations causing subsidence, and, by thus pressing downwards the earth's crust, cause it also to be compressed within less lateral dimensions, but the lateral pressure thus developed can only be considered as inducing a *tendency* to form flexures; its

[1] Memoirs of the Geological Survey, vol. ii. p. i. p. 66.

[2] Fragments derived from the hills also enter into the composition of the Hollybush Sandstone (Lower Silurian).

extent being limited to the difference between the measurement of the portion of the earth's circumference and the Chord of its Arc included in any area referred to. This variation will be found comparatively so slight as to be utterly inadequate to account for the presence of such foldings as occur in many districts; though it is to such a cause they are not infrequently attributed. The impossibility of these contortions being the result of such subsidence may be best illustrated by taking two slips of wood (Fig. 1 *a*, *b*) of equal length —say 10 feet—fastened together at one end by a hinge (*c*); one (*a*) being fixed so as to remain straight, the other (*b*) bent to represent a curve, the greatest distance (*d*) between the chord (*a*) and the curve (*b*) being six inches; it will be apparent that the distance between the extremities of the slips of wood will be very slightly over three-quarters of an inch (*e*); an amount too insignificant to be



capable by the pressing down of the one upon the other to form foldings such as are frequently met with in geological formations.

(*To be continued.*)

II.—Notes on Altered Igneous Rocks of Tintagel, North Cornwall.

By W. Maynard Hutchings, Esq.

In the autumn of 1887, during a stay in North Cornwall, I paid a hasty visit to Tintagel, and took away a few specimens of rocks, without, however, having time or opportunity to examine more than very superficially into their field-relationships.

In subsequently studying sections with the microscope I found myself unable to correctly interpret some of them, notably a certain highly schistose rock consisting mainly of calcite and chlorite, with residues of triclinic felspars. Mr. Teall, who very kindly looked over several sections for me, suggested that this was a highly altered and mechanically metamorphosed igneous rock, which might prove to be derived from a certain epidiorite occurring not far from it; and made other remarks and suggestions which decided me to pay another and longer visit to Tintagel in the following year.

As a result of this visit, and the subsequent examination of a series of rock-specimens then collected, I venture to offer a few notes on the altered igneous rocks of the coast in the immediate vicinity, viz. from a point near Boscastle to the south end of Trebarwith Strand.

The more or less altered "Greenstones" of the coast further south have been studied and described to a considerable extent. A résumé of the work done is given and discussed in Teall's "British Petrography." So far as I am aware, the corresponding rocks of the more northern part of the coast have not received a similar amount of attention.

Referring to the map of the Geological Survey of the district, we find no occurrences of "Greenstone" marked along the coast, or its immediate vicinity, from the neighbourhood of Port Isaac to that of Tintagel, where several outcrops are indicated, extending along to near Boscastle, where we pass from the Devonian to the Carboniferous rocks. There are, however, other prominent occurrences of greenstone around Tintagel which are not shown on the map, notably the very extensive exposure at Trebarwith Strand which is alluded to by De la Beche in his "Report of the Geology of Cornwall, Devon, and West Somerset" (1839).

In this report there are several references to the igneous rocks of this special strip of the coast. Thus, on pp. 56 and 57, Beche speaks of "schistose beds" which are intermingled with the "slates and grits which emerge from beneath the Carboniferous system," and describes these schistose rocks as "strongly reminding us of the substance of greenstone, finely comminuted and permitted to settle in water in which calcareous matter was occasionally present." He states that "greenstones, some large-grained, occur near Tintagel, and the trappean schistose rock is also discovered mingled with them, particularly towards Bossiney."

He looks on the "schistose trappean rock" as an altered ash, and considers that the two kinds, compact and schistose, have "probably been erupted, one in the state of igneous fusion, and the other in that of ash, during the time that the mud now forming slates was deposited."

This sharp distinction made by Beche between the compact and schistose rocks of this neighbourhood, and the definite inference he draws as to their different conditions of origin, would not now, with modern methods of examination, hold good in all cases. Passages of his "large-grained" or "compact" greenstone into the most highly schistose rock may be observed which leave no doubt that the original material was one and the same for both.

There are other occurrences of schistose rock whose origin we may safely say was igneous, but concerning which, in their present extremely altered condition, we could not arrive at any safe conclusion as to whether they have been derived from massive or fragmental material.

The occurrence which I will first notice is seen in the cliff at the side of a cove which is not named on the map, and of which I heard no name on the spot. It is the next little inlet south of Bossiney Cove, separated from it only by the neck of land off which lie the rocks called "The Sisters." The exposure in question is at the south side of this nameless cove. There is an outcrop, at the surface above the cliff, of angular craggy blocks, and the continuation may be seen dipping steeply down towards the sea. At the outcrop the rock is coarse-grained and massive, showing no foliation at all. It is very hard and tough, making excellent road-metal, for which purpose it is taken in quantity from a similar outcrop in a field a little way off. Numerous large irregular grains of hornblende are seen set in a greenish-grey speckled mass. It is doubtless an example of the "large-grained greenstone" alluded to by De la Beche.

A little way down the cliff the rock becomes much foliated, is much altered in general appearance, and is softer; and still further down, near the water, it has become very highly schistose, tolerably soft and easily fissile, differing in appearance in every way from the rock at the outcrop. Foliation is coincident with the dip and with the cleavage of the slates, shales, etc., above and below.

Specimens were taken at three points: No. 1, outcrop; No. 2, a few yards down the cliff; No. 3, near the bottom, a few yards above the level of the sea. Microscopic examination of sections from these specimens shows internal changes corresponding to the outward differences in texture and general appearance.

No. 1 is essentially a hornblende-plagioclase rock. The hornblende is all green, secondary and uralitic. It is mostly pale in colour with very moderate pleochroism, but some portions are of a much deeper colour and powerful pleochroism, the contrast being often seen in contiguous parts of one individual, one portion being nearly colourless, and the other a very deep green, though they extinguish together and give nearly the same colours of polarization.

The felspar is nearly all very turbid, but the columnar form of many of the crystals is still perfect, and they are still fresh enough to show twinning, binary and multiple. The structure of the original rock is shown to have been markedly ophitic by the fact that many of the individuals of hornblende are penetrated by felspar crystals, in some cases being nearly bisected. Crystals of apatite are seen here and there. There is comparatively little chlorite or calcite, but epidote is abundant, both in finely granular form in the hornblende and in crystals and irregular fragments and grains all over the sections. It is all quite colourless and non-dichroic. Leucoxene is plentiful in large plates and patches surrounding varying amounts of residual ilmenite; and some granular sphene may be seen. There are grains and little patches of secondary quartz, and a very few bits of perfectly water-clear, obviously secondary felspar, without any trace of definite form or of twinning, recognized by its optic behaviour.

This rock is a typical epidiorite, of which we may say with tolerable certainty that it was derived from a coarse-grained ophitic dolerite.

Sections of No. 2 show that hornblende is much diminished in quantity, with a corresponding increase in chlorite. All stages may be seen of the passage of the hornblende into chlorite. Calcite is also very much increased in amount.

The felspar is largely in the state of a confused, crushed, turbid mass mixed up with chlorite, without any form or sign of twinning, but with this there are a very large number of bigger grains and patches which are water-clear and contain needles of hornblende in some cases, together with numerous grains of chlorite. But few of these water-clear bits show any twinning. Quartz has increased also considerably in amount. Leucoxene and epidote remain in about the same proportions as in No. 1.

But it is more the mechanical than the chemical or mineralogical change which is very striking in this part of the rock. It has become very much foliated, and sections cut across the schistosity show in a beautiful manner what a great amount of stress and internal movement it has undergone. The chlorite is drawn out into long, curving parallel bands and streaks, and most of the calcite and leucoxene have been squeezed out into long lenticles, tapering off into thin tails. Hornblende also is crushed into layers, but in a less degree, and much of it is now in the form of detached needles and fibres. Epidote has not been drawn out into streaks, but is more broken up and separated and more or less arranged in lines; and the irregular bits of this mineral lying in among the bands and lenticles of the other constituents which have behaved more plastically, often serve to more distinctly mark the amount of "flow" which has taken place around their angles. It would be difficult, I imagine, to find anywhere a more striking example of the great alteration which may be effected in rock-structure by pressure and shearing-movement than is here given within a space of some thirty yards or less.

Sections of No. 3 show that hornblende has wholly disappeared, chlorite taking its place. Calcite is more abundant than in No. 2, while epidote is nearly wholly absent. It may be stated that over a large number of sections of rocks of this district which I have examined, calcite and epidote very generally appear in inverse proportions. They are, of course, very liable to be *originally* developed in inverse proportions. They both originate from the alteration of the same calcareous silicates, and varying conditions under which this alteration is carried on may give rise to varying amounts of the two minerals in question, even in closely adjoining parts of a rock. But it seems not unlikely that epidote may be altered into calcite under some circumstances. I have seen no mention of this, nor have I detected any epidote actually undergoing the change to calcite. Nevertheless, the frequent oscillation in the relative amounts of the minerals in these rocks has constantly suggested such a change, which is likely enough from a chemical point of view, as a possible explanation.

The most striking change in No. 3, as compared with No. 2, is that turbid felspar has now almost entirely given way to water-clear. Much of it here shows twinning. It is more or less full of bits of chlorite, and other mineral enclosures which cannot be determined. Quartz has undergone a further very decided increase. Leucoxene is still abundant, but some patches of it are seen to be very much altered to rutile in grains; and small crystals of rutile, some as sagenite, are abundant in some parts of the chlorite. The foliation is seen to be more highly developed, the parallelism of the bands of chlorite, etc., being greater, and their course less curved and wavy, which corresponds with the much greater tendency of this part of the rock to split into flattish pieces.

I may here mention that it was a section of this schist which Mr. Teall saw, together with a piece of the epidiorite, though from another outcrop. His suggestion that they might prove to be directly connected in derivation was made at the time without the slightest knowledge of the actual field-relationships, but has proved to be perfectly correct.

We have here, then, a very interesting case of the passage of a massive epidiorite into a perfect chlorite-schist; and doubtless a further series of specimens, taken at shorter intervals, would prove very instructive.

This sheet is of but moderate thickness—a few feet only. It appears to be separated from a very much thicker sheet, which underlies it, by a bed of shale or slate, the contact with which is well seen at the lower part of the cliff. Concerning the question as to whether this and other sheets of igneous material to which I shall allude are intrusive or contemporaneous, it seems that De la Beche regarded them all as being the latter. So far as my own observation goes, I should incline to hold the same opinion, at least as concerns those exposures where a considerable extent of the upper and lower contacts with the slates, etc., is plainly visible. But I would express this opinion with much diffidence, in view of the great disturbances which have everywhere taken place in this district, and the great amount of alteration the rocks have undergone.

The sheet just considered appears to follow the curve of the coast and to wind round towards Barras Nose and the Castle Cove; but much of the intervening shore is inaccessible and examination could not be made. About two-thirds of the way towards Barras Nose there is another outcrop of chloritic epidiorite, intermediate in nature between No. 1 and No. 2.

In the Castle Cove is exposed a sheet of rock which I am inclined to think is very likely a continuation of the one just described, though it is not possible to trace the connection to the point of proof. The nature of the rock is here different in many respects, but nothing is more striking than the considerable and often rapid changes of character which the igneous rocks of this district show. The sheet I allude to is seen on both sides of the Cove. On the left it is inaccessible in the cliffs of "Tintagel Head," but on the right it may be freely examined. It overlies a bed of black shale, with which its contact is sharply defined;—the same bed of shale which, curving steeply upwards from the Cove, passes right under a portion of the "Mainland," part of the Castle. So that originally this sheet of igneous rock swept up over the country inland, but is now wholly removed by denudation. As seen at the right-hand side of the cove, where the fishing-boat is hung on davits, it is a hard, grey, rather fine-grained, moderately-foliated rock. It is a good deal jointed and cracked, and all these cracks are filled with quartz. This is the only case in the district of an igneous rock being veined with quartz instead of the usual calcite.

The microscope shows it to consist mainly of felspar and chlorite, without any trace of original ferro-magnesian mineral or of secondary hornblende. The felspar is much the predominant constituent, and part of it is better preserved here than in any other local rock I have examined. Much of it is again in the indefinite and untwinned water-clear condition, but with this there are a great many well-twinned crystals of columnar form. Binary twinning is most prevalent. A series of measurements of maximum extinctions shows that much of the felspar belongs to the labradorite-anorthite group, though more acid felspars seem to be present, most likely of secondary metamorphic origin. Chlorite and calcite are in only moderate amount. Secondary quartz is tolerably plentiful, both in grains of good size and as a mosaic of smaller ones. Leucoxene with residual ilmenite, granular sphene, a little epidote, apatite, small flakes of biotite, and rutile in slender needles, and bunches of needles go to make up this rock. Bent and broken crystals of felspar, and strongly undulous extinctions both of felspar and quartz, bear witness to severe strain. The fact that much of the quartz shows these effects of stress goes to prove that the rock was very much altered before this stress was applied.

In the centre of the Cove, almost under the waterfall, another exposure of igneous rock is seen, quite at the bottom of the cliff. The extent of it visible is small. It makes the impression of being the upper part of a curve or fold of a sheet. If this is so, and supposing the sheets to be contemporaneous and not intrusive, this rock is older than the last described, considerable thickness of sedimentary material intervening. This rock is very schistose. It is highly altered, very little of its abundant felspar having any definite form as compared with the last. Calcite, chlorite and quartz are in large amount, there is also much ilmenite in various stages of alteration to leucoxene, and many of the large patches of chlorite are full of beautiful sagenitic rutile.

Again, passing from the Castle Cove by the path between the mainland and the so-called "island" of Tintagel Head, and descending to the shore below the steep west cliff of the mainland part of the Castle, we come upon a section of several sheets, or bands, of igneous rocks of various thickness, with intervening black shale. The upper sheet is some feet in thickness, then comes a bed of shale in which are two or three sharply separated bands of igneous rock of a few inches only, and finally a lower sheet of which some four to six feet are seen. They are only exposed for a few yards. It is not possible to make out anything with certainty, but very probably the upper portion of this exposure is connected with the rock seen near the waterfall in the Castle Cove.

I have examined specimens from the upper band of the series. It is again a very schistose rock. Microscopically it is interesting because it contains a good deal of what may undoubtedly be considered to be *original* igneous structure. The felspar, very abundant, is partly turbid and partly water-clear, and all the larger individuals are more or less full of flakes of muscovite. Crystal forms are well retained, and twinning, both binary and multiple, is very little obliterated. Tabular crystals are most numerous, but columnar shapes are also well represented. Besides the large crystals, however, there are a considerable number of much smaller lath-shaped felspars. These are all water-clear, well twinned, and quite fresh as to optic qualities. They all extinguish at very small angles. There is no sign of any original ferro-magnesian mineral, which is now only represented by abundant chlorite. There is much leucoxene; but little sphene or rutile. Broken, bent, and optically strained crystals are in plenty here as in the other rocks.

The two rocks of the Castle Cove may have resulted from the alteration of either massive or fragmental igneous materials; the microscopic study of them does not afford sufficient evidence for decision one way or other. But the structure of the rock just described seems plainly to show that it was a massive one, its numerous larger felspars set in a ground-mass of which the smaller lath-shaped crystals formed part. It was probably a basic rock, though much of its felspar seems now altered, by dynamic metamorphism, to mere acid forms.

The main occurrence of altered igneous rock in this district, however, is on a very much larger scale than any of those above described, and forms, indeed, one of the principal features of the coast at some parts of the parish of Tintagel.

(*To be concluded.*)

III.—On the Ballantrae Rocks of South Scotland and their Place in the Upland Sequence.

By Prof. Charles Lapworth, LL.D., F.R.S., F.G.S.

(With Plate III. and a folding Table extra).

(*Concluded from page* 24.)

Part II.—The Sequence in the Southern Uplands.

NEXT to the metamorphic region of the Northern Highlands there is perhaps no area in Britain where the strata have been so contorted and convulsed as in the great Lower Palæozoic region of the Southern Uplands of Scotland, and it is only by the *zonal* method of stratigraphy that these complexities can ever be successfully unravelled. So far as the present results of the application of that method enable us to judge, it appears that, underlying all these stratigraphical complexities, there is, in reality, a broad tectonic structure of great simplicity. For, if we make exception, on the one hand, of the lowest strata (the *Ballantrae* or *Arenig* rocks), which, as we have seen, only rise to the surface within the limits of the Ballantrae district; and on the other hand of the highest formations (*Wenlock-Ludlow*), which merely skirt the Upland plateau upon its north-west and south-west flanks, we find that almost the whole of the Lower Palæozoic strata of the Uplands are naturally grouped in two grand lithological terranes, viz. (I.) a *Lower Terrane* (*Moffat Terrane*), including strata ranging from the Upper Llandeilo to the Upper Llandovery; and (II.) an *Upper Terrane* (*Gala or Queensberry Terrane*), embracing strata generally of Tarannon age.

The rocks of the Lower or *Moffat Terrane* attain their maximum development in the Ballantrae-Girvan district to the extreme north-west of the Uplands. In this district the terrane is made up of the three successive local rock-formations which have been termed by myself[1] (*a*) the *Barr or Stinchar Series* (of Bala-Llandeilo age), (*b*) the *Ardmillan Series* (of Bala-Caradoc age), and (*c*) the *Newland Series* (Llandovery). Its strata are here very varied in lithological character, contain an abundant fauna of all the usual Lower Palæozoic life types, and have an aggregate thickness which has been estimated at about 4000 feet. Followed thence, however, as they reappear in the many anticlinal forms of the Uplands towards the south-east, they diminish very rapidly in vertical extent, until, when we reach the Moffat district (50 miles to the south-eastward), the strata of the entire terrane are reduced to a collective thickness of 300 or 400 feet. In this district also they have lost their original varied lithological characters, and have dwindled down into a comparatively homogeneous mass of black, grey and white shales: while their diversified fauna has degenerated into one almost exclusively Graptolitic.[2] Nevertheless, in spite of the remarkable attenuation of the strata of the terrane, its three component formations are still recognizable as the three local divisions of the Moffat Series, (*a*) *Glenkiln Shales*, (*b*) *Hartfell Shales*, and (*c*) *Birkhill Shales*. Palæontologically these answer broadly to the three Girvan divisions, the Graptolites characteristic of the lowest Moffat or Glenkiln Shales being equally characteristic of the lowest or Stinchar formation of Girvan: those Graptolites in the second or Hartfell division being found in the second or Ardmillan formation of Girvan: while those of the highest or Birkhill shales agree precisely with the forms characteristic of the third or Newland formation of Girvan. This parallelism is not only evident as respects each of the three successive subfaunas, but many of the subordinate zones in these widely separated districts admit of an equally satisfactory parallelism in sequence and in lithology, as well as in characteristic fossils.[3]

To the south-west of the Moffat district the rocks of the Moffat Terrane soon plunge below strata of more recent age, and are seen no more within the limits of the Scottish Uplands. They must, however, still retain their attenuated and deep-water character for many miles in their subterranean course in this direction; for when they re-emerge in the Lake district (as the *Coniston Limestone Group* and *Skellgill Graptolitic Shales*), their middle members (*Coniston Limestone Series*) have only gained a few hundreds of feet in collective extent, while the strata of their highest division (*Birkhill* or *Skellgill Shales*) are practically unaltered in lithology, thickness, and in fossils.[4]

Graduating upward conformably from the highest beds of the

[1] Lapworth, Girvan Succession, Q.J.G.S. 1882, pp. 537–666.
[2] *Ibid*, Moffat Series, Q J.G.S. 1878, pp. 240–346.
[3] Compare Tables Q.J.G.S. 1882, p. 660, and 1878, p. 250.
[4] Marr and Nicholson, Q.J.G.S. 1888, pp. 706–708.

GEOLOGICAL SECTIONS THROUGH THE

Fig. 1. Eastern Districts.

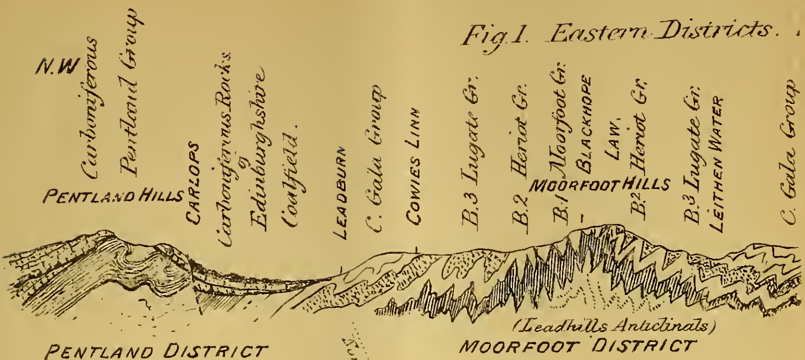


FIG. 2. Centra

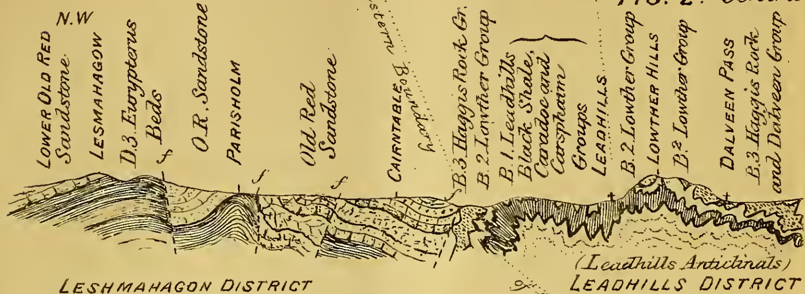
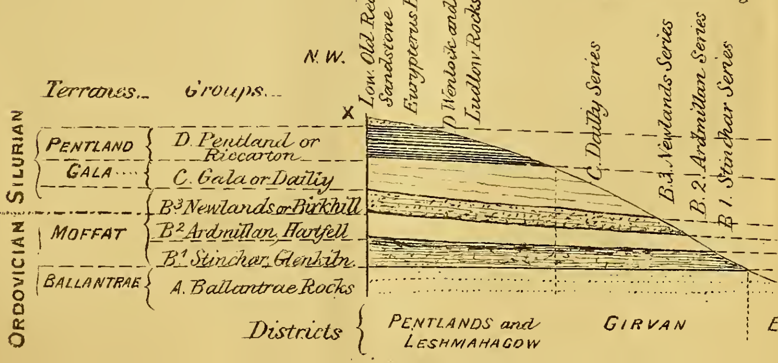


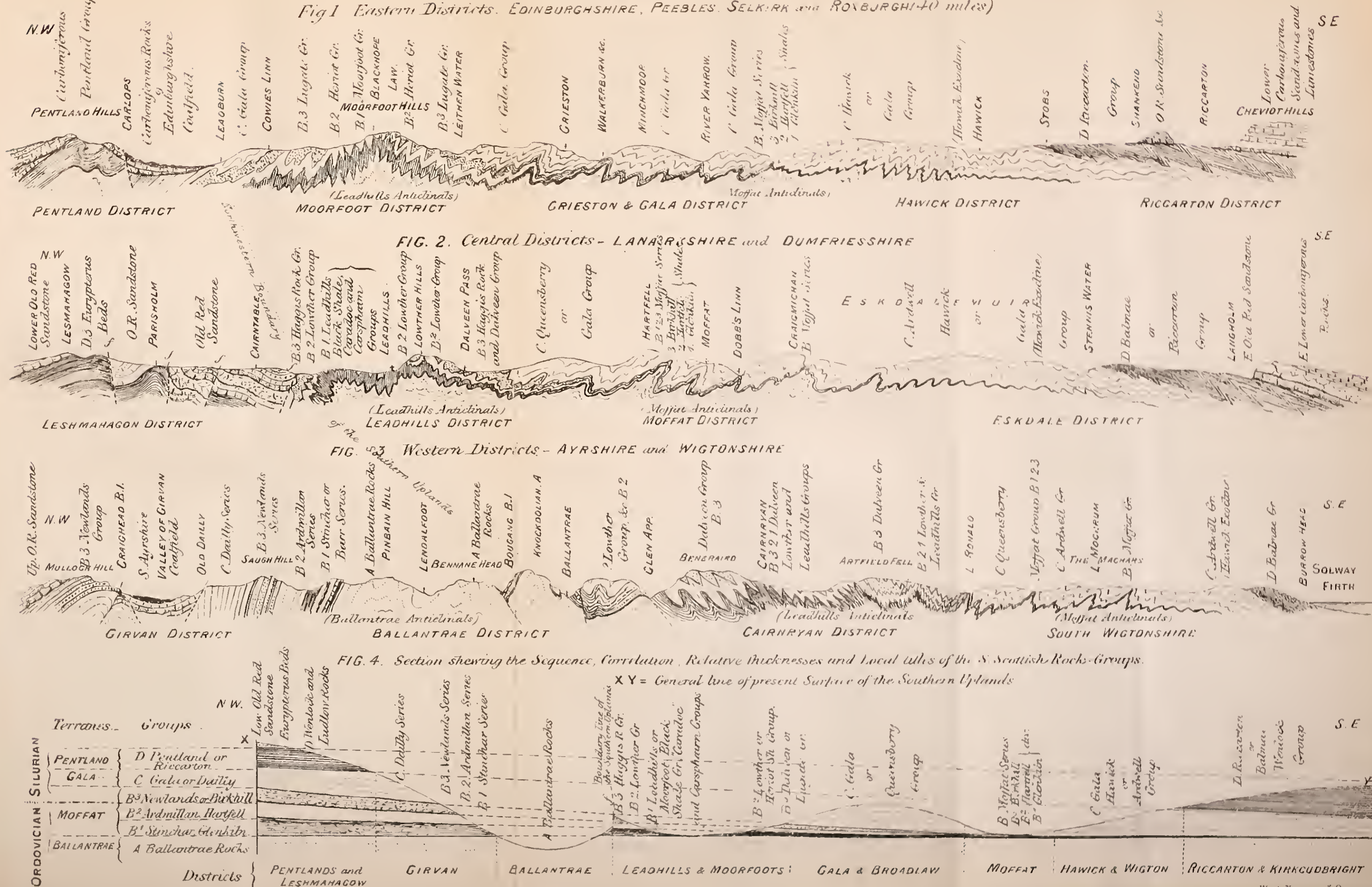
FIG. 3 Western Distr

FIG. 4. Section shewing th



GEOLOGICAL SECTIONS THROUGH THE LOWER PALÆOZOIC ROCKS OF THE SOUTHERN UPLANDS OF SCOTLAND

By C Lapworth 1889.



West, Newman & Co. imp.

Moffat Terrane in the Scottish Uplands we find the grand mass of more or less barren flagstones, shales, and greywackés which make up the overlying *Gala* or *Queensberry Terrane.* In the Girvan district the rocks belonging to this terrane form the local *Dailly series*,[1] and are about 2500 feet in thickness, consisting mainly of repetitions of gray grits, flagstones, and red, green and purple shales. The Graptolitic fauna of the terrane is more or less transitional in character. Several forms are certainly peculiar to the Gala beds, but the older zones contain many survivors of the Moffat (*Birkhill*) fauna, while the higher zones yield several species which recur in the overlying *Riccarton* (Wenlock) rocks. The strata of the Gala Terrane grow somewhat thicker and coarser as they are followed eastward from Girvan over the Uplands, and fossils become rarer; but even in the central parts of the plateau (Dumfriesshire and Selkirkshire) a *lower* (Queensberry) and a *higher* (Grieston) division can still be roughly made out. Followed, however, still farther to the south-eastward, the rocks of the terrane soon imitate the example of the underlying Moffat series, becoming much finer in grain and decreasing in thickness. Finally, the whole terrane plunges in this direction (Hawick, etc.) below the Wenlock rocks of Riccarton and Kirkcudbright, and when it re-emerges in the Lake district, it has dwindled down to an attenuated series of coloured shales and flags (*Browgill* or *Pale Shales*) with a collective thickness of less than 300 feet.[2] Even here, however, its strata are still marked by the same two transitional subfaunas as those of the great *Gala Group* of the Scottish Uplands.

We find, therefore, that while the South Scottish strata of the *Moffat Terrane* are reduced to nearly a tenth of their original thickness within a comparatively short distance (25 to 50 miles) of the Girvan district, the thickness of the massive Gala Terrane remains practically undiminished over most of its visible range in the Scottish Uplands, and is even augmented in the central parts of the plateau. Hence in spite of its greatly inferior systematic importance, the Gala Terrane has a collective thickness over the Upland region far in excess of that of the underlying Moffat series. It follows, as a natural consequence of this fact, that when we regard the Upland region from the structural or tectonic point of view, we find the main mass of its visible rocky floor is formed of the rocks of this great greywacké or *Gala terrane.* This has been crushed into innumerable wrinkles and puckers; the strata of the underlying *Moffat* series rising to the surface only along some of the larger anticlinal forms. As in other convoluted regions, the vast majority of these folds are of the class known as *overfolds* or *inverted folds*,—the axial plane of each fold being more or less inclined to the horizon; and thus the apparent dip of the truncated strata seen in section gives no clue whatever to the natural succession of the beds. But for many years it has been acknowledged on all hands that these overfolds are broadly related in position to two main struc-

[1] Q.J.G.S. 1882, p. 659.
[2] Marr and Nicholson, Q.J.G.S. 1888, pp. 674–678, etc.

tural lines, to which their axial planes strike more or less parallel, along which they are practically perpendicular, and *from* which, or *to* which, they slope as we pass outwards in opposite directions. These neutral lines run longitudinally (but somewhat obliquely) through the Upland region from sea to sea. The southern line sweeps from St. Abb's Head past Hawick and Dumfries towards the Mull of Galloway, and the northern line from Dunbar through the Lammermuir and Moorfoot Hills, past Lead Hills and Carsphairn to the sea near Port Patrick. From the opposite sides of the Southern (*Hawick line*) the axial planes of the parallel overfolds slope *outwards* to the south-east and north-west, the axes of the two opposed sets of folds having been pushed over in opposite directions upon the neutral line. Along the opposite sides of the northern (*Lead Hills*) line the axes of the inverted folds usually dip *inwards*, the axial planes of the two opposed sets of folds sloping obliquely outwards above from off the neutral line. In this second case (Lead Hills line) we have clearly nothing more than the ordinary "fan structure" of mountain areas. In the first case (Hawick line) we have merely the "fan structure" inverted. I have discussed elsewhere[1] the stratigraphic significance of these forms in mountain areas generally, and have shown that we must naturally expect to find the deepest strata in the "fan structure" (*endocline*) or pseudo-synclinal form and the highest in the folds of the inverted fan structure (*exocline*) or pseudo-anticlinal. These deductions are strikingly exemplified in the present instance. The whole of the Gala terrane has been swept off for some miles on both margins of the Lead Hills pseudo-synclinal, and the locally thick Moffat terrane, which is there some thousands of feet in vertical extent, has been eroded almost to its base. Along the Hawick pseudo-anticlinal, on the contrary, the rocks of the Moffat terrane are wholly buried from sight, while the Gala terrane is present from base to summit, and subsides to the southward under the still higher group of the Riccarton and Balmae series (the Upland equivalents of the Wenlock and Lower Ludlow strata of Siluria).

Roughly parallel with these two neutral lines (or axes of axes), to others less perfectly defined, and also to several gigantic strike-faults, the strata of the Scottish Uplands are ridged up into overfolds of all degrees of importance and complexity, from the crests of which the rocks of the Gala terrane, in many cases, have been removed, and the strata of the underlying Moffat terrane laid bare. The exposures of these pre-Gala strata usually occur in more or less connected areas, in broad boat-like patches, or in narrow disconnected moniliform lines. These are disposed in broad geographical bands or zones which range longitudinally through the district parallel with the chief axial lines. Three of these bands are especially conspicuous: (1) the S.E. band of Wigtown, Moffat and Melrose (*Moffat-Melrose band*), (2) the central band of Port Patrick, Lead Hills and Lammermuirs (*Lead Hills—Moorfoot band*), and (3) the western zones of *Ballantrae* and *Girvan*. Each of these bands is in

[1] Lapworth, Geol. Mag. 1883, p. 138, etc.

reality the locus of a complex anticlinal form, whose component simple folds have been crushed together, overthrust, and irregularly denuded. As we pass from the Moffat area to the north-eastward, we find that each of these compound anticlinals increases in length, depth, and systematic importance. In the anticlinal forms of the first band (*Moffat-Melrose*) the exposures of the strata of the Moffat rocks appear as narrow inliers in the locally ended Gala terrane, and are at the most a score or two of yards in width; while the total thickness of the pre-Gala rocks exposed (Birkhill to Glenkiln) is only from 300 to 400 feet. In the anticlinal forms of the second band (*Lead Hills—Moorfoot*) the exposure of the pre-Gala rocks are often more than a mile in diameter; and the strata of the locally thick Moffat Series are occasionally laid bare to a depth of at least two thousand feet, down to the calcareous strata at their base (Duntercleuch and Wrae Hill). Finally, in the most westerly anticlinal forms (those of *Ballantrae and Girvan*) the exposures of the pre-Gala rocks are four or five miles across; and, as we have seen, not only is the locally massive Moffat series exposed from summit to base (4000 feet), but even the underlying Ballantrae or Arenig rocks are laid bare, as far down as the horizon of the Skiddaw Slates.

In the complex synclinal zones, between these complex anticlinal zones, the rocks of the Gala terrane form broader parallel bands sweeping longitudinally through the Uplands from sea to sea. The widest bands are those ranging along the exocline (Hawick line) already described, and those of Gala, Broadlaw, and Queensberry. These bands, however, are all united into a more or less continuous sheet, the Moffat exposures which locally divide them being usually of small longitudinal extent. The Gala beds, on the other hand, which occur north of the main Lead Hills anticlinal (*endocline*), as at N.W. Peebles, L. Doon, Girvan, etc., are usually disconnected, narrower, and of minor importance.

The component formations of the underlying *Moffat terrane* are frequently well exhibited along the eroded crest of the intermediate anticlinal bands between the more or less continuous sheets of Gala rocks, and their gradual change in thickness, lithology, and palæontology can be followed, stage by stage, as we pass from place to place, and from fold to fold.

Commencing with the most southerly, or Moffat-Melrose band, we find that in the typical area of the Moffat district we have merely the three Graptolitic zones of the Glenkiln, Hartfell and Birkhill, forming a comparatively homogeneous mass of grey and black shales and mudstones. Followed, however, even along the line of strike to the north-west, towards Selkirk and Melrose, the beds thicken, and bands of grit, flagstone, and conglomerate come in between the shale zones in definite and recognizable order. But when followed at right angles to the strike from S.E. to N.W. transversely across the Uplands, the change is very much greater. The entire series thickens rapidly, and the black shale bands are replaced one by one from above by barren flagstones and shales, similar in all their lithological features to those characteristic of the overlying Gala terrane.

Proceeding still farther in this north-westerly direction to the grander anticlinal forms of Carsphairn, Wenlockhead, Moorfoot Hills, etc., we find the Moffat Series represented by a great thickness of grey shales, flagstones, greywackés, and fine conglomerates, with occasional black shale zones (which are most numerous near the base of the series), the whole being intermediate in geographical position, in thickness, in lithological features, and in palæontological characters between the attenuated Moffat Series to the S.E. and the magnificent development of the same terrane in the Girvan region to the N.W. In these intermediate anticlinal forms we can rudely distinguish three main rock-groups, which are, however, so convoluted and interfolded that their details are as yet only partly worked out, their thickness is unsettled, and their boundaries ill defined. In the cores of the main anticlinal forms of the Lammermuir-Moorfoot area we find (1) a group of grey and black shales, with flinty bands, grits, and conglomerates (*Moorfoot Group*), the inner zones of which yield the Graptolites of the Glenkiln Shales, and the outer bands those more characteristic of the Lower Hartfell. Outside this group follows (2) a thick series of more or less barren grey flagstones, shales, grits (*Heriot Group*), which seems to answer in position and character to the barren beds of the Upper Hartfell. Finally, between these barren shales and the base of the Gala terrane, we recognize a third group (3) (*Lugate Group*) of grey shales, flagstones, and conglomerate (? *Haggis Rocks*), with rare fossil-bearing bands, yielding some of the characteristic Graptolites of the Birkhill Shales. In the anticlinal forms of the Lead Hills, Carsphairn and Shinnelhead districts to the south-west, as shown by the published Maps[1] and Explanations of the Geological Survey, the same geographical and geological grouping is discernible. The local *Dalveen and Haggis Rock Group* of that region come into the place of the Lugate Series, the *Lowther Group* apparently into the position of the Heriot Series, while the *Leadhills Black Shales* correspond in place and fossils with the Moorfoot Series. But as these south-westerly anticlinal forms are of greater diameter, and lie many miles nearer to the Girvan District, there appear, in addition, within the limits of the Leadhills Shale Group, representatives of the lowest Moffat strata of the Girvan area in the form of the Brachiopod-bearing limestones, grits, conglomerates of Wrae Hill, Duntercleuch, and Glendowran.[2]

Finally, when we reach the most distant group of anticlinal forms —those of the Girvan-Ballantrae District itself—the lithological and palæontological modification of the typical Graptolitic Moffat Series is complete, and the terrane is represented by the three rock-formations already referred to, which are as richly varied petrologically and zoologically as are their equivalents in the well-known districts of Wales and the West of England.

[1] Compare Maps 15, 9, 3, 4, etc. and the accompanying Explanations, Geol. Survey, Scotland.

[2] Explan. Sheet 15, p. 14, etc.

Such I have long held to be the general structure and succession of strata[1] of the Lower Palæozoic region of the Southern Uplands, as deduced from the facts and conclusions essentially dependent upon the zonal method of stratigraphy. Upon this view the sequence, lithology and palæontology of the several recognizable zones of strata in the Upland region become mutually intelligible, and the various rock-formations and their fossils admit of satisfactory parallelism with those of the corresponding Proterozoic deposits of other districts both in Britain and abroad. See the accompanying table on page 66.

It may be objected by some of those geologists who are familiar with the literature of discovery and speculation among these South Scottish rocks, that these views are opposed to those advocated by previous observers.[2] But I believe that this opposition is more in appearance than reality. The physical facts and phenomena upon which the earlier views of the succession were based remain unquestioned. They are here, however, supplemented by the conclusions drawn from the abundant stratigraphical and palæontological discoveries of the last fifteen years, and have received the only interpretation which seems to me to be possible in the present state of our knowledge. We have to recollect that all the earlier views of the succession were based almost exclusively upon the very natural theory that the Hawick-Dumfries axis is a true anticlinal form, and the Sanquahar-Moorfoot axis is a true synclinal, propositions upon which no one familiar with our actual knowledge of the stratigraphical phenomena of mountain regions would at the present day place the least reliance; while at the time when the very latest of these earlier schemes was published, the paramount value of the Graptolite as a geological index was unknown and unsuspected. The lithological "groups" of these earlier and local classifications fall naturally into their proper places in the present scheme, and find their simple interpretation as successive geographical bands in the same great Lower Palæozoic succession as it slowly changes in thickness and lithology when followed from the shore line into deeper water: while, under this arrangement, their formerly conflicting Graptolitic faunas show the same sequence they hold over the rest of the Lower Palæozoic world. The present views have also this further recommendation that they depend upon, and necessitate, the harmony of all the ascertainable phenomena—geographical position, thickness, lithology, local sequence, and palæontology—and admit of being tested in each of these characters in the field at every stage, and of being confirmed, extended and corrected as discovery progresses.

But although I hold that all the known facts and phenomena bearing upon the sequence of the rocks of the Southern Uplands

[1] Compare Lapworth, Transactions Geol. Soc. Glasgow, 1878, pp. 78 to 84, etc.

[2] Sedgwick, 1849, Rep. Brit. Assoc. p. 103; Nicol. Q.J.G.S. 1850, p. 53; Murchison, ibid. 1851, p. 137; Siluria, 4th edition, pp. 148–158; A. Geikie, Trans. Geol. Soc. Glasgow, 1867, p. 74; Explan. Sheet 3, Geol. Survey Scotland, 1873, pp. 4–18; ibid. sheet 15, p. 9, etc.

[To Illustrate Prof. C. Lapworth's Paper on the Ballantrae Rocks of South Scotland and their place in the Upland Sequence, Geol. Mag. Decade III. Vol. VI. No. 2.]

TABLE I.

SHOWING THE GENERAL SYNONYMY OF THE UPLAND ROCK-GROUPS.

Terranes.		Ayrshire, etc.	Lanarkshire, etc.	Edinburghshire, etc.	Selkirk & Roxburgh.	Dumfries and Kirkcudbright.	Lake District.	West of England.	
D. Pentland. Terrane			Lesmahagow Beds.	Pentland Beds.			Kirkby Moor Flags, etc.	Upper & Middle Ludlow.	Silurian.
					Riccarton Series.	Balmae Group.	Coniston Grits and Flags, etc.	Lower Ludlow and Wenlock.	
C. Gala Terrane		Dailly Series.	Queensberry Gr.	Gala Group.	Hawick Group.	Ardwell Group.	Browgill Beds.	Tarannon.	
B. Moffat Terrane	B. 3	Newlands Series.	Dalveen & Haggis Rock Group.	Lugate Group.	Birkhill Shales.		Skellgill Shales.	Llandovery.	
	B. 2	Ardmillan Series.	Lowther Group.	Heriot Group.	Hartfell Shales.	Moffat Shales.	Coniston Limestone Group.	Caradoc.	Ordovician.
	B. 1	Stinchar or Barr Series.	Leadhills Black Sh. Carsphairn, and Caradoc Groups.	Moorfoot Group.	Glenkiln Shales.		Borrowdale Volcanic Series.	Llandeilo.	
A. Ballantrae Terrane.		Ballantrae Rocks.					Skiddaw Slates.	Arenig, etc.	

can only be harmonized upon the lines here laid down, it must be frankly admitted that, in spite of all that has been already accomplished, our knowledge of these strata is still in its infancy. We have so recently become aware of the proper methods of attacking the many geological problems they present for solution, that the most interesting and complicated part of the work yet remains to be done; and those geological students who have made themselves familiar with the new developments of our knowledge of the older rock-formations will find this South Scottish region a fruitful field for original research. My own intermittent labours for the last twenty years in this great plateau (which covers an area of at least 5000 square miles) have been only sufficient to permit of my working out in detail the sequence in the two contracted areas of Moffat and Girvan, and of studying in much less minuteness a sufficiency of the test districts elsewhere to enable me to feel assured of the general truth of the views here developed. It remains for others, and especially for local geologists, to verify and to apply these views to the detailed mapping of the Uplands generally.

In the palæontological part of this work the *Graptolites* must, of necessity, play the chief *rôle*, for they are almost the only fossils met with in the strata of this wide region. But the *minor* stratigraphical conclusions to which those fossils point ought not to be overstrained, but should be tested and re-tested upon every available opportunity. We cannot expect to recognize from end to end of the Uplands all the minuter "zones" of Moffat, Girvan, Skellgill or Scania; but we ought certainly to be able to identify by their means all the major stratigraphic subdivisions. Nothing more can be claimed for the Graptolites than that which is claimed by all geologists for the corresponding species of Trilobites or Ammonites. Each formation has its characteristic Graptolitic species and varieties, and each species has a certain fairly known vertical range in the detailed sequence of the Lower Palæozoic rocks;[1] while the invariable association of special forms in beds of corresponding systematic position affords a presumptive palæontological index of the true systematic place of strata marked by the same forms elsewhere. With this we must rest content; but even here I hold we have sufficient palæontological criteria, when checked and aided by all the available local stratigraphical evidences, to enable us to map out, in time, the Lower Palæozoic rocks of the Uplands in all their main geological subdivisions.

The known restriction of the entire family of the *Monograptidæ* to Silurian strata, and its absence from Ordovician rocks, affords us the means of determining the outcrop of the Upland boundary-line between the Ordovician and Silurian deposits; and the laying down of this line will give us the first useful geological map of the region. Next must follow the tracing of the less important divisional lines at the bases of the Glenkiln (Upper Llandeilo) and Hartfell (Caradoc) Groups in the Ordovician, and those at the summits of the Birkhill (Llandovery) and Gala (Tarannon) Series of the Silurian. Not

[1] Lapworth, Geol. Dist. Rhabdophora, Tullberg, Skånes Graptolither, etc.

until this work has been accomplished, and the Scottish Arenig, Wenlock and Ludlow strata studied in equal detail, can we claim that our knowledge of the geological structure of the Scottish Uplands is even fairly complete.

But, if the ideas expressed in this paper are well founded, the main results of future investigations, in so far as they affect the general mapping of the Upland area proper, can even now be sketched in outline. The *Axial* or *Ardwell* Group of the earlier investigators will disappear as a separate series, and will take its place as the southerly extension of the Gala or Queensberry Group to the north. The *Dalveen* (and Haggis Rock) (*Lugate Series*); the *Lowther Group* (*Heriot*), and the *Leadhills Black Shale* and *Caradoc* and *Carsphairn Group* (*Moorfoot Series*) will all be found to be regional geological complexes of a thickness far inferior to that with which they have hitherto been credited: but, nevertheless, each possessing a high local value, as significant of the local peculiarities and intermediate lithological condition of the Moffat Terrane in the central districts. These three "central" groups, when worked out in detail and restricted to their natural components, will be found to follow each other in the order given above:—the Dalveen-Lugate Group answering to the Birkhill Shales, the Lowther-Heriot Group to the Hartfell (Upper, etc.), while the strata of the Leadhills-Moorfoot Group must be re-arranged, and will fall, part into the Lower Hartfell (Caradoc), and part into the Glenkiln (Upper Llandeilo) formations.

The general geological map of the Uplands will show that the rocky floor of that region is composed of strata ranging almost from the base of the Ordovician up to the summit of the Silurian. The outcrop of the main boundary-line between the strata of the two systems (which is on or about the horizon of the so-called Haggis Rock) will be found to pass obliquely across the region from the north-east margin of the Uplands near Dunbar, over the crest of the Lammermuirs, to the south of the Moorfoots, and north of the town of Peebles, over the valley of the Tweed near Neidpath and the Crook, into the valley of the Clyde near Elvanfoot; and thrown next to the southward by the anticlinal of the upper reaches of the Shinnel, will be found to cross the southern part of the granitic range of the Kells towards the sea-coast south of Portpatrick. To the north and north-east of this guiding line the mass of the strata will be proved to be *Ordovician;* such Silurian rocks as occur forming outliers parallel with the great boundary fault. To the south-east of the divisional line the mass of the strata must be classed as *Silurian*; the Ordovician rocks only occurring locally as long lenticular inliers, gradually diminishing in systematic importance as they are followed across the country from north to south, and from west to east.

Of the Upland "formations," the *Arenig* appears to have the smallest superficial extent, its outcrops being as yet confined to the Ballantrae region (unless indeed some of the so-called Old Red Sandstone near the boundary-line is of this age): the true *Caradoc* will be mapped as narrow boat-like sheets along the greater anticlinal

TABLE II.

ORDOVICIAN.	Mo[...]			... *Dicrano.* ... *Pleurogr. linearis*, etc.		Co[...]	
	Lower Division.	BARR OR STINCHAR SERIES. 5. *Balclatchie Grits*, flags and shales, with *Dicrano. rectus*, *Glosso. Hicksii*, *Clima. tricornis*, etc. 4. *Barr. conglomerate*. 3. *Didymograptus Shales*, etc., with *Didymo. superstes*, *Dicello. sextans*, *Diplo. euglyphus*, *Clathrograptus*. 2. *Stinchar Limestone* with *Maclurea Logani*, *Ophileta compacta*, *Tetradrium Peachii*, *Leptena sericea*, etc. 1. *Purple Sandstones*, flags, and conglomerates, with *Orthis confinis*, etc.	LEAD HILLS BLACK SHALE (in part), together with the *Caradoc* and *Carsphairn Groups* of Lead Hills, Sanquahar and Carsphairn. Fossils: — *Didymo. superstes*, *Dicellogr. sextans*, *Dip. euglyphus*, *Dip. mucronatus*, *Cænogr. gracilis*, *Dicrano. rectus*, and Llandeilo - Bala Brachiopoda.	MOORFOOT GROUP (in part). (*b*) *Lower zones* (Browbeat Zones) of Browbeat water, Blackhope, Corsehope, etc., with *Didy. superstes*, *Cæno. gracilis*, *Dicello. sextans*, *Glossogr. Hicksii*, etc.	GLENKILN SHALES (Moffat, etc.) Black, grey, and coloured shales and mudstones, with ashy sandstones, and felspathic and siliceous ribs. Fossils:—*Didymogr. superstes*, *Cænograptus gracilis*, *Dicello. sextans*, *Dicello. divaricatus*, *Diplo. mucronatus*, etc.	BORROWDALE VOLCANIC SERIES.	UPPER LLANDEILO of Rorington (W. Salop), with *Cænograptus gracilis*, *Didymo. superstes*, *Dicello. sextans*, *Dicrano. rectus*, *Dicello. divaricatus*. MIDDLE AND LOWER LLANDEILO beds of Meadowtown, Builth, etc., with *Ogygia Buchii*, *Didy. Murchisoni*.
	BALLANTRAE TERRANE.						UPPER ARENIG ROCKS of Llanvirn, etc., with *Placoparia*, *D. bifidus*, *D. Nicholsoni*, etc.
		BALLANTRAE SERIES (restricted). With *Phyllo. typus*, *Tetra. bryonoides*, *T. quadribrachiatus*, *Didymo. bifidus*, *D. extensus*, etc.				SKIDDAW SLATES, with *Phyllo. typus*, *Tetra. bryonoides*, *Tetra. fruticosus*, *Tetra. quadribrachiatus*, *D. bifidus*.	MIDDLE ARENIG beds of Shelve, St. Davids, etc., with *Tetra. bryonoides*, *Tetra. quadribrachiatus*, etc.
							LOWER ARENIG (AND UPPER TREMADOC), with *Bryograptus*, etc.

[To illustrate Prof. C. Lapworth's paper on the Ballantrae Rocks of South Scotland and their place in the Upland Sequence.]

(*To face page* 69.)

forms — surrounding included and narrower bands of Llandeilo rocks, and enveloped in turn by still broader sheets of Llandovery strata, etc. The great *Gala* (*Tarannon*) terrane must be coloured as the prevailing visible rock-mass of the Uplands, sweeping along the central and southern parts of the plateau in a broad sheet (from 20 to 25 miles in width) from the North Channel to the German Ocean, only interrupted locally by long and narrow lenticles of pre-Gala rock, which decrease both in number and importance as we pass from south-west to north-east. Finally fringing the Gala Terrane along the south-east flanks of the Uplands from Burrow Head to the Cheviots will follow in natural superposition the slowly widening band of the *Wenlock Ludlow* (Riccarton) beds, the boundaries of which have been already sketched out by the officers of the Geological Survey.

In the accompanying Plate (Plate III.) I have given some sketch-sections across the Upland region illustrative of my views of the general disposition and inter-relationships of its strata; and in the following "Table of Correlation" will be found incorporated some of the more important palæontological data which bear upon the question of the Upland Sequence. (See Folding Table II.)

IV.—On Local Thickening of Dykes and Beds by Folding.

By Alfred Harker, M.A., F.G.S.,

Fellow of St. John's College, Cambridge.

In his "Geology of North Wales" (p. 102, 2nd ed.), Sir A. Ramsay figures a vertical cross-section of a greenstone dyke, which he describes as running along the cleavage-planes of the slate in the Ffestiniog quarries, and alternately "bulging and thinning off in a rapid succession of oval-shaped masses of 3 or 4 feet in length." He seems to imply that this is one of the dykes posterior to the disturbance which produced the cleavage of the district. The ordinary post-Carboniferous dykes of North Wales, however, strike nearly at right angles to the cleavage; and further it is not easy to imagine any circumstances attending the intrusion of this one that would account for the phenomenon of alternate thickening and attenuation described. A precisely similar peculiarity is to be seen in 'Dew's quarry' at Pen-y-bryn, Nantlle. The same thing is figured by Lehmann ('Altkrystallinischen Schiefergesteine,' pl. xiii. fig. 4) from granite-veins in the Saxon granulites.

At several places in the Cambrian *massif* of Rocroi, notably north of Mairus near Monthermé, beds of grit intercalated among the slates are seen to swell and contract in the same manner. Their thickness at the ventral segments is usually at least double of that at the nodes. The distance between the nodes seems to depend on the thickness of the bed. Gosselet has recently given a photograph of this 'almond-like' arrangement of the 'quartzites' in his great memoir on the Geology of the Ardenne. In these cases, at least, since we have to deal with sedimentary strata, it is clear that the

TABLE II.

SHOWING THE CORRELATION AND BRITISH EQUIVALENTS OF THE LOWER PALÆOZOIC ROCKS OF THE SOUTH OF SCOTLAND.

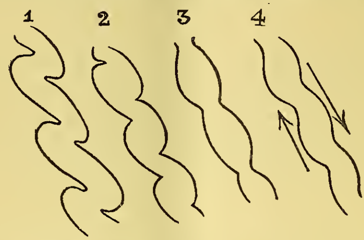
System	Terrane	Division	LOCAL TYPES OF THE SOUTH SCOTTISH DEPOSITS. North-Western District. Ayrshire (Girvan and Ballantrae).	West Central District. Lanark, N. Dumfries, N. Kirkcudbright, N. Wigton, etc.	East Central District. Edinburgh, Peebles, N. Selkirkshire.	South-Eastern District. Roxburgh, S. Selkirk, Central Dumfries, S. Kirkcudbright, Wigton.	SOUTH BRITISH EQUIVALENTS. Lake District.	Wales and the West of England.
SILURIAN.	Pentland Terrane.	Upper.		Lesmahagow Flags and shales, graduating downwards from Old Red Sandstone. Fossils:—*Eurypterus, Slimonia, Pterygotus.*	Upper Pentland Sandstones shales and grits, with abundant Ludlow fossils.		Kirkby Moor Flags and sandstones, with Ludlow fossils.	Upper and Middle Ludlow Formations of Salop and Hereford.
	Pentland Terrane.	Lower.			Lower Pentland Flagstones and shales, with *Monogr. vomerinus, Retiolites Geinitzianus.*	Riccarton Flags and Shales of Langholm, Riccarton, Balmae, etc., with *M. colonus, M. priodon, M. Flemingii*, etc.	Bannisdale Slates, etc., Coniston Grits and Flags, with *M. colonus, M. Flemingii, M. vomerinus*, etc.	Wenlock and Lower Ludlow beds of Salop, and Denbighshire Grits with *M. colonus, M. vomerinus*, etc.
	Gala Terrane.		Dailly Series of Girvan District. (*c*) Straiton Beds, with *M. personatus*, etc. (*b*) Barganv Beds, with *Monogr. acus.* (*a*) Penkill Group. (2) *Upper* Flags, Grits and Mudstones, with *Retio. Geinitzianus, Cyrtograptus Grayæ*, etc. (1) *Lower* purple shales, flags and grits, with *M. exiguus, M. crispus, Protovirgularia, Crossopodia*, etc. Newland Series (Girvan).	Queensberry Group of N. Dumfriesshire, Kirkcudbright, and S. Wigtonshire: with *Crossopodia, Protovirgularia*, etc.	Gala Group of S. Edinburgh, Selkirk and Peebles. 2. *Higher beds.*—Grieston flags and shales, with *R. Geinitzianus, C. ? spiralis, M. priodon*, etc. 1. *Lower beds.*—Gala grits and coloured mudstones, with *M. exiguus, M. crispus, Protovirgularia, Crossopodia*, etc.	Hawick Rocks of Roxburgh, Selkirk, etc., with *Proto. virgularia, Crossopodia*, etc. } { Ardwell Group of Dumfriesshire, Kirkcudbright, etc. with *Proto. virgularia, Crossopodia*, and *Monograptidæ*.	Browgill Beds (pale slates). (*b*) *Upper Beds* (barren). (*a*) *Lower Beds*, with zones of 2. *Monogr. crispus, R. Geinitzianus*, etc. 1. *M. turriculatus, M. exiguus*, etc.	Tarannon Shales of Tarannon and Llanbrynmawr. 2. *Middle Zones* with *R. Geinitzianus, Cyrto. Grayæ*, etc. 1. *Lower Zones* with *M. turriculatus, M. exiguus*, etc.
	Moffat Terrane (*continued*).	Upper Division.	(*c*) Camregan *grits*, limestones, shales, etc., with *Pentamerus oblongus, Rastrites maximus, M. turriculatus*, etc. (*b*) Saugh Hill Group. 3. Flags and shales, with *M. spinigerus, M. distans*, etc. 2. Grits and shales, with *M. gregarius, M. fimbriatus, Rastrites peregrinus.* 1. Woodland conglomerates, flags and shales, with *Pentamerus lens, M. cyphus, M. revolutus, Dimorphograptus*, etc. (*a*) Mulloch Hill Group. Sandstones, shales and conglomerates, *Meristella angustifrons, Diplo. acuminatus, Monogr.* sp.	? Part of Queensberry Group. Dalveen and Haggis Rock Group.	Lugate Group. Upper. 4. Shales, flags, and grits of Walkerburn, etc., with *Rastrites maximus*, etc. 3. Flags, black shales, and grey shales of Trowier Burn, with *M. spinigerus*, etc. Lower. 2. Conglomerate, grits, flags and shales of Sit Burn, etc., with *M. gregarius, R. peregrinus*, etc. 1. Conglomerates, grits and shales of Channelkirk, (Leader) and Still Burn (Lugate), with *Diplo. acuminatus*, etc.	Birkhill Shales (Moffat, etc.). 3. Zone of *R. maximus, M. turriculatus*, etc. 2. Zone of *M. spinigerus, M. distans*, etc. 1. Bands of *M. Clingani*, and *Petalogr. cometa*, with *M. crenularis, R. hybridus*, etc. 3. Zones of *M. gregarius*, with *R. peregrinus*, etc., *M. fimbriatus, M. convolutus.* 2. Zone of *Dip. vesiculosus*, with *M. cyphus, M. tenuis.* 1. Zone of *Dip. acuminatus*, with *Dimorph. elongatus ? Monogr.* sp.	Skellgill Beds. *Upper Skellgill Zones.* 3. *Rast. maximus.* 2. *Mon. spinigerus.* 1. *Mono. Clingani.* *Lower Skellgill Zones.* With *M. gregarius*: 5. *M. convolutus.* 4. *M. argenteus.* 3. *M. fimbriatus.* 2. *Dimorph. confertus, Dip. vesiculosus, M. tenuis.* 1. *Diplo. acuminatus, M. revolutus, Dimorph. elongatus.*	Llandovery Beds of Cardiganshire and valley of the Dee, with *Ras. maximus, Ras. peregrinus, M. Clingani, M. cyphus, M. Sedgwicki* (*spinigerus*), *M. convolutus, Clima. normalis, Diplo. folium*, etc.
ORDOVICIAN.	Moffat Terrane.	Middle Division.	Ardmillan Series. 7. Drummuck Beds. Grey shales. (*b*) Upper zones, with *Staurocephalus globiceps.* (*a*) Lower zones, with *Trinucleus, Asaphus, Dionide, Dicellograptus anceps, Diplo. truncatus.* Shalloch Flagstones and Shales, *Diplo. truncatus, Nematolites.* Whitehouse Beds. (*b*) Grey and coloured flags and shales, with *Dionide, Ampyx, Asaphus*, etc. *Dicello. complanatus, Dip. socialis.* (*a*) Black and grey shales and flags, with *Lepto. flaccidus, Diplo. foliaceus, D. quadrimucronatus, C. tubuliferus.*	Lowther Group of S. Lanark, N. Dumfries, Kirkcudbright, etc. Greyflags, shales and felspathic grits, usually destitute of fossils.	Heriot Group of S. Edinburgh, N. Peebles, Haddington. Grey flags, shales and conglomerates of Ladyside Burn, Blackhope Burn (Heriot), etc. *Climaco.* sp., *Diplo.* sp.	Hartfell Shales (Moffat, etc.) *Upper Hartfell,* 3. Zone of *Dicello. anceps, D. truncatus, C. scalaris.* 2. *Barren Mudstone.* 1. Lowest zones of the Barren Mudstone zone of *Dicello. complanatus, Dictyonema Moffatensis.*	Coniston Limestone, Dufton Shale, and Ashgill Shale Groups of Lake District.	Upper Caradoc. Central Shropshire, with *Trinucleus concentricus, Orthis Actoniæ*, etc., *Diplo. foliaceus, D. truncatus.*
			Ardwell Beds. (*b*) *Upper* flags, shales and grits, with *Dicello. Forchhammeri, Dicrano. ramosum, Clima. caudatus.* (*a*) *Lower* flags and shales, with *Crypto. tricornis, Dip. rugosus, Lasiogr. Harknessi, Clim. Scharenbergi.*	Lead Hills or Upper Black Shale Group (in part). Black, grey and ribbed shale, flags, and grits of Lead Hills, St. Patrick, with *Dicello. Forchhammeri, Crypt. tricornis, Lasio. Harknessi, Dicrano. ramosus.*	Moorfoot Group (in part). Grey and black shales and flags with ribs of siliceous and felspathic grit, and bands of coloured sandstone and conglomerate. *Higher zones* (Headshaw zones), Moorfoot Hills, Headshaw Burn, Friars Nose, Lugate Head, etc., with *Dip. foliaceus, Dicello. Forchhammeri, Dicrano. ramosus, Pleurogr. linearis*, etc.	*Lower Hartfell.* 3. Zone of *Pleuro. linearis*, with *Lepto. flaccidus, Diplo. foliaceus, Ct. tubuliferus.* 2. Zone of *Dicrano. Clingani*, with *Clima. caudatus, C. bicornis, D. Forchhammeri, Dicrano. ramosus.* 1. Zone of *Clima. Wilsoni*, with *Crypt. tricornis, Diplo. rugosus, Lasio. Harknessi, Clima. Scharenbergi.*		Lower Caradoc Beds of Western Shropshire. *Aldress Beds*, with *Diplo. foliaceus, Diplo. rugosus, Clima. bicornis, C. Scharenbergi, C. caudatus, Dicello. Morrisi, Dicrano. ramosus.*
		Lower Division.	Barr or Stinchar Series. 5. *Balclatchie Grits*, flags and shales, with *Dicrano. rectus, Glosso. Hicksii, Clima. tricornis*, etc. 4. *Barr. conglomerate.* 3. *Didymograptus Shales*, etc., with *Didymo. superstes, Dicello. sextans, Diplo. euglyphus, Clathrograptus.* 2. *Stinchar Limestone* with *Maclurea Logani, Ophileta compacta, Tetradrium Peachii, Leptena sericea*, etc. 1. *Purple Sandstones*, flags, and conglomerates, with *Orthis confinis*, etc.	Lead Hills Black Shale (in part), together with the *Caradoc* and *Carsphairn Groups* of Lead Hills, Sanquahar and Carsphairn. Fossils: — *Didymo. superstes, Dicellogr. sextans, Dip. euglyphus, Dip. mucronatus, Cænogr. gracilis, Dicrano. rectus*, and Llandeilo-Bala Brachiopoda.	Moorfoot Group (in part). (*b*) *Lower zones* (Browbeat Zones) of Browbeat water, Blackhope, Corsehope, etc., with *Didy. superstes, Cæno. gracilis, Dicello. sextans, Glossogr. Hicksii*, etc.	Glenkiln Shales (Moffat, etc.) Black, grey, and coloured shales and mudstones, with ashy sandstones, and felspathic and siliceous ribs. Fossils:—*Didymogr. superstes, Cænograptus gracilis, Dicello. sextans, Dicello. divaricatus, Diplo. mucronatus*, etc.	Borrowdale Volcanic Series.	Upper Llandeilo of Rorington (W. Salop), with *Cænograptus gracilis, Didymo. superstes, Dicello. sextans, Dicrano. rectus, Dicello. divaricatus.* Middle and Lower Llandeilo beds of Meadowtown, Builth, etc., with *Ogygia Buchii, Didy. Murchisoni.*
	Ballantrae Terrane.							Upper Arenig Rocks of Llanvirn, etc., with *Placoparia, D. bifidus, D. Nicholsoni*, etc.
			Ballantrae Series (restricted). With *Phyllo. typus, Tetra. bryonoides, T. quadribrachiatus, Didymo. bifidus, D. extensus*, etc.				Skiddaw Slates, with *Phyllo. typus, Tetra. bryonoides, Tetra. fruticosus, Tetra. quadribrachiatus, D. bifidus.*	Middle Arenig beds of Shelve, St. Davids, etc., with *Tetra. bryonoides, Tetra. quadribrachiatus*, etc.
								Lower Arenig (and Upper Tremadoc), with *Bryograptus*, etc.

[To illustrate Prof. C. Lapworth's paper on the Ballantrae Rocks of South Scotland and their place in the Upland Sequence.]

(*To face page* 69.)

phenomenon must be referred to some peculiarity in the disturbances to which the rocks have been subjected.

To explain it, we must go to North Devon, a district, like North Wales and the Ardenne, deeply affected by great lateral pressures operating on the solid rocks. At various points of the coast east of Ilfracombe we find among the slates beds of limestone exhibiting a succession of swellings and constrictions analogous to those already described; and we see that this disposition is due to the welding together of the adjacent limbs of sigmoid folds under a powerful thrust. The stages of the process are clearly exhibited. After the formation of a series of S-shaped flexures in the ordinary manner (Fig. 1), the direction of the pressure relatively to the bed has



changed, and the folds have been pressed upon themselves in the fashion indicated in Figs. 2 and 3. A node corresponds to the attenuated middle limb of a fold, while a ventral segment represents the union of the complementary parts of two adjacent folds.

It appears probable that the process indicated is also that by which the varying thickness of the greenstone dykes and the quartzite beds has been brought about. It is also seen in various stages in thin bands of grit in the Ilfracombe district. It is not necessary, however, to suppose that the sharp sigmoid folds must be actually formed as a preliminary stage. A series of slight undulations, as in Fig. 4, affected by a shearing motion in the direction shown by the arrows, might equally give rise to the alternate nodes and swellings of Fig. 3.

V.—On the Occurrence of Soda-Felsites (Keratophyres) in Co. Wicklow, Ireland.

By Frederick H. Hatch, Ph.D., F.G.S.

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

In an Appendix to the Explanatory Memoir on Sheets 138 and 139 of the Map of the Geological Survey of Ireland (Dublin, 1888), I have given some notes on the petrographical characters of the igneous rocks of Co. Wicklow. One or two of the facts elicited by an examination of these rocks are sufficiently interesting to deserve a wider circulation.

Associated with various types of greenstone, which will form the subject of another communication, there occur in the Lower Palæozoic strata of this district (Bala) numerous beds of felsite. These are frequently accompanied by felspathic tuffs; and there is no doubt that they are the product of contemporaneous extrusion during the deposition of the sedimentary rocks in which they occur.

Microscopical examination and chemical analysis show that these rocks consist, in part at least, of soda-felsites or keratophyres. The keratophyres (so named from their resemblance to hornstone[1]) were first described by Gümbel;[2] but it is to K. A. Lossen[3] that we are mainly indebted for the investigation of the characters of these peculiar rocks and the vindication of their claim to consideration as a definite rock-type. They are characterized by a remarkably high percentage of felspar, especially of soda-felspar, which in some cases appears to be soda-orthoclase or soda-microcline, in others, albite. In consequence, splinters of the rocks fuse more readily before the blow-pipe than the normal quartz-orthoclase-felsites.

Normally constituted felsite, that is to say, rocks composed of a cryptocrystalline aggregate of quartz and felspar (in great part orthoclase), with or without porphyritic quartz, also occur in the Wicklow District;[4] but there is little doubt that the two types graduate into one another.

Some specimens, collected from a rocky eminence a quarter of a mile west of Brittas Bridge, seven and a half miles west of Rathdrum (Sheet 130), will serve to illustrate the characters of the keratophyres of this district. The rock cropping out at this place is a compact felsite, having, when weathered, a curious mottled appearance, due to the presence of numerous greyish-brown spots of about a quarter of an inch diameter. These spots are crowded closely together, being only separated by a small quantity of a dark grey interstitial substance. Where still more exposed to the action of the weather, the rock is coated with an opaque white crust. When fresh it is of a dark bluish gray to black colour and splinters readily under the hammer.

Under the microscope it is seen to be composed almost entirely of felspar and quartz, the former being in excess. The few porphyritic crystals are invariably felspar, the quartz being confined entirely to the ground-mass. The texture of the latter is extremely variable. In general it is microcrystalline, consisting then of square and lath-shaped sections of felspar, between which are entangled irregular grains of quartz; in places, however, the texture sinks almost to cryptocrystalline, the individual granules becoming so small as to be scarcely distinguishable; but even then, by the use of a higher power, the microcrystalline structure can generally be made out, and there is no evidence of the presence of any "microfelsitic" (isotropic) matter.

Scattered sparingly through the sections are scales of chlorite,

[1] Gr. κέρας, a horn.

[2] Die paläolithischen Eruptivgesteine des Fichtelgebirges, Munich, 1874, p. 45.

[3] Zeitsch. deutsch. Geol. Ges. xxxiv. (1882), pp. 199 and 445; xxxv. (1883), p. 215; Jahrb. k. preuss. Geol. Landesanst. für 1884 (1885), p. 21.

[4] See Explan. Mem. on Sheets 138 and 139 of the Map of the Geol. Survey of Ireland, 1888, p. 50.

and isolated granules of sphene; occasionally also a few tiny specks of iron-ore.

The porphyritic structure is not well defined, there being but little difference in point of size between the "porphyritic" felspar and the crystals of that mineral in the more evenly crystalline portions of the ground-mass. It is only the occurrence of an isolated large crystal in a cryptocrystalline part that gives the porphyritic appearance. These large felspars form broad rectangular crystals, which are sometimes slightly rounded. In some cases they present a fine twin-lineation either on one (the albite) or two (albite and pericline) types. In other cases the crystals show no trace of twinning. Such crystals, however, are characterized by another and somewhat remarkable structure. They appear, namely, between crossed Nicols to be divided up into a number of rectangular patches by narrow partitions, which have an extinction-angle differing slightly from that of the main portion. In other cases the central portion extinguishes uniformly, while a marginal layer goes out at a slightly different angle. The latter case can sometimes be made out without the use of the Nicols; the rim of the felspar-section being clear, while the central portion is speckled over with minute opaque particles, giving it a somewhat cloudy appearance. Have these phenomena, more especially the first-mentioned, anything in common with the "felderweise mikroperthitische" structure mentioned by Lossen and Rosenbusch as characteristic for the felspar of the keratophyres? The smaller felspars of the ground-mass are mostly striated.

A chemical analysis of this rock gave me the following result:—

SiO_2	=	77·29
Al_2O_3 ... ... / Fe_2O_3 (a trace) }	=	14·62
CaO (a trace)		—
MgO	=	·38
K_2O	=	·16
Na_2O	=	7·60
Loss on ignition	=	·57
		100·62
Sp. G.	=	2·64

From this analysis the mineral composition of the rock was calculated to be the following:—

Free quartz			=	32·49
Orthoclase	=	·95 }		
Albite...	=	64·33 }		
Felspar				65·28
Other substances			=	2·23
				100·00

This analysis shows that the rock consists almost entirely of quartz and a soda-felspar (albite).

During two visits to Counties Wicklow and Waterford in June and November of last year I collected, among other rocks, a large series of felsites. It is exceedingly probable that a petrographical examination of these specimens will demonstrate the wide distribution of soda-felsites in these districts. Felsites bearing a strong resemblance in age, association and mode of occurrence, to the Irish rocks occur in Wales. We may confidently expect to find keratophyres among them; indeed, Prof. Rosenbusch has already predicted their occurrence among the Welsh rocks.[1] They appear also to occur in Arran. An analysis of a felsite from this island by Mr. J. A. Phillips is almost identical as regards the alkalies with the one given above.[2]

It is interesting to correlate with the facts given above Prof. Haughton's researches on the Wicklow granites.[3] As far back as 1859 he showed that in many of these granites there is a dominant soda-felspar; and for these he introduced the name "soda-granite." An interesting relation has thus been established between the granites and felsites of Co. Wicklow. What bearing this has upon their mode of origin remains still to be seen.

VI.—An Analysis of the Kentish Rag.

By P. Gerald Sanford, F.I.C., F.C.S.,

Metallurgical Laboratory, Royal School of Mines, London.

In May last I visited the Preston Hill Quarry, near Maidstone, in the company of the "Geological Field Class," conducted by Professor Seeley, F.R.S., and took from it the specimen, the analysis of which is given below. In appearance the rock was a hard, grey, sandstone, containing fine quartz grains disseminated throughout its mass; its sp. gr. = 2·685; on the addition of an acid sulphuretted hydrogen was evolved, from the decomposition of calcium sulphide. The sample contained:—

Insoluble Residue	72·190	per cent	= {Silica	72·051 %
			{$Fe_2O_3 + Al_2O_3$ =	0·137
Alumina	1·331	,,	} = 2·068	
Ferric Oxide	0·682	,,	}	72·188
Phosphoric acid, P_2O_5. ...	0·055	,,		
Lime, CaO.	12·523	,,		
Magnesia, MgO.	0·054	,,		
Alkalies as K_2O.	0·122	,,		
Carbonic acid	9·984	,,		
Sulphuric acid, SO_3. ...	0·647	,,	as insoluble Ca SO_4, no soluble sulphates.	
Calcium sulphide, CaS. ...	1·334	,,		
Moisture, at 100°C.	0·995	,,		
	99·917			

[1] Die Massigen Gesteine, Stuttgart, 1887, p. 418.

[2] This Magazine, Vol. IX. 1872, p. 540. I give the analysis for comparison:—

SiO_2	=	78·32
Al_2O_3	=	11·39
FeO	=	1·67
CaO	=	·13
MgO (a trace)		—
K_2O	=	·20
Na_2O	=	7·62
H_2O	=	1·47
		100·80

[3] Trans. Roy. Irish Acad. vol. xxiv. (1859), p. 608.

VII.—On a Remarkable Sodalite Trachyte lately discovered in Naples, Italy.

By H. J. Johnston-Lavis, M.D., B.-ès-Sc., F.G.S., etc.

In the last two British Association Reports of the Vesuvian Committee, I drew attention to some very large masses of trachyte traversed, at the back of Naples, by the tunnel of the Cumana Railway. A full account of the stratigraphy of these will be deferred until some further excavations, now in progress, are completed. I propose at present merely to describe the earliest-discovered and most striking of these masses.

This trachyte is cut through on the E.N.E. side, at 1890 metres from the terminus end of the tunnel at Monte Santo, in a slightly oblique manner, which traverses it for 1980 metres on the southern side, and 2000 on the northern. Thus, it will be seen that the tunnel forms the chord of an arc, the circumference or boundary-line of the trachyte being directed southerly, or towards the present sea-coast. Both contacts are old escarpments, and at the W.S.W. end a talus is cut through of fragments of the trachyte and other materials, on which is superposed a series of pumice, ash, lapilli and vegetable soil-beds, representing many successive eruptions; the latter are also met with at the opposite escarpment, placed at a high angle of rest. We thus see that this mass was no doubt erupted as a subaerial lava-stream, probably cut back by the sea, or other denuding agents, to a vertical cliff, and subsequently covered by the different tuffs that constitute the hills above.

The rock is divided into rather large blocks by irregular cooling cracks, very similar to the Mont Olibano trachyte, which it most resembles in general characters. It is of light grey colour, with a somewhat bluish tint and earthy fracture, is harsh to the touch, adheres slightly to the tongue, and a drop of water falling on its surface is immediately absorbed. These latter characters are probably dependent upon actual spaces between the crystals and microliths, whilst the colour can be seen to be due to the admixture of glassy felspar with numerous minute dark particles. The sanidine crystals are mostly very thin, tabular in form, and show sections up to nearly two centimetres in length, in which Carlsbad twinning can be seen. A few rare but large individuals are compacter in shape, and prism-like, resembling those of the Drachenfels trachyte. Microscopically they are much fractured and fissured, very clear, with a few glass cavities, whilst in each fractured fragment much internal strain is evidenced by the ring of colours just within its outline. The sanidine is decidedly the most important constituent of the rock, and next to it we have the amphibole, which exists in two or three varieties. One is usually in larger crystals, attaining a maximum measurement of two or three millimetres or more, and commonly occurring as irregular crystalline grains, with sharp edges, as if fractured shortly before consolidation in consequence of the internal friction of the semi-solidified pasty mass. Some sections exhibited typical cleavage. The colour of this variety is yellowish or greenish brown, and comparatively slightly pleochroic. The smaller crystals are also very irregular in shape, and range down in size to large microliths. Even when a comparatively well-formed rod is examined, no extinction can be obtained, the whole undergoing aggregate polarization, as if some molecular change had taken place, or as if each individual were constructed of an association of minute grains. By changes that have occurred in much larger crystals of extraneous enclosed masses, it would appear that these microliths and crystals really consist of a mixture of pyroxene and amphibole. Another fact is that the greatest darkening is obtained at two points in rotating through 90° between crossed Nicols corresponding with the extinction of these two mineral species. The other variety of amphibole is certainly more recent in formation, but seems to have undergone the same molecular change, for it is almost impossible to get any definite extinction. The crystals are well formed, and associated with cavities, and no doubt are the same as those that project as long rods from the sides of the vesicles of this rock. In colour, they are very dark bluish-green, faintly pleochroic, but their opacity prevents a just estimation of such.

The ground-mass consists principally of sanidine microliths of large size in fact, so large that in many cases Carlsbad twinning can be made out. Interspersed amongst these felspar microliths, and those of amphibole already mentioned, are numerous grains of magnetite, which apparently have crystallized mostly as octahedra, their form being partly obliterated by a rusty iron stain surrounding them. Rarely, highly refracting colourless grains occur of uncertain character, and within some felspars long four-sided orthorhombic? prisms with domes, of a fibrous-looking mineral, occur, which in some sections looks much like a triclinic felspar in structure. Some attempts were made to isolate one of these, but unsuccessfully, and, on account of their rarity, none other suitable examples could be met with.

Some parts of this mass of trachyte are vesicular, though the cavities are not very close together. There are also a certain number of fissures formed before the rock had quite consolidated. These vesicles and fissure-spaces are lined by a number of minerals which constitute the beauty and striking characteristic of this trachyte. Projecting from the walls of these spaces, long pseudo-hexagonal prisms, sometimes solid, at others tubular, occur; in the former case they are usually colourless, and as limpid as cut glass. In size they range up to and beyond one centimetre long, and from one to four millimetres broad. They may be traced by gradations to fine well-formed dodecahedra of sodalite, which are somewhat white or milky in colour. Associated with these sodalites are numerous rods of black amphibole, thin and long, usually about a millimetre broad and from a half to one centimetre and a half in length. Much rarer and irregular hollow-faced crystals of a black colour, with usually a rough submetallic lustre, which is commonly steel-black, but may be of dark bronze colour; most of these crystals are imperfect, and frequently arranged in chains. As far as I could make out, they have much the form of a pyroxene with the faces 110, 100, 112 and 111 well developed. A few were sliced, and show under the microscope a yellowish-green mineral, changed on the surface and along the cracks to a dark almost opaque brown mass. Unfortunately no very characteristic cleavage or extinction angles could be obtained. A grain reduced to powder and fluxed with carbonate of soda gave a strong manganese reaction. These facts would seem to indicate that we have pyroxene crystals which are undergoing decomposition, either from the separation of an oxide or hydrated oxide of manganese, or the introduction of this from without. The former I take to be the correct explanation, since the brown stains only occur on these crystals and in their immediate neighbourhood, and also the amphibole rods are unaltered except where in contact with these pyroxene crystals.

In some of the vesicles are bunches of hair-like crystals of chocolate colour, which at first sight look like breislakite. Examined under the microscope they are seen as absolutely opaque rods, even to the smallest dimensions. Although easily visible as large sprays, the actual amount of material is very small, so that I was unable to obtain more than two or three milligrammes. Part of this was treated by the four acids, but proved very slightly soluble in HCl and HF.

The HCl solution gave a blue precipitate with K_3CyFe_6. Another portion was fluxed with alkaline carbonates and proved very refractory, lixiviated with subsequent addition of HCl evaporated to dryness, then, dilute HCl added and filtered. The filtrate gave strong iron reactions, whilst the filter was burnt, and the ashes treated with HF and H_2Go_4 evaporated and fluxed with PotBisulphate and a HCl solution made which gave faintly the reaction for titanium. With salt of phosphorus in reducing flame it gave a blood-red bead. From these reactions we may conclude that we have to deal with a compound containing principally titanium and iron, and the question remains open whether we have to deal with a fibrous hematite containing titanium (Scacchi has proved the fibrous mineral in the piperno to be an iron-oxide), or a fibrous rutile very rich in iron, or lastly perhaps a breislakite containing titanium.

Most of the cavities are completely lined by a carpet of minute sanidine crystals; but superposed on these, in a few, are small elongated hexagonal-looking prisms which rarely attain to more than half a millimetre in length and about a sixth in breadth.[1] Under the microscope they are larger in the centre, so as to appear fusiform, whilst the surfaces of the prism are striated longitudinally, so that in only a few cases can they be made out to be hexagonal. The prism is terminated sometimes by basal planes, but in others by a low pyramid.

Various attempts were made to measure the angle between the pyramid and prism, and most often with a resulting angle of 116°,

[1] Often poised delicately on the amphibole rods, or the fibres of the breislakite-like mineral.

but in some cases as much as 125° was obtained. Under high powers a large number of minute well-formed cubes about 0·02 millim. are observable attached all over the surface of these hexagonal crystals. What either of these minerals may be is a difficult matter to decide, but the striking resemblance of the hexagonal one and its analogous mode of occurrence would easily lead one to refer it to microsommite. Lastly, but rarely to be met with, are minute acicular orange yellow crystals that look at first sight like small titanites (semeline). In HCl, however, these dissolve with much effervescence, and the solution gives an abundant precipitate with ammonic oxalate, and, therefore, may be referred to scalenohedra of calcite.

The order of crystallization in the cavities seems to have been as follows :—

1, Sanidine ; 2, Amphibole ; 3, Pyroxene ; 4, Rutile ? ; 5, Sodalite ; 6, Microsommite ? ; 7, Calcite.

Strangely enough I have not been able to find a trace of mica, either in the matrix or in the vesicles. I am the more struck with this, since in some blocks of a very similar rock near Pianura, enclosed in the cavities with the amphibole are most beautiful large brown plates of biotite.

The minerals are no doubt sublimates, or more properly result from the reaction of different vapours under special conditions of temperature and pressure.

A bulk analysis of this rock was made with special precautions as to sampling and the avoidance of regions in which vesicles occurred. The results are given below :—

$Si\ O_2$	...	...	57·909
$Ti\ O_2$	...	...	0·654
$Al_2\ O_3$	...	...	15·786
$Fe_2\ O_3$	...	...	6·807
$Fe\ O$	...	...	0·010
$Mn\ O$	...	...	0·230
$Ca\ O$	...	...	2·986
$Mg\ O$	...	...	1·656
$Na_2\ O$	...	...	6·013
$K_2\ O$	...	...	7·270
$P_2\ O_5$	...	...	0·007
Cl	...	...	0·606
$H_2\ O$	...	...	0·336
			100·270
	Sp. Gr.	=	2·516

This analysis gives the composition of a trachyte somewhat similar to that of Scarrupata. The uncommon point is the high percentage of titanic acid.

What is remarkable is the very fresh appearance of this rock, whilst the minerals of the vesicles seem hardly to be altered, yet the bisilicates in the base are in a state of molecular instability, so that some doubt exists as to whether these changes are pre- or post-eruptive. The great interest of this trachyte will be its relationship to two other masses lately met with in its neighbourhood.

VIII.—Note on *Pleurotoma turbida*, Solander, and *P. colon*, Sow.

By the Marquis Antonio De Gregorio.

Mr. EDWARDS in his beautiful work (Eoc. Moll. p. 311, pl. 32, fig. 2) described a species of *Pleurotoma* under the title of *Pl. turbida*, Sol. He regards *Pl. colon*, Sow., as a synonym, but not *Pl. colon*, Sow., in Deshayes. In this I think he was mistaken. The species described by Deshayes appears to me different from the *Pl. colon*, Sow., and identical with the species figured by Solander under the name of *Murex turbidus*. In the second edition of his work Deshayes says that he "noted this species for mischief," because it is not found at Soisson, but he retained the name of *colon*, Sow.

The species described and figured by Edwards appears to me different from *Pl. turbida*, and like *Pl. colon*. These last two species are thus distinguished.

Murex turbidus, Brander (Foss. Hant. pl. 2, fig. 31), has the costæ biseriated, the whorls excavated in the middle, the sinus of mouth situated in their depression. *Pl. colon*, Deshayes (non Sow.), is a synonym of the same species.

Pleurotoma colon, Sow. (Min. Conch. p. 106, pl. 146, figs. 7, 8), has the whorls swollen in the middle and nodulous, the sinus is placed on the periphery of the whorl. *Pl. turbida*, Edw. (non Sol.), is a synonym of it.

These two species, I believe, are not only distinct, but belong to different subgenera. *Pl. turbida*, Sol., belongs to the subgenus *Clavatula*. *Pl. colon*, Sow., to the subgenus *Strombina*.

Pl. turbida, Nyst. (Coq. et Polypières des Belgique, p. 513, pl. 40, fig. 8), differs from both, but it is more analogous to *Pl. turbida*, Sol., than to *Pl. colon*, Sow.; but it has the anterior canal more oblong and the ribs not interrupted in the middle.

To conclude, I believe that there are three distinct species:

Pleurotoma turbida, Brander (= *colon*, Deshayes).

Pleurotoma colon, Sowerby (= *turbida*, Edwards).

Pleurotoma turbida, Nyst.

For this last I propose the name of *Lethensis*, from the locality where it has been found.

Palermo, *November*, 1888.

NOTICES OF MEMOIRS.

I.—On some Fossils of the Limestones of South Devon.[1] By Rev. G. F. Whidborne, M.A., F.G.S.

From the three localities of Woulborough, Lummaton and Chudleigh about 334 species are known, of which 104 are common to the two former places, and five occur in all three; among these are *Orthis distorta*, Barr; *Pterinea Wormii*, F. A. Rö., *Pt. ala*, Barr., *A. rudis*, Ph., *A. plicatellus* (= *P. plicatus*, Ph., Pal. Foss.), *A. Cybele*, Barr., *A. consolans*, Barr., *P. lateralis*, Sow., *Hoplomytilus crassus*, Sandb., *Megalodon obliquus* (= *M. carinatus*, Ph. not Goldf.), *Pl.*

[1] Communicated to the British Association, Bath, Sept. 1888, Section C. Geology.

Vilmarensis, d'A. and de V., *Pl. pugnans* (= *Pl. minax*, Ph. Pal. Foss.), *H. interscapularis*, Ph. (including *H. depressus*, Aust.), *H. macrotatus*, Aust. (= *H. tuberculatus*, Ph. not Mill.), *H. ornatus*, Goldf., *Pl. fritillus*, Wiet. and Zieler; *H. Vicarii* (= *H. pentangularis*, Ph. not Mill.), *Pl. quintangulus* (= *Pl. pentangularis*, Aust. not Mill.), and *Rh. crenatus*, Goldf.?; *Receptaculites*, sp. and *Serpula*? *semiplicatus*, Sandb.; and also the following which are new, *Pterinea obovata*, a small deep species like *Pt. texturata*, Ph., but without concentric lamellæ; *Pt. placida*, flatter and more angulated than the last and with more distant ribs than *A. urbana*, Barr.; *Pt. dilatata*, which is larger and wider and with fewer and more distant ribs than the preceding, crossed by crowded growth lines; *Pt. crenatissima*, a longer shell with very anterior umbo, and covered with fine granulated lines crossing minute rays; *Pt. bellula*, a species like *Pt. fasciculata*, Goldf., but with few alternating ribs crossed by distant zigzag striæ; *Aviculopecten hirundella*, separated from *Pt. texturata* by its shorter hinge-line and finer reticulation (the right valve has transverse marks similar to those of *Pt. ala*, Barr.); *A. aviformis*, a flat recurved shell much produced and rounded behind, with very small umbo and wings; *A. comma*, similar to the preceding, but much smaller and with reticulated surface; *A. gracilinus*, a flat elongate sub-equilateral form with minute umbo, notched anterior ear and close alternating ribs; *Mytilus Robertsii*, which is more ovoid and less produced in the postero-superior region than *M. dimidiatus*, Goldf.; *M. stultus*, a short squarish form with fine concentric striæ and a few stronger ones; *M. pinnoides*, which is shorter and has a more direct umbo than *M. uncinatus*, Eichw.; *Myalina elliptica*, a smooth convex ovoid shell differing from *Unio castor*, Eichw., in its more incurved umbo and less dilate wings; *Megalodon? columbinus*, separated from *M. carinatus*, Goldf., by its finer regular plaits, more terminal umbo and the contour of its elevated keel; *M.? prominens*, larger than the last, and with coarser wavy plaits, loftier and more projecting umbo and more oblique anterior margin; *Ctenodonta? lepida*, a small flat transverse shell, which is narrower and more convex anteriorly than *P. modiolaris*, F. A. Rö.; *Cardiomorpha? polita*, a flat oblique species unlike *A. damnoniensis*, Ph., in its smoothness and its shorter hinge-line; *Cypricardia neglecta*, with fewer stronger ribs and more definite wing than *M. scalaris*, Ph.; *C. guttata*, with fewer plaits and rounder indentations than *C. crenistria*, Sandb.; *C. ensiformis*, a much flatter and wider shell than *C. neglecta*, and with more and finer plaits; *Edmondia? dubia*, a large wide convex shell, with a recurved anterior umbo, deep area and close indistinct bifurcating growth lines; *Hexacrinus perarmatus*, with calix like *H. macrotatus*, Aust., but covered with sharp regular non-confluent tubercles; *H. microglypticus*, with a convex calix, very long basals and fine ornamentation; *Platycrinus aberrans*, with trilobed attachment, elongate calix, three squarish basals, four or five long radials intercalated with one large and one small subsidiary anal; *Haplocrinus decipiens*, a minute crinoid having a short calix with an elevated conical summit with key-shaped grooves for the arms; *Tricœlocrinus? Leei*, with shorter limbs and shallower excavations than *T. Woodmani*, Wachsm. and Springer; and *Serpula? devoniana*, a long straight smooth and cylindrical tube.

II.—Dr. Rüst, on the Occurrence of Radiolarians in the Cretaceous Strata.

Beiträge zur Kenntniss der fossilen Radiolarien aus Gesteinen der Kreide, von Dr. Rüst, in Hannover. Palæontographica, Bd. 34, 1888, pp. 181—214, Taf. xxii. bis xxix.

In his first memoir on the Radiolarians from the Jurassic rocks, which has been already noticed in the Geol. Mag.,[1] Dr. Rüst called attention to the apparent scarcity of these organisms in Cretaceous strata, but a subsequent examination of about two thousand microscopic sections of the rocks of this period has shown that they are very abundant in some of the lower beds, though very rare in the higher beds of the series. Thus, for example, a reddish hornstone of Neocomian age from Katzenberg in the Trauchgebirge was so filled with Radiolarians that it might properly be considered as a former "Radiolarian ooze." On the other hand, in the Upper Chalk only two species were found, and these were in limited numbers. They were very abundant in beds of the age of the Gault at Zilli, near Wasserleben in Saxony, at Oker and Goslar in Hanover, at Braussrote in the Basses Alpes, and at Escragnolles. In these Gault deposits the Radiolarians were mostly met with either in the body-chamber of Ammonites or in true Coprolites. In these latter they were invariably associated with spicules of siliceous sponges as well as fragments of other organisms, indicating, the author believes, that the animals which produced the coprolites largely fed on sponges. A peculiar feature of many of these coprolites is that they are almost entirely made up of small oval pellets, which are supposed to be casts or moulds of intestinal follicles of the Saurians or fishes through whose bodies they passed.

From the Cretaceous marls of Haldem in Westphalia Dr. Rüst only records the six species of Radiolarians, which were first discovered in these beds and described by Prof. v. Zittel, and from the flints of the Upper Chalk of this country he obtained but two species, *Dictyospyris chlamydea*, and *Dictyomitra Anglica*, both of them new forms. The author thinks that this paucity of forms in the Upper Chalk may indicate their comparative absence in the seas of this period, but it is not improbable that the same destructive action which has dissolved the siliceous skeletons of most of the Upper Chalk sponges, has been still more effectual in destroying the far more minute and delicate Radiolarian tests, most of which only range between one-twentieth and one-fourth of a millimètre in diameter.

From the Cretaceous rocks as a whole, 165 species included in 74 genera were obtained, of which 49 species occur in Jurassic rocks. In general characters the Cretaceous Radiolarians more nearly

[1] Dec. III. Vol. III. 1886, p. 79.

approach those from the Jurassic strata than the Tertiary and Recent forms. The new species are arranged according to the classification proposed by Hæckel in his Challenger work, and figures of them are given in the accompanying eight plates. Dr. Rüst also adds a tabular list showing the geological distribution both of the Jurassic and Cretaceous species.—G. J. H.

REVIEWS.

I.—Fossils of the British Islands, stratigraphically and zoologically arranged. Vol. I. Palæozoic, comprising the Cambrian, Silurian, Devonian, Carboniferous, and Permian Species. With Appendix to 1886. By Robert Etheridge, F.R.S. L. & E., F.G.S. 4to. pp. 468. (Oxford, Clarendon Press, 1888.)

THE ranks of our geological army, like that of most other special scientific bodies, are well-filled with workers of all kinds, nor are writers and compilers absent from its many-sided staff.

Text-books are now so numerous that it is often difficult to advise the tyro which to adopt,—nor are the writers of separate essays and memoirs by any means waning, to judge from the constant flow of these productions which find their way into the pages of the Geological Magazine, the Quarterly Journal, and other similar publications.

The writing of original articles, and describing individual specimens, form perhaps the lightest stratum of our geological architecture.

Monographs on special subjects have also their attractive aspect, but they may fairly be reckoned amongst the more solid portions of our palæontologic structure.

Text-books may be, and very often are, the necessary outcome of a long course of oral instruction, carefully and conscientiously given to students in training; or of an equally arduous pursuit of field-work; but some, doubtless, have originated mainly from a careful application of "scissors and paste," with connective tissue of more or less firm consistence—usually less.

But of those who mainly work for the benefit of others, none deserve our gratitude more than the compilers of Catalogues, especially of such a confessedly arduous work as that of a Catalogue of British Palæozoic Fossils, such as that now before us, prepared by Mr. Etheridge. Indeed, the sources of information lie so scattered, and so much diligence and discernment are needed in dealing with and assorting the varied matters to be gathered together, that one can hardly over-estimate the gravity of the task.

And when all is done—if it ever is done!—much promptitude seems needed to seize the right moment for publication and to get it out before the next flood-wave of new matter pushes the patient and indefatigable compiler back again and prevents him from ever getting his Catalogue issued, or at any rate before it must be modified, owing to the progress of new palæontological discovery and new publications.

In 1830 Samuel Woodward, of Norwich, published the first attempted list of British fossils, a little book of fifty pages octavo, entitled "A Synoptical Table of British Organic Remains," wherein the number of recorded British fossils is given as 2008.

Prof. John Morris published the first edition of his Catalogue of British Fossils in 1845, and a second edition in 1854. It must not, however, be overlooked that in 1848–49, between the issue of the first and the second edition of Morris's Catalogue, the great work of Dr. H. G. Bronn, entitled "Index Palæontologicus," in three vols. 8vo. (Stuttgart), had appeared. This work really formed the most important and correct contribution to Palæontological nomenclature, giving us the most complete and accurate census of past life-forms ever attempted.

The author of the present work, Mr. Etheridge, is no novice at the task of tabulating British fossils, as may be abundantly proved from his very numerous published palæontological Appendices to the Memoirs of the Geological Survey (especially that to Vol. III. on North Wales), his great Memoir "On the Physical Structure of West Somerset and North Devon and on the Palæontological Value of the Devonian Fossils" (Quart. Journ. Geol. Soc. 1867, vol. xxiii. pp. 568–698), and his Anniversary Addresses as President of the Geological Society, 1881–82.

Mr. Etheridge also largely aided the late Dr. J. J. Bigsby, F.R.S., in the production of two very valuable Catalogues, one entitled "Thesaurus Siluricus" (4to. 1868), and the other "Thesaurus Devonico-Carboniferus" (4to. 1878).

In Prof. Morris's second edition are enumerated 8359 species of British fossils, from rocks of all ages; in the present volume, which gives a list of fossils recorded only from the British Palæozoic rocks known up to 1886, we find the number to be 6022 species, whilst those met with in the Neozoic formations (not included in the present Catalogue) number, according to Mr. Etheridge, no fewer than 13,000—giving a grand total for the British Islands of 19,022 species at the date when the present list closed in 1886.

Undoubtedly we are mainly indebted to Morris for the first really important *critical list* of British fossils, and this has been of the greatest use to workers in palæontology and also in stratigraphical geology, by directing them to those published sources of fuller information, such as Sowerby's Mineral Conchology, Mantell's and Dixon's works, the Transactions and Journal of the Geological Society, and later to the grand series of volumes of the Palæontographical Society, whose vast stores of information needed such a Catalogue raisonnée to make them available to the ordinary working student seeking to arrange and name his collection and to fix with certainty the horizon from which he had obtained his fossils.

Most of all do such works attain their highest usefulness when they can be appealed to as critical guides, and safeguards against the unnecessary multiplication of names in palæontology.

In that vast maze of modern scientific nomenclature to which the multitude of specialists have given origin, in which the student of palæontology finds himself too often entangled, it is no small matter to find some friendly clue offered ready to his hand, which if it will not in every case carry him safely out of the labyrinth, may at least give him a help in the right direction by showing him how to get at the reference he wants.

It is only right to state, with regard to the work before us, that ten years ago it was quite ready and ripe for publication; but owing to family illness and official duties having intervened, the work, which might have been issued in 1878, appeared only in 1888. As a consequence of this unfortunate delay, a very much larger Supplement has been found indispensable in order to bring the several long lists of fossils up to the closing date of 1886.

Turning a critical eye to the work itself, we are at once struck by the important difference in arrangement between Mr. Etheridge's Catalogue and that of its nearest predecessor, Morris's Catalogue of British Fossils (1856). In the latter work we had a small 8vo. page only, and the species from the oldest Palæozoic to the Recent were all arranged under their respective orders, families, and genera, the latter alphabetically, save in great groups, such as the Ammonites and the Brachiopods, which are simply subdivided into Palæozoic and Oolitic; or Oolitic and Cretaceous. In Mr. Etheridge's volume we have a large quarto page subdivided into ruled spaces and columns, with the genera and species alphabetically arranged under the great zoological groups, and further into Cambrian and Silurian, Devonian, Carboniferous and Permian, whilst their range is indicated through a limited number of geological subdivisions by asterisks placed in the column headed with the name of the formation, as Harlech, Menevian, Lingula Flags, Lower, Middle, or Upper Devonian, according to the several horizons included on the page.

Taking the genera and species, these are given with one or more references to the works published, but without localities, not as was the case in Morris's Catalogue.

Whenever a species has remained for some time under an earlier generic appellation than that by which it has since been recognized, it will be found duly recorded both under the old and disused genus and under the new and present recognized one, only the former reference is printed in *italics* and the latter in roman type, with a cross-reference to the newer name.

The earlier part of the Catalogue, up to p. 376, is provided with an admirable index.

The Appendix which follows, covering about ten years down to the end of 1886, is more concise in its references as compared with the earlier part of the work and it has also an index to it.

Without consulting this Appendix it might appear that the former part of the work was incomplete, which is not the case; but, taking a single group like the Sponges, a still newer revision of the genera has taken place subsequent to 1886, which will necessitate a further re-arrangement of these organisms whenever a new edition of this Catalogue shall appear.

The recent revision of the fossil Mammalia, the fossil Reptilia, and the Fishes—still in progress—will all materially affect the possibility of making a moderately complete catalogue of British fossils for some time longer, and then the new edition will have to be pushed forward in a briefer space of time through the press than has the present issue.

For owing to the large army of specialists which has arisen within the last 25 years, the task of the scientific compiler who undertakes to codify the long lists of species under each and every separate biological heading, becomes more and more difficult as the years roll on, and the Diogenes in Science who expects to find a perfect Nomenclator had better return to his tub and hang up his lantern.

Whilst, however, it cannot be overlooked that there are many literary defects as to words and references which have unfortunately remained uncorrected even in the list of errata and corrigenda at the end of the volume, we cannot ignore our great indebtedness to the author for the time and patience he has bestowed in bringing out the work under many trials and drawbacks only known to some few of his more intimate personal friends.

As might be expected of a work published by the Oxford University Press, the general aspect of these complex and difficult pages with their numerous columns—in some cases as many as twenty on a single page—is excellent and deserves great praise.

This labour of love which the author has now so happily completed, as regards Part I., has extended over fully thirty years of Mr. Etheridge's life, having been the work of his leisure hours and done quite apart from his official duties, indeed, having been carried on often into the hours which most men wisely set apart for "Nature's sweet restorer, balmy sleep."

We feel sure that every one will read with regret the author's announcement at the end of his Preface that, although the Mesozoic and Cainozoic portions forming Part II. of his Catalogue are completed in MS., his other occupations deter him from attempting the task of preparing the remainder for publication. It is to be earnestly hoped that with the assistance of friends this difficulty may yet be overcome.

Of one thing we feel sure, namely, that this first instalment of a much-needed and long-delayed work will be heartily welcomed by all, and will find its place as a work of reference on the shelf of every scientific library.

II.—Report of the Geological Survey of Ohio. Vol. VI. Economic Geology. Royal 8vo. pp. 831, with Maps and Figures. (Columbus, 1888.)

THIS volume is mainly devoted to a history of the origin and mode of occurrence of the natural gas and petroleum present in the rock-series of the State of Ohio. About four years since a deep well-boring in Hancock County, in the north-western part of the State, revealed the existence of large accumulations of carburetted hydrogen gas and petroleum in limestone strata, about 1100 or 1200 feet beneath the surface. The rocks proved to be of Trenton age, *i.e.* Ordovician, about the horizon of our Llandeilo Flags. The existence of these products in workable quantities at this low horizon was an entirely new and unexpected fact to American geologists, and as the geological structure of Ohio is extremely simple, without breaks or important disturbances, and it was known that the Trenton formation would be found at depths varying from 1000 to 2000 feet beneath the surface, throughout the western areas of the State, wells were rapidly drilled in all directions. The great majority of these were unproductive, but in certain limited areas the yield of gas and petroleum has been on a marvellous scale. The facts brought to light by these borings were carefully collated by the Geological Survey of Ohio, and they are presented by Professor Edward Orton, the State Geologist, in a detailed and lucid manner in the present volume. Owing to the simple and undisturbed character of the geological series in Ohio, the questions affecting the origin and accumulation of natural gas and petroleum are more likely to be solved here than in areas where rock disturbances tend to make the problem more complicated.

In the north-western part of Ohio, beneath the mantle of boulder clay, the rocks outcropping at the surface belong for the most part to the Lower Helderberg series, the upper portion of the Silurian. These are mainly bituminous limestones, with an average thickness of about 300 feet. Beneath these in conformable succession, and with dips so small as to be scarcely appreciable, are the Niagara series of limestones and shales, and the Clinton series, together about 400 feet thick; then a thin deposit of Medina shales; beneath these the Hudson River or Cincinnati group of shales and limestones, with an average thickness of 600 feet, and the Utica shales 300 feet in thickness; under which the Trenton limestones are found. Both gas and petroleum are present in small and variable amounts in each of these different rock-series, but not sufficient to be of economical value. Even in the Trenton rocks, the accumulation of these products in workable quantities seems to depend on two conditions; first, a rise or elevation of the strata in the productive areas above the beds of those adjoining, and next, that the upper portion of the Trenton beds consists of a porous dolomite or magnesian limestone. This dolomite appears to have resulted from the alteration of true limestones; at all events, it occurs in patches surrounded by the normal limestones containing the usual fossils. The Trenton limestone itself has been penetrated for 500 or 600 feet, but it has been ascertained that the profitable accumulation of gas or oil was limited to the upper beds.

The facts point to the inevitable conclusion that the Trenton limestone is the source of the inflammable products; that resulting from artesian pressure they accumulate in the areas which are slightly elevated and where the rocks have become dolomitized and porous. The petroleum and gas can only be derived from the decomposition of the animal organisms, the skeletons of which now compose the limestones. Judging from the fossils in this rock where it outcrops at the surface in other areas, the fauna is entirely invertebrate, and mainly consists of Crinoids, Trilobites, Brachiopods, Corals and Polyzoa. The volatile products of the decomposition are confined to the upper beds of the limestones by the presence of the massive overlying beds of the Utica shale. The animal origin of the petroleum in these limestones most probably accounts for the fact that the crude material contains a greater amount of sulphur, and is consequently more difficult to deodorize, so as to be suitable for burning, than the petroleum from the Pennsylvania wells, which in all probability is derived from the organic matter of bituminous shales, and is of vegetable origin. Prof. Orton is of opinion that in Ohio the petroleum has been produced at normal rock temperatures, and is not a product of destructive distillation of bituminous shales, and that the stock of petroleum in the rocks is already practically complete. This has been forcibly shown by the practical exhaustion of the supply in many areas which were at first productive, the place of the oil being taken by strongly saline water.

In certain localities in the north-eastern part of Ohio, where Carboniferous and Devonian rocks occur, an important supply of petroleum and gas has been obtained in a sandstone rock of sub-Carboniferous age, known as the Berea grit. The petroleum is believed in this case to be derived from thick beds of bituminous shale underlying the grit, and it is probably of plant origin. Prof. Orton likewise discusses the value of the Ohio (Devonian) shales in Ohio as a source of oil and gas. Many particulars are likewise given of the amounts produced, the mode of drilling the oil-wells, and the transportation and methods of using the natural gas.

G. J. H.

III.—Geological Survey of England and Wales.

1.—The Geology of the Cheviot Hills (English side). By C. T. Clough, M.A., F.G.S. 8vo. pp. 60. Price 1*s.* 6*d.*

THE country described in this Memoir belongs entirely to Northumberland; it is for the most part hilly, the highest point (Cheviot) being 2676 feet above sea-level. The oldest rocks, consisting of grey-green shales and greywackes, are grouped with the Wenlock Beds. They contain "apparently very few distinct fossil remains." These beds are overlaid unconformably by the Cheviot volcanic series—porphyrites, ashes, and ashy sandstones—grouped as Lower Old Red Sandstone. There is also a granitic core, probably of the same age. Higher still, there are representatives of Upper Old Red Sandstone, in certain conglomerates at Windy Gyle, etc.; these are not to be clearly separated from the conglomerates at the base of the Carboniferous system. The Lower Carboniferous beds are divided as follows:—

Fell Sandstones = Bernician (in part).
Cementstone Series } = Tuedian.
Lower Freestone (flaggy sandstones) }
Basement Conglomerates.

The conglomerates probably occur on many different horizons, but when traced northwards into Scotland, they are associated with red and yellow sandstones containing undoubted Upper Old Red Sandstone fishes. Several basaltic dykes (in part, probably Tertiary) occur in the area. The remarks on igneous and eruptive rocks are based to some extent on researches made by Mr. Teall, but the author gives the result of much personal observation, and his notes on crushed granite are of especial interest.

A short chapter is devoted to Glacial Deposits, the author remarking that the higher summits of Cheviot, etc., seem never to have been over-ridden by foreign ice, but to have acted as independent centres of glaciation. There are also notes on recent accumulations (peat mosses, etc.), on the physical structure of the district, on some aspects of scenery in relation to geology, and on the economic resources of the area.

2.—The Geology of the Country around East Dereham. By J. H. Blake, F.G.S., etc. (Parts by H. B. Woodward, F.G.S., and F. J. Bennett, F.G.S.) 8vo. pp. 59. Price 1*s.* 6*d.*

In this Memoir we have descriptions of the Chalk, Pebbly Series (Bure Valley Beds), Glacial Drift, River Gravel, and Alluvium. The district occupies the central portion of Norfolk, and includes (besides East Dereham) Litcham, Reepham, and North Elmham. Geologically speaking, the country is but little known, the previously published notices being confined to papers by the late S. V. Wood, jun., and Mr. Blake, and to references by the late C. B. Rose. A full list of fossils from the Chalk is now given, and detailed notes of the various pits and sections exposed. The Pebbly Series has yielded no fossils in the area now described, and its precise age is a subject on which opinions differ, Mr. Blake grouping it with the Glacial Drift, while Mr. H. B. Woodward places it in the Norwich Crag Series. A large part of the area is covered by the Chalky Boulder Clay, and this is overlaid in places by coarse "cannon-shot" gravel and sands. Notes on the economic resources, and records of a number of well-borings are given.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—December 19, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. "*Trigonocrinus,* a New Genus of Crinoidea from the 'Weisser Jura' of Bavaria, with Description of New Species, *T. liratus*; Appendix I. Sudden Deviations from Normal Symmetry in Neocrinoidea; and Appendix II. *Marsupites testudinarius,* Schl., sp." By F. A. Bather, Esq., B.A., F.G.S.

This genus is proposed on the evidence of two calyces in the British Museum (Natural History), which were found among specimens of *Eugeniacrinus* from Streitberg. The species of *Eugeniacrinus*, *Phyllocrinus*, and *Trigonocrinus* may be arranged in a series which is apparently one of evolution. The present genus is, therefore, to be placed with the Eugeniacrinidæ, although its characters are not those of the family as heretofore defined. This is seen from the following diagnosis:—

Trigonocrinus, gen. nov.—Calyx roughly triangular or trilobate in section. Basals 4, but one so atrophied as to be almost invisible; all fused into a basal ring. First radials 4; the two on either side of the smallest basal half the size of the others, thus maintaining the triangular symmetry; all closely united, with each suture-line in a groove. Processes of radials well developed, forming spines homologous with the petals of *Phyllocrinus*; excepting the adjacent processes of the smaller radials, which only form a minute ridge. Articular surface of radials curved gently inwards and upwards; muscular impressions indistinct or absent; no articular ridge; no canal-aperture. Arms unknown; ? represented by fleshy appendages. Calycal cavity contained in first radials; with small round ventral aperture, surrounded by a rim, which is the only relic of a muscular attachment. Stem unknown.

The two calyces belong to the same species, viz. *T. liratus*, sp. nov.—Calyx rather more elongate than in the known species of *Phyllocrinus*; basals ornamented with minute granules; radials ornamented with similar granules run into curved ridges, which, owing to their differing intensity, give an imbricated appearance; spines triangular in section, with the base of the triangle directed inwards, the apex outwards, the angles often rounded.

The differentiation of *Trigonocrinus* from the central Eugeniacrinid type has been effected on the one hand in accordance with the principles of "Degeneration," "Reversion," and "Use and Disuse"; while, on the other hand, it exemplifies certain methods of change in organic forms, which may be referred to the categories of (1) Sport, (2) Hypertrophy and Atrophy, (3) Fusion and Fission. Thus considered it is of unique interest among Crinoidea. An examination of the variations in symmetry presented by the Echinodermata suggests the conclusion that the Pentamerous type was originally evolved from another system, or at least that it was selected from among other variations, that it has survived, and that it has been kept true, as being the fittest.

Appendix I. Sudden deviations from normal symmetry in Neocrinoidea.

A collection of instances from previous authors, with a few additions, the whole illustrating the latter portion of the paper.

Appendix II. On *Marsupites testudinarius*, von Schlotheim, sp.

A synonymy of the genus *Marsupites*; it contains but one known species, and all other names must yield to this one.

2. "On *Archæocyathus*, Billings, and on other Genera allied thereto, or associated therewith, from the Cambrian Strata of North America, Spain, Sardinia, and Scotland." By Dr. G. J. Hinde, F.G.S.

A revision of the type specimens of the three species included by Mr. Billings in the genus *Archæocyathus* shows that each of the species represents a distinct genus. *Archæocyathus profundus*, having been selected by Mr. Billings in 1865 as the typical species, was retained as such, and the characters of the genus, as shown in this species, were defined; *Arch. atlanticus*, Bill., was made the type of a new genus, *Spirocyathus*; and the third species, *Arch. minganensis*, which proves to be a siliceous sponge, was included in a new genus, *Archæoscyphia*.

Including the genera allied to *Archæocyathus*, described by Meek and Bornemann, the following constitute the family ARCHÆOCYATHINÆ, proposed by this last-named author; *Archæocyathus*, Bill.; *Ethmophyllum*, Meek; *Coscinocyathus*, Born.; *Anthomorpha*, Born.; *Protophareta*, Born.; and *Spirocyathus*, g.n.

The genera of this family are characterized for the most part by turbinate or subcylindrical forms with stout walls enclosing an interior tubular or cup-shaped cavity. Their skeletons are of carbonate of lime in a minutely granular condition. The walls in the first four of the above-named genera consist of an outer and inner lamina connected by vertical and radial septa; dissepiments are generally present between the septa; save in the genus *Anthomorpha*, the outer lamina of the wall is regularly and minutely perforate, and the inner lamina and septa are likewise cribriform; *Ethmophyllum* is particularly distinguished by oblique canals connecting the interspaces of the wall with the central cavity, *Coscinocyathus* by transverse, perforate tabulæ, and *Anthomorpha* by the apparently imperforate character of the surface laminæ and septa. *Protophareta* and *Spirocyathus* are either non-septate, or very obscurely septate; their skeleton consists of anastomosing laminæ and fibres; in the latter genus the laminæ are remarkably thickened by successive secondary deposits of calcareous material.

The Archæocyathinæ are regarded as a special family of the *Zoantharia sclerodermata*, in some features allied to the group of perforate corals. The family is restricted, so far as is known at present, to the lowest fossiliferous zone of the Cambrian strata, that characterized by the genus *Olenella*, Hall, and it occurs at Anse-au-loup, Labrador; Troy, New York State; Nevada; in the Sierra Morena, Spain; and in the south-west of the Island of Sardinia.

The genus *Archæoscyphia*, based on *Archæocyathus minganensis*, Bill., is shown to be a lithistid sponge, and *Nipterella*, g.n., based on *Calathium* (?) *paradoxicum*, Bill., belongs likewise to the same group of sponges. The genera *Calathium*, Bill., and *Trichospongia*, Bill., are also undoubted siliceous sponges. These various sponges, which were either included in *Archæocyathus* by Mr. Billings, or regarded as allied thereto, have no relation whatever to the genus, or to any member of the family in which it is included. They come from a higher geological horizon, the Calciferous formation of the Canadian geologists, which is probably the summit of the Cambrian. They occur in the Mingan Islands and in Newfoundland. *Archæoscyphia* and *Calathium* are present in the Durness limestones.

3. "On the Jersey Brick Clay." By Dr. Andrew Dunlop, F.G.S.

This clay is of a dull yellow colour and somewhat sandy; in places it effervesces with acids; bedding and lamination have been noted. The lower part contains angular stones, usually with their longest diameter parallel to the surface of the underlying rock, and either derived from it or from some other rock not far distant. The bulk of the rocks consist of granite, diorite, rhyolite, quartz-felsite, etc., but there is an argillaceous shale, locally hardened, which is largely developed over considerable areas. The clay occurs in patches, covering all kinds of rocks, and is spread over the raised beaches; it seems more abundant on the higher grounds. A similar clay occurs in Normandy and in the other Channel Islands.

The author was disposed to regard this clay as probably a fluviatile deposit laid down towards the close of the Glacial Period, when the Channel Islands were at a lower level and united to the mainland. Subsequently he conceived that it might be the result of the decomposition of shale, felspathic porphyry, etc., some sections seeming to show this process as still going on; the clay, too, seems better developed over this class of rock; if so, it would require a moving force more energetic than ordinary rainwash.

II.—Jan. 9, 1889.—H. Woodward, LL.D., F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "On the Growth of Crystals in Igneous Rocks after their Consolidation." By Prof. J. W. Judd, F.R.S., F.G.S.

That the characteristic structures of the "granophyric" rock were not acquired by them during the act of consolidation, but have resulted from secondary changes taking place subsequently, was suggested in a former communication to the Society. Additional evidence was now brought forward concerning the nature of the processes by which these structures — variously known as the micropegmatitic, the centric or ocellar, the pseudospherulitic, the microgranitic, and the drusy or miarolitic—which are found in the peripheral zones and the apophyses of granitic intrusions, must have been produced.

That fragments of crystals in detrital rocks undergo enlargement and redevelopment has been shown by Sorby, Van Hise, Bonney, and many other authors. The fact has also been frequently recognized that curious outgrowths may often be detected in connection with the crystals of igneous rocks; such outgrowths have usually been regarded, however, as having been formed during the original consolidation of the rock.

In a "labradorite-andesite" (labradorite of French petrographers) belonging to the older or "felstone" series of ejections in the Tertiary volcano of Mull, large crystals of a plagioclase-felspar, near to labradorite in composition, are found to exhibit large and remarkable outgrowths of very irregular forms. The distinction between these outgrowths and the original crystals is rendered very obvious from the circumstance that the original crystals have been corroded by the enveloping magma and contain enclosures of the same, and that they have been much cracked, and sometimes even partially kaolinized before growth recommenced in them. In some cases the crystals have been actually broken and recemented by newly deposited felspar-material.

While there is a general crystallographic continuity between the old felspar-crystals and the new outgrowths from them, the variations in the position of extinction in different portions of the enlarged crystal show that, as growth went on, the composition of successively formed zones gradually and progressively changed from near the anorthite limit to close upon the albite limit.

These facts prove that, under suitable conditions, felspar-crystals in solid rock-masses may grow at the expense of the unstable glass-magma by which they are surrounded. This conclusion is in complete harmony with some other recent researches—especially those of Dr. J. Lehmann on the mode of production of the perthite-structure in felspars. In conclusion, the circumstances which have given rise to the exceptionally clear illustration of the processes described in the rock under consideration were explained, and the bearings of the principles enunciated on the theory of metamorphism are indicated.

2. "The Tertiary Volcanoes of the Western Isles of Scotland." By Prof. J. W. Judd, F.R.S., F.G.S.

In his recently published memoir, "The History of Volcanic Action during the Tertiary Period in the British Isles," Dr. A. Geikie, while adopting many of the views propounded in a communication made to this Society in 1874, "On the Ancient Volcanoes of the Highlands," takes exception to certain of the conclusions which are maintained in that paper.

Among the ideas set forth in 1874, of which Dr. Geikie now announces his acceptance, and to which, indeed, he supplies valuable support and confirmation, from his own observations and those of various members of the Geological Survey, are the following:—

(1) The perfect transition between the plutonic rocks of the district (granites and gabbros) and the lavas ("felstones" and basalts), and the dependence of each variety of texture exhibited by them—from the holocrystalline to the vitreous—on the conditions under which solidification took place.

(2) The presence of great masses composed of volcanic agglomerates, breccias and tuffs, with numerous intrusive bosses, sheets, and dykes, at five well-marked eruptive centres, namely Mull, Ardanmurchan, Rum, Skye, and St. Kilda, and the subaerial character of the ejections at these five centres.

(3) The Tertiary age, not only of the lavas, but also of the gabbros and granites found associated with them at these different centres.

The conclusions to which exception is taken are as follows:—

(1) That the ejection of the "felstone" lavas and the intrusion of the granites preceded the appearance of the basalts and gabbros.

(2) That the five centres of eruption mark the sites of as many great volcanic cones, now ruined and dissected by denudation.

The view that the acid rocks were, as a whole, older than the basic ones, was originally put forward by Prof. J. D. Forbes and Dr. F. Zirkel, and is supported by the memoir of 1874. Dr. Geikie admits that, around several of the centres indicated, basalts may frequently be seen resting on more acid rocks; but the latter he regards as being, in every case, of an intrusive character; he also allows that the tuffs intercalated with the basalts often contain fragments of felsite, but he does not accept this as a proof that the felsites must have been erupted before the basalts. Much of the divergence of opinion that has arisen appears, however, to be due to the circumstance that Dr. Geikie classes as basalt many of the dark-coloured lavas (augite-andesites, etc.), which were, in the original paper, grouped under the name of "felstones." In these "felstones" the granites and gabbros alike were shown to be intrusive; and it was also admitted that there were many intrusions of acid rocks of later date than both the "felstones" and the basaltic lavas.

With respect to the existence of great volcanoes in the district, Dr. Geikie, while confirming most of the statements which were made in 1874 as to the several centres of eruption, prefers to refer the origin of the great plateaux of basaltic lava to "fissure-eruptions." He maintains that the numerous basic dykes of the district mark the actual cracks through which the lavas in question rose up and welled out at the surface.

In opposition to this view, it was pointed out that the numbers and dimensions of the Tertiary dykes are not such as would warrant us in inferring that they formed the conduits through which the enormous masses of lava forming the plateaux were erupted; and the absence of all proofs of contact-metamorphism at their sides, and of evidence that the majority of them ever reached the surface at all, was commented upon. In 1874 it was pointed out that some of these dykes appeared to mark the radial fissures on which sporadic cones ("puys") were thrown up, after the great central volcanoes became extinct; and this view is supported by the circumstance of the close analogies between the materials erupted at this later period, and the rocks which constitute some of the undoubtedly Post-Mesozoic dykes.

Dr. Geikie supports his view that the plateau-basalts of the Western Isles of Scotland and of Antrim were formed by "fissure-eruptions," by facts which he noticed in the Snake-River country, in the year 1879, while he was making an excursion to the Yellowstone Park, and also by observations made by Captain Dutton in the Grand Cañon country, in Utah, and in New Mexico.

With respect to Dr. Geikie's own observations, it was pointed out that geologists who have had more time and opportunity for the detailed study of the district in question, like Captain Reynolds, Dr. Hayden, and Mr. Clarence King, all agree that there is abundant evidence of ordinary volcanic action having occurred in the Snake-River country; and the last-mentioned author distinctly points out the great paucity of dykes, and the absence of any evidence of the existence of fissures such as those from which "fissure-eruptions" are supposed to have taken place.

Captain Dutton, although originally inclined to refer the lava-fields of the Western Territories of the United States to "fissure-eruptions," has, since his visit to Mauna Loa, and his study of the floods of basalt that have flowed from that volcano, very candidly confessed that, in view of these later observations, he is no longer prepared to maintain his original position.

If the effusive action taking place at many volcanoes be rightly understood and appreciated—and the recent very interesting researches of Prof. J. D. Dana in the Sandwich Islands have thrown much new and important light on this subject—the theory of "fissure-eruption" will be found to be as unnecessary as it is vague. At some volcanic centres there is a preponderance of explosive action; at others the main result consists in the extrusion of lava-currents; while in most cases we find a combination of both kinds of action. The Tertiary volcanoes of Scotland, like the existing volcanoes of Iceland, are interesting as exhibiting evidence of both the effusive and the explosive action on the very grandest scale.

CORRESPONDENCE.

UNIFORMITY IN SCIENTIFIC BIBLIOGRAPHY.

Sir,—Mr. Davison's suggestion in the Geological Magazine for January, that the British Association should appoint a committee for securing a uniform and intelligible system of quotation of scientific serials is a very good one. Experience, however, shows us that many compilers, from carelessness or conceit, do not trouble to use those intelligible abbreviations which are employed in Bibliographic lists already published, and therefore, *not seeing the necessity* of making their references clear to those outside their subject, they possibly may not take any notice of another list, even though it receive the authority of the British Association.

Mr. Davison proposes a rearrangement of titles of serials, which is decidedly open to very serious objections. The experience of those who have had to deal with large libraries and bibliographic work finds that it is misleading and disadvantageous to alter the plan of the title or use any other than that on the title-page of the volume. If once the rearrangement of titles be permitted, individual idiosyncrasies would come into play, and we should have the same serial in two, three, or more disguises.

Nor can we take the place of meeting as a guide for library reference; but the systematist must take the place of *publication*, this being the method at all large libraries and in all the best catalogues.

The best plan in making references is to give the title of a serial in the perfect sequence in which it is printed on the title-page of the identical volume referred to, abbreviating the necessary words only, so as to be perfectly intelligible to one unacquainted with the serial, and give the name of the place of meeting in full (or if, as is often the case, no place is mentioned, it is as well to insert it in parenthesis), add the place of publication at the end of the quotation, and the reference will be complete. This method, followed by all who have dealt with the subject in an extensive and practical way, is found to be the only one that will work satisfactorily.

C. Davies Sherborn.

UNIFORMITY IN SCIENTIFIC BIBLIOGRAPHY.

Sir,—Concerning the manner of quoting works of reference, I also have to make complaint, namely, that authors sometimes quote, as if it were a complete work, a paper which may be part of some larger publication.

Authors, however, are not always to blame in this matter, because it arises from the cause upon which I have another complaint, namely, that some of the Societies who issue Proceedings, etc., often fail to state on the "Authors' copies" anything at all concerning the fact that the papers are extracts from their publications.

Some of our County Field Clubs are adepts at withholding information. Sometimes they append no date at all to their publications; while their authors' copies suffer, in addition to the omission mentioned, from absence of date, absence of number of volume, and changed paging. I notice that even the Geological Society omits to give the volume number upon its "authors' copies."

I would suggest that the Council of the Geological Society first rectify this matter, and then issue a strongly-worded circular to every Secretary or Editor of every scientific society in the kingdom drawing attention to these omissions, and stating what is required.

Since it is the habit of some booksellers and private individuals to break up odd volumes of Proceedings into their different papers, I would suggest that it is also recommended that these data be printed at the heading of every paper in every volume of Proceedings; at present such information is lost if one happens to buy the parts of volumes so treated.

Date of papers.—I cannot agree with Mr. Davison (Geol. Mag. Dec. III. Vol. VI. No. I. p. 48) that the date of reading be taken as the date of a paper. A new species must date from the time when it is figured, and this cannot happen until the publication of the volume. If authors' copies be printed in advance, they should be so dated, both themselves and in the volume. S. S. Buckman.

Stonehouse, *Jan.* 7, 1889.

PROFESSOR BLAKE'S "MONIAN SYSTEM."

Sir,—Professor Blake's reply to my "Notes" on his "Monian System" requires a few brief comments.

Prof. Blake now admits the presence of true schists as derived fragments in the Upper Archæan of Anglesey; but he attempts to neutralize their effect by alleging examples where such fragments occur in the upper part of the formation from which they are derived. He says, "The conglomerate of Bull Bay is made of the underlying quartz rock." But he has to prove that the quartz rock was not of contemporaneous origin, if the cases are to be parallel.

The schist in the Llanfechell Grit is not of volcanic origin *tanquam* schist; it must have originated as rock, and been metamorphosed into a schist, before the grit was deposited. The metamorphism must have taken place at some depth, and there must have been a period of denudation previous to the exposure of the schist at the surface. His examples of the conglomerates of Llangefni and some of the Bangor beds are not to the point; since the fragments derived from the associated beds are volcanic, and contemporaneous denudation in volcanic rocks is common enough. That the "conglomerate of Moel Tryfaen is largely composed of the immediately preceding Cambrian slates" I dispute. I have seen this conglomerate on Llyn Padarn, and I followed it all along the crest of Mynydd y Cilgwyn, but not a bit of Cambrian slate did I find in it. Dr. Hicks studied it in the intermediate ground of Moel Tryfaen without finding slate. I therefore venture to reject all Prof. Blake's supposed parallel cases, and I call upon him to prove that a true crystalline schist could have been included as a derived fragment in a (roughly) contemporaneous sedimentary formation.

As to Llyn Trefwll, I am quite aware that a large part of the ridge close to my sections consists of basic igneous rocks; but as they had no bearing upon my work, I have not referred to them. The rock *in situ*, which Prof. Blake now admits is a true slate, on the authority of Prof. Bonney, contains rounded pebbles of the adjacent granite; and Prof. Blake has no right to say either that I mistook diabase for slate, or that I sent to Prof. Bonney certain derived fragments in mistake for rock *in situ*.

I am sorry the two examples of a supposed passage between the "lower and upper groups," which I selected because they happened to turn up first, prove to be bad ones. Perhaps Prof. Blake would consider his succession in the northern area more satisfactory. If so, I do not think he will mend matters. He makes the Llanfechell Grit to overlie the schists of Mynydd Mechell; but there is more reason to believe that they are one and the same set of beds in different stages of alteration.

Prof. Blake has disappointed me. I asked for particulars of the fauna by whose aid he correlated the Longmyndian with the Bray Head Series, and he refers me to *Arenicolites didyma!* I supposed I must have overlooked some important palæontological discovery; but no, our familiar little friend turns up in immortal bloom! I respect *Arenicolites* for its antiquity, but as a time indicator it is worthless.

The "Malvernian" rocks, which I said were included by Prof. Blake in his "Middle Monian," are called by him "the granites and altered rocks of Primrose Hill." I do not think any one who knows the region disputes that these masses are approximately of Malvernian age.

Prof. Blake dwells upon the consequences of my acceptance of the igneous origin of the hornblende schists. I stated those consequences unreservedly in my "Notes," and I do not feel a bit ashamed that I worked on the accepted principles of our science, and was not able to penetrate the "dim and distant future." My descriptions of the older Archæan rocks and their distribution are not materially affected by the theory of mechanical metamorphism; but we must of course cease to construct time-series out of them. Alas! how many a stately time-edifice goes down before the blows of those gods of the hammer, Lehmann and Lapworth! CH. CALLAWAY.

THE SERPENTINE OF THE LIZARD.

SIR,—Would you kindly allow me to reply to the letter of Prof. Bonney in your January issue on the above subject regarding my alleged "two slight errors."

1. I think the Professor's mind has very naturally (perhaps without reference to the map) reverted to the south end of the Pentreath Beach, where the hornblende schist occurs in conjunction with the serpentine, which he has so ably and minutely described; but the dyke in question is at the north, or Kynance end, near a large exposure of banded gneissic rocks forming the foreshore of Holestrow, similar to what occurs in many other localities described by the Professor as "granulitic," as at Caerleon and Kennack, at the west end of which latter Cove the dykes cutting the serpentine are seen to coalesce with the "granulitic" rocks forming the foreshore.

2. For my own part I know of no "granulitic group" in the whole area with igneous rocks involved or included in it, but a group of rocks to which the term "granulitic" might be applied, which every evidence seems to point at as having a common igneous origin, although differing widely from each other; neither do I know any separation between these and the hornblende schists save in the extremes of their compositions, both of which are frequently mingled together in the same dykes.

I quite agree and deeply feel with Prof. Bonney the very great difficulties connected with some of these Lizard rocks, such as the explanation of the banded gneissic series which has been so philosophically dealt with by Mr. Teall; and it was for this very reason that I ventured my short communication on the dyke and its lessons, in the hope that it might throw some little additional light on these gneissic and other rocks, which I have always regarded as presenting very much that is problematic. ALEX. SOMERVAIL.

59, FLEET STREET, TORQUAY, *Jan.* 9th, 1889.

MISCELLANEOUS.

ADDENDA.—In the section illustrating Prof. Hughes' paper, GEOL. MAG. Jan. 1889, p. 9, the asterisk indicating the third fossil locality mentioned in the text has been omitted. The spot referred to is immediately under the Bronllwyd Grit, vertically below the Y of that word on the diagram.

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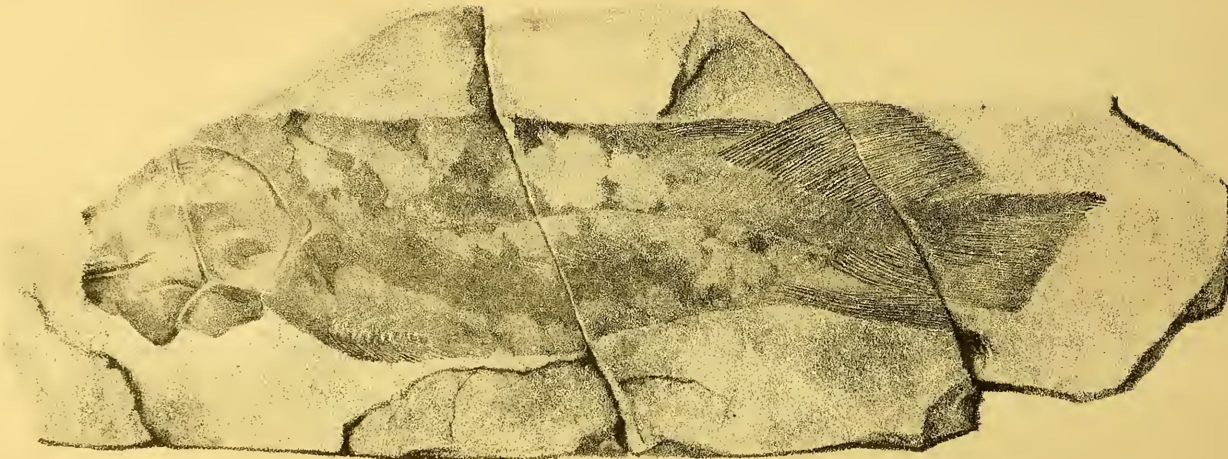

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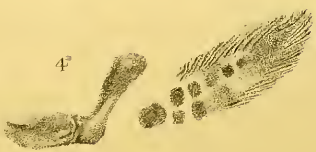

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F. C. Woodward del. et lith.

West, Newman & Co. imp.

Dipterus macropterus, *Traquair.*

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VI.

No. III.—MARCH, 1889.

ORIGINAL ARTICLES.

I.—On a New Species of *Dipterus*.

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

(PLATE II.)

FROM the Old Red Sandstone of Caithness, four species of *Dipterus* were originally named by Sedgwick and Murchison,[1] those being as follows:—

1. *Dipterus brachypygopterus*, anal fin short.
2. *D. macropygopterus*, anal fin long.
3. *D. Valenciennesii*, small in size, narrow in shape.
4. *D. macrolepidotus*, not characterized although figured.

It is evident from the figures of "*D. macrolepidotus*" that it does not belong to the same genus, even to the same family, as the other forms. Those have circular scales, whereas in "*macrolepidotus*," the scales are rhombic, and the head bones are clearly seen to be very different from those of *Dipterus*.

Nevertheless all the four "species" were reunited by Agassiz[2] into one, for which the name "*macrolepidotus*" was adopted, in the belief that the rhombic scales of that form were normal for the genus, and that their circular appearance in the others was due to wearing.

McCoy, however, correctly recognized the circular contour of the scales in the true *Dipteri*, and rightly refused to recognize "*macrolepidotus*" as the type of the genus, or as a *Dipterus* at all, and in fact proposed to transfer it to *Diplopterus*.[3] The other species proposed by Sedgwick and Murchison he restored to independence.

In his "Footprints of the Creator," Hugh Miller showed that Agassiz's *Polyphractus platycephalus* was the head of a *Dipterus*,[4] and not a Placoderm, but he did not seek to identify it with any previously described species.

Pander[5] of course confirmed McCoy's statement that *D. macrolepidotus*, of Sedgwick and Murchison, was not a *Dipterus* at all, but he reverts to Agassiz's idea as regards the three other reputed species. He united them again into one, for which he preferred the name

[1] Trans. Geol. Soc. 2nd ser. vol. iii. p. 143, tab. 15–17, 1829.
[2] Recherches Poissons Foss. Tome i. 1835–43, p. 115.
[3] Brit. Pal. Foss. Fasc. iii. 1855, pp. 590–592. I have made "*macrolepidotus*" the type of my new genus *Thursius*, Geol. Mag. November, 1888.
[4] 1861 Edition, p. 57.
[5] Pander (Dr. C. H.) u. d. Ctenodipterinen d. Devonischen Syst. 1858, St. Petersburg, pp. 1-32.

Valenciennesii, in order that the honour which the proposers of that name wished to confer on the distinguished French ichthyologist might not thereby be lost. As he also constantly uses the name *D.* "*platycephalus*," it would appear that he considered these large crania also to constitute a distinct species.

After a careful examination of a very large number of specimens, including Sedgwick and Murchison's original types, in the Museum of the Geological Society, I have come to the same conclusion as Pander, namely, that the species, *brachypygopterus*, *macropygopterus*, and *Valenciennesii* are one. In the original type-specimens the apparent difference in the size of the anal fin in the first two reputed species is certainly due to the mode in which the specimens have been crushed, and as to *Valenciennesii*, I can only recognize in it a young example of the same common species. In the same way the adult condition of this species is to my mind represented by the large heads which have been called "*platycephalus*."

If we follow, with absolute strictness, the rules of the British Association in adopting the *first* of the specific names given by Sedgwick and Murchison, then we shall be compelled to use the very inappropriate one of "*brachypygopterus*," as well as to deprive the name of Valenciennes of the homage which the discoverers of those fishes wished to offer to it. I hope, therefore, that the scientific world will grant an indulgence to Pander's view, and allow the name *Dipterus Valenciennesii* to stand for the species in question.

D. Valenciennesii is very characteristic of the Lower Old Red Sandstone of Banniskirk and Thurso, but it occurs also in the fish beds of the shores of the Moray Firth, as at Cromarty (Hugh Miller Collection); Lethen (Museum of Science and Art); Nairnside near Inverness (Wallace); Tynet (Collection of Rev. Mr. Kyle at Presholm, Banffshire).

Another and very distinct species occurs, however, at John O'Groats, where it was discovered by the late Mr. C. W. Peach in the same beds which yielded *Tristichopterus alatus*, Eg., and *Microbrachius Dickii* (Peach). It is mentioned in Dr. A. Geikie's list of Old Red Fishes,[1] and has been very briefly characterized by myself in a recent number of the Geological Magazine, where I proposed for it the name of *Dipterus macropterus*.[2] In the present communication I propose to give a somewhat more detailed description of this interesting form, accompanied by the figures on Plate II.

Ordinarily at least this species does not seem to have attained any great dimensions, as the specimens in the Edinburgh Museum average about six inches in length. In general form (Fig. 1) it resembles *D. Valenciennesii*, and the osteology of the head appears to be similar, though I have not found the ctenodont plates preserved in any instance. In Fig. 2 the outlines of the plates of the posterior part of the cranial buckler are given, from which it appears that they are rather shorter and broader than the corresponding plates in *D. Valenciennesii*, and there is an absence of the small plate which in

[1] Trans. Royal Soc. Edin. vol. xxviii. p. 452..
[2] Geol. Mag. for November, 1888.

that species is intercalated at the inner angles of the four plates in front of the median occipital. Fig. 3 represents the broad rounded operculum. The scales seem to be very thin, so much so that the internal skeleton is often seen through them, the axis being notochordal, and well-developed ribs being present. The leading feature of the species is seen in the form of the second dorsal fin, which has its base proportionally nearly twice as long as in *D. Valenciennesii*, while the shape of the fin, instead of being triangular-acuminate, is broad and oblong-rounded, the posterior rays being nearly as long as the anterior ones. Both pectoral and ventral fins are as in *D. Valenciennesii* "archipterygian" in their conformation, the pectoral being represented in Fig. 4. The first dorsal and the anal are narrow-lanceolate, the heterocercal caudal is triangular, and not bifurcated.

EXPLANATION OF PLATE II.

Fig. 1. *Dipterus macropterus*, Traquair, natural size. From the Lower Old Red Sandstone, John O'Groats, Caithness.
Fig. 2. Outline of posterior cranial plates, from another specimen.
Fig. 3. Operculum.
Fig. 4. Pectoral fin and shoulder girdle.

II.—Restoration of *Brontops robustus*, from the Miocene of America.[1]

By Professor O. C. Marsh, Ph.D., LL.D., F.G.S.

(PLATE IV.)

THE largest mammals of the American Miocene were the huge *Brontotheridæ*, which lived in great numbers on the eastern flanks of the Rocky Mountains, and were entombed in the fresh-water lakes of that region. They were larger than the *Dinocerata* of the Eocene, and nearly equalled in size the existing Elephant. They constitute a distinct family of Perissodactyles, and were more nearly allied to the Rhinoceros than to any other living forms.

The deposits in which their remains are found have been called by the author the Brontotherium beds. They form a well-marked horizon at the base of the Miocene. These deposits are several hundred feet in thickness, and may be separated into different subdivisions, each marked by distinct genera or species of these gigantic mammals.

The author has made extensive explorations of these Miocene lake-basins, and has secured the remains of several hundred individuals of the *Brontotheridæ*, which will be fully described in a monograph, now well advanced towards completion, to be published by the United States Geological Survey. The atlas of sixty lithographic plates is already printed, and the author submitted a copy to the Section. The last plate of this volume is devoted to a restoration of *Brontops robustus*, one-seventh natural size, and a diagram enlarged from this plate to natural size was also exhibited.[2]

[1] Abstract of a paper read before Section D of the British Association for the Advancement of Science, at the Bath meeting, Sept. 7th, 1888.

[2] The present Plate (IV.), one twenty-fourth natural size, shows a reduced copy of the same restoration.

The skeleton represented in this restoration is by far the most complete of any of the group yet discovered. It was found by the author in Dakota, in 1874, and portions of it have been exhumed at different times since, some of the feet bones having been recovered during the past year. It is a typical example of the family, and shows well the characteristic features of the genus and species which it represents.

The most striking feature of the restoration here given, aside from the great size of the animal, is the skull. This is surmounted in front by a pair of massive prominences, or horn-cores, which are situated mainly on the frontal bones. The nasals contribute somewhat to their base, in front, and the maxillaries support the outer face. These elevations, or horn-cores, vary much in size and shape in the different genera and species. They are always very small in the females.

The general form of the skull and lower jaw is well shown in the figure. The prominent occipital crest, the widely-expanded zygomatic arches, and the projecting angle of the lower jaw, are all characteristic features. In general shape, the skull resembles that of *Brontotherium*, but may be readily distinguished from it by the dental formula, which is as follows:—

Incisors $\frac{2}{1}$; canines $\frac{1}{1}$; premolars $\frac{4}{4}$; molars $\frac{3}{3}$.

The presence of four premolars in each ramus of the lower jaw is a distinctive feature in this genus. This character, with the single, well-developed lower incisor, marks both the known species.

The number of teeth varies in the different genera. The form of the teeth, especially in the molar series, is more like that in *Chalicotherium* and *Diplacodon* than in any other known forms. The teeth in the allied genus *Brontotherium* have already been figured and described by the author.

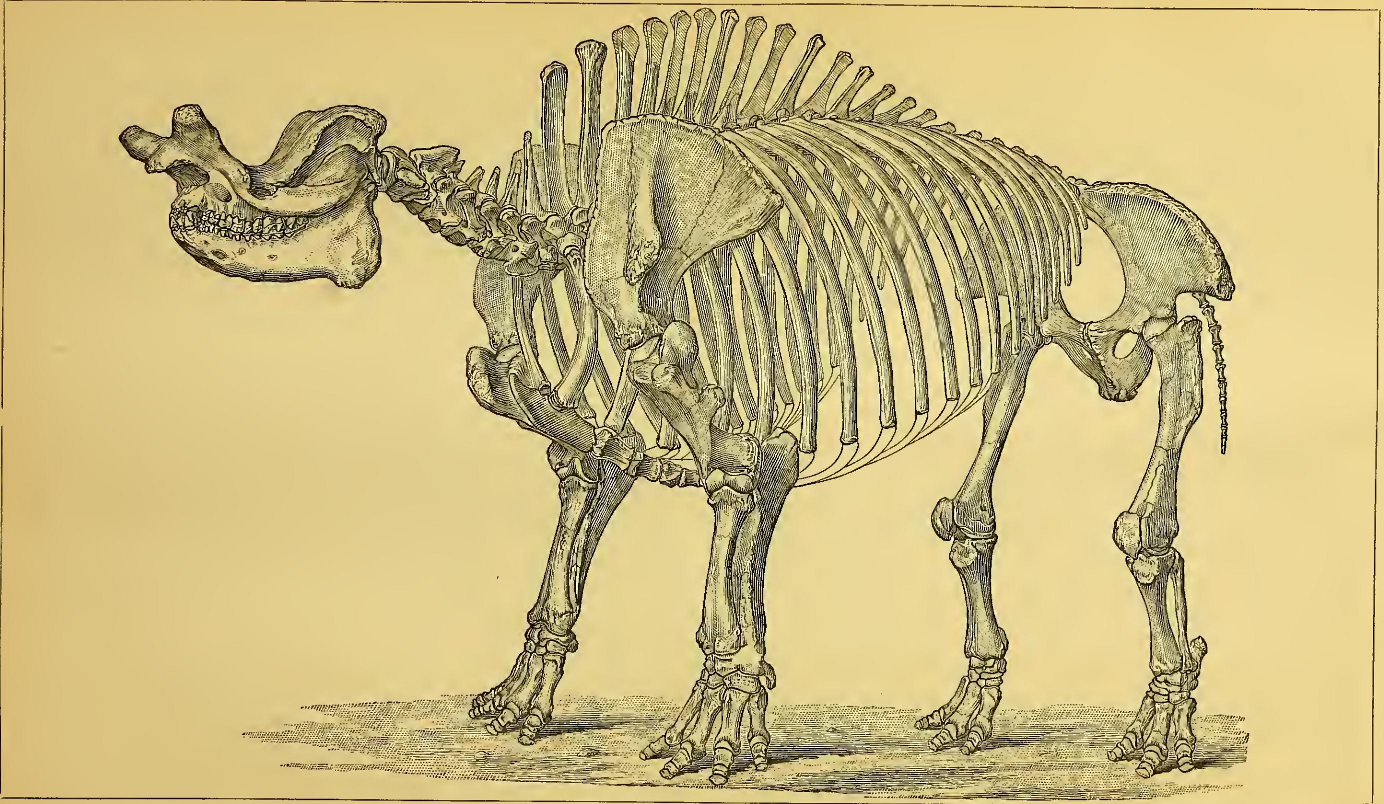
The vertebræ are somewhat similar to those of the existing Rhinoceros. In the present genus, *Brontops*, the neural spines of the dorsal vertebræ are elevated and massive. There are four sacral vertebræ in this genus, and in the known species the tail is short and slender, as in the individual here described.

The ribs are strong and massive. The sternal bones are compressed transversely. The exact form of the first one is not known with certainty, and is here restored from the Rhinoceros. This is the only important point left undetermined in the restoration.

The fore limbs are especially robust. The humerus has its tuberosities and ridges very strongly developed, and the radius and ulna have their axes nearly parallel. There are four well-developed digits in the manus, the first being entirely wanting.

The pelvis is very wide and transversely expanded, as in the Elephant. The femur is long, and has the third trochanter rudimentary. The tibia and fibula are quite short. The calcaneum is very long, and the astragalus is grooved above. There are only three digits in the pes, the first and fifth having entirely disappeared.

Diplacodon of the Upper Eocene is clearly an immediate ancestor of the *Brontotheridæ*, while *Palæosyops* and *Limnohyus* of the Middle



Skeleton of BRONTOPS ROBUSTUS, *restored by Prof. O. C. Marsh, from the Miocene of Dakota, North America.*

One twenty-fourth natural size.

Eocene are on the more remote ancestral line. The nearest related European form is the Miocene *Chalicotherium.* No descendants of the *Brontotheridæ* are known.

Menodus, Megacerops, Brontotherium, Symborodon, Menops, Titanops, and *Allops,* all belong to the family *Brontotheridæ,* and their relation to the genus here described, and to each other, will be fully discussed in the monograph, to which reference has already been made.

III.—Notes on Altered Igneous Rocks of Tintagel, North Cornwall.

By W. Maynard Hutchings, Esq.

(*Continued from page* 59.)

COMING along the cliffs from Boscastle towards Tintagel, at the part just seawards of the village of Trevalga, and between the outlying rocks known as "Short Island" and "Long Island," we see one or two limited outcrops of a schistose rock different from the surrounding slates, shales, etc. A thoroughly good sight of it is not, however, obtained till we reach the extreme north side of Bossiney Cove, a little way south of Long Island, when a very fine exposure of the sheet in question is observed, lying in among the sedimentary rocks, sharply marked off from them at contact, so that the junction-lines can be seen distinctly even from some distance.

It dips seawards in the cliff, and a very little way inland it rises to the surface and ends abruptly in an escarpment facing towards Trevalga. To the north, towards Boscastle, the sheet disappears and passes away under the quarries in the cliffs opposite the Growar rock. Going southwards it is not seen anywhere in the cliffs at the back of Bossiney Cove, which has been eroded through it; but at the south side of the Cove a section of it is again seen, similar to the one at the north side, the corresponding inland escarpment, on a larger scale, facing towards the village of Bossiney. The distance across the Cove in a straight line is nearly exactly a mile.

Passing through the neck of land which separates Bossiney Cove from the little cove next following it, the sheet is again exposed along the shore, here dipping steeply into the sea. The configuration of the land does not here lead to the formation of a prominent escarpment looking inland, but a small outcrop is seen here and there towards the village of Trevena (or Tintagel as it is called).

The sheet now disappears;—the mass of sedimentary rocks in which are the slate-quarries on the church glebe, curving seawards, covers it up in the cliffs, and there is no valley or broken ground to cause an exposure of it inland. It is thus hidden for a distance of rather over a mile and a quarter. Supposing it to be continuous, it is again seen at the north end of Trebarwith Strand, where it rises from beneath the slate-quarries and continues along in one uninterrupted exposure in the cliffs right away to the south end, a distance of three quarters of a mile. That what is seen at Trebarwith is really a direct continuation of what is seen at Bossiney Cove seems very little open to question. The direction of strike, position with regard to the slates, mode of occurrence, thickness and general structure and composition, all appear to affirm it. In the Trebarwith cliffs it is again dipping steeply towards the sea. The upper few yards of it only are seen, the deeper portions underlying the beach. For a great part of the distance, and indeed wherever the rocks have not been disturbed by falls of cliff and landslips, the contact with the overlying sedimentary rocks is very sharply defined.

At the south end of the Strand the sheet disappears under the sedimentary rocks of Dennys Point, and so far as I am aware, it does not show again in the cliffs going southwards; certainly not for some three miles or so examined by me wherever accessible. Whether or not it has any connection with the igneous rocks near Port Isaac I do not know.

Near the south end of the Strand a valley, with a road, comes down to the shore. A little way up this road good sections of the entire thickness of the sheet are obtained, near the little village of Trenow and on the opposite side of the valley. It here again forms escarpments in which its upper and lower contacts with shales are sharply defined, and is again cut off abruptly as at Bossiney.

We can thus trace this sheet of rock, from north to south, for $3\frac{1}{2}$ miles. Its thickness may, on a rough average, vary from 70 to 100 feet. It doubtless originally continued some distance inland. De la Beche speaks of some parts of it (the northern) as connected with rocks several miles away, so that it evidently formed part of a very considerable igneous mass, which was older than any of the rocks already noticed.

Considered petrologically this occurrence is very interesting. Macroscopically, the chief observable components are green chloritic minerals and calcite. At some points micas more or less replace the chlorite. Pyrites and magnetite are seen in varying amounts, and at some parts epidote crystals in plenty may be noticed with the naked eye. Foliation is highly developed throughout, always coinciding with the cleavage of the slates and shales above and below. The texture of this foliation varies in every degree, from a fissility almost equal to that of a slate to a series of bands or layers of considerable thickness.

Both texture and mineralogical composition vary so much at different points that it would be equally useless either to attempt to give one description that should apply to the whole of the sheet, or to give detailed accounts of all of the series of sections I have examined from different parts. A better general idea will be conveyed by picking out and describing a few of the most strikingly characteristic examples.

At several places the rock is seen to be very coarsely laminated, layers of comparatively soft chloritic or micaceous material alternating with others of a hard, compact, non-foliated stony substance. This is seen most strongly exemplified towards the south part of Trebarwith Strand, where the layers of the stony material are as much as $1\frac{1}{2}$ to 2 inches thick in some cases, the softer layers being rather less. A serrated form results from weathering at these parts of the cliffs, the soft layers wasting away and leaving the hard ones projecting.

Where this coarse lamination is most developed it would almost lead one to believe that it represented an original stratification, or bedding, of different materials; but this impression is much weakened by the fact that this coarsest structure can be traced, in a short distance, passing gradually into finer and finer foliation, and finally into rock in which the chloritic and stony materials are so closely interwoven, so to speak, as to be no longer separable by eye or lens.

The material of the hard layers is of a slightly bluish-grey colour. It sometimes contains numerous crystals of magnetite, but beyond this and occasional grains of calcite no separate minerals can be made out with a lens. It effervesces so briskly with acid that this, and its appearance, might easily cause it to be set down as calcite, but its hardness and the fact that fragments do not dissolve, nor even disintegrate, in acid, show that its main component is not calcitic.

Portions of contiguous, very coarse, hard and soft layers were submitted to microscopic examination, and a description of them is interesting, not simply as bearing on this special form of occurrence, but also because, with slight modifications, a more or less intimate mixture of these two materials makes up a great part of the entire sheet of rock.

The material of the hard layers may be best described by saying that grains of calcite, and grains and more or less imperfect crystals of felspar, are set in what may for convenience be called a sort of "ground-mass" of felspar, chlorite, small grains of calcite, muscovite flakes, and quartz, with much iron ore.

The larger bits of felspar are mostly of quite indefinite and rounded outlines, though a few of them show a certain amount of regular shapes. Some of them show well-developed cleavage, but twinning is so rare as to be practically absent. All are quite water-clear, but are more or less full of minute flakes of muscovite.

In the "ground-mass" felspar very much predominates. Its degree of intermixture with the other materials varies, so that at some parts of a slide the whole forms a very fine-grained mosaic, while at others it is much more coarsely compounded. Grains of felspar of ample size to permit of optic tests for its discrimination from quartz are plentifully dispersed throughout. It is all brilliantly water-clear, and no sign is anywhere seen of any definite forms, nor of any twinning. The quartz is wholly secondary, and is rather irregularly dispersed, as single larger grains and as a fine-grained mosaic, either alone or in intermixture with felspar and chlorite. Flakes of muscovite abound throughout the entire mass. Sphene is very plentiful in transparent colourless grains and as rather larger, brownish, less transparent bits; and a good deal of leucoxene is seen in various stages of progress to granular aggregates of sphene. A little rutile is present, mainly in the larger bits of chlorite.

Iron ores are diffused in very great abundance all over the sections. Crystals of magnetite predominate, but there is a great deal of rounded, crushed and quite indefinite form down to almost a powdery condition. Among this, small, ragged, flat, thin, plates may be seen, and some thicker tabular bits, but there is nothing which could safely be set down as ilmenite, unless it be a few extremely thin flakes, faintly translucent, with brown colour, in some of which sagenitic rutile is visible. These appear to be micaceous ilmenite. It may be as well to remark here that throughout all the sections examined from this sheet of rock, magnetite is the only iron ore which can be specified with certainty. Crystals of it are very abundant, and it is seen that though the greater part of it was formed prior to, or during, the foliation of the rock, much has also been formed since. Much, if not nearly all, of the rounded, flattened and totally crushed material is also magnetite; the deformation of crystals under pressure and movement is seen in various stages. Larger plates, with or without leucoxene, which could be classified as ilmenite, are not seen anywhere. Tabular fragments of fair size occur often enough, and leucoxene is present frequently with them; but this, as Mr. Teall points out (British Petrography, p. 167), is not enough to warrant their being set down as ilmenite, because the same result might be equally obtained from titaniferous magnetite in decomposition. The presence in the rock of a noticeable amount of leucoxene, together with the abundance of sphene and rutile, make it probable that ilmenite was originally present in considerable quantity, but is now represented mainly by alteration-products. As bearing on the nature of the original material of this sheet the question as to ilmenite is, of course, of considerable importance, and I have looked carefully for any cases of its definite occurrence.

The corresponding soft layer does not really differ essentially in nature from the hard layer. The chlorite has increased much in quantity and is in larger pieces. Muscovite also is present in larger amount and in larger flakes and crystals, and also in good-sized patches. Calcite is less in quantity, while quartz again is much increased. For the rest, there is the same ground-mass of felspar, chlorite, etc., only that it is not so regularly diffused. There are plenty of large grains of water-clear felspar, and several bits show more or less of twinning. There is a prevalence of very intensely undulous extinctions in the felspars and quartz grains, due to great mechanical stresses. This is more marked here than in any other part of the sheet. The same is true of the minerals of the hard layer, but not in quite so great a degree. The iron ores are very much more in a *crushed* condition here too. A high power shows the diffusion of minute grains and crystals of rutile all through the sections, together with other grains and microlites which are indeterminable.

Microscopic study of these layers, therefore, does not bear out the idea that they are connected with any original bedding of materials of different nature. Much as they now differ in physical condition and general appearance, their constitution is mineralogically the same, and, it is an interesting question as to how this local separation into bands has taken place, and how it is that while the soft layers are highly foliated and split easily into thin pieces, the hard layers have not a trace of such foliation or cleavage.

From the microscopic evidence of great stress in some of the minerals of both layers, it seems safe to conclude that both have been alike subjected to the pressure and movements which caused the foliation of the entire sheet, and that their separation is thus not due to any subsequent causes. And if, as seems reasonable, the passage of these sharply-separated layers into quite close inter-foliation negatives the idea of any prior bedding, it would appear probable that this curious structure was developed concurrently with the ordinary foliation, when the earth-movements took place which have so much affected all the rocks of this district.

As before stated, much of the entire sheet of rock consists of the materials of these layers just described, variously intermixed, together with one or two other minerals. At some parts chlorite and calcite increase almost to the exclusion of felspar, at others felspar again plays a more prominent part. Biotite and muscovite vary from total absence to great predominance, and epidote again, which at some parts is very abundant, disappears entirely at others. Large bits of felspar are the exception, most of it being in smaller grains and fine mosaic, and with one exception, nothing at all approaching to *original* felspar is seen.

Specimens from one point along Trebarwith Strand show the presence of a large amount of actinolitic hornblende. It is very pale green, almost colourless, and very slightly dichroic. It occurs with chlorite, into which much of it is in course of alteration. Felspar is in rather largish bits in these sections. A large amount of epidote is present, of yellow colour and rather strong dichroism. It is all in broken crystals and large, detached, irregular fragments, which frequently, at some distance apart, show their former unity. Sections cut across the schistosity of the rock show very plainly that the movements which caused foliation broke and dragged asunder fine large crystals of epidote, and gave an approximately parallel arrangement to a portion of the fragments. This question as to the age of epidote and other minerals, relatively to the foliation of the rock, will be referred to again. In the present instance there is no doubt that epidote crystals were formed in great plenty *before* the movements took place, and there is no sign of any having been developed since.

Hornblende was not seen in any other sections, but would doubtless prove to be present at other parts of the sheet if more specimens were taken. At a point only a few yards away it had totally disappeared, and epidote was present only in very small amount.

Specimens from both sides of Bossiney Cove are interesting owing to the very large development of mica and of epidote.

Some of the rock from the south side is made up mostly of biotite, with chlorite and numerous large crystals of epidote. Much of the biotite has a greenish tinge, and is at many points more or less altered to chlorite, much of which appears to have originated in this manner. Most of the biotite is in large irregular flakes, which lie with their flat sides parallel to the schistosity and are drawn out with the chlorite into long, slightly curving lines. But there is also a good deal of biotite which is not so arranged, but lies with its flat sides in various directions, mostly vertical or highly inclined to the foliation. It occurs as very numerous individuals with sharp outlines and boundaries of tabular crystals. It is all quite fresh and more transparent than the other form, and as it has so evidently not been in the least degree affected by the rock-movements, it appears to be younger than the irregular flakes, and to have been developed since the foliation took place.

Felspar, some of it twinned, is well represented, and there is quartz as usual. Rutile is very abundant in some parts of sections, as good-sized crystals and grains. The epidote crystals are more numerous and larger than in any other specimens examined. Many may be picked out with a penknife, and their forms examined with a lens, or even with the naked eye; but smaller crystals, not perceptible without the microscope, are also plentiful.

These epidotes lie, by far the greater number, with their long axes parallel to the plane of foliation, lying in various directions in this plane. Hence slides prepared parallel to foliation show hardly any cross-sections of the crystals, while such sections predominate in slides prepared transversely. Dichroism is moderate, varying from colourless to pale yellow. The crystals are mostly very perfect. The usual elongation in the direction of the orthodiagonal is so strongly developed that the length is mostly very great in proportion to the thickness. The forms do not present anything unusual. The ends are in no cases bounded by definite planes. Cross-sections parallel to the clinopinacoid, show mostly six-sided forms bounded by the faces 001, 100, and $\bar{1}01$, but owing to the disappearance in some crystals of the faces 100, there are also many rhombic sections. Twinning is frequent, both as simple binary twins and as others in which several lamellæ are inserted between the two main portions. It is developed not only in the larger crystals, but also in the the smaller microscopic individuals. The occurrence of twinning in small epidotes is stated to be not very frequent.

In the sections of rock now under consideration the epidote has not, as a rule, been very much affected by the shearing which has developed a very high degree of "flow" structure in mica, chlorite, calcite, iron ores, etc. There are many crystals which do not show signs of having suffered any kind of stress or disturbance at all, and which would incline one to believe that they had been formed subsequently to the foliation of the rock. But there are also others which have been broken or bent, some to even an extreme degree, though actual separation of fragments is rare; and a large number of others which have not been so severely affected still show that their internal structure is modified in harmony with the foliation of the other minerals, lines of iron ore continuing their straight or curving courses right through the epidote sections. Also the layers of mica, chlorite, etc., are sharply curved and bent over the angles of the crystals lying in their way. It is clear, therefore, that much of the epidote here was in existence before foliation took place, though there is some of it of which it would not be possible to decide whether it is subsequent to foliation, or whether it is only that some crystals, for some reason, escaped all sign of stress.

Some of the rock from the north side of Bossiney Cove differs from that just described in the fact that it contains a large amount of muscovite, which mineral was absent in the former case. The muscovite here exceeds the biotite in quantity and is, indeed, the main component of the rock. It occurs mainly in small flakes, lying parallel to the plane of foliation, and felted together into compact layers. Sections cut parallel to these layers show many patches in which the muscovite is almost wholly unmixed with other minerals, and which, notwithstanding the presence of many flakes which lie in transverse directions, behave between crossed Nicols as if only one larger individual were present, giving sharp and distinct optic figures in convergent light. In other patches there is more or less intermixture of chlorite, or of biotite-flakes, giving a greenish or yellowish colour and causing blurred and indistinct optic figures. It is in transverse sections that the layers in question are best recognized as being built up of countless muscovite flakes compacted together.

Similar occurrences of muscovite take place at several other points in the sheet, but it was not seen anywhere else in such large amount.

The biotite of this occurrence resembles in all respects that of the one last described, including the apparent formation of a younger lot of it, but the individuals of the latter are fewer, and are larger and less sharply defined. Felspar is absent in this case; quartz is rather plentiful. There is no rutile in crystals of any size, but under high power the entire rock is seen to be full of very minute crystals and grains of it.

Epidote is almost as plentiful here as in the last instance, and its arrangement in the rock is practically the same, but it is not in quite such large crystals.

The sections show that here the epidote has been intensely affected by the rock-movements, not only being broken and dragged asunder, and curved and twisted in all degrees, but being in some cases squeezed into lenticular streaks of crushed material, which is, so far as my observation goes, rare in the case of epidote, and tells of very great stress indeed. So far as these special sections go, there seems no question that *all* the epidote was formed prior to the foliation of the rock.

Lying in among the micaceous and chloritic material at the south side of Bossiney Cove I found an occurrence of rock which deserves special mention, because it differs so very much in many respects from anything else seen in this sheet. It is dark grey in colour, very hard and compact, with quite a splintery fracture. Neither macroscopically, nor microscopically, is there the least sign of any foliation. The part exposed, or at all events seen at any accessible part of the outcrop, was limited to a layer of perhaps a foot and a half in thickness and four to six feet in length, forming a projecting ledge in among the rest of the rock. It made the impression of being part of a thin bed lying more or less parallel with the foliation of the sheet, but it was not possible to make sure whether this was the case, or to get any idea of its extent.

The microscope shows this rock to be made up of much felspar, with a great deal of chlorite, some secondary quartz, a little calcite, a few flakes of biotite, and large amounts of epidote and of granular sphene.

Most of the felspar is water-clear and indefinite, but there are also a good many well-defined columnar forms, of various sizes, showing twinning, binary, and multiple. In the amount of individualized felspar this rock stands out quite distinct from any other specimens from the sheet, as it does also in regard to *quantity* of felspar present.

Many of these felspar crystals are bent and broken and show curved twinning-lines, and a very large proportion of them, as well as of the water-clear bits and the quartz grains show strongly undulous extinctions. The epidote also is much broken up and the ends of many crystals are surrounded by quantities of small crushed fragments. But for the absence of foliation, this rock seems to have undergone quite as much stress as any other part of the sheet. Were it not so, one would be rather inclined to think it might be a later igneous matter intruded into the already altered rocks of the sheet. It appears, however, more likely, in view of the similarity of its alteration-products, both in nature and extent, to those of the other specimens examined from various parts of the sheet, that it is really a part of the same original mass, which has escaped foliation for some reason we cannot explain. Were this foliated like the rest, it would differ only from some other specimens in being more felspathic; and even this difference might very probably disappear, owing to development of mica and other minerals from the felspar, which there is reason to believe would be brought about during the process of foliation.

A thorough study of this interesting sheet of rock would require further attention in the field, and the examination of a much larger series of sections than I have prepared. From what I have adduced above it seems reasonably certain that the entire mass is of igneous origin, but there does not seem to be any basis whatever on which to decide as to whether the original material was a massive rock, consolidated from a molten condition, or whether it was a fragmental deposit of tuff or ash. It seems likely that where such great alterations have taken place as are here shown, all clue to the original nature and condition of the rocks would be equally destroyed in either case.

Whatever was the original nature of the material, we see from the microscopic record that even prior to the great earth-movements of the district it had undergone very complete alteration under the ordinary influence of chemical action, and doubtless much pressure from the masses of sedimentary rocks piled above it. Secondary hornblende had formed and probably mostly passed in its turn into chlorite. Calcite was everywhere abundant and much quartz had been deposited.

Epidote was plentiful at some parts, as was probably also mica of both kinds, though it is most likely that much of the muscovite now seen was formed at the time when the great crushing and shearing took place. The same may be said of the sphene which is so plentiful in nearly all the sections, and which probably originated from leucoxene during the same period, together with much rutile. The great pressure and movement of the mass, we may suppose, also caused the re-generation of the decayed original felspars and the formation of the water-clear material which now plays so large a part in these schists.

It can be seen that since the foliation took place some chlorite and quartz, and very large amounts of calcite have been deposited. This later calcite may easily be distinguished in all the sections, and penetrates the rocks through and through, filling up also all the joints and cracks. At some outcrops it has increased so much in amount that it makes up most of the rock, as in the sides of the valley opposite Trenow.

IV.—On the Occurrence of a Variety of Picrite (Scyelite) in Sark.

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

LAST summer I had the pleasure of passing a fortnight in the Channel Islands under the guidance of my friend the Rev. E. Hill, who has done so much to elucidate their geology. During our short visit to Sark we spent some hours in the beautiful little cove called Port du Moulin, examining the interesting sections of the hornblende-schist and underlying gneissic rocks. I was wandering on the beach looking at the wave-worn boulders which afford most interesting studies of the structure of this crystalline series, when my eye was attracted by one which differed much from the rest, and resembled a dark-coloured serpentine of a slightly exceptional character. With some difficulty, owing to its form, I detached a tolerable specimen, and on examining the fresher surface, felt convinced that I had found a rock composed chiefly of an altered olivine and a silvery talc-like mineral. At the time it recalled to my memory in some respects the scyelite described by Prof. Judd, though it did not exhibit the conspicuous porphyritic structure of that rock. The conjecture proves on microscopic examination to be accurate, and I subjoin a short description.

Macroscopically the rock exhibits a compact invisible-green or nearly black ground-mass, interrupted by specks and larger grains of a pale-grey mineral with a rather silky or silvery lustre; the grains being interrupted by black spots as is common with bastite. The water-worn surface shows an irregular mottling of black and grey. On using a lens the latter part suggests the presence of two minerals, one having a more fibrous structure and silky lustre; the other a more lamellar structure and more silvery lustre. Some small flakes of a brownish mica can be distinguished, and one or two grains of fair size are distinctly green in colour, resembling penninite. The specific gravity of the rock is 2·88.[1] Examined with the microscope the rock is seen to be composed mainly of the following minerals:—

1. Olivine, in process of conversion into serpentine. The grains, in diameter from about ·07″ downwards, exhibit the characteristic network structure produced by 'strings' of serpentine, often blackened, as usual, with opacite, but give brilliant chromatic polarization in the interstices occupied by the unaltered olivine.

2. A pyroxenic mineral, often in larger grains, most of which is either colourless or of a very pale greenish-grey tint. Evidently more than one variety or species is present. Occasionally the cleavage of a hornblende may be recognized; but much, especially of the greener variety, has an acicular habit, though the needles lie parallel; thus, though sections be taken at right angles, the characteristic cleavage of hornblende is much more rarely seen than one would expect. These acicular or possibly platy groups often have their divisional planes spotted with opacite and are traversed by thin strings of serpentine. They extinguish simultaneously and usually at angles below 20°, but occasionally range up to 24°. Moreover, here and there grains occur with augite cleavage or augite extinction, colourless or a very light brown, some of which, with crossing Nicols, have a curious pallid 'moribund' aspect. These are commonly surrounded by a felted mass of a fibrous mineral, which gives brilliant tints with the polarizing apparatus. It occurs elsewhere in the slide, and sometimes almost resembles a ground-mass. I regard it as a form of actinolite. On the whole I believe that the original mineral of the rock was augite, perhaps a little variable in composition, and that, as has often been noted in picrites, we now find it in different stages of alteration into varieties of hornblende.

3. A mica-like mineral. Some of this exhibits a distinct though rather weak dichroism, changing from colourless with vibrations perpendicular to the basal plane to pale brown with vibrations parallel with it. Occasionally there is a slight 'edging' of pale dull green. This mineral, when rotated from the positions of extinction (parallel with the cleavage planes), exhibits rather brilliant colours, and the peculiar mottled or 'shot' look so common in a mica. The remainder (and greater part) of the mineral is perfectly clear and colourless, and between the crossed Nicols only varies from black to a dull pallid grey or white. Rods or plates of opacite are frequently present between the cleavage planes. I have no doubt that the former is a magnesia-biotite, probably similar to that described by Prof. Judd[2] in the scyelite of Caithness, and the latter represents an alteration product of the same. I find a rather similar mineral in some of my slides of chlorite schists, and Prof. Judd's analysis does not differ much from that of a penninite, where the percentage of magnesia is rather low. Certainly a rather large plate in one of my hand-specimens much resembles that mineral. There are also

[1] Kindly determined for me by Mr. J. H. Holland in Prof. Judd's laboratory.
[2] Quart. Journ. Geol. Soc., 1885, vol. xli. pp. 401–407.

occasional elongated enclosures, shuttle-shaped in section, like those of calcite figured by Prof. Zirkel.[1] These often appear to be composed of a fibrous or lamellar mineral rather similar to the microlithic actinolite already mentioned. The larger grains of the mica inclose small grains of olivine, and grains or crystals of this hornblendic mineral. In some cases needles of actinolite, in length up to about ·04″, pierce it obliquely, like pins, making an angle of about 35° with the cleavage planes. The penetrating power of acicular hornblende has often been noticed,[2] so I regard these as probably secondary. In other cases they lie, as above described, between the cleavage planes.

4. Grains of iron oxide (in addition to much scattered opacite and small interstitial plates or rods, especially in the mica). These are no doubt original constituents, but I think that from their peculiar outline they have in some cases received secondary augmentation. Most of these grains are perfectly black and opaque, but occasionally a deep brown tint is just discernible at the edges, and two grains are in parts fairly translucent and of a distinct dull green colour. Hence it is probable that the mineral is chromiferous, and varies from magnetite or chromite to picotite.[3]

One would not be surprised to find some variety of rhombic pyroxene in the rock, but I have failed to identify it, and am disposed to refer all the cleared and colourless mineral to mica, rather than to bastite or bronzite. But this group of rocks is so variable that another investigator may find something which I have not noticed.

Some of the grains, I may observe, which I take for altered mica or a chlorite, exhibit a remarkable twin structure—singularly like the lamellar twinning of plagioclase—one set of bands extinguishing parallel or nearly parallel with the cleavage planes, the other at an angle with it which in one case is actually 18°, though generally it is less than 10°. Beyond this it has no resemblance whatever to a felspar. It might possibly be an enstatite, but I think the reference to the mica is more probably correct. I have seen similar twinning, mimicking both the 'albite' and 'pericline' types in an undoubted altered pyroxenic mineral—probably enstatite—in a serpentine from Carn Sparnack (Lizard), and in other cases.[4] Probably we shall not be wrong in adopting Prof. Judd's explanation, and referring the structure to molecular strains, which might well be set up in the changes which this mass has undergone.

It is evident from the microscopic examination that this rock is very closely allied to the scyelite (altered mica-hornblende picrite) described by Prof. Judd.[5] The published analysis of the latter, as

[1] Microscopic Petrography of 40th Parallel, pl. v. fig. 1.

[2] Quart. Journ. Geol. Soc. vol. xxxiii. pp. 910, 913; Teall, British Petrography, p. 162.

[3] Wadsworth, Lithological Studies, p. 170, etc.

[4] One of my slides from the Rill (Lizard) is full of small crystals of a mineral which I formerly took to be enstatite (altered), but I now see has a very close resemblance to the bleached mica.

[5] *Loc. cit.* pp. 402, 405.

well as the microscopic study, show that the principal minerals occur approximately as follows: Hornblende, 58·5; altered olivine, 22·0; altered mica, 18·5 per cent. I think that the proportions in the Sark rock are not very different. Hence it is the result of the alteration of a picrite (using the word in the sense in which I have been accustomed to employ it), rather than of a normal peridotite, viz. of a group transitional between the latter and the dolerites.[1]

So far as we could see this rock does not occur *in sitû* in the cliffs at Port du Moulin, but during both our visits there was a rising tide, and we were not able to reach nearly to low-water mark. Moreover, we found so much of interest in the hornblende-schist and its associates, that we had no time to search thoroughly the craggy slopes above. I have, however, little doubt that the rock occurs *in sitû* at no great distance. The boulder—more than half a cubic yard in solid contents—is far too large to have been brought as ballast,[2] for it could only have been shipped by means of a crane, and nothing larger than a fishing boat (except in case of a wreck) would be likely to touch at Port du Moulin. Besides, I do not know of any seaport at which such a rock occurs.

Since our visit, Mr. Hill has called my attention to the following passage in Ansted's Geology of the Channel Islands (p. 264): "An important vein of serpentine and steatite, with asbestos and talc, has been traced crossing the central part (of Sark) near Port du Moulin." This vein, Mr. Hill tells me, he did not find when engaged in the work for his paper on Sark; and as the term 'serpentine' was often used rather vaguely at the time when Ansted wrote, he did not attach much importance to it, and the matter had even escaped his memory at the time of our visit. The coast of Sark is very precipitous, and if the dyke is not well exposed, it might easily be missed, even by so careful a worker as my friend. It would now seem probable that Ansted was substantially right in his identification, and that the rock which I have described comes from his 'vein.'

As there is no probability of my returning to Sark for years, if ever, I publish this note in the hope that some one will trace this interesting rock to its home. No doubt it will occur as a dyke, and there is a special interest in finding it here, because the hornblende-schist of Sark is lithologically identical with much of that from the Lizard peninsula, where varieties of serpentine are also intrusive in the crystalline series.

I may add that, after my return to England, Mr. Hill found a picrite in Alderney, though it is nearer to the olivine-dolerites than that which forms the subject of the present note; this will be described in a paper which he is preparing on the geology of that island.

[1] It is, I think, inconvenient to apply the term picrite both to these rocks and to members of the peridotite group, composed of olivine and augite, where the former mineral dominates, and the percentage of magnesia nearly equals that of silica; for the latter (probably rarer) form a new name might be coined, if augite-peridotite will not suffice.

[2] Afterwards I noticed two or three others of smaller size.

V.—On the Recent Discovery of the Remains of the Mammoth in the Valley of the Darent.

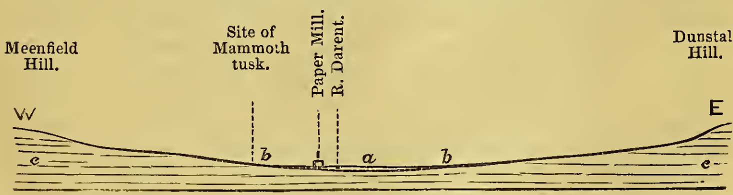
By Prof. J. Prestwich, M.A., F.R.S., V.P.G.S., etc.

ABUNDANT as the remains of the Mammoth and its associated group of Pleistocene Mammalia are in the adjacent valleys of the Medway and the Cray, none have been yet recorded in the valley of the Darent, to which the Mammoth no doubt commonly resorted at the same time. One reason may be that this valley is very bare of Drift, and between Dartford and Otford there is not a single pit in the little drift-gravel that is met with.

Shallow and narrow sections, 3 to 8 feet deep, were, however, opened out in the drift beds last summer for the purpose of the new drainage works for the village of Shoreham. The drift was there found to consist mostly of light-coloured loam, sand and chalk debris, full generally of angular and unworn flints. No organic remains were found in passing through the village, but at its north-west corner, in carrying a trench from the main road down to and under the river, the workmen came, at the depth of $3\frac{1}{2}$ feet, upon the tusk of a Mammoth, about 6 feet long, lying in a bed of sand and gravel. It was in an extremely friable condition, and fell to pieces in getting it out. A piece only one foot long reached me.

I found the usual loam, chalk and flint rubble here replaced by a bed of sharp sand and subangular gravel, no doubt of fluviatile origin. I succeeded, by washing some of the materials, in obtaining a few fragments of shells, which I would refer with some doubt to *Pisidium*, *Planorbis* and *Helix*, but they were extremely scarce and friable, and I could not obtain a single entire specimen. The gravel consisted of subangular flints, pebbles of chalk, subangular fragments of chert and ragstone from the Lower Greensand of Sevenoaks, and Tertiary flint pebbles, showing the flow of the river to have been then as now from south to north.

Section across the Valley of the Darent by the Paper-Mill at Shoreham:—Distance about 1 Mile.



a. Alluvium. *b.* Old River-drift. *c.* Chalk.

The height of the spot where the remains were found is 30 feet above the present stream, or 202 feet above Ordnance datum. The earlier works for the main drainage had already shown that the Alluvial beds of clay in the valley were from eight to ten feet thick, with an underlying bed of gravel and chalk rubble five to six feet thick. Therefore the old river at that Quaternary time must have flowed on a bed some 30 to 40 feet higher than at its last stages.

Above the village the chalk slopes are entirely bare and without traces of a higher-level river-drift. The foregoing woodcut gives a section of the valley at this spot (see p. 113).

No other remains were found here, but at Eynsford, three miles lower down the valley, the foreman informed me that they had found, at about the same depth, but only 20 feet above the river, the entire tooth of a Mammoth. At Green Street Green in the adjacent valley of the Cray remains of the Mammoth, together with those of the Woolly Rhinoceros, Musk Ox, Horse, Ox and Deer, etc., have been met with, and in the associated beds of loam I have found numbers of the small shells of *Pupa marginata*.

VI.—On a Breccia and an Altered Hornblende-Schist at Housel Cove, Lizard.

By Alexander Somervail, Esq.

The rocks forming Housel Bay consist of the normal dark hornblende-schists with the exception of those out of which the charming little Cove bearing the same name has been formed, which holds nearly the central part of the Bay, facing the south-east.

The Cove has three small recesses, an east and a west, and a central one, which receives a small stream flowing into it; the whole, however, a few yards seawards forming one well-defined Cove.

On descending into the Cove one is immediately confronted by rocks presenting a very different aspect from the ordinary hornblende-schists of the adjoining area. A little careful attention on the part of an observer will also lead to the detection of a breccia in the centre of the Cove, close to the stream; the best guide to it being a slickensided surface on which it will be found resting.

The breccia is only a few inches in thickness, and is confined to the under surface of the rock overlying the slickenside. It is composed of numerous broken crystals of a greenish-white felspar, varying in size from mere specks up to others of nearly an inch in length, set in a reddish paste formed out of the rock by crushing. It also contains angular and semi-rounded fragments of its own mass, and what looks like small well-rounded pellets of quartz coloured red by the presence of iron. Besides these there is some extraneous like matter possibly introduced or formed during the process of its being cemented together. Altogether its origin is without doubt due to a thrust, or other movement of the one mass of rock over the other with such force as to shatter and groove their opposing faces.

The rock throughout the entire extent of the Cove (which appears to define its limits) weathers into various shades of yellowish-brown and red, and when broken up with the hammer is seen to have a very near approach to a felsite, which it also resembles in composition, being composed principally of felspar and some quartz almost to the exclusion of the hornblende. It also contains scattered throughout its mass some steatitic or serpentinous mineral of greenish colour arranged in (veins and) small concretionary forms. It is, however, evidently only an altered condition of the hornblende-schist, as it contains large eyes of that rock. It can be studied to much advantage towards the east end of the Cove, where the huge eyes of the hornblende-schist are distinctly seen gradually to pass into the felsitic rock, which in turn passes into the hornblende-schist at either extremity of the Cove, thus precluding the idea of the former rock being intrusive in the latter.

In my short communication[1] to the MAGAZINE for December last, I referred to the various rocks and minerals formed out of a magma cooling under different conditions, or by its mineral constituents separating during the cooling process. In the present instance we note what seems equally referable to subsequent mechanical and chemical change after the rock had passed into a consolidated state, as attested by the breccia and the highly altered condition of the hornblende-schist. This is but one among the many examples of these Lizard schists passing into each other. Such a passage may also be noted between the hornblende, the mica-diorite, the mica-schist, and other varieties. In the field we catch them, as it were, in the very act of alteration into each other, at least we can observe them in all their transition stages, and these from their decidedly squashed appearance, their frequent lenticular, irregular, and other inconstant characters, betray their dynamic and secondary origin. Still it must, I think, be conceded that however much dynamic metamorphism may have altered these Lizard rocks from their original mineral aspects, every such change in the main has been predetermined by some difference in there primary composition.

VII.—ON SOME PHYSICAL CHANGES IN THE EARTH'S CRUST.

(*Part II.*)

By CHARLES RICKETTS, M.D., F.G.S.

(*Continued from* p. 53.)

SUBTERRANEAN landslips differ from landslips occurring in cliffs along the coast, and in escarpments elsewhere, in that, a fissure having been formed and its sides become separated (Figs. 2 and 3 *a*), so that they are without support along the line of division,

Fig. 2.

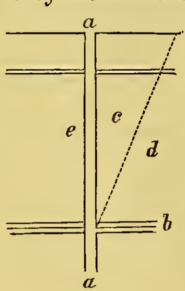
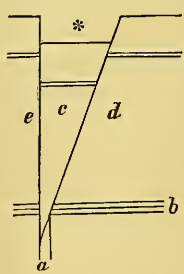


Fig. 3.



it may happen that by the giving way of some soft or unconsolidated stratum (*b*), at any depth, from a few feet only, down to the molten nucleus, wedge-shaped masses (*c*) extending parallel to the fissure

[1] On a Remarkable Dyke in the Serpentine of the Lizard.

would break off (*d*) and slipping down strike against the opposite wall (Fig. 3*e*) and thus fill up the fissure. An immediate effect of the impulse must be the occurrence of an earthquake shock, more or less intense, according to such various conditions as the size and weight of the falling mass, the space through which it falls or slips, the structure of the rocks involved, and other circumstances. If from a subsequent change this enlarged area is placed in a restricted position, the compression thus caused not only affects to a certain extent the dip of the strata, but causes the 'fault-rock' included within the crevice to be compressed into slabs lying parallel to the sides of the fault, forming a coarse but true slaty-cleavage. This cleavage is of very frequent occurrence in the north and south or main faults in the Triassic sandstone of the district around Liverpool.

In the Presidential address to the Liverpool Geological Society for the Session 1872—1873 [1] it was explained that the occurrence of earthquakes (not including some connected with volcanic eruptions) was due to the formation of faults, each of which must register at least one, or probably a succession of earthquake shocks. The examination of strata has as yet discovered no other cause than the formation and settling down of geological faults, capable of producing all the varied phenomena recorded as accompanying earthquakes, including that of the huge sea waves, which not infrequently are one of their most destructive accompaniments, when occurring near the coast; being probably caused by the rushing of water into the trough (Fig. 3*) formed by the depression of the faulted mass, immediately succeeded by the consequent rebound; at all events these waves are not due to the *shock* of the earthquake, for some occurring in the near neighbourhood of the sea, as in that of Essex (1884), and in North America, at Charleston, S. Carolina (1886), were entirely unaccompanied by such disturbances of the water.

The reporter of an excursion along "the line between the Highlands and the Lowlands," made in 1875 by the Geological Class of Edinburgh University, under the guidance of Professor Archibald Geikie, noticed the fact that Comrie, celebrated for its earthquake shocks, lies almost directly over the great fault extending across Scotland, 170 miles in a direct line from Stonehaven to the Isle of Arran. He spoke of this as being "the first attempt to connect the abundance of tremors at that place with the geological structure of the ground underneath." [2] Professor J. Milne, F.R.S., of the Imperial College of Engineering, Tokio, infers "that in Japan faults are still being formed, and that the earthquakes there are to us the announcement of these fractures;" [3] "also that certain earthquakes and faults are closely related phenomena, the former being an immediate effect of the latter." [4] Dr. H. J. Johnston-Lavis, F.G.S., [5] and Mr. G. K. Gilbert, of U.S. Geological Survey, [6] refer the oc-

[1] Proc. Liverpool Geological Society. An abstract of this Essay ("On Fissures, Faults, Contortion and Cleavage," by Charles Ricketts) appeared in the GEOLOGICAL MAGAZINE, Vol. X. 1873, p. 202.

[2] Nature, vol. xii. p. 93. [3] Brit. Assoc. Report, 1881, p. 201.

[4] Earthquakes and other Earth Movements, by John Milne, F.G.S., 1886, p. 279.

[5] Nature, vol. xxiii. 1881, p. 498. [6] Nature, vol. xxix. 1883, p. 45.

currence of earthquakes to the formation of fissures described as "falling" or "slipping"; the blow thus occasioned being felt as an earthquake. Fissures and displacements likewise occur as the *effect* of the shock, in unconsolidated strata or in the banks of rivers; this latter was especially evident in that of Cachar, East Indies, in 1869; but instances have been recorded in which an extent of land has at the time of the shock separated and changed its level under such circumstances as are indicative of the formation of these faults having originated and *caused* the earthquake. Several have been described by Lyell,[1] and also by others.

On two occasions systematic attempts have been unsuccessfully made (by Mr. Robert Mallet after the Neapolitan earthquake of 1857;[2] and by Dr. Oldham with respect to that of Cachar in 1869;[3]) to discover the exact site, the cause of displacements, or the changes which originated the shocks, by tracing back the secondary effects to their source. Though in each case the near neighbourhood whence the shock originated was determined, the exact cause was not discovered.

Contortions of strata, even those of great extent, have very generally been attributed to secular cooling of the earth, consequent on its crust being compressed into a less space as it followed the cooling and therefore sinking nucleus. But if subsidence has occurred from such a cause, how is it that, with an increasing loss of caloric, the areas supposed to have been depressed in this manner have been again raised, it may be to a greater height than that which they previously occupied? Sir Charles Lyell remarked that "the wide extent in North America, and in parts of Russia, of Carboniferous, Devonian, and Silurian strata, which, although upraised above the sea, continue almost as level as when the beds were first thrown down beneath the waters, clearly demonstrates the limitation of the agency, to which great foldings and contortions of stratified rocks have been due, to very confined spaces in each epoch;"[4] but as these localities are to a great extent situated in regions of excessive cold, in some so intense that the ground is frozen to the depth of many hundred feet, it, I think, likewise follows that, if loss of heat can induce flexures, it must be, as in these instances, to a very limited extent.

Mr. T. Mellard Reade, F.G.S., considers "there is a fallacy in the reasoning which attributes the corrugation of the earth's surface to the contraction of the nucleus" and "has arrived at the conviction that the cooling of our earth has not extended to such a depth that we need consider the internal contraction as a geological cause."[5]

The Rev. Osmond Fisher, F.G.S., goes farther; he has calculated

[1] Principles of Geology, vol. ii. chap. xxviii.-xxx.

[2] Report of the Royal Society of London to investigate the great Neapolitan earthquake of 1857.

[3] Memoirs of Geol. Survey of India; vol. xix.; also Quart. Journ. Geol. Soc. vol. xxviii. p. 255.

[4] Quart. Journ. Geol. Soc. vol. vi. p. xlii.

[5] Origin of Mountain Ranges, p. 125.

what would be the effects of contraction of the globe in cooling, upon the supposition of the temperature of solidification being respectively 7000° Fahr. and 4000° Fahr. The result arrived at is, that in the former case the contraction of the radius would be six miles, and in the latter two miles only; that the mean heights of the surface-elevation formed by compression would amount in the one to 19 feet and in the other to only two feet;[1] that is, as I understand him, the mountains caused by this supposed contraction of the earth in cooling might, in one case, be so high as a moderate sized cottage, in the other, as that of a dog-kennel. This being so, well may Mr. Fisher exclaim, "*Nascuntur montes, genuit quos ridiculus mus!;*" which may be translated, "The mountains are born, an insignificant mouse is their mother!" This calculation corroborates what has been previously alluded to as to the comparatively small effect subsidence has in causing lateral pressure or a tendency to cause contortions. Too much, far too much, has been accredited to the effects these movements could produce in causing lateral pressure. Certainly in many instances where there has occurred great disturbance of the strata, by their becoming contorted and folded and dipping various ways, depression to a great extent has also taken place; whereas in others, where it can be proved that there has been at least as great an amount of subsidence, the strata continue as level or nearly so as when first deposited. The difference between the conditions in the different localities is so great, that the contortions cannot be referred to vertical movements common to each.

There are other flexures dependent on minor local causes not necessary to be considered at the present time.

An important step towards determining the causes of foldings in strata must be to ascertain, so far as is possible, at what period they were produced. Where they exist to the greatest extent, especially in deposits formed of fine mud, cleavage has also been frequently developed, and the particles have so changed their relative position that the embedded fragments of rock lie with their longer diameter obliquely to the stratification, and the flatter sides parallel to the direction of the cleavage; included fossils are distorted, the lower portions being often pressed into their substance, whilst the upper have become elongated; indicating that the expansion has been from below upwards. Both contortion and cleavage arise from lateral compression; it is therefore assumed that the same power that has caused the one has at the same time also caused the other. Such changes must have taken place before the original pasty condition of the strata became so consolidated as to prevent, on the application of pressure, movement of the particles of which the mass consists amongst themselves. This might be at any period prior to these clayey rocks becoming solidified by their being raised above the sea level, and the consequent drainage of their contained water, or from other causes. Great power has been exerted in the production of these flexures; but there is no indication of violence; their state

[1] Phil. Mag. Jan. 1888; see also for Nov. 1887.

coincides with a suggestion of Lyell's, that "they have been the result of intense pressure, so moderated as to be just sufficient to overcome the resistance opposed to it; and that this motion has been as insensible as the unfolding of the petals of a flower."[1]

Professor A. Favre of Geneva gives in "La Nature" illustrations of experiments[2] in which layers of plastic clay were laid upon a sheet of caoutchouc, stretched one-third more than its length; on being allowed to resume its normal dimensions, the bands of clay were diminished to that extent, and became greatly contorted. The experiments were conceived for the purpose of illustrating the method of formation of the great inequalities on the earth's surface, such as mountains, etc., by means of lateral thrust or crushing, which are considered by him to be due to the cooling of the earth. They do not appear at all applicable in explaining the cause of eminences and depressions in the contour of the land; they more nearly represent those foldings and contortions of strata which have been universally attributed, since the time of Sir James Hall, to lateral pressure; but it is too much to conceive that from any contraction, whether by loss of heat or otherwise, extensive areas have been compressed into a third less than their original dimensions; as this is a condition of by no means infrequent occurrence in geological formations, the cause of the compression and consequent foldings of strata must be searched for in other directions.

(*To be continued.*)

VIII.—On a Cœluroid Dinosaur from the Wealden.

By R. Lydekker, B.A., F.G.S., etc.

In going through the remains of Chelonia preserved in the British Museum I came across two vertebræ from the Wealden of the Isle of Wight, which had been inadvertently included in that series. These specimens (B.M. No. R. 901) formed part of the collection of the late Rev. Mr. Fox, and clearly indicate a small Dinosaur allied to the genus *Cœlurus*.

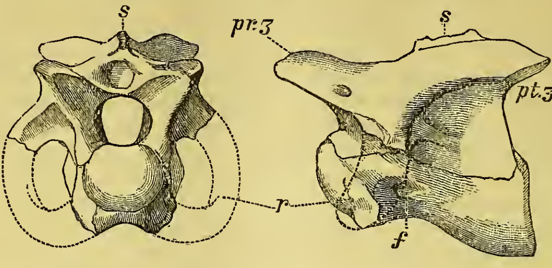
Both specimens belong to the cervical region, and are precisely similar; but whereas one is almost entire, the other has lost nearly the whole of the neural arch. The former specimen is represented of two-thirds the natural size in the accompanying woodcut; from which it will be seen that it is practically entire, with the exception of the loss of the greater part of the ribs (see p. 120).

The chief characters of this specimen may be summarized as follows. The vertebra is considerably elongated, with a markedly opisthocœlous centrum, of which the terminal faces are oblique. The arch is comparatively low, with only a slight ridge to represent the neural spine. The ribs were anchylosed to the arch and centrum, and (from the contour of the basal portion) were evidently much bowed outwards. The sides of the centrum exhibit a pneu-

[1] Quart. Journ. Geol. Soc. vol. vi. p. lxiii.

[2] They are copied in "Nature," vol. xix. December 5, 1878, p. 103. The Rev. Osmond Fisher has reproduced one in "Physics of the Earth's Crust," p. 128, but does not coincide with the deduction Prof. Favre draws from the experiments.

matic foramen, and a fracture across the centrum of the imperfect specimen shows that the inner structure was completely honeycombed. The length of the centrum is 1·74 inches.



Anterior and left lateral aspects of a cervical vertebra of *Calamospondylus Foxi*; from the Wealden of the Isle of Wight, ⅔ nat. size; *prz.* prezygapophysis; *ptz.* postzygapophysis; *r.* rib (restored); *f.* pneumatic foramen; *s.* neural spine.

These features show that the reptile to which these vertebræ belonged was closely allied to the genus *Cœlurus*, Marsh;[1] and it remains to indicate in what manner the two forms differ. Now, in the American *C. fragilis*, and also in *C. Daviesi*[2] of the English Wealden, the cervicals were longer than the present specimen, and while the anterior ones were opisthocœlous, the others were amphicœlous.[3] Again, the vertebræ of *Cœlurus* have the arch placed more forwardly on the centrum, so that the prezygapophyses project more in advance of the terminal ball of the latter; while the free posterior border of the rib is extended backwards to join the postzygapophysis, and thus forms a kind of penthouse over the side of the centrum. This penthouse seems, moreover, to cause a flattening of the lateral and upper surface of the arch, which is quite wanting in the present specimens; while the ridge representing the neural spine is much more elongated antero-posteriorly in *Cœlurus*.

Other minor differences can be seen by comparing the woodcut with the figures given by Prof. Marsh; but the above features are sufficient to indicate that the present form cannot be included in *Cœlurus*, if we use generic terms in the sense in which they have been generally accepted in the Theropoda, but that it clearly indicates a member of the same family.

Now, putting aside the specimen on which the genus *Thecospondylus* was based as being too imperfect to admit at present of any interpretation of its affinity;[4] the only other genus which appears to have been hitherto referred to the *Cœluridæ* is *Tanystrophæus* of the Trias, which Prof. Cope considers to be allied to *Cœlurus*. In the absence of figures of the American forms referred by Prof. Cope to *Tanystrophæus*, an exact comparison cannot be instituted between

[1] Amer. Journ. Sci. ser. 3, vol. xxi. p. 341, pl. x. (1881).
[2] See Lydekker, Cat. Foss. Rept. and Amphib Brit. Mus. pt. i. p. 156 (1888).
[3] In the definition of the *Cœluridæ* on p. 155 of the work last cited, the words in anterior region are omitted before the word opisthocœlous.
[4] Prof. Seeley has proposed to refer *Cœlurus Daviesi* to this genus.

its cervicals and the present specimens; but a marked distinction is evident by the amphicœlous character of the former. There is, however, in the Wealden the genus *Aristosuchus*, which appears to be allied in some respects to *Cœlurus*, and of which the type may be taken to be the sacrum.[1] Now the present specimens are much too large for that sacrum, and therefore clearly indicate a distinct species; while if the dorsal vertebra [2] referred to *Aristosuchus* be rightly associated, we have evidence not only of the generic, but also of the family distinction of the present form from the latter.

Seeing, therefore, that we have evidence of the generic distinction of this form from *Cœlurus* and *Tanystrophæus*, and also of its certain specific and probable generic distinction from *Aristosuchus*, I have ventured provisionally to regard it as the type of a new genus and species under the name of *Calamospondylus Foxi.* This genus being characterized by the opisthocœlous character of such of the cervical vertebræ as are known, and by the much shorter length of these vertebræ as compared with those of *Cœlurus.*

IX.—Note on the Deciduous Septa of *Ascoceras Murchisoni*, Barrande.

By Arthur H. Foord, F.G.S.

An interesting paper has lately been contributed to this Magazine (December, 1888, p. 532), by Dr. Gustav Lindström, of Stockholm, in which he announced his discovery of the earlier, or *Nautilus*-stage, as he termed it, in several specimens of *Ascoceras* from the Silurian of the Island of Gothland. I find, however, in looking over the supplementary volume of the Syst. Sil. du centre de la Bohême,[3] that Dr. Lindström's discovery has been anticipated by M. Barrande, who observed and described two of the normal chambers (*Nautilus*-stage, of Lindström) attached to a specimen of *Ascoceras Murchisoni* from the Silurian strata (Étage E) of Karlstein in Bohemia. I give here a translation of Barrande's description, together with exact copies of the figures accompanying it, and the explanations of the same. A copy of Dr. Lindström's figure is also added for comparison with Barrande's.

"We have always assumed, especially in the original description of the genus *Ascoceras*,[4] that there existed below the body-chamber a series of deciduous air-chambers which became successively detached from the shell by normal truncation. This supposition is confirmed by the specimen which we figure on plate 491. It is quite apparent that fig. 3 on this plate [see p. 122. Fig. 1] represents a specimen which is distinguished from all those before figured upon our plate 95, by the relative length of the septate part which remains attached to the body-chamber. This septate part, when examined,

[1] Lydekker, *op. cit.* p. 158. R. 178. [2] *Ibid.* R. 178, a.
[3] Vol. ii. pt. i. 1877, Supplém. et Série tardive, p. 98, plate ccccxci. figs. 3–7.
[4] *Ascoceras* prototype des Nautilides, Bull. Soc. géol. de France, tome xii. p. 157, 1855.

shows distinctly two air-chambers of very unequal height, and bounded by three superposed septa, in the following order:—

"1. Terminal septum of the body-chamber, as seen in other examples of *Ascoceras*.

"2. Septum placed below the preceding, at a distance of about 7 mm. from the body-chamber. A like distance has never been observed in any other specimen in which two septa could be recognized below the body-chamber.

"3. Terminal septum, situated about 2 mm. below the preceding one, and constituting the abrupt truncation characteristic of the posterior extremity of *Ascoceras*.

"This truncated end is very distinct and has a smooth surface. The edge of the test is seen around its external border, and from

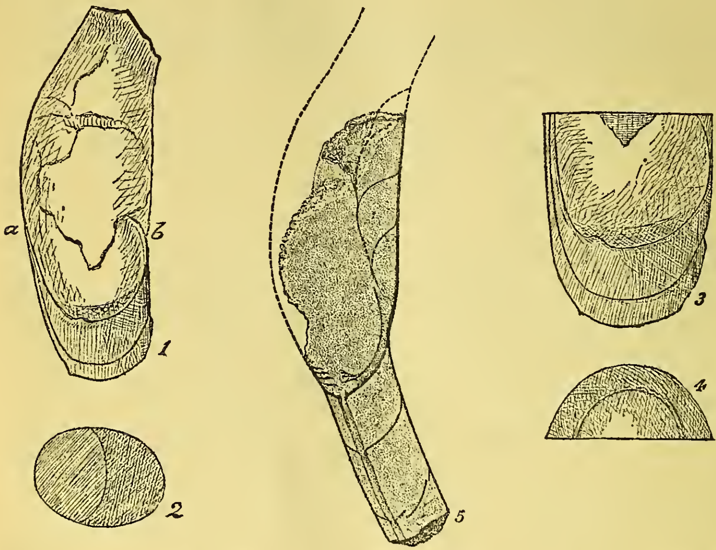


Fig. 1. Lateral view of *Ascoceras Murchisoni*, Barr., showing the body-chamber nearly complete, excepting the margin of the aperture. The lower part presents a longitudinal section, showing three very unequally spaced septa, abruptly truncated below.

Fig. 2. Transverse section of the same specimen, following the line *a—b* (Fig. 1).

Fig. 3. Lower extremity of the same specimen, enlarged twice, to show more clearly the three septa.

Fig. 4. Surface of terminal septum (pan coupé) of the same specimen; bordered by the edge of the test, which is here broken by natural truncation.[1]

Fig. 5. *Ascoceras*, after Lindström.

[1] Fig 7 of Barrande's plate, an enlargement of the ornaments of the test, is omitted, as unnecessary for the present purpose.

this border the test spreads over the external surface of the fossil, and exhibits the ornamentation characteristic of this species, consisting of a net-work of fine striæ.

"The phenomena just described clearly prove that, in *Ascoceras*, as in various genera of Nautiloid shells, the earlier part of the shell was composed of a series of air-chambers, and that these chambers were periodically thrown off by natural truncation.

"Judging by the form of the lower part of the specimen under discussion, it may be presumed that the series of deciduous septa was considerably elongated, and that truncation took place at successive periods.

"The length of the specimen described is 48 mm., and its greatest breadth 18 mm. . . . .

"This very instructive fossil was found at Karlstein, together with numerous examples of the same species, in the limestones of band *e* 2. It may be added that this specimen has been in our possession for many years, but it was not until the spring of 1875 that we decided to have a longitudinal section made at its posterior extremity [see Fig. 1], which resulted in the discovery of three unequally spaced septa."

Although, as we have seen, Barrande was the first to observe and to describe the deciduous septa of *Ascoceras* in Bohemia, Dr. Lindström's recent discovery of similar septa in Swedish specimens is extremely interesting, and warrants us in hoping that by still further research the initial chamber of *Ascoceras* may be brought to light, and thus complete our knowledge of this singular genus.

NOTICES OF MEMOIRS.

I.—Om Lias i Sydöstra Skåne. Af Joh. Chr. Moberg. Kongl. Svenska Vetenskaps-Akademiens Handlingar. Bdt. 22, No. 6. Stockholm, 1888.

On the Lias in South-Eastern Scania. By J. C. Moberg. 4to. 86 pp. with One Map and Three lithographed Plates.

FROM several places in the neighbourhood of Kurremölla in the south-east of Scania, Dr. Moberg discovered in beds of shale and sandstone associated in places with thin beds of coal, a series of fossils differing materially from those occurring in the Liassic strata of other parts of the same province. The forms which mostly belong to lamellibranchiate Mollusca are carefully described and figured in the present memoir. They number in all 64 species, of which 52 are determinable, and 25 new forms. From a comparison of the known forms, the author concludes that the Kurremölla Lias fauna represents the zones of *Ammonites Bucklandi*, *Am. zipihus*, and *Am. Jamesoni*, and that although there is a considerable number of fossils belonging to the Lower Lias, yet the most characteristic forms indicate that it is equivalent to the lowest part of the Middle Lias. It is thus on the same horizon as the Lias of the Island of Bornholm and higher in the series than the Liassic strata of the north-west of Scania. G.J.H.

II.—List of the Fossil Faunas of Sweden. Edited by the Palæontological Department of the Swedish State Museum (Natural History). II. Upper Silurian. Stockholm, 1888, Norstedt and Sons. 8vo. 29 pp.

THIS second part of the List of Swedish fossils, prepared by Prof. G. Lindström, contains the names of the species occurring in the Upper Silurian strata of that country. The principal locality in which rocks of this period are developed is the Isle of Gotland, from which place no fewer than 960 species are recorded, and, according to Prof. Lindström, this number will be considerably increased when all the fossil groups are thoroughly worked out. Of those already studied in detail the Crustacea number 133 species, the Gasteropoda 192 species, the Brachiopoda 150 species, and the Crinoidea 180 species. The Silurian strata in Gotland are ranged under eight divisions, corresponding approximately with the divisions of the same rocks in this country, and the range of each species in the different divisions is carefully noted. Of the other localities in which Silurian rocks occur in Sweden, those in the province of Scania have yielded 75 species, in Dalecarlia 22 species, and in Jemtland 48 species. G. J. H.

III. — Öfversigt af Sveriges Mesozoiska Bildningar. Af Bernhard Lundgren. (Ur Lunds Universitets Årsskrift, Tom. xxiv.), Lund, 1888.

A Review of the Mesozoic Formations of Sweden. By Bernhard Lundgren. (From the Yearbook of the University of Lund.) 4to. 37 pp.

AS is well known, the Mesozoic strata of Sweden are exposed *in situ* only in a very limited tract of the southern part of that country, and they are but very imperfectly represented by two groups of beds; a lower, belonging to the Trias and older beds of the Lias; and an upper, belonging to the newer beds of the Cretaceous system. In the present memoir Prof. Lundgren discusses in detail the distribution, the petrographical characters and the fossil contents of these various beds, as well as their relationship to the corresponding strata in other countries. The lower series of beds are included in (I.) the Kågaröd-group, which is regarded as probably of Keuper age; and (II.), the Coal-bearing beds, of Rhætic and Liassic age. The interval between the Lias and the Upper Chalk is entirely unrepresented, and it is probable that the South of Sweden was a land surface at the time. The Cretaceous beds belong to the Lower and Upper Senonian and the Danian stages. A list of the literature on the subject is appended. G. J. H.

REVIEWS.

I.—Prof. Dr. von Zittel on Palichthyology.

Karl A. von Zittel. Handbuch der Palæontologie. Palæozoologie. Band III. Lief. I. II. (R. Oldenbourg, Munich, 1887–88.)

THE latest two instalments of Prof. von Zittel's valuable "Handbuch" form the first part of the third volume, which is to be devoted entirely to the Vertebrata. The parts consist together of 436 pages, extending as far as the end of the section upon Amphibia; and no less than 333 pages are occupied with the discussion of the Pisces. Woodcuts, as usual, are numerous and excellent; and in the last-named section these are over 300 in number, while many are so novel for a text-book that to glance over the pages is quite refreshing.

The introductory remarks upon the class of Fishes, in which we are somewhat astonished to find *Amphioxus* still included, occupy fifty pages, and form perhaps the most philosophical concise account of the anatomy of the fish-skeleton that has hitherto been published. The scales are first treated in detail, and then other dermal structures, like spines and fin-rays; next follow the teeth; and, lastly, the various parts of the endoskeleton. Full references are given to the principal memoirs; and the description of the anatomy is followed by some brief remarks upon the systematic arrangement of the class.

As remarked by Prof. Cope,[1] the classification adopted is one of the very few remnants of a bygone era of Ichthyology to be noted in the work. Moreover, family-terminations are often used in ordinal-names, and ordinal-terminations in family-names; and whereas, in some cases, the vernacular designation of the families is placed after the scientific name (e.g. *Notidanidæ* Grauhaie), the non-German reader especially is liable to be perplexed in other cases where precisely the same punctuation is employed and an author's name is substituted (e.g. *Scylliolamnidæ* Hasse). However, these are small matters, and when the rich store of information is indexed, the work will be as convenient for reference as it would have been had the principles of the more precise systematists of the present day been strictly followed. The summary is, indeed, so complete to the date of publication that in reviewing the work it seems most profitable to note the bearing of later researches upon the facts and speculations recorded.

Dismissing the unnecessarily introduced "Leptocardii," the Cyclostomi follow for consideration. The only fossil remains said to have been referred to this "sub-class" are the well-known *Conodonts*, and these problematical bodies are regarded as being so doubtfully assignable to the Vertebrata, that they are treated only in a long footnote. Zittel and Rohon's conclusion is adopted, that they are almost certainly annelid jaws.

[1] American Naturalist, 1887, p. 1014.

Selachii.

In the lengthy section upon the Plagiostomi (about 50 pp.), special prominence is given to the important researches of Kölliker and Carl Hasse upon the structure of the vertebral column; and there are several clear diagrams to illustrate the conclusions of the Breslau Professor, who has succeeded in determining, at least generically, the detached fossil vertebræ. The *Cyclospondyli*, *Tectospondyli*, and *Asterospondyli*, of Hasse, are respectively defined, and then follows a brief account of the earliest traces of the Selachian fishes hitherto discovered, in the form of *Onchus*, *Thelodus*, etc.

The systematic description naturally commences with the primitive Notidanidæ, and the long-lived *Notidanus* itself is recorded as the only undoubted member of the family as yet recognized; the diagram illustrating the dentition of the genus, however, is accidentally overturned, the lower jaw being placed uppermost. It may be well also to add that a fossil representative of *Chlamydoselache* is now known from the Pliocene of Italy.[1]

Of the extinct family of Hybodontidæ, as defined by Zittel, the recognized generic types are similarly but few; no well-known forms besides *Hybodus* and *Cladodus* being regarded as referable to this division with certainty. More, however, is known of the type genus than the author records; reference might have been made to the characters of the shagreen, and especially to Charlesworth[2] and Day's[3] determination of the so-called *Sphenonchus* as a cephalic dermal spine of *Hybodus*. At the present time, also, we are acquainted with a portion of the head and vertebral column of a closely allied fish from the Chalk.[4] In fig. 62, the letters *a* and *b* are transposed.

The Cochliodontidæ follow the Hybodonts, and form an unsatisfactory "family," of which no structural characters beyond those of the teeth (except perhaps in *Pleurodus*) are known. Full references are given to the numerous detached teeth named by Agassiz, McCoy, St. John, Worthen, Newberry, and James W. Davis; to which is added a notice of Traquair's important discovery of the jaw of *Psephodus* in the Scotch Carboniferous. A new genus, *Chalcodus*, is also founded upon a jaw, having each ramus armed with a single thin dental plate, from the Kupferschiefer of Thüringia. So far as external features are concerned, this fossil is very suggestive of the teeth of *Squaloraja* from the Lias, and it would be interesting to know to what extent there is an agreement in microscopical structure.

To the still-surviving Cestraciontidæ, *Orodus*, *Acrodus*, *Strophodus*, and other genera are referred, and excellent illustrative figures are given. Owen's mistake of assigning to *Cestracion* a side-view of the jaws of *Myliobatis* is, however, repeated (fig. 69). The arrangement adopted again reminds us of the extreme imperfection of our knowledge of the extinct allies of *Cestracion*. The true *Acrodus*

[1] J. W. Davis, Proc. Zool. Soc. 1887, p. 542.
[2] Mag. Nat. Hist. N.S. vol. iv. (1839), p. 245, pl. iv.
[3] Geol. Mag. Vol. II. (1865), p. 565.
[4] Proc. Zool. Soc. 1886, p. 218, pl. xx.

(not including the so-called *A. falcifer*) passes imperceptibly into *Hybodus*, so far as the dentition is concerned; and in the two genera the dorsal fin-spines, head-spines, and shagreen are identical. Nevertheless, *Hybodus* is the type of the "Hybodontidæ"; *Acrodus* is by common consent admitted into the Cestraciontidæ. Already, the progress of research begins to suggest emendations. *Ptychodus* proves to have not the slightest affinity with the Cestracionts;[1] and it is somewhat misleading to mention in connection with the teeth of this genus the large ribbed spines, which are afterwards correctly referred to *Pelecopterus* [=*Protosphyræna*] in the section on Ichthyodorulites, though truly pertaining to a Teleostean fish.

The Scylliidæ and Scylliolamnidæ are not of much palæontological importance, but the succeeding Lamnidæ and Carchariidæ naturally occupy a considerable space for full treatment. Doubt is rightly cast upon the supposed Carboniferous representatives of these families, and *Sphenodus*, of Jurassic age, is recorded as the earliest undoubted member of the Lamnidæ yet known. *Meristodon* is given as a synonym of *Oxyrhina*, but the type-specimens in the British Museum are fragments of Hybodont teeth; *Otodus* is retained, though with a reference to its suggested demolition by F. Noetling; and *Corax*, as usual, is also placed in this family. In the description of *Carcharodon*, the omission to note *C. longidens*, Pillet,[2] is perhaps unfortunate, this tooth being supposed to occur in beds equivalent to the Maastrichtian, while all other undoubted representatives are Tertiary. On p. 83 *Alopiopsis* is misprinted *Hopiopsis*, and this ought to be placed as a synonym of *Protogaleus*, Molin (Sitzungsb. k. Akad. Wiss. Wien, vol. xl. 1860, p. 583).

The Spinacidæ, with cyclospondylic vertebræ, are next considered, and the Liassic *Palæospinax* holds its accustomed place as their earliest recognized representative. Quite lately, however, this fish has been found to possess an anal fin, and to have many vertebræ feebly asterospondylic; and these characters, together with those of the teeth, remove it to a position among the Hybodonts.[3] The so-called *Spinax primævus*, from the Lebanon Chalk, is assigned to *Centrophorus* (after Hasse), and fragments of other genera and species are recorded both from the Chalk and Tertiaries. But it is time that the Cretaceous "*Spinax major*" were entirely omitted from lists, such smooth dorsal spines being indeterminable; and Egerton[4] and Hasse[5] have both shown that some, if not all, of the fossils in question are Cestraciont.

The primitive family or group of *Xenacanthidæ* follows. The remarkable preservation of the Continental Permian specimens of *Xenacanthus* renders possible a somewhat detailed account of the hard parts of this genus, and thus throws considerable light upon

[1] Quart. Journn. Geol. Soc. vol. xliii. (1886), p. 121; Proc. Geol. Assoc. vol. x. (1888), p. 295.

[2] Mém. Acad. Sci. Savoie, [3] vol. ix. 1883, p. 277.

[3] Geol. Mag. [3] Vol. V. (1888), p. 499.

[4] Mem. Geol. Surv. Dec xiii. (1872), pl. ix.

[5] Neues Jahrb. 1883, vol. ii. p. 66.

the affinities of the family. The characters of the pectoral fins, indeed, would justify its being placed in a much more isolated position than that it occupies, as already suggested by Cope[1] from features in the structure of the skull, and lately by C. Brongniart[2] from more general considerations. *Xenacanthus*, *Pleuracanthus*, and *Orthacanthus* are separately described; though, with Mr. J. W. Davis,[3] we fail to appreciate the distinctive features.

The Squatinidæ introduce the series of tectospondylic Selachians. This family is first recorded from the Lithographic Stone of Bavaria, and in addition to the ordinary recognized species of this age, the author includes the fragmentary fossil from the corresponding formation in Ain, France, named *Phorcynis catulina* by Thiollière. A figure of a most perfect example of *Squatina alifera* from Eichstätt is given, showing for the first time that the median fins are arranged precisely as in the living species.

At this point Dr. von Zittel defines and explains the "Unterordnung Batoidei" (mainly after Günther), and includes therein the remaining Selachian families. The Pristidæ (Saw-fishes) are believed to be represented by vertebræ in the Chalk (very doubtfully determined), but remains of the characteristic snout have not hitherto been recognized from beds below the Eocene. Most of the latter fossils are referred to *Pristis*, and a few from Egypt to *Propristis*, Dames. To these may now be added *Amblypristis*, Dames (*antea* p. 28).

The definition of the Pristiophoridæ demonstrates the illogical nature of the "Unterordnung," one *family*-character being noted as "Kiemenöffnungen seitlich gelegen, nicht auf der Unterseite," while on the previous page exactly the reverse ("Kiemenspalten auf der Unterseite") occurs unqualified in the definition of the major division. Only doubtful vertebræ of Pristiophoridæ are known from the Tertiaries; but the Liassic *Squaloraja polyspondyla* is also assigned to this family—a position from which later researches have necessitated its removal.[4]

The Psammodontidæ are an extinct family of Rays with great crushing teeth, confined to the Carboniferous period, and the symmetrical teeth named *Copodus* are placed here equally with the more typical paired teeth of *Psammodus* itself. Nothing, however, is known of these fishes beyond their fragmentary dentition. The Petalodontidæ, of Carboniferous and Permian age, are a little more satisfactorily understood, a portion of the body of one genus, *Janassa*, having been discovered in the Continental Kupferschiefer. Teeth like those named *Petalodus* are exclusively adapted for cutting, while in the most specialized genus, *Janassa*, the coronal edge is blunt and overturned, so that the dentition is admirably suited for crushing and trituration. Fig. 109 ought to be named *Polyrhizodus magnus*, McCoy; and the tooth shown in fig. 111

[1] Proc. Amer. Phil. Soc. 1884, p. 577.
[2] Comptes Rendus, April 23rd, 1888.
[3] Quart. Journ. Geol. Soc. vol. xxxvi. (1880), p. 321.
[4] Proc. Zool. Soc. 1886, p. 527.

certainly does not belong to *Ctenopetalus*, but has lately been named *Callopristodus* by Traquair.[1] *Peripristis* was defined by O. St. John, not Newberry and Worthen.

The Myliobatidæ are next described, and Cope's *Apocopodon*, from the Chalk of Brazil, is quoted as their forerunner. Here must now also be added *Ptychodus*. Numerous species of the common genera are cited, and the complete specimen of *Myliobatis Gazolai*, discovered by Baron de Zigno at Monte Bolca, is referred to. The genus *Zygobatis* is retained distinct from *Rhinoptera*.

In the Rhinobatidæ, the Jurassic *Spathobatis* is said to be only distinguished from the living *Rhinobatus* by the less jointed character of the pectoral fin-rays, and a fine figure of *S. mirabilis* (original 1·7 m. long) is given. *Asterodermus* and *Belemnobatis* are also included in this family. The Rajidæ follow, and are mostly known only by fragments of the dermal armour. The Liassic *Arthropterus* and *Cyclarthrus* are doubtfully placed here; and there are a few teeth of *Raja*, besides the placoid asperities so common in the Tertiaries. In the *Trygonidæ* are included fossil representatives of *Trygon*, *Tæniura*, *Anacanthus*, and *Urolophus*, besides two supposed extinct genera, *Alexandri[n]um* and *Xiphotrygon*, all from Tertiary strata. To the Torpedinidæ are assigned *Torpedo* (*Narcobatus*) *gigantea* from Monte Bolca, and vertebræ of *Astrape* from the North German Tertiaries; also the Cretaceous *Cyclobatis*, which really belongs to the Trygonidæ.[2]

Holocephali.

The Holocephali occupy the succeeding nine pages, and all except two are placed in the family Chimæridæ. The dentary plates are described as "teeth," but Newton's determination of those of the upper jaw as "premaxillary" and "maxillary" is regarded as erroneous, and these are merely termed respectively "vorderer Oberzahn" and "hinterer Oberzahn." The Devonian *Rhynchodus* and *Ptychodus* appear as the earliest representatives of the family. *Ischyodus* is next treated in detail, with a figure of von Meyer's *Ganodus avita* (Lith. Stone), which is considered a member of the genus. *Ganodus* is retained for the Stonesfield fossils, originally so named by Egerton; and the new generic name of *Metopacanthus* is proposed for Egerton's *Ischyodus orthorhinus*, from Lyme Regis. Then follows an account of the later Chimæroids, so far as known; and a distinct section is devoted to the Liassic *Prognathodus*, and a new allied genus, *Chimæropsis*, from the Lithographic Stone of Bavaria. Dr. von Zittel considers that the so-called maxillary teeth of *Prognathodus* are really mandibular, and that the curious elongated spine-like tooth pertains to the lower jaw. *Chimæropsis* has subsequently been more completely elucidated by J. Reis in the Palæontographica.

The description of the Selachian and Chimæroid fishes is concluded by a long section upon Ichthyodorulites, which treats of all doubtful

[1] Geol. Mag. [3] Vol. V. (1888), p. 85.
[2] Geol. Mag. [3] Vol. IV. (1887), p. 508.

spines, besides several whose relationships have already been discovered. We prefer to restrict the vague term, however, to the fossils of the first category. The classification is not very satisfactory. *Erismacanthus* cannot be claimed to have much similarity to a dorsal fin-spine, nor *Harpacanthus* to an unsymmetrical pectoral; they seem much more like such head-spines as those of *Hybodus*, *Acrodus*, the Chimæroids, and *Squaloraja*. An unfortunate error, moreover, occurs in fig. 130, in which *Tristychius arcuatus* is named *Harpacanthus arcuatus*. *Harpacanthus* was proposed by Dr. Traquair for a spine erroneously referred to *Tristychius*, and not for Agassiz's type-species of this genus. *Pristodus* is not very appropriately placed with undetermined Ichthyodorulites, when Mr. Robert Etheridge's description of *P. Benniei* [1] is taken into account. Moreover, it is satisfactory to be able to add that one of the most characteristic of Ichthyodorulites, *Asteracanthus*, has quite lately passed to its correct systematic position, having proved to belong to the Cestraciont Shark with the teeth named *Strophodus*.[2]

A. S. W.

(*To be continued.*)

II.—Geological and Natural History Survey of Canada. Annual Report (New Series), Vol. II. 1886. Accompanied by Geological and Topographical Maps, Sections, Plates, and Woodcuts. Royal 8vo. pp. 976 and xxix. (Montreal, 1887.)

It will only be possible in the limited space at our command, to give a very brief account of the contents of this large volume, which contains the reports of the Field Geologists and of others connected with the Survey, commencing with a "Summary Report" by the Director. Each of the thirteen reports which make up the volume are, as usual, distinguished by a letter of the alphabet and separately paginated, with a view to their separate issue. We shall take them seriatim, omitting Mr. J. B. Tyrrell's report, which has already been reviewed in this Magazine.[3]

The Director's report contains a brief résumé of the operations of the Survey for the year 1886, and is especially interesting for the information it gives respecting the mineral products of the Dominion, samples of which were exhibited at the Indian and Colonial Exhibition, South Kensington, 1886. The following are particularly mentioned:—plumbago, mica, soapstone, asbestos, gold and silver ores, manganese, petroleum, ochres, slate, granites and marbles, agates, &c., phosphate.

The reports of the Field Geologists begin with that of Dr. George M. Dawson (pp. 1B—129B);—"On the Northern part of Vancouver Island, from Comox to Quatsino Sound, with the coasts of adjacent Islands, and portions of the mainland."

The report is divided into "General Geology" and "Descriptive Geology." The Queen Charlotte Islands (southern half) and

[1] Geol. Mag. [2] Vol. II. (1875), p. 243, Pl. VIII. Figs. 3, 4.
[2] Ann. Mag. Nat. Hist. [6] vol. ii. p. 336, pl. xii.
[3] August, 1888.

Vancouver Island (northern half) form portions of a single axis of elevation, which here constitutes the western member of the Cordillera. The similarity of the rock formations in these two regions is "so close as almost to amount to identity." Their relations are exhibited in the table below :—

	QUEEN CHARLOTTE ISLANDS.	NORTHERN PART OF VANCOUVER ISLAND.
UPPER CRETACEOUS.	A. Upper shales and sandstones, 1500 feet.	Port McNeil beds (?). A. Upper shales.
MIDDLE CRETACEOUS.	B. Coarse conglomerates, 200 feet.	B. Coarse conglomerates.
	C. Lower shales and sandstones, with coal, 5000 feet.	C. Lower sandstones and shales, with coal.
	D. Agglomerates, 3500 feet.	D. Wanting.
	E. Lower sandstones, 1000 feet?	E. ,,

In the northern part of Vancouver Island rocks of volcanic origin, forming portions of a stratified series of great thickness, are abundant. They include, besides the volcanic materials, argillites and limestones, holding Triassic fossils. These volcanic rocks are classed as diabases and felsites, with occasional examples of diorite.

Associated with the volcanic rocks are limestones, argillites and quartzites, which have been recognized at a number of places, from the northern part of the Strait of Georgia, round the northern end of Vancouver Island, and in Quatsino Sound. This intercalated zone is at one place on the north coast of Vancouver Island estimated to be 2500 feet thick. As no complete section of the volcanic rocks with the alternating sedimentary materials could be made out, recourse was had to the fossils contained in the latter for determining the age of the whole series, which was found to be that of the Alpine Trias. The fossils upon which this determination was arrived at belonged to the following species :—*Monotis subcircularis*, Gabb, *Halobia* (*Daonella*) *Lommelli*, Wissmann; *Aulacoceras Carlottense*, n. sp.; *Arcestes Gabbi*, Meek; *Celtites* (?) *Vancouverensis*, n. sp. The descriptions of these species, by Mr. J. F. Whiteaves, are contained in Appendix I. to Dr. Dawson's report. For the entire series Dr. Dawson proposes the name *Vancouver Series*, including under this designation "not only the entire mass of volcanic materials which unconformably underlie the Cretaceous, but also the interbedded limestones and flaggy argillites and quartzites." The series is intended also to include "the similar beds of the Queen Charlotte Islands, as well as those of the southern part of Vancouver Island, to which it was originally applied by Dr. Selwyn in 1871."

The *Vancouver Series*, which are the oldest beds of the district described, are in contact with, or rest upon granitic rocks of later date, a very anomalous circumstance, for which the following explanation is offered, viz. that probably by the excessive folding together of the rocks the thickness of the series became so great as to bring its lower portions below the plane of fusion. This is shown by the fact that in some places—notably in the vicinity of Blunden Harbour and Seymour Narrows—both the granites and the rocks of the Vancouver Series have been subjected to great pressure in a horizontal direction, causing the fragments in the agglomerates to assume lenticular forms, and to become more or less schistose, and when darker fragments are abundantly present having an almost gneissic lamination. When this was taking place the granites must have been in a plastic state. The granites are almost always hornblendic and grey, or darker in colour, resembling diorites. Dr. Dawson observes that "the relations here exemplified by the contact of the Vancouver Series with the subjacent, though newer granites, precisely repeat those fully detailed by Mr. A. C. Lawson, in his report on the Huronian (Keewatin) and so-called Laurentian rocks of the Lake of the Woods."[1]

The Cretaceous rocks of the northern part of Vancouver Island are probably outliers, originally continuous with an older basin in the Queen Charlotte Islands (see Table). They are found to rest unconformably on an irregular, denuded surface of the older rocks, and have filled pre-existing hollows and valleys in this surface, during a prolonged period of more or less uniform progressive depression.

Coal should be looked for in the more central portions of the basin, because where the beds come in contact with the older rocks, they probably represent only a succession of shore deposits which do not include the entire thickness of the formation.

The Coal-bearing rocks are those of Comox and Nanaimo, which border the south-western shore of the Strait of Georgia forming a belt of rolling country between the mountainous region of the interior of Vancouver Island and the coast. They are largely littoral in character, being composed of conglomerates and sandstones, with intercalated shales, holding marine fossils. It is supposed that these Cretaceous strata underlie a great part of the Strait of Georgia, and that many of the beds were laid down along a sea-margin nearly at the level of the present coast.

On the north side of the west and Rupert Arms of Quatsino Sound there is an area of coal-bearing Cretaceous rocks which has attracted the attention of capitalists, and attempts have accordingly been made to turn it to profitable account, but the records of boring and the geological data obtained in the exploration of this area (called the "Koskeemo Cretaceous area") show that no coal seams of workable extent have been found in it. The entire exposed thickness of the Koskeemo coal-basin is "at least 1500 feet." Records of the borings are given at p. 95B of Dr. Dawson's report.

A brief account is next given of the "Glacial and Superficial Deposits" of the region explored (pp. 99B to 106B). Two great

[1] Annual Report, Geol. Survey Canada, 1885, p. 61CC, et seq.

glaciers are described as having existed at one time in what is now the Strait of Georgia, and in Queen Charlotte Sound. These were described by Dr. Dawson in the Geological Society's Journals for 1878 and 1881.

Appendix I. of the report contains Triassic and Cretaceous fossils described by Mr. J. F. Whiteaves; the former are enumerated above, the latter are as follows:—*Aucella Piochii*, Gabb, *Yoldia arata*, Whiteaves, *Astarte Packardi*, White, *Opis Vancouverensis*, Whiteaves, *Pleuromya lævigata*, Whiteaves, *Placenticeras occidentale*, n. sp., *Scaphites Quatsinoensis*, Whiteaves.

Appendix II. is a list of plants obtained on Vancouver Island and adjacent coasts in 1885 by Professor Macoun. Appendix III. is a record of meteorological observations taken on the coast of British Columbia, June to October, 1885.

This excellent report is illustrated with a geological map of Vancouver Island and the adjacent coasts on a scale of eight miles to an inch.

Mr. R. G. McConnell supplies a report "On the Geological Structure of a portion of the Rocky Mountains, accompanied by a section measured near the 51st Parallel," in the vicinity of the passes followed by the Canadian Pacific Railway.

The following formations were met with, and are represented in the coloured sections accompanying the report, viz.

Mesozoic 5000 ft.	Cretaceous	Kootanie Group to Benton.
Palæozoic 29,050 ft.	Carboniferous passing down into Devonian ..	Upper and Lower Banff Series
	Devonian	Intermediate Limestone.
	Silurian	Halysites Beds.
	Cambro-Silurian	Graptolitic Shales. Upper part of Castle Mountain Group.
	Cambrian	Lower part of Castle Mountain Group. Bow River Group.

The rocks here enumerated are exposed along the Bow and Wapta Valleys, from Banff westward to Golden City on the Columbia. Some new names (Banff limestone series, Intermediate limestone, Halysites beds, Graptolitic shales, and Castle Mountain Group) are introduced, because some of the groups could not be correlated exactly with rocks found in the southern part of the range as described in the various United States reports. It may be mentioned that the Graptolites of the "Graptolitic shales" were submitted to Professor Lapworth for identification. The following species were recognized:—*Didymograptus*, n. sp., allied to *D. enodus*, Lapw., *Glossograptus ciliatus*, Emmons, *G. spinulosus*, Hall, sp., *Cryptograptus tricornis*, Carr. sp., *Diplograptus angustifolius*, Hall, *D. rugosus*, Emmons, *Climacograptus cælatus*, Lapw., with doubtful species of *Phyllograptus*, etc.

Concerning these fossils, Professor Lapworth observes:—"The fact that these Graptolites have been obtained from the distant region of the Rocky Mountains gives them an especial interest, as few Graptolites have hitherto been noticed from that region." They are referred by him to the age of the Utica slate, or to the Trenton-Utica fauna of the United States and Canada.

Mr. A. P. Low's report (pp. 1 F—24 F) refers to the tract of country between lake Winnipeg and Hudson's Bay, with notes upon the formations met with along the route followed by the explorer. These consisted of Laurentian, Huronian, Cambro-Silurian [Ordovician], Silurian, and Post-Tertiary (Drift). The report contains also a list of rare plants collected, and concludes with an Appendix containing meteorological observations.

Dr. Robert Bell's report (pp. 1 G–38 G) contains an account of "An Exploration of portions of the Attawapishkat and Albany Rivers, Lonely Lake to James' Bay. Besides recording the geological features of the country passed through, observations were made upon its physical aspect, soil, climate, vegetation, etc., as far as these could be noted in a boat voyage. The rocks met with on the Albany river (upper part) consisted of hornblende-schist, granites (cut by dykes of diorite), and gneisses. Huronian rocks (hornblende schists) made their appearance in some parts of the river. At Lake Lansdowne (an expansion of the Albany) rocks of Silurian and Devonian age, the latter fossiliferous, made their appearance.

The extent of the Palæozoic rocks west and south-west of James' Bay leads to the inference that they occupy an area "as extensive as the whole region between the Ottawa River and Lakes Ontario, Erie, and Huron." No evidence was found of the presence of Carboniferous rocks in this great basin.

This report concludes with a description of the Drift deposits (principally Boulder-clay) overspreading the Palæozoic area westward of James' Bay. These deposits were estimated to have a thickness ranging between 30 and 90 feet. The report is illustrated with photo-engravings of views upon the Boulder, Attawapishkat, and Albany Rivers.

Mr. R. W. Ells treats in his report (pp. 1 J–70 J) of the geology of a portion of the Eastern Townships (Province of Quebec) "relating more especially to the counties of Compton, Stanstead, Beauce, Richmond, and Wolfe." The report is accompanied by a geologically coloured quarter-sheet map of this part of the Province, on a scale of 4 miles to 1 inch. The geological systems recognized were the following:—

Silurian.	Cambrian.
Cambro-Silurian [or Ordovician].	Crystalline and igneous, volcanic, and plutonic.

The Silurian rocks, which consist of limestones (sometimes fossiliferous), calcareous slates, and conglomerates, associated with dolomitic slates, are much involved with the underlying older rocks, so that they were formerly mistaken for parts of the older systems. The Cambro-Silurian rocks consist of "graphitic, blackish or dark-grey limestone, with, in several localities, associated slates and sandstones," which were formerly regarded as of Silurian age, or, in part, Lower Devonian, but are now recognized by their unconformability to the Silurian, as well as by their fossil contents, to belong to the Cambro-Silurian. Intrusions of granite are common in the rocks of this system, and there is frequent evidence of metamorphic action in the condition of the sandstones and limestones. The Cambrian is represented by slates, sandstones—sometimes quartzose—quartziferous schists and conglomerates. The latter are generally unconformable to the slates and limestones of the Cambro-Silurian above, and to the "underlying ridges of crystalline rocks, from the débris of which they are largely formed." The pre-Cambrian rocks form some of the mountain ranges of the district (Stoke Mountain, etc.), and are composed of hard felspathic schists, gneissic felsite, granitic gneiss, talcose and micaceous schists, with, in some places, masses of granitic and dioritic rocks, "the whole presenting a marked resemblance to Huronian strata." The "copper-bearing rocks" of the Eastern Townships, which are of pre-Cambrian age, are described by the author of this report as strikingly similar to the Archæan rocks of England and Scotland, and those of Wales known as the Dimetian, Arvonian, and Pebidian, of Hicks. "Whatever may be the exact age of these altered rocks," adds Dr. Ells, "their present aspect entitles them to be classed as very ancient sediments." The crystalline and igneous rocks consist of granitic, dioritic, and serpentinous rocks, and they constitute lofty ranges of hills, such as Megantic Mountains, Orford and Victoria Mountains, etc. Some observations upon the drift deposits are supplied by Dr. Ells, who endeavoured to ascertain their connection with the auriferous character of the sand and gravel which are widely distributed in the region he explored. He considers that the probable source of the gold of the Townships is in the areas of Cambrian slates which flank the old ridges of the Maine and New Hampshire boundary and the central axis, and that local glaciers were probably instrumental in effecting the disintegration of these slates and distributing an auriferous débris over the "great Cambro-Silurian area of Compton, Stanstead, and Beauce counties." Besides gold, the following minerals, viz. copper, silver, chromic iron, antimony-ore, asbestos, soapstone, slate, etc., occur in the district, and are of more or less economic importance.

Mr. R. Chalmers' report (pp. 1 M–39 M) treats of the surface geology (Post-Tertiary) of Northern New Brunswick and South-Eastern Quebec. It is illustrated with two maps each on a scale of four miles to 1 inch, having the locality and superficial extent of the various formations defined upon them. The surface deposits met with are divided by the author into two series, viz. those of fresh-water, and those of marine origin, the former comprising peat-bogs, shell-marl, lacustrine and fluviatile marshes, river-terraces, kames, etc., the latter, estuarine flats, salt marshes, sand dunes, Saxicava-sand Leda-clay, and kames of marine origin, etc., and lastly till or boulder clay, moraines, and erratics.

Messrs. L. W. Bailey and W. McInnes report upon their explorations carried on in portions of the counties of Victoria, Madawaska, Northumberland and Restigouche, New Brunswick. Their report is accompanied with a geologically coloured map on a scale of four miles to one inch. One of the objects of this Survey was to determine "the succession of the Silurian strata in the northern portion of the province, and their relations to other systems." The formations met with were the following:—

Lower Carboniferous.
Devonian.
Silurian.
Cambro-Silurian.
Pre-Cambrian.
Granite and related rocks.

The Lower Carboniferous rocks consist mainly of red sandstones, grits and conglomerates, with extensive beds of gypsum, near the top of the formation. The Devonian is represented by a small patch of soft calcareous sandstones and slates, of Oriskany age, as shown by the fossils, determined by Mr. H. M. Ami. Calcareous slates, fossiliferous in places, are the prevailing rocks of Silurian age. The Cambro-Silurian consists chiefly of hard quartzites and slates, apparently unfossiliferous; other rocks of this system are of a more highly altered, schistose, and foliated character. The Pre-Cambrian rocks are hard crystalline felsites, gneisses, felspathic and other schists, all highly contorted. Granite occurs in two areas, and is of similar character and age (Devonian) to that which is found in intrusive masses further to the south.

A voluminous report is contributed to the volume by Mr. Hugh Fletcher (pp. 1 P–128 P) containing an account of explorations and surveys in the counties of Guysborough, Antigonish, and Pictou, Nova Scotia. This report embodies the results of work (mostly topographical) done during the summers of 1882–1886. A map of the region on a scale of 1 mile to an inch has been constructed.

The physical geography of the district presents no features worthy of special note. The highest land extends along the shores of the Gulf of St. Lawrence, from Cape George to the East River of Pictou, but the highest summits rarely exceed 1000 feet, and deep and broad valleys are cut by the rivers flowing into the Gulf. The geological systems recognized in the area included in Mr. Fletcher's explorations are the following:—

Permian.	Silurian.
Carboniferous.	Cambro-Silurian.
Devonian.	Pre-Cambrian.

There are associated volcanic rocks in all but the Permian.

The Carboniferous rocks, which are the most important in the series, "occupy three well-marked belts, often folded obliquely to the longer axis." These are (1) the St. George's Bay basin; (2) the the Merigomish basin; (3) the St. Mary's basin; the latter holding fossil plants, which would indicate either a Millstone Grit or Lower Carboniferous age; but the altered aspect of the rocks would rather refer it to the latter.

The volcanic rocks belong to several distinct periods which are provisionally referred to the following groups:—felsites, syenites and schists to the pre-Cambrian; igneous rocks cutting Lower Cambro-Silurian conglomerates; volcanic rocks contemporaneous with Middle and Upper Cambro-Silurian. Dykes cutting through Silurian, Middle, and Upper Devonian strata, and volcanic rocks contemporaneous with Middle Devonian. Finally the Carboniferous conglomerate is traversed by volcanic rocks and dykes of contemporaneous origin.

Several pages of this report are devoted to an account of the surface geology, scenery, climate, agriculture, and economic minerals, of the district explored. The latter include coal, iron, gold, gypsum, phosphate of lime, building stones, etc.

Mr. E. R. Faribault reports (pp. 129 P–163 P) upon the Lower Cambrian rocks of Guysborough and Halifax counties, Nova Scotia, including the gold-bearing slates and quartzites, "which cover nearly one-half the superficies of the Province, that is, according to various authorities, from 6000 to 7000 square miles."

A further contribution by Dr. G. M. Dawson (pp. 1 R–62 R) is supplied to the volume under review in the shape of "Notes to accompany a geological map of the northern portion of the Dominion of Canada, east of the Rocky Mountains." The map is "designed primarily as a supplement to the general geological map of the southern portion of the Dominion, published by the Geological Survey in 1884, for the compilation of the western part of which the writer [Dr. Dawson] was largely responsible."

The "notes" accompanying the map form a succinct account of the geology of the most northerly part of the continent, embracing the Arctic regions. The information concerning these lands is derived from many scattered sources, including the well-known works of voyagers in the polar seas from Ross to Nares, and Greely. A very full bibliography of Arctic travel is appended to the "notes."

The prevailing rocks of these northern lands are Archæan, and they probably form the greater part of Greenland, and "doubtless underlie, at no great depth, the entire Arctic Archipelago." The different subdivisions of the Archæan occurring in the more southerly portions of Canada are repeated in the north; amongst these the Huronian is met with on the west coast of Greenland, probably on the Labrador coast, and on the west coast of Hudson's Bay. Rocks of similar character to those of the Keewenaw or Animikie of the Lake Superior region, have been recognized in the vicinity of the Coppermine River, and are probably of Lower Cambrian age. This formation is of such wide extent that Dr. Dawson considers that it ranks as "one of the most important geological features of North America." It is composed largely of volcanic rocks, and is apparently everywhere unconformable to the underlying Laurentian and Huronian systems. The Silurian and Cambrian systems, which are also widely developed, consist chiefly of "pale limestones, often of a yellowish or cream colour, and frequently more or less dolomitic. They rest everywhere unconformably on the Archæan or on the Cambrian rocks." The extent and relations of the rocks of Devonian age have not yet been satisfactorily determined, but their occurrence is recorded on the Mackenzie River, and their presence is inferred in the limestone formation which stretches from the vicinity of Lake Winnipeg to the mouth of the Mackenzie, and thence to Baffin's Bay and Grinnell Land. A revision of the fossils from the Mackenzie and the Arctic basin is recommended as very desirable.

An important series of Coal-bearing rocks of Lower Carboniferous age (of the so-called "Ursa Stage" of Heer) are distributed in the Arctic Archipelago, but no estimate appears to have been formed of their thickness, nor indeed of that of any of the older rock-series in the Arctic basin. Rocks of Liassic or Jurassic age, of unknown extent, are said to occur in the northern part of the Arctic Archipelago. The so-called "Miocene" of Greenland and Grinnell Land "is now regarded as equivalent to the Laramie, or at least not newer than the Eocene." The superficial deposits are not dealt with in these notes, as the information respecting them is not such as can be expressed upon a geological map. A few observations upon glacial phenomena are however added.

Mr. Coste (pp. 1 S—85 S) supplies some useful statistical tables, with explanations, of the "production, value, exports and imports, of minerals in Canada during the year 1886 and previous years."

Mr. G. C. Hoffmann, assisted by Messrs. F. D. Adams, and E. B. Kenrick, gives the results of work done in the chemical laboratory of the Survey. There is a full index at the end of the volume.

A. H. F.

III.—Richmond Coal Field, Virginia.

The scanty literature of the Virginia Triassic has lately been increased by the appearance of a pamphlet by Mr. William Clifford,[1] describing this complicated field and illustrating the structure by maps and sections. The history, geography, the mining methods and difficulties are concisely outlined. There are also given some of the characteristics of the rocks of the basin, and analyses of coals and natural cokes. As a whole the author dwells more on the economic and engineering side, than on the purely geologic; but as he devotes some space to a discussion of the latter, I would venture to criticize, or at least call the attention of others, to his facts and some theoretical conclusions based thereon.

The statement of first importance, on which many deductions rest, is that the strata thin out at the outcrop, or, to give the exact words, "the rocks thin out toward the sides of the basin as though, during their deposition, the rock material had slid somewhat down the steep sides on which it was thrown down."

A careful exploration made this year failed to give conclusive evidence of such a general thinning. It is true the opportunities now of examining the strata are very few—and without doubt there

[1] Richmond Coal Field, Virginia, by William Clifford, M.E., read before the Manchester Geological Society, December 6th, 1887.

are beds once exposed in mines now closed which tend to give support to the opinion just quoted.

The deduction, that the rock material was deposited on a steep slope, in all probability will not stand searching investigation. There is far too much stress put upon the assumption made by Lyell, and since then unquestioned, that the *present* basins were basins at the *beginning of the Triassic*, and that the irregularities are due to deposition on uneven surfaces rather than to subsequent bending and crushing. The evidence, on the contrary, points to the fact that this coal series was deposited in a horizontal position. Not enough allowance has been made for the effect of subsequent crushing and erosion of these soft rocks.

It is well known that one of the principal coal beds, dipping at an angle averaging 30°, has been worked along the strike for, say a mile, and has been explored on the dip for 1500 feet, equivalent to a vertical depth of 750 feet. Throughout this breadth of 1500 feet it maintains approximately a uniform thickness. Surely no theory can satisfactorily explain this uniformity of thickness through such a *vertical* range, without admitting the original horizontality of the coal floor. The author of the paper cannot have carefully considered his position when he says, "The coal seams in the main basin are equally thick at the outcrop and in the deep; the tenacity of the roots having given the coal plants a firm hold up the steep sides of the trough."[1] Not only the uniform thickness of the coals on the dip, but the laminæ of shale between the coals, the fire clays and impure limestones between the beds, all testify to the original horizontality of these beds. And the innumerable "troubles," as the areas of crushing and faulting are locally called, give the strongest proof of the enormous subsequent movements.

A conclusion of great practical importance depends upon the confirmation of this set of facts—and this is the persistence of the coal throughout the bottom of the main basin. If it is conceded that the strata do not thin at the outcrop, and that they were deposited on horizontal surfaces, then all the hypotheses of Lyell, Lesley,[2] and others, based on the supposition that the bottom of the present basin was under different conditions of depth and water currents from the present sides, fall to the ground, and we have no reason to suppose that the beds in the centre of the basin differ in original characteristics as to number, thickness, and continuity of coals from those at the outcrop.

It does not follow from what has been said that any one workable coal is continuous across under the basin to the outcrop on the other side. On the contrary, this is probably not the case. The identification of any one coal seam for a distance of even one or two miles is a matter of great uncertainty, owing to the number of the seams, the changes in the thickness both of the coal and accompanying shales, the bending and crushing to which all have been subjected,

[1] Page 7, idem.

[2] Quoted in McFarlan's "Coal Regions of America," p. 512, from Lesley's U.S. Railroad and Mining Register, Philadelphia.

and the rapid decomposition of the whole series. When the change of thickness of the coal beds and the large number of thin coals—usually overlooked—are given due consideration, strong doubt is thrown upon the identifications that have been often attempted, between the coal in one mine and that in another mine a mile or more away. The probabilities are that the coal of economic importance in the one mine is represented by some one of the smaller neglected coals in the other.

The areas of crushing and faulting are, owing to the softness of the rocks, more impervious to water than the undisturbed portions of the beds. In this I differ from Mr. Clifford, when he says, "The measures which overlie the coke seams are very much fissured, and consequently the pits working coke are more heavily watered than coal pits. Some of the most promising ones in the northern end of the field had to be abandoned on that account."[1] This idea probably arose from the fact that the workings in the northern portion of the coal area carried on by many owners, at various times, without system, have intersected each other, so that water from one coke pit will now flow to any other. Thus, the perviousness to water, which has caused the abandonment of these mines, is due to artificial and preventable rather than natural or wide-spread causes.

F. H. Newell.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—January, 23, 1889.—W. T. Blanford, LL.D., F.R.S., Vice-President, in the Chair.—The following communications were read:

1. "On the prevailing Misconceptions regarding the Evidence which we ought to expect of former Glacial Periods." By Dr. James Croll, F.R.S. Communicated by T. G. Bonney, D.Sc., F.R.S., F.G.S.

The imperfection of the geological record is greater than is usually believed. Not only are the records of ancient glacial conditions imperfect, but this follows from the priciples of geology. The evidence of glaciation is to be found chiefly on *land-surfaces*, and the ancient land-surfaces have not, as a rule, been preserved. Practically the several formations consist of old sea-bottoms, formed out of material derived from the degradation of old land-surfaces. The exceptions are trifling, such as the under-layers of coal-seams, and dirt-beds like those at Portland. The transformation of an old land-surface into a sea-bottom will probably obliterate every trace of glaciation; even the stones would be deprived of their ice-markings; the preservation of Boulder-clay, as such, would be exceptional. The absence of large erratic blocks in the stratified beds may indicate a period of extreme glaciation, or one absolutely free from ice. The more complete the glaciation the less probability of the ice-sheet containing any blocks, since the rock would be covered up. Because there are no large boulders in

[1] Clifford's paper, p. 13.

the strata of Greenland or Spitzbergen, Nordenskjöld maintains that there were no glacial conditions there down to the termination of the Miocene period. The author maintained that glaciation is the normal condition of polar regions, and if these at any time were free from ice, it could only arise from exceptional circumstances, such as a peculiar distribution of land and water. It was extremely improbable that such a state of things could have prevailed during the whole of the long period from the Silurian to the close of the Tertiary.

A million years hence it would be difficult to find any trace of what we now call the glacial epoch; though if the stratified rocks of the Earth's crust consisted of old land-surfaces, instead of old sea-bottoms, traces of many glacial periods might be detected. The present land-surface will be entirely destroyed in order to form the future sea-bottom. It is only those objects which lie in existing sea-bottoms which will remain as monuments of the Post-tertiary glacial epoch. Is it, then, probable that the geologist of the future will find in the rocks formed out of the non-existing sea-bottom more evidence of a glacial epoch during Post-Tertiary times than we now do of one, say, during the Miocene, Eocene, or Permian period? Palæontology can afford but little reliable information as to the existence of former glacial periods.

2. "On Remains of Eocene and Mesozoic Chelonia, and on a Tooth of (?) *Ornithopsis*." By R. Lydekker, Esq., B.A., F.G.S.

This communication treated in the first place of remains of Chelonia from the Cambridge Greensand, Wealden, and London Clay. Firstly, *Rhinochelys*, from the Cambridge Greensand, was considered to indicate a Pleurodiran type; and four new specific names were proposed, viz. *R. macrorhina*, *R. brachyrhina*, *R. Jessoni*, and *R. cantabrigiensis*. From the same deposits a skull was described which was considered to indicate a new species of *Chelone*, for which the name *C. Jessoni* was proposed. Other remains of marine Chelonians from these beds were regarded as indicating a Turtle allied to the Loggerhead, and were provisionally referred to the genus *Lytoloma*, as *L. cantabrigiensis*. In the course of the description, it was proposed to replace the name *Euclastes* (preoccupied) by *Lytoloma*. Of other Chelonidæ, the new generic name *Argillochelys* was proposed for *Chelone cuneiceps*, Owen, of the London Clay, which would also include some other forms from the same beds. A shell of a *Plesiochelys* from the Wealden of the Isle of Wight was regarded as indicating a new species, which was named *P. Brodiei*.

It was also shown that *Chelone gigas*, Owen, of the London Clay, did not belong to the Chelonidæ at all, but indicated a species of the genus *Psephophorus*—a member of the Dermatochelydidæ. The next section of the paper described a peculiar mandibular symphysis from the London Clay, which was taken to indicate a new genus of Chelonia, to be named *Dacochelys*; and it was suggested that *Emys Delabechei*, Owen, might be the same form.

The paper concluded with a notice of a tooth from the Wealden, of the same general type as one previously referred by the author to

Ornithopsis; and it was shown that teeth from the Portlandian of Boulogne, which had been described as *Neosodon* and *Caulodon*, and regarded as Iguanodont, were likewise of the same general type. It was also shown that *Cardiodon*, Owen, from the Forest Marble, belonged to the same group.

3. "On the Dentition of *Lepidotus maximus*, Wagn., as indicated by specimens from the Kimeridge Clay of Shotover Hill, Oxford." By R. Etheridge, Esq., F.R.S., and H. Willett, Esq., F.G.S.

The paper commenced with a list of fourteen species of *Lepidotus* known in England, from beds between the Lias and Upper Chalk inclusive, and an account of the range of the Lepidosteoid fishes from Permian times to the present day followed. The occurrence of separate teeth of *Lepidotus maximus*, Wagn. (= *Sphærodus gigas*, Ag.), in the *Exogyra-virgula* zone of Shotover and Kimeridge, has been previously recorded; but in the present communication four specimens of jaws containing teeth were noticed.

I. Comprises the upper dentition; it belongs to the same species and, possibly, to the same individual as No. IV. Eighteen teeth occur in its two fragments.

II. Contains two teeth, an upper and a lower, belonging to the same species as No. IV.

III. Probably the right dentary bone appears to belong to a distinct species. It is very perfect, and exhibits sixteen teeth, of which the successors of six are exposed on the underside. The marginal series comprises the seven smallest teeth, those placed most inwardly being the largest. Compared with the dentary bone of those species of which that element is already known, the fossil approaches most closely to *Lepidotus maximus*, Wagn., but the bone is broader in proportion to its length, and the teeth are more numerous.

IV. Corresponds undoubtedly to *Lepidotus maximus*, Wagn. The dentition of this specimen does not, however, appear to belong to the left upper jaw, but to the dentary bone. Its upper surface contains seventeen teeth, and the lower, or successional, series consists of fifteen = 32 in position.

II.—February 6, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Occurrence of Palæolithic Flint Implements in the neighbourhood of Ightham, Kent, their Distribution and probable Age." By Joseph Prestwich, D.C.L., F.R.S., F.G.S.

The author stated that Mr. Harrison of Ightham has discovered over 400 palæolithic implements lying on the surface at various heights and over a wide area around Ightham. A description of the physiography of the district and the distribution of the various gravels and drifts was given, and in the absence of fossils, attention was called to the different levels at which the deposits occurred, and to their physical features and characters. Besides the river-gravels, two groups of unclassed gravels were described, one occupying a low level, and the other levels higher than that to which the river-drifts reach; the latter is of varied composition.

In the case of the Shode valley, only beds below the contour-level of 350 feet in its upper part, and of 300 feet or less in its lower part, can be referred to the former action of the Shode, and those above this belong to a high-level drift of uncertain age. The composition of the various gravels was described in detail.

The implements are found on the surface of the land at all levels up to 600 feet, and Mr. Harrison has discovered them at 40 localities in the hydrographical basins of the Shode, the Darent, the Leybourne stream, and in part of the Thames basin. Two groups of implements extend far beyond the limits assigned to the river-drifts formed since the present hydrographical basins were established, and must be accounted for by some other means than those in connection with the former *régime* of the existing streams. A description of the general characters and variations observable in the implements was given. It is evident from the condition of most of the implements, that they have been imbedded in some matrix which has produced an external change of structure and colour. In the case of the river-gravel sites, the question presents no difficulty. Three classes of implements have been found—(i.) where the flint still shows some of its original colour; (ii.) those of which the surface has turned from black to white, has been altered in structure, and acquired a bright patina, and which shows no trace of wear; (iii.) those of which the flint has also lost its original colour, but has been stained, and is with or without patina; these are generally much rolled. The characters of the first call for no comment. Those of (ii.) and (iii.) are very marked, and there is no difficulty in referring each to a distinct matrix. The implements of class ii. have been embedded in a stiff brick-earth, generally of a reddish colour, and those of class iii. seem to have lain in ferruginous beds of sand or gravel. Reasons were given for supposing the surface to have been once covered with a deposit of clay or loess, since denuded except where preserved in pipes, and that a continuous plane descended from the high range of the Lower Greensand to the Thames valley, which has since been lowered 300 feet or more. It was also shown that the high-level deposits were formed anteriorly to the Post-glacial drifts of the Medway and Thames Valleys. It is probable that the loess is a deposit from flood-waters, and that some of it may be referred to the Medway flowing at a higher level; but the highest deposits cannot be so accounted for, and the author referred to the possibility of glacial action, without insisting on it. The deposit on the Chalk-plateau is abruptly cut off by the river valleys, and the rudest forms of implements, such as those of Ash and Bower Lane, occur on this plateau at from 500 to 550 feet, and the author thinks they may possibly be of Pre-glacial age. The changes which have taken place in the physiography of the district, and the great height of the old chalk-plateau, with its clay-with-flints and southern drifts, point to long intervals of time, and to the great antiquity of the rude implements found in association with these drifts. That the removal of the material indicates the existence of agents of greater force than those operating under the present river *régime* closes up the time required for the completion of the great physical phenomena, though the author's inquiry tends to carry man further back geologically than is usually admitted.

CORRESPONDENCE.

A CORRECTION.—MESOZOIC MONOCOTYLEDON.

Sir,—In my review of Mesozoic Angiosperms in the Geological Magazine for May, 1886, I was induced to figure a specimen from the Woodwardian Museum, which I found placed in a case among Jurassic plants, and which I was informed had come from the Yorkshire Oolites. It is no plant, and really comes from Ascension, and presents one of those extraordinary cases of mimicry which all students of fossil plant-remains are familiar with. While presenting the external form of a fruit it exhibited no trace of internal vegetable structure, and I therefore abstained from cutting a section for the microscope which would have revealed it true nature. It is evidently, as pointed out to me by Prof. Judd, a gobbet of lava, which has been ejected in a molten state to a great height, and has taken its ropy and elongated form in its descent through the air. Knowing its origin, it is easy to see how the mimic spathe has been formed by the overrunning of the still melted top down one side of the already congealed body, like a guttering candle; the indistinct seeds being minute air-bubbles caught between the two surfaces. I fortunately forbore to give it any sort of name.

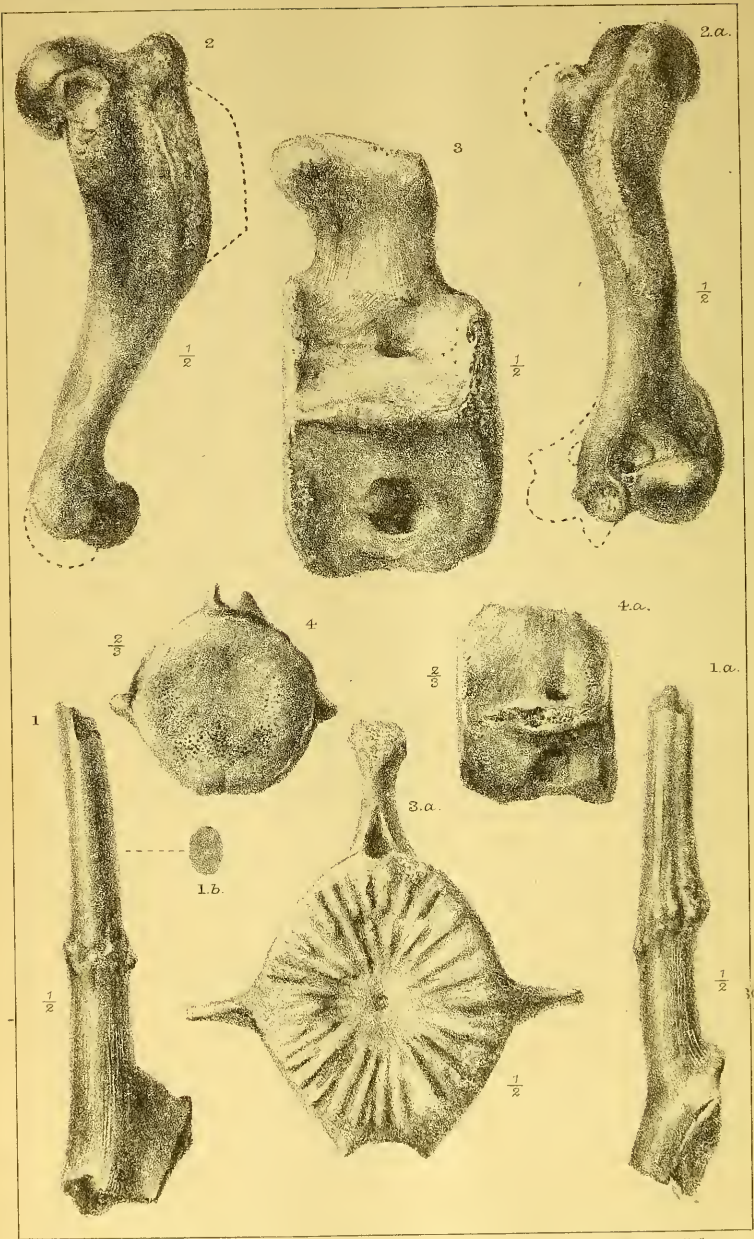
In endeavouring to collect together and describe the rare and scattered, ill-preserved, and mineralized plant-remains from the marine Mesozoic beds which alone fill in much of the gap between the Carboniferous and the Tertiary, the most experienced are liable to err. Only a few days since some concretions were sent to me by a well-known geologist as plants.

Unfortunately many of our museums abound with specimens to which hypothetical localities and imaginary formations are assigned. I spent the best part of a day in noting down errors of this description in the Tertiary and Cretaceous collection of a northern university museum, and sent them to the Curator, who up till now has not acknowledged their receipt. J. Starkie Gardner.

A SOUTH AFRICAN GEOLOGISTS' ASSOCIATION.

Sir,—You will be pleased to know that a "South-African Geologists' Association" has been established at Grahamstown in connection with the Albany Museum there. Dr. Atherstone, F.G.S., has been appointed its first President; and there are Vice-Presidents in Cape Town, Natal, the Free State, and Transvaal. Dr. Atherstone had long endeavoured to get up such a Society, and the Exhibition there gave the opportunity for carrying it out. T. Rupert Jones.

Dr. J. W. Spencer, Professor of Geology at the University of Georgia, has been appointed State Geologist of Georgia.



E. C. Woodward lith. ad nat. West, Newman & Co. imp.

Mammalian Remains from the "Forest-bed-Series"

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. VI.

No. IV.—APRIL, 1889.

ORIGINAL ARTICLES.

I.—Some Additions to the Vertebrate Fauna of the Norfolk "Preglacial Forest Bed" with Description of a New Species of Deer (*Cervus rectus*).

By E. T. Newton, F.G.S., F.Z.S.

(PLATE V.)

VERTEBRATE remains from the "Forest Bed" continue to be brought to light by the rapid denudation of the East Anglian coast, and I have again to acknowledge my indebtedness to Mr. A. Savin. of Cromer, whose assiduous collecting has preserved so many of these fossils, and made them available for scientific study. One of the specimens which he has now sent me is a species of *Cervus*, apparently new to science, while the others, although referable to living forms, are now for the first time definitely recorded from the "Forest Bed," and if my determinations prove to be correct, the following names may be added to the list of Mammalia from this deposit:—

Cervus rectus, new species.
Bison bonasus, Linn., var. *priscus*, Bojanus
(to replace *Bos primigenius*).
Phoca barbata, Fabricius.
Delphinapterus leucus, Pallas.
Phocæna communis, Lesson.

Cervus rectus, new species. Plate V. Figs. 1, 1*a*.

One of the most interesting specimens recently discovered in the Cromer "Forest Bed" is a small cervine antler from Sidestrand, attached to the frontal bone by a long pedicle, which reminds one of the recent Muntjac; the form is new to these deposits and, ırently, is an undescribed species.

The frontal suture has been broken away, and consequently the real width of the frontal is uncertain; it is now about 29 mm., and, when perfect, could scarcely have been more than 33 mm.; so that the entire width across the two frontals, just above the orbit and including the bases of the pedicles, could not have been more than 66 mm. (a little more than 2½ inches).

The pedicle is nearly round, where it is free above the frontal, and has a circumference of 58 mm.; seen from the front it is nearly vertical upon the skull, having but a slight divergence; while in a side view, it is so oblique to the frontal as to extend a long way down the face of the skull; being still prominent so far as the specimen extends, and forming at its lower part a distinct angle in front and another at the outer side, with a flattened space between. At the back the pedicle is about 30 mm. long: in front, about 60 mm. About 70 mm. of the beam are preserved, including the burr, the latter being rugose, irregular and ill-defined. Above the burr, the beam is laterally compressed, and is set somewhat obliquely upon the pedicle, so that from the front it is seen to diverge more from its fellow than does the pedicle itself.

The length of the pedicle, as well as the manner in which it is set on the skull, is quite unlike anything hitherto described from the "Forest Bed series," or indeed from any other British Pliocene or Pleistocene deposit. The simple character of the antler at once suggests the possibility of its having belonged to a young animal, perhaps, the first antler developed. If this be the correct interpretation I am still unable to find any species which, in its early stages, would be likely to have similar pedicles.

The young Roebuck has at first a somewhat similar simple antler, but not flattened, and the pedicle is shorter and differently set on the skull. The nearly allied *Cervus cusanus* (Croizet and Jobert, pl. viii. fig. 1) also has a much shorter pedicle. *Cervus anoceros* (Kaup, Oss. Foss. Mam. 1832–9, pl. xxiv. fig. 2), which with *C. trigonoceros* is now included in the one species *C. dicranoceros*, has a pedicle much longer than this Forest Bed specimen, besides having the antler bifurcate. *Cervus (Prox) furcatus* as figured by Rütimeyer (Naturliche Geschichte der Hirsche, Abh. Schweiz. Pal. Ges. vol. vii. 1870) also has a much longer pedicle and a bifurcated antler.

As this "Forest Bed" specimen cannot be referred to any known species, and appears to be a new form, it is well that it should have a distinctive name; I propose, therefore, in accordance with the upright character of the antler, that it should be called *Cervus rectus*.

Bison bonasus, Linn., var. *priscus*, Bojanus.

At the time when the Survey Memoir on the "Forest Bed" Vertebrata was published (1882) much doubt was expressed (p. 42) as to whether the bovine remains then known should be referred to *Bos* or *Bison*.

I am now able to speak with certainty as to the occurrence of Bison in these deposits. Mr. Randal Johnson obtained at Bacton and Happisburgh several horn-cores with frontals, undoubtedly belonging to Bison, which are now preserved in Mr. J. J. Colman's collection at Corton, and their "Forest Bed" origin seems to be attested by their mineral condition. Mr. Savin is also in possession of three examples of Bison, undoubtedly from the "Forest Bed."

The first of Mr. Savin's specimens is a much crushed horn-core with part of the skull, from the Iron-pan of the "Forest Bed" at Sidestrand. The condition of the specimen and the place where it was found leave no doubt as to its age, and, although much crushed, the unmistakable extension of the skull behind the base of the horn-core shows that it belongs to *Bison* and not to *Bos*.

The second specimen is from the "Forest Bed" of Trimingham; it consists of a pair of horn-cores from which the skull has been broken away; they are slender and more curved than in most fossil examples of the Bison; but a portion of the skull, still attached to one of the cores, shows that they were placed a little forward from the back, and consequently must be referred to *Bison*.

The third specimen is a fine large horn-core from the "Forest Bed" of Overstrand. There is not sufficient of the skull left to show its characteristic extension behind the horn-core; but it is evidently that of a Bison; being very thick and compressed at its base, where its circumference is 340 mm., and comparatively short, its length, measured along the convex surface, being 390 mm.

There can be no question as to the reference of these specimens to the genus *Bison*, and as there is no good reason for supposing that they are other than the well-known Pleistocene species, they are placed with *Bison priscus*, or rather, to use the corrected nomenclature, *Bison bonasus*, var. *priscus*.

Having then undoubted evidence of the occurrence of *Bison* in the Cromer "Forest Bed," and as all the bovine specimens hitherto found may belong to that genus. it will be necessary to remove the genus *Bos* from the lists of "Forest Bed" mammals, until there is definite proof that both forms existed.

Phoca (*Erignathus*) *barbata*, Fabricius (Bearded Seal). Pl. V. Figs. 2, 2*a*.

The genus *Phoca* has already been recorded from the Cromer "Forest Bed" (Survey Memoir, p. 29); but the specimens known did not allow of specific identification, although it was thought they might belong to *Phoca vitulina*. Mr. Savin now possesses a very fine characteristic humerus of a large Seal from Overstrand, near Cromer.

The deltoid crest as well as the proximal and distal tuberosities are somewhat broken, so much of the latter being lost that only a trace of the supra-condylar foramen remains. In spite of these defects, however, there can be no question as to the form of the bone. The deltoid crest is strongly developed and extends half-way down the bone, its outer side having a well-marked depression. The shaft is laterally compressed; the upper part of the back is rounded, but lower down there is a ridge, which passing outwards is continuous with the outer or supinator ridge. A smooth space on the inner side a little above the distal articulation shows the position of the supra-condylar foramen. The principal measurements of the bone are:—greatest length, 143 mm. (5·55 inches); short diameter of middle of shaft, 19 mm.; length of deltoid crest, 76 mm.; diameter of head, 30 mm.

On comparing this humerus with those of the Seals in the Royal College of Surgeons and in the British Museum, I find it differs in certain important points from all but one of them, namely, *Phoca barbata*, and with this it agrees so exactly in every particular, except in being a trifle smaller, that I have no hesitation in referring the fossil to the same species.

Phoca barbata is found living at the present day in the more northern parts of the Atlantic and in the Arctic Seas. Although the species has been recorded as British, yet, according to Bell (British Quadrupeds, second edition, 1874, p. 238), it seems to be very doubtful whether the species has ever been found living on the coasts of Britain. The skeleton in the British Museum is said to have come from the North Sea.

Monodon monoceros, Linn. (Narwhal).

The occurrence of the Narwhal in the "Forest Bed" was noted in the Survey Memoir, a portion of a tusk in the Norwich Museum having been identified. It is satisfactory, however, to be able to confirm this identification by a specimen of peculiar interest from the "Forest Bed" of Overstrand, near Cromer, now in the possession of Mr. Savin. It is well known that the male Narwhal has, as a rule, only one large tusk developed, and this on the left side; the right one being aborted and so small as to be entirely buried in the bones of the snout. Mr. Savin's specimen is a portion of the right side of a Narwhal's skull, which having been broken open, shows the hinder half of the aborted tusk *in situ*. This portion of tusk is 140 mm. in length and 25 mm. in diameter. The hinder end is curved inwards, as in some recent specimens, and the pulp cavity is entirely obliterated by a deposit of irregular dentine, which forms a globose mass at the base of the tusk.

Delphinapterus leucus, Pallas (Beluga, or White Whale). Plate V. Figs. 3, 3*a*.

To this genus and species is referred a fifth or sixth caudal vertebra from the "Forest Bed" of East Runton, which is more nearly perfect than most of the Cetacean vertebræ from these beds. The terminal epiphyses are wanting and the ends of the transverse processes are somewhat broken, but the forms of the centrum and neural arch are well preserved. The greatest height of the specimen, including as much of the neural spine as is present, is 113 mm.; the front surface of the centrum is slightly hollow and shows distinctly the radiating ridges from which the epiphysis has separated; it is about 76 mm. high and 68 mm. wide. The hinder surface is slightly convex and is rather smaller than the front. The greatest length of the centrum, in its present condition, is about 55 mm., so that with its epiphyses its length must have been nearly if not quite equal to its width.

The transverse processes are a little below the middle of the centrum, and their bases, or rather the sides of the centrum at their bases, are each pierced vertically by a large vascular canal, which is rather nearer the back than the front of the centrum. Immediately below the lower opening of each of these canals is another which passes obliquely through the lower part of the centrum and enters the hæmal groove, seen on the lower surface of the specimen.

Having compared this vertebra with the specimens in the Royal College of Surgeons and in the British Museum, I find it to be larger than the corresponding one in *Tursiops tursio*; but smaller than that of *Globicephalus melas, Pseudorca* or *Monodon.* It agrees, however, so nearly in size and shape with the fifth or sixth caudal vertebra of the White Whale (*Delphinapterus leucus*), that I feel justified in placing it in that species.

Mr. Savin has another vertebra from the "Forest Bed" of Overstrand which, although much damaged, is evidently from the lumbar region, and has on the under surface two distinct, oblique grooves, similar to those seen in the White Whale; but which I have been unable to find in any other Cetacean skeleton of a corresponding size. This vertebra is also referred to *D. leucus.*

A Cetacean vertebra in the Owles collection, British Museum (No. 46,290) dredged in the North Sea has been placed in this species by Mr. R. Lydekker (Cat. Foss. Mamm. Brit. Mus. part v. p. 79), but this is probably of more recent origin, as pointed out by my friend Mr. W. Davies (Geol. Mag. Dec. II. Vol. V. p. 97, 1878).

At the present day the White Whale is an inhabitant of the Arctic seas, although it has occasionally been met with on the north British coasts.

Phocæna communis, Lesson (Porpoise). Plate V. Figs. 4, 4*a*.

I have now to call attention to a caudal vertebra of a small Cetacean from the "Forest Bed" of Sidestrand. It is of similar size to that of the Dolphin, a species already recorded from these beds, but its proportions are different. The neural arch and transverse processes are broken away; but the epiphyses are firmly united and the sutures obliterated. The vertical vascular canals pass through the bases of the transverse processes, and are similar to those of the caudal vertebra of the White Whale described above. The faces of the centrum are nearly round and flat, with only a slight concavity in the middle; the height and width being each about 36 mm., while the length of the centrum is about 33 mm. or nearly equal to the width. This proportion of length to width is quite unlike what is found in the Dolphin, but agrees with that seen in the Porpoise; and indeed the agreement of this specimen with the fifth or sixth caudal vertebra of *Phocæna communis* is sufficient to justify its reference to that species.

The Porpoise is now living in the North Atlantic and is common around the coasts of Great Britain.

EXPLANATION OF PLATE V.

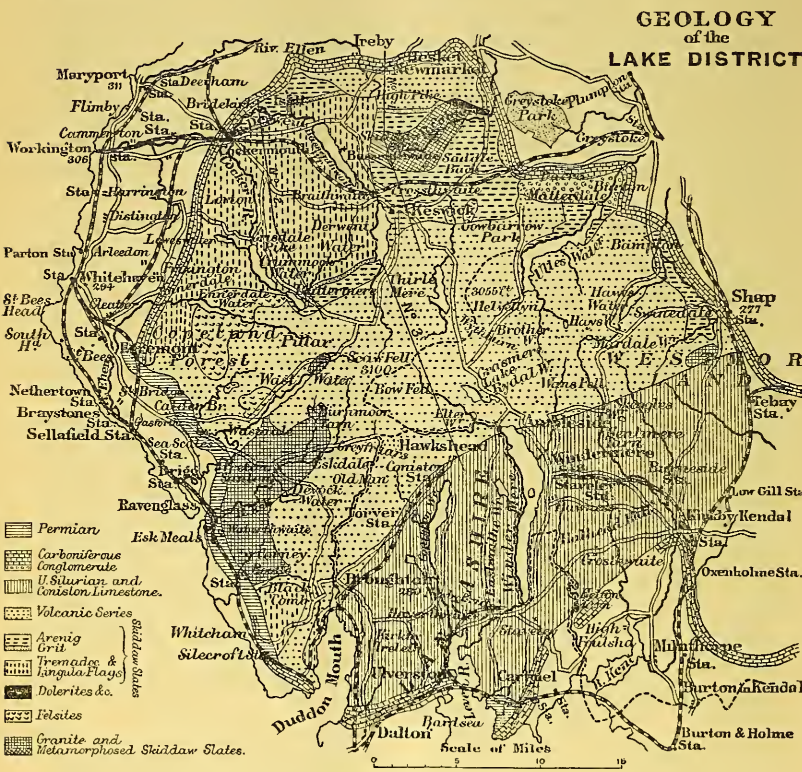
All specimens from the "Forest Bed Series" and in Mr. Savin's Collection at Cromer.

Fig. 1. *Cervus rectus*, n. sp. Right antler and frontal, from Sidestrand; front view.
Fig. 1*a*. *Cervus rectus*, side view.
Fig. 1*b*. Section of antler.
Fig. 2. *Phoca barbata*, Fabricius, Left humerus, from Overstrand, inner side.
Fig. 2*a*. *Phoca barbata*, front view.
Fig. 3. *Delphinapterus leucus*, Pallas. Caudal vertebra (5th or 6th), from East Runtou; side view.
Fig. 3*a*. *Delphinapterus leucus*, front view.
Fig. 4. *Phocæna communis*, Lesson. Caudal vertebra (5th or 6th), from Sidestrand; side view.
Fig. 4*a*. *Phocæna communis*, front view.

II.—On the Superimposed Drainage of the English Lake District.

By J. E. Marr, M.A., Sec. G.S.

"What was the condition of our present mountain tract during the great Carboniferous period? Was it wholly submerged after the elevation and denudation to which we have already seen it subject, or was there always a nucleus of dry land—an embryo of Cumbria—around which the Carboniferous deposits were laid down? I do not think this is a question that can ever be decidedly answered."[1]



It is a question which has frequently been asked, and the answers given are various. In the present communication I intend to look at it from a somewhat different point of view from that in which it has usually been approached, though the view here adopted in many respects resembles that taken by the late Mr. Hopkins.[2] The exact

[1] On the Physical History of the English Lake District, by the Rev. J. C. Ward. Geol. Mag. Dec. II. Vol. VI. p. 58.

[2] On the Elevation and Denudation of the District of the Lakes of Cumberland and Westmoreland, Q. J. G. S. vol. iv. p. 70.

influence which the faults have had in determining the trend of the major valleys is however of little importance to my present inquiry.

§ 1.—*Structure of the District.*

The well-known general structure of the district is seen in the sketch-map, which exhibits the Lower Palæozoic rocks nearly surrounded on every side by a girdle of Carboniferous Limestone, the strike of which is always approximately parallel to the line of demarcation between the older and newer rocks, the former rising up as an irregular dome within the latter. Whereas the main axis of the older rocks *within the district* runs through the Skiddaw group of hills, the present watershed is marked by an east and west line running through the Scawfell group across Kirkstone, and the passes at the heads of the Kentmere and Long Sleddale valleys to Shap Wells, whence it is continued in an easterly direction over ground occupied by Carboniferous rocks, separating the head-waters of the rivers Eden and Lune.

§ 2.—*Condition of the area at the commencement of Carboniferous times.*

Mr. Hopkins pointed out that the dip of the Carboniferous rocks was everywhere sufficient to carry them far above the present surface of the older rocks in the central part of the district, and he gives cogent reasons for supposing that they actually did so extend. As it is of the utmost importance that this point should be definitely settled, I propose here to give further arguments in favour of the submergence of the whole of the Lower Palæozoic area during Carboniferous times, and to show that the present drainage was certainly not impressed upon the district in pre-Carboniferous days.

The very uniform plain of denudation upon which the Carboniferous rocks were laid down in the Ingleborough region is well known, but those who maintain the existence of a pre-Carboniferous ridge over the area of the present Lake District require the cessation of this plain towards the west. But MM. de Koninck and Lohest[1] show that the Lower Carboniferous beds of Belgium are represented by the conglomerate of the Ingleborough district, and it is probable that beds quite as low occur in the immediate proximity of the Lake District, though this point will be definitely settled when Mr. E. J. Garwood, B.A., who is now engaged in a detailed examination of the Carbonifeous zones of the region has published his researches. If the Lake District area had stood out as an elevation at this period, the equivalents of the lowest strata of Ingleborough should be absent here. Not only does the Mountain Limestone form a nearly complete ring round the lakes, but at one point where the ring is broken by the complex group of faults uniting the Craven and Pennine fractures, great masses of the limestone are let down into the dome, as at Grey Rigg and Kendal, indicating that the limestone at any rate extended thus far.

Again, the folding of the Lower Palæozoic rocks would not give

[1] Notice sur le Parellélisme entre le calcaire Carbonifère du nord-ouest de l'Angleterre et celui de la Belgique, Bulletins de l'Académie royale de Belgique, 3me. série, t. xi. no. 6.

rise to a ridge along the present line of watershed of the Lake District, but along the centre of the anticline, though there may have been higher ridges of older rock existing to the north of the Skiddaw axis, which determined the trend of the pre-Carboniferous valleys, and that this was the case is indicated by an examination of the mode of occurrence of the irregular patches of the basal Carboniferous conglomerate, and a study of their included pebbles. These conglomerates, from their extremely local distribution, are generally and probably rightly supposed to have been deposited in the troughs of inequalities, though there is some doubt as to the region from which the material was brought. Mr. Clifton Ward, in the paper cited, comments upon the close similarity between the pebbles of the Mell Fell conglomerate to the rocks forming the Ludlow beds of the Kendal district, and the great rarity of local rocks in the conglomerate. I have recently detected a pebble in the same conglomerate at Roman Fell near Appleby, containing a fossil which appears to be *Rhynchonella nucula*, a characteristic Ludlow form. But, that these pebbles came from the south is unlikely for the reason to be noted immediately, and similar rocks occur in the southern uplands of Scotland on the south side of what probably constituted a pre-Carboniferous mountain axis, so that the drainage may well have come from this direction. Prof. Hughes has detected in the same conglomerates in the Lune Valley, pebbles of the well-known Keisley limestone of Appleby, a peculiar and easily recognizable rock, which is developed in this form in no other part of the district, and which, for reasons which cannot be here given, is unlikely to occur elsewhere. This discovery indicates a drainage on the pre-Carboniferous slopes in a southerly direction, and suggests a northern source for the pebbles of the conglomerate. Now Keisley is separated from the Lune Valley by a continuation of the main watershed of the Lake District, so that at the time of the formation of the conglomerate, if the pebbles of the Lune Valley have actually come from Keisley, *the present watershed did not exist*, and indeed the way in which the Carboniferous rocks rise from Tebay to Shap Wells, and then sink to the Eden Valley, proves that this elevation was post-Carboniferous.

Recent discoveries, it will be seen, fully confirm Mr. Hopkins's conclusion that the Carboniferous rocks were laid down over the area of the present Lake District upon an even horizontal surface.

§ 3.—*Post-Carboniferous Changes. Formation of the Dome, and Determination of the Drainage.*

The examination of the area has shown, what would be *a priori* expected, that the pre-Carboniferous drainage was not determined by the more modern Lower Palæozoic rocks of the district, and these could be converted into the highest ground of the region by no other means than a further upthrust, which took place in post-Carboniferous times. Even then, the drainage would not radiate from an area of Lower Palæozoic rocks, unless these rose above the surrounding high ground caused by the accumulation of the upheaved newer sediments, and the thickness of the latter in the immediate proximity to the centre of the district forbids the supposition that a high mountain tract over which Carboniferous rocks were never deposited arose in that centre. If we prolong the Carboniferous rocks over the present area in accordance with their various dips at the margins, we shall find that *the centre of the dome composed of these rocks would coincide with the small tract from which the principal valleys radiate*, viz. the region of Scawfell and Gable. The appearance of the eight principal valleys extending from this point, like the spokes of a wheel, is beautifully described by Wordsworth.[1] They are Windermere, Coniston, Duddon, Eskdale, Wastdale, Ennerdale, the Vale of the Cocker, and Borrowdale. Further to the east the symmetry of the dome is destroyed by its prolongation in an easterly direction as an anticlinal (though even here the Carboniferous beds dip eastward on the summit of the anticlinal axis, showing that the district does not merely comprise the end of an anticline), and by the proximity of the great faults of the Lune Valley. Here, also, the radial character of the valleys is noticeable. To the north of the axis are the vales of Thirlmere, Ulleswater, and Haweswater, and to the south, those of Kentmere, Long Sleddale, Crookdale, Bannisdale, and Wastdale. This radial arrangement is well exhibited in the case of the valleys containing the larger lakes, on examining the small map. The valleys do not in all cases coincide with the observed or theoretical faults shown by Mr. Hopkins upon his map, though the general direction is the same.

The radiating disposition of the vales could not have been determined except by a somewhat regular dome-shaped upheaval of the country, and the trend of the Lower Palæozoic rocks shows no tendency towards the formation of a dome in them before the deposition of the Carboniferous rocks, whereas, as has been above noted, the dips of the Carboniferous rocks do point to the production of a post-Carboniferous dome, whose centre coincides with the point from which the valleys diverge. The drainage system is, in fact, strikingly similar to that represented by Mr. Gilbert in the case of the Ellsworth Arch,[2] even to the slight irregularity which occurs at the north end of the latter, owing to the proximity of Mounts Holmes and Hillers, and at the east end of the Lake District owing to the anticline separating the Lune and Eden Valleys, and the faults of the Lune Valley.

It is hard to resist the conclusion that in the Lake District, as in the Henry Mountains, we have a case of *superimposed drainage*, the valleys having had their direction determined by the slopes caused by the upheaval of the Carboniferous and possibly of newer rocks, though they now run in the centre of the district entirely through Lower Palæozoic rocks, the newer rocks which were the cause of their present trends having been completely removed by denudation.

This seems to me the strongest argument in favour of the former

[1] A Complete Guide to the Lakes, third edition, page 111.

[2] Geology of the Henry Mountains, p. 139, fig. 71.

extension of the Carboniferous rocks over the district, and the study of the valley-systems of other areas will probably enable us in many cases to argue concerning the former extension of beds over regions from which they have long since disappeared.

The duration of the movement which caused the elevation of the dome is hard to determine. There is no doubt that elevation had taken place before the deposition of the New Red Sandstone deposits of Edenside and the Cumbrian coast, for the latter rest unconformably upon the Lower Palæozoic rocks in places, and the former contain fragments of Mountain Limestone, whilst the sandstones were probably derived in great part from the denudation of the Carboniferous sandstones. In connexion with this point the rarity or absence of Lower Palæozoic pebbles in the New Red breccias of Edenside is noticeable, and has been commented upon by Mr. Goodchild.[1] It furnishes another argument in favour of the extension of the Carboniferous rocks over the central part of the district. But that the elevation was entirely carried on during the time that elapsed between Carboniferous and New Red Sandstone times is negatived by the dip of the New Red itself, which, as observed by Mr. Hopkins and Mr. Goodchild, is sufficient to carry these deposits also over the central dome. Now, the north-east portion of the Lake District dome coincides with the western margin of the New Red basin of Edenside, and was therefore partly determined simultaneously with the latter.

The New Red Sandstones were apparently deposited in a fjord-like indentation produced during the deposition of these rocks (a point which is well worth working out in detail by any one who has carefully studied the characters and distribution of these rocks). But there appears to be no important physical break between the New Red deposits of Edenside and the lowest Jurassic beds of Carlisle. The position of the latter indicates that they also were deposited during the continuance of the formation of the basin, and there is no reason why these and newer Mesozoic rocks should not have once extended over the gradually rising dome of the Lake District. If this be so, the valleys of the district need not date back to any very remote period, and may even have been commenced in Tertiary times.

§ 4.—*Origin of the Dome.*

It has been observed, that although the Lake District dome is a continuation westward of an anticlinal axis, it is, nevertheless, in a certain sense distinct from this axis. Not only is this the case, but it will be noticed, on examining a geological map of England, that the dome causes a marked asymmetry in the arrangement of the Carboniferous rocks.

The north and south Pennine axis, and the east and west axis separating the coal-field of Yorkshire, Derbyshire, and Nottinghamshire from that of Newcastle, and that of South Lancashire and North Staffordshire from that of Cumberland, give rise to a cruciform

[1] Trans. Cumb. and West. Assoc. 1885, p. 37.

arrangement of the coal-fields, but the north-west part of the cross is interfered with by the Lake District dome, and hence the Cambrian coal-field is of small dimensions as compared with that of Newcastle. Whilst the widespread movements which caused this cruciform arrangement were proceeding, a local movement has produced the asymmetry of the north-west portion. To what is this local movement due? Can the comparison with the laccolitic structure be carried further, and may we suppose that a lenticle of igneous rock lies at some depth below the Lower Palæozoic rocks of the Lake District? The evidence on this point is wanting. Most of the igneous rocks which penetrate the Lake District slates appear to have been intruded before the formation of the Carboniferous deposits, and the latter are remarkably free from igneous intrusions. Those which do occur are of a basic character.

The existence of the Whin Till indicates the occurrence of large masses of basic rock at a lower level, and it might be compared with one of the outlying sheets of the Henry Mountain laccolites. But the position of the igneous masses with which it is connected are not easy to fix, and the rocks of the Lake District and the surrounding area do not exhibit the abundance of basic dykes which one would expect in the vicinity of a laccolitic mass. There are a few dykes in the Carboniferous rocks of the Whitehaven district and near Ulleswater, and another dyke pointing to the Lake District is mapped by the geological surveyors in the Carboniferous rocks of Caton Green near Lancaster. Near the centre of the dome are several radial and tangential basic dykes, as seen in the geological map of the country around Wastwater, and these dykes are newer than the numerous acid dykes which cut through the same rocks, for they displace them. We may be allowed, then, to suggest the possibility of a mass of basic rock underlying and connected with the formation of the Lake District dome, without in any way insisting upon its probability.

Be this as it may, the superimposed drainage of the Lake District appears to be an actual fact, and the occurrence of this is an interesting point in the fascinating study of the physical history of this beautiful and remarkable area.

III.—The Work of Prof. Henry Carvill Lewis in Glacial Geology.

By Warren Upham, of the United States Geological Survey.

THE recent notice[1] of the life and work of Prof. Henry Carvill Lewis, whose lamented death occurred in Manchester, July 21st, 1888, in his thirty-fifth year, well indicates the wide range of his scientific labours. He published valuable results of investigations in astronomy, mineralogy and petrology, and especially in glacial geology, the last being based on his exploration of the drift

[1] This Magazine, III. Vol. V. pp. 428–430, September, 1888. A similar but more extended notice, with portrait, appeared in the American Geologist for December, 1888.

and its terminal moraines in the United States, and later in Ireland, Wales and England. The present article reviews his contributions to our knowledge of these drift formations and of the history of the Ice Age, bringing into comparison and correlation the glacial records of America and Europe. Comprehensive as were Professor Lewis' observations and studies in this field, he was planning yet more thorough and extensive exploration of the drift in Britain, Germany and Scandinavia, when he was taken from us. In his death the geologists of two continents mourn the loss of a most gifted and faithful fellow-worker, who indeed already had achieved a grand life-work in the few years allotted to him.

Professor Lewis first became specially interested in the glacial drift and the terminal moraine of the North American ice-sheet during the later part of the year 1880, when in company with Prof. G. F. Wright he studied the remarkable osars of Andover, Mass., the gravel of Trenton, N.J., containing palæolithic implements, the drift deposits of the vicinity of New Haven, Conn., under the guidance of Professor Dana, and finally the terminal moraine in Eastern Pennsylvania, between the Delaware and Lehigh rivers. The following year Professors Lewis and Wright traversed together the southern border of the drift through Pennsylvania, from Belvidere on the Delaware west-north-west more than 200 miles across the ridges of the Alleghanies to Little Valley, near Salamanca, N.Y., and thence south-westerly 130 miles to the line dividing Pennsylvania and Ohio, which it crosses about fifteen miles north of the Ohio river. The report of this survey of the terminal moraine was published in 1884, forming volume Z of the Reports of Progress of the Second Geological Survey of Pennsylvania. With the similar exploration of other portions of this great moraine done a few years earlier by Prof. Chamberlin in Wisconsin, Profs. Cook and Smock in New Jersey. and the present writer in Long Island, thence eastward to Nantucket and Cape Cod, and also in Minnesota, it completed the demonstration of the formation of the North American drift by the agency of land-ice.

The observations of the moraine in Pennsylvania detailed in this volume are summarized by Prof. Lewis as follows:—"The line separating the glaciated from the non-glaciated regions is defined by a remarkable accumulation of unstratified drift material and boulders, which, heaped up into irregular hills and hollows over a strip of ground nearly a mile in width. forms a continuous line of drift hills (more or less marked) extending completely across the State. These hills vary in height from a few feet up to 100 or 200 feet; and while in some places they are marked merely by an unusual collection of large transported boulders, at other places an immense accumulation forms a noteworthy feature of the landscape. When typically developed this accumulation is characterized by peculiar contours of its own,—a series of *hummocks*, or low conical hills, alternate short straight ridges, and inclosed shallow basin-shaped depressions, which like inverted *hummocks* in shape are known as *kettle holes*. Large boulders are scattered over the surface; and the unstratified *till* which composes the deposit is filled with glacier-scratched boulders and fragments of all sizes and shapes."

From its lowest point in Pennsylvania, where it crosses the Delaware 250 feet above the sea-level, this terminal moraine of the ice-sheet extends indiscriminately across hills, mountains and valleys, rising over 2000 feet above the sea in crossing the Alleghanies, and attaining the maximum of 2580 feet on the high table-land farther west, being there "finely shown at an elevation higher than anywhere else in the United States."

Preliminary outlines of Professor Lewis's work on the glacial drift of England, Wales and Ireland are given in his papers in the Reports of the British Association for 1886 and 1887; and the first of these also appeared in the American Naturalist for November, and the American Journal of Science for December, 1886, and in this MAGAZINE for January, 1887. Their most important new contribution to knowledge consists in the recognition of the terminal moraines formed by the British ice-sheets, which Lewis traced across Southern Ireland from Tralee on the west to the Wicklow Mountains and Bray Head, south-east of Dublin; through the western, southern and south-eastern portions of Wales; northward by Manchester and along the Pennine Chain to the south-east edge of Westmoreland; thence south-easterly to York and again northward nearly to the mouth of the Tees, and thence south-eastward along the high coast of the North Sea to Flamborough Head and the mouth of the Humber. It is a just cause for national pride that two geologists of the United States, Lewis in Great Britain in 1886, and Salisbury[1] the next year in Germany, have been the first to discover the terminal moraines of the ice-sheets of Europe. Like the great moraines of the interior of the United States, those of both England and Germany lie far north of the southern limit of the drift.

Another very important announcement by Professor Lewis relates to the marine shells, mostly in fragments and often worn and striated, found in morainic deposits and associated kames 1100 to 1350 feet above the sea on Three Rock Mountain near Dublin, on Moel Tryfan in Northern Wales, and near Macclesfield in Cheshire, which have been generally considered by British geologists as proof of marine submergence to the depth of at least 1350 feet. These shells and fragments of shells, as Lewis has shown, were transported to their present position by the currents of the confluent ice-sheet which flowed southward from Scotland and Northern Ireland, passing over the bottom of the Irish Sea, there ploughing up its marine deposits and shells, and carrying them upward as glacial drift to these elevations, so that they afford no testimony of the former subsidence of the land. The ample descriptions of the shelly drift of these and other localities of high level, and of the lowlands of Cheshire and Lancashire, recorded by English geologists,[2] agree

[1] American Journal of Science, III. vol. xxxv. pp. 401-407, May, 1888.

[2] Quart. Journ. Geol. Soc. vol. xxx. 1874, pp. 27-42; xxxiv. 1878, pp. 383-397; xxxvi. 1880, pp. 351-5; xxxvii. 1881, pp. 351-69; and xliii. 1887, pp. 73-120; also, GEOL. MAG. Dec. II. Vol. I. 1874, pp. 193-197.

perfectly with the explanation given by Lewis, which indeed had been before suggested, so long ago as in 1874, by Belt and Goodchild.[1] This removes one of the most perplexing questions which glacialists have encountered, for nowhere else in the British Isles is there proof of any such submergence during or since the Glacial period, the maximum known being 510 feet near Airdrie in Lanarkshire, Scotland.[2] At the same time the submergence on the southern coast of England was only from 10 to 60 feet,[3] while no traces of raised beaches or of Pleistocene marine formations above the present sea-level are found in the Shetland and Orkney Islands.[4] The work and writings of Professor Lewis emphasize the principle that glacially transported marine shells and fragments of shells, which occur in both the till and Boulder-clay and the modified drift in various parts of Great Britain, are not to be confounded with shells imbedded where they were living or in raised beaches, for only these prove the former presence of the sea.

The drift deposits of England south of the terminal moraines traced by Lewis were regarded by him as due to floating ice upon a great freshwater lake held on the north by the barrier of the ice-sheet which covered Scotland, Northern England and the area of the North Sea, and on the south-east by a land barrier where the Strait of Dover has been since eroded. Under this view he attributed the formation of the Chalky boulder-clay in East Anglia, and of the Purple and Hessle boulder-clays in Lincolnshire and much of Yorkshire, to lacustrine deposition. But shortly after the British Association meeting in 1887 his observations on Frankley Hill in Worcestershire and thence westward[5] led him to accept the conclusion, so thoroughly worked out by other glacialists both in America and Great Britain, that there were two principal epochs of glaciation, divided by an interglacial epoch when the ice-sheets were mostly melted away. There can be little doubt that the continuation of Lewis's study of the drift in England, if he had lived, would have soon convinced him of the correctness of the opinions of Searles V. Wood, jun., Mr. Skertchly, and James Geikie,[6] that land-ice during the earlier glacial epoch overspread all the area of the Chalky boulder-clay, extending south to the Thames. Small portions of Northern England, however, escaped glaciation both then and during the later cold epoch, when the terminal moraines mapped by Lewis were accumulated; and these tracts of the high moorlands in Eastern Yorkshire and of the eastern flank of the

[1] Nature, vol. x. pp. 25, 26, May 14, 1874; Geol. Mag. Dec. II. Vol. I. pp. 496–510, Nov. 1874. A similar opinion was held fifty years ago by Mr. James Smith (Researches in Newer Pliocene and Post-Tertiary Geology, pp. 11, 16), though he attributed the drift to debacles instead of glaciation.

[2] Quart. Journ. Geol. Soc. vol. vi. 1850, pp. 386–8; xxi. 1865, pp. 219-21.

[3] Quart. Journ. Geol. Soc. vol. xxxiv. 1878, pp. 454-7; xxxix. 1883, p. 54. Geol. Mag. Dec. II. Vol. II. 1875, p. 229; Dec. II. Vol. vi. 1879, pp. 166–72.

[4] Quart. Journ. Geol. Soc. vol. xxxv. 1879, p. 810; xxxvi. 1880, p. 663.

[5] Geol. Mag. Dec. III. Vol. IV. pp. 515-17, Nov. 1887; Vol. V. p. 430, Sept. 1888.

[6] Quart. Journ. Geol. Soc. vol. xxxvi. 1880, pp. 463-500; Great Ice Age, second ed. pp. 350–365.

Pennine Chain[1] are similar to the driftless area of South-western Wisconsin.

Comparison of the drift in North America and Great Britain enabled Prof. Lewis to refer the British modified drift, both that often intercalated between deposits of till and that spread upon the surface in knolly and hilly kames and more evenly in plains and along valleys, to deposition from streams supplied by the glacial melting, the material being washed out of the ice-sheet. These beds are to be carefully distinguished from others, similar to them in condition and material, which are of interglacial and post-glacial age. In this connection it is also important to discriminate between subglacial till or ground moraine and englacial till that was contained in the ice-sheet. The differences marking these deposits in New England and generally through the northern United States[2] are the remarkable compactness and hardness of the subglacial till, due to compression under the ice-sheet, contrasted with the looseness of the englacial till; the abundance of glaciated stones and boulders in the former, and their comparative infrequency in the latter; and the usually greater proportion of large boulders in the englacial till. Weathering has changed the small ingredient of iron from the protoxide combinations which it still retains in the lower or subglacial till to hydrous sesquioxide in the upper or englacial till, giving to the latter a yellowish or reddish colour, in contrast with the dark grey or blue of the former.

Beds of modified drift, that is, of gravel, sand and clay, brought by streams from the melting ice-sheet, may occur (1) enclosed within subglacial till, (2) intercalated between the subglacial and englacial till, or (3) overlying all other drift formations. In the first and second cases they were deposited beneath the ice-sheet, or sometimes in the second case were laid down in front of the ice-border and afterward became covered with englacial till by an advance of the ice. Prof. C. H. Hitchcock describes abundantly fossiliferous marine modified drift which he believes to have been thus overlaid by englacial till at Portland, Maine.[3] To the third case, where the modified drift is superficial, belong osars and kames, formed in ice-walled channels, and the more extensive plains and valley drift spread along the course of the floods that descended from the ice-border to the sea. In districts to which the ice-sheet transported fragments of marine shells, these are liable to be found not only in both divisions of the till but also in any portion of the modified drift.

The geologists of Sweden record a similar order of drift formations in that country, there being generally recognizable subglacial and englacial till, with associated beds of stratified gravel, sand and clay.[4]

[1] A. Geikie's Text-Book of Geology, p. 903; Quart. Journ. Geol. Soc. vol. xxxii. 1876, pp. 184-190.

[2] Geol. Mag. Dec. II. Vol. VI. 1879, p. 283; Third Annual Report of the U.S Geological Survey, p. 297.

[3] Geology of New Hampshire, vol. iii. pp. 279-282; Geol. Mag. Dec. II. Vol. VI. 1879, pp. 248–250.

[4] American Journal of Science, III. vol. xiii. 1877, pp. 76-79; Great Ice Age, second ed. p. 405.

In north-eastern England it seems worthy of inquiry whether the Purple and Hessle boulder-clays may not be in like manner the subglacial and englacial till of a single ice-sheet, its modified drift being the Hessle gravel and sand. If this view be admissible, the Hessle beds containing *Cyrena fluminalis* and mammalian remains, where they are overlain by the Hessle boulder-clay, mark an extensive recession and subsequent advance of the ice.[1] Again, in north-western England the Lower and Upper boulder-clays and Middle beds of gravel and sand have the same relationship. These groups of drift deposits, bounded wholly or in part by the terminal moraines traced by Lewis, probably belong, like the conspicuous terminal moraines of the United States, to the second or last glacial epoch; while the Chalky boulder-clay, like the southern portion of the glacial drift in the Mississippi basin, extends beyond these to the limits of an earlier glaciation.

IV.—On Soda-Microcline from Kilimandscharo.[2]

By J. S. Hyland, Ph.D., M.A.,
Of the Geological Survey of Ireland.

The material, in which this felspar occurs, was collected by Dr. Hans Meyer during his visit in 1887 to the East-African "snow-mountain," the Kilimandscharo, and kindly entrusted to me for description by Prof. F. Zirkel of Leipzig, to whom I desire to express my indebtedness for assistance and advice supplied me whilst working in his laboratory.

The rocks which possess this mineral as felspathic constituent are Nepheline- and Leucite-basanites,[3] and were found *in sitû* on the south and south-east flanks of the Kibo peak. As rock-constituent this felspar is presumably confined to the outflows from the higher peak—the Kibo[4]—as no trace of it is to be found in the large series of rock-specimens, which represent the materials of which the other and lower peak—the Kimawenzi—is formed.

It is remarkable that Gustav Rose,[5] who described the collection of specimens brought back from the same locality by Baron von der Decken in 1861 and 1862, mentions the occurrence in a rock he terms "trachyte" of a curious porphyritic felspar "whose crystals are rhombic prisms, so that a transverse section parallel to the best cleavage face appears as a rhomb." From his description I hold this felspar to be identical with that which Dr. Meyer collected.

[1] Quart. Journ. Geol. Soc. vol. xvii. 1861, pp. 446–456, and 473–5; Great Ice Age. second ed. pp. 372–380.

[2] The orthography used by R. Andree and A. Scobel in their Map of Africa (Leipzig, 1884) is here employed.

[3] Under "Basanite" Rosenbusch (Mikrosk. Phys ii. p. 753) includes all Tertiary massive rocks, which possess as essential constituents plagioclase (usually a basic lime-soda-felspar), nepheline or leucite, augite. olivine and magnetite. The name was first employed by Alex. Brongniart (Classification et caractères minéralogiques des roches homogènes et hétérogènes, Paris et Strasbourg, 1827, pp. 102–105). This is the *first* occurrence of Leucite in Africa. For further particulars, see Hyland, "Ueber die Gesteine des Kilimandscharo und dessen Umgebung," Tschermak's Mitt. 1888, X. 203-267.

[4] 6090 metres high.

[5] Zeitschrift für allgemeine Erdkunde, Berlin, 1863, vol. xiv. p. 246.

In 1886 Mr. Miers[1] published an account of a felspar from the same locality, to which his attention had been called by Prof. Bonney, and concluded it to be an orthoclase, similar to that described by Brögger[2] in the Norwegian "Rhombenporphyr." A supplementary note[3] was issued in 1887 with analyses by Mr. Fletcher.

Several loose crystals were included in Dr. Meyer's collection, and these, although not quite fresh, favoured a study and determination of their characters.

The felspar is, when fresh, of a pearl-grey colour, with a highly vitreous lustre on both cleavage faces, and possesses the usual cleavage parallel to P and M, with a maximum length of 29 millimetres.

The following combinations were observed:

1. OP (001), ∞ P̶ ∞ (010), ∞ P (110), 2 P̶ ∞ ($\bar{2}$01) : ∞ P̶ ∞ and 2 P̶ ∞ well developed.
2. OP, ∞ P, ∞ P̶ ∞ : ∞ P (T and l) predominating: ∞ P̶ ∞ is mostly very small and often almost disappears.

OP is sometimes represented by a cleavage face; the edges of the faces are mostly rounded off.

Mr. Miers has recorded these faces in the article already referred to. The presence observed by him of a macroscopic twinning according to the Carlsbad law with the striking peculiarity, that ∞ P̶ ∞ ($\bar{1}$00) appears both as plane of composition and of twinning I was able to confirm as regards the second combination only, for wherever I found the face *y* (2 P̶ ∞) developed, there was no trace—optically or crystallographically—of any such macroscopic structure. Hence such crystals are in this respect simple individuals.

Upon careful examination of these twin-crystals a peculiar anomaly becomes apparent. The occurrence of the twin-structure demands that the two halves of such a crystal be symmetrical as regards ∞ P̶ ∞; one is in fact led to expect at the one end a roof-like top, at the other a re-entering angle (einspringenden Winkel). The latter can at once be noticed on our felspar, but the roof-like top is wanting, its place being taken by one surface, the face OP.

By striking this surface a portion flies off, and we recognize the characteristic form. Further, a section cut parallel to M (∞ P̶ ∞) from a crystal twinned after the Carlsbad type ought to be resolved under crossed Nicols into two fields optically different. In contradiction to this, such sections cut from the outermost portions of a crystal behave as if they were derived from un-twinned individuals. If, on the contrary, a section be cut parallel to the same surface, but from a point nearer the geometrical centre, one is able to observe the ordinary phenomenon and the inclination of the basal cleavages to each other can also be determined: this amounts to 42° 15′. That this curious anomaly does not owe its origin to any mistake in the directions of the sections, I was able to settle by measurement and comparison with the crystals from which the sections were

[1] Mineralogical Magazine, 1887, vii. pp. 10–11.
[2] Die silurischen Etagen 2 and 3, 1882.
[3] Min. Mag. 1887, p. 131.

prepared.[1] This conclusion is further supported by mechanically removing the outer portions of the crystals till the twin junction (Zwillingsnaht) is observed. In fact, we have probably here to deal with a nucleus twinned after the Carlsbad type, surrounded by felspar-substance free from such a structure.

From a crystallographical standpoint it is interesting to note the angle between P and M. This I have determined on several cleavage pieces, and obtain as mean 90° 3′. The physical condition of the surfaces was not very favourable for such a determination, still the variation was always very small. Miers observed 90°, and mentions that the variation never exceeded 16′. It is interesting to note, that Brögger determined 90° 3′ on the felspar from the dykes at Fredriksvärn.[2]

On examination under the microscope Mr. Miers[3] observed that parts of the crystals viewed by polarized light exhibited a well-defined cross-hatching parallel to the pinacoidal faces, but could, however, discover no trace of striation on sections parallel to OP. On the contrary, all the crystals I examined—ten in number—were seen to be built up of fine triclinic lamellæ of variable breadth. The examination of numerous sections cut parallel to OP showed that the lamellæ mostly follow the albite law; in such sections the extinction is nearly parallel and perpendicular to the edge P:M.

The extinction of the very fine striæ on OP may be measured as 1°—2°, the larger ones ascending to $3\frac{1}{2}$°. The surface of such a striated section under crossed Nicols is therefore never dark. Certain portions however exhibit no striæ, in fact the lamellæ appear to taper off and finally disappear. Brögger has made a similar observation.

Sections parallel to M possess an extinction-angle of 5°—6° and exhibit no striation.

One very thin section parallel to OP from the middle of a crystal showed at certain portions, in addition to the striæ of the albite type, a second system crossing these at right angles, thus producing a structure similar to though not perhaps identical with that of microcline. This microcline-structure is, however, to be seen best in sections cut at right angles to P and M. Such sections appear composed of very fine and distinct lamellæ crossed by another series perpendicular to the first and of irregular breadth. The extinction-angle is here 8°—11° to their length, but others appear to possess a straight extinction.

The triclinic character of the felspar is well marked in the rock-sections. The felspars of the ground-mass are identical with their porphyritic representatives, although the former are mostly lath-shaped. Where, however, the felspar forms laths of very small breadth, there is certainly no striation to be recognized; but this is an observation already made by those writers who have examined the felspar of the "Rhombenporphyr," to which, as has been

[1] The sections were made by Fuess of Berlin, and Voigt and Hochgesang of Göttingen.

[2] Brögger, op. cit. p. 259.

[3] l.c. p. 11.

stated, the felspar from Kilimandscharo bears a striking resemblance. I see nothing to lead one to conclude, that the ground-mass consists of felspar, which is partly monoclinic, partly triclinic, and as the result of my observations I must agree with Mügge,[1] when he accounts for the phenomenon by the fineness of the striæ combined with the small extinction-angle.

With regard to the chemical constitution the felspar was first analysed by Mr. Fletcher, who was unable to remove the numerous inclusions of glass and other material present. By means of a laborious method, which occupied nearly two weeks, I was enabled to separate these inclusions and to satisfy myself by microscopical examination of the powder that it was chemically pure.

The sp.g. was determined with aid of the Westphal balance to be 2·63 at a temperature of 18° C.

For comparison the composition of similar felspars from Svenör, Tyveholmen, and Pantelleria are given.

I. Felspar from Kilimandscharo (mean of two analyses) *Fletcher.*
II. do. do. do. *Hyland.*
III. Felspar from the Augitesyenite of Svenör. *Vogt.*[2]
IV. Felspar from the "Rhombenporphyr" of Tyveholmen. *Fischer.*[3]
V. "Plagioclase" from Cuddia Mida, Pantelleria. *Förstner.*[4]

	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	K_2O	Na_2O	H_2O etc.	Totals.	Oxygen ratios.	Sp.g.
I.	60·78	2·32	23·0	2·84	trace	4·50	6·65	0·21	100·30	9·88 : 3·3 : 1	—
II	61·3	—[5]	23·1	3·02	—	5·34	7·11	0·09	99·96	9·08 : 3·02 : 1	2·63
III.	61·35	—	22·37	4·66	0·04	4·97	6·59	—	99·98	8·41 : 2·7 : 1	2·63
IV.	59·50	2·47	22·69	5·05	0·42	2·50	6·38	1·34	100·35	8·65 : 2·9 : 1	2·65
V.	66·63	0·72	19·76	0·38	0·30	4·86	7·31	—	99·96	12·1 : 3·1 : 1	2·55

From a chemical standpoint the constitution of this felspar is remarkable inasmuch as there is present, in addition to a large amount of soda, a considerable quantity of potash. Further, that the 3·02 % of lime found cannot be accounted for by inclusions of apatite or other lime-bearing minerals is evident, when we remember the pure condition of the powder analysed and the fact that the removal of the inclusions increased the amount of lime found, as a comparison with the analysis made by Mr. Fletcher shows. We may therefore consider this mineral as an admixture of lime, soda, and potash felspars, distinguished, however, from all other such compounds by the fineness of the triclinic lamellæ. My analysis is therefore equivalent to a molecular relation of 1 Mol. $Ca\ Al_2\ Si_2\ O_8$: 2·1 Mol. $KAl\ Si_3\ O_8$: 4·02 Mol. $Na\ Al\ Si_3\ O_8$. There is therefore present 1 Mol. $KAl\ Si_3\ O_8$ to 1·91 Mol. $Na\ Al\ Si_3\ O_8$. Mr. Fletcher gives $An_1\ Or_{0{\cdot}94}\ Ab_{2{\cdot}11}$ and has therefore regarded the composition of anorthite as $Ca_2\ Al_4\ Si_4\ O_{16}$. Förstner and others

[1] "Feldspath aus dem Rhombenporphyr von Christiania," Neues Jahrbuch, 1881, 2, p. 114.
[2] Brögger, op. cit. p 261.
[3] Mügge, l.c. p. 119.
[4] "Ueber die Feldspathe von Pantelleria," Z. f. Kryst. viii. 2 u. 3, p. 182.
[5] There was no trace of iron.

Locality.	Rock.	Molecular ratio.			Ratio of $KAlSi_3O_8$ to $NaAlSi_3O_8$		Sp.g.	Obliquity of Extinction.		Authors.
		$CaAl_2Si_2O_8$	$KAlSi_3O_8$	$NaAlSi_3O_8$	$KAlSi_3O_8$	$NaAlSi_3O_8$		On P	On M	
Pico do Teyde, Teneriffe	Vitreous Lava ...	1	1·96	4·94	1	2·52	2·59	3,80°	9,30°	Deville[1] & Förstner
Fréjus in the Esterelgebirge	Dacite	1	0·34	1·14	1	3·35	2·68	$\bar{1}^\circ$—$\bar{3}^\circ$	$\bar{2}$—$\bar{5}$	Rammelsberg, Descloizeaux.[2]
Lille Frogner, Christianiageb.	Rhombenporphyr	1	0·80	0·90	1	1·12	—	$\bar{1}$—$\bar{2}$	$\bar{5\frac{1}{2}}$—$\bar{6\frac{1}{2}}$	Brögger, Kjerulf.
Svenör	Augite-syenite ...	1	1·18	2·48	1	2·1	2·63	1—2	?	Brögger, Vogt.
Cuddia Mida Pantelleria ...	Vitreous Pantellerite	1	7·36	16·86	1	2·29	2·56	2,10	9,80	Förstner.[3]
Kilimandscharo	Nepheline Leucite Basanite	1	2·1	4·02	1	1·91	2·63	1—2	5—6	Hyland.

[1] Comptes rendus, 1844, 19, p. 46. [2] Rammelsberg, Min. Chem. 1875, p. 569, and Deville, Bull. géol. (2), 6, p. 410. [3] *loc. cit.*

take, however, only one molecule, which course has also been followed in this paper. Considering the formula to be $Ca\ Al_2\ Si_2\ O_8$, Mr. Fletcher's ratio would be $An_1\ Or_{1\cdot 83}\ Ab_{4\ 22}$.

The triclinic nature of the felspar having been shown, there remains only to add that according to Brögger's view the felspar should receive the name "soda-microcline."

Mügge[1] has described the occurrence of a "Natron-Mikroklin" in the younger igneous rocks from the neighbourhood of Naiwaseha Lake and (*in situ*) from the Kiwangaine Valley, two localities not far from the Kilimandscharo *massif*.[2] This felspar contains "along with Na and K some Ca." Unfortunately no quantitative analysis is given.

It is interesting to compare the Kilimandscharo felspar with others of a similar character from various districts. The following table will assist the comparison.

The interpositions are very numerous and may be recognized as olivine, augite-needles, apatite, particles of the ground-mass with its constituent minerals, and devitrified glass enclosures. The latter mostly possess a regularity in their relative positions to each other, and appear in sections cut at right angles to P and M rudely rectangular. At places grouped round the vesicles in the felspar occur very fine acicular crystals, which are brown and show a decided dichroism.

[1] N. Jahrbuch, 1886, Beilage-Band iv. p. 591.

[2] Kiwangaine lies 130 kilometres N.W. of Kilimandscharo.

These remind the observer of breislakite, although their presence in the felspar-substance instead of lining the vesicles may appear to contradict this diagnosis. If they be not breislakite they may possibly be cossyrite,[1] but their smallness does not permit of a more definite determination.

V.—On some Physical Changes in the Earth's Crust.

(*Part III.*)

By Charles Ricketts, M.D., F.G.S.

(*Concluded from* p. 119.)

On the western flanks of the Malverns, the Upper Silurians are folded in several great anticlinals and synclinals, formed parallel to the axis of the Hill itself. To the west of Ledbury and again near Woolhope these contorted strata dip beneath the Old Red Sandstone, which, as computed by Phillips, has a maximum thickness of 8000 feet,[2] that of the Upper Silurians being 2690 feet.

The thickness of the strata of which the Longmynd is formed has been estimated by the Government Surveyors at not less than 26,000 feet, as exposed in their highly inclined edges; the beds dipping at an average inclination of 60° to the W.N.W.[3] They thus appear as if they had been tilted by pressure against the more ancient rocks of the Caer Caradoc Range.

In each of these instances the immense accumulations formed may have had effect in causing the great disturbance to which the strata have been subjected. Whether the ridges of the Malverns or of the Caradoc Range are recognized as having once formed the summits of ancient mountains, or the dividing ridges between valleys, there is abundant evidence that a great thickness of sediment has been laid down in their vicinity, burying the slopes on their sculptured sides; the deposit being greater at a moderate distance, where the slopes extend deeper, than near the summits.

An example affording more conclusive evidence of the nature of the causes by which contortions and cleavage are produced occurs in the neighbourhood of Llangollen. At three different periods during Palæozoic times, namely, the Lower Silurian, the Upper Silurian, and the Carboniferous periods, the area around Llangollen continuously sank below the sea-level whilst deposits were accumulating. Three times they were raised above that level, and at the same time these deposits underwent denudation; *i.e.* previous to the deposition of the Upper Silurians, the Limestone and later Carboniferous rocks, and again as we observe at present. During each of these periods valleys were excavated to a depth so great, that the summits so far presented a mountainous character that they were raised 1500 feet and more above the then sea-level.

Previous to the deposition of the Upper Silurian strata, a pre-Wenlock valley was excavated in those of the Bala formation to a

[1] H. Förstner, "Ueber Cossyrit, ein Mineral aus den Liparitlaven von Pantelleria," Zeits. f. Kryst. 1881, Y 348-362.

[2] Mem. Geol. Survey, vol. ii. pt. i. p. 102.

[3] Siluria, 1859, p. 23.

depth greater than that of the present valley; and in width extending from Llansantfraid Glyn Ceiriog, to the Cyrn-y-brain mountain, a distance from each other of seven miles in a direct line. Between these two points, though the strata have been deeply cut into, by the formation of the present valley of the Dee, no traces of the older rocks are discovered. Upon each side of this assumed valley, especially where the Upper Silurian strata abut against the older or Bala rocks, bendings and foldings have taken place, and slaty-cleavage has been developed, whilst at Llangollen, half-way between the two localities, the beds are seen, in the course of the river Dee, lying in a horizontal position. It has been already shown that such foldings could not have resulted from compression produced solely by subsidence to the extent indicated by the thickness of the deposit. This may be considered to be further confirmed in the same locality, where a repetition of the circumstances has so far taken place, that a deep valley, formed by the denudation of this Wenlock rock, had its bottom covered with the Red Basement beds of the Carboniferous system, and was subsequently buried underneath a deposit of 1025 feet[1] of limestone, which, instead of folding, has a dip of 15° only to the N.E., passing beneath 3000 to 4000 feet[2] of later Carboniferous strata. There are essential differences in the character of the deposits in the two periods; the Silurian, consisting of fine mud, which, long after its deposition, would remain in a plastic state and readily yield when subjected to irregular pressure, whilst the limestone would soon consolidate and become rigid.[3]

In the Ingleborough district the Lower and Upper Silurians are greatly bent and contorted, and the muddy deposits are also cleaved;[4] they were greatly denuded, and formed hills and valleys, previous to the deposition upon them of the Carboniferous limestone, "the lowest beds of which," as Playfair (§ 197) remarked, "contain in them many fragments of stone which, on comparison, resemble exactly the schistus underneath." A thickness of limestone, amounting to 600 feet, rests on the basset edges of the Silurians, and this is surmounted, as seen in the mountain peaks of

[1] The Carboniferous Limestone and Cefn-y-fedw Sandstone of North Wales by G. H. Morton, F.G.S., p. 21.

[2] The Coal-fields of Great Britain, by Professor E. Hull, 2nd ed. p. 99.

[3] I have seen at least ten instances where the Carboniferous Limestone during the period of its formation had been locally raised above the sea-level, and had thus been exposed for a time to atmospheric action and erosion. In eight of the examples thin beds of coal were formed, either resting immediately on the sculptured surface, or on a bed of clay which covered it; the thickest amounts to about a foot, at Ingleton; others varied down to a mere film of carbonaceous matter in the clayey deposit. Subsidence taking place, the deposition of the limestone again progressed to a great extent. The methods of weathering go to prove that the limestone had become consolidated previously to its elevation and erosion; in some cases shrinkage joints are present, and are filled with calcite, which stands out in relief on the eroded surface; the condition of these small joints indicates that the limestone must have become solidified before being raised above the sea-level, prior to the formation of the coaly beds. In some instances angular or weathered fragments of limestone are embedded in the clayey deposit which fills hollows in the surface of the limestone.

[4] They have been described in an Essay by Professor T. McK. Hughes, "On the Break between the Upper and Lower Silurians of the Lake District," Geol. Mag. Vol. IV. p. 346.

Whernside, Ingleborough and Penigent, by the Yoredales and Millstone Grit. These also were formerly covered by a considerable thickness of Coal-measures, as is evident from the presence of the Coal-field of Ingleton on the southern or down-throw side of the Great Craven Fault; whilst the whole series rested in a position as horizontal as when first laid down, though, in order to permit the accumulation of this succession of strata, they must have sunk continuously whilst deposition progressed, until their base reached a depth of 4500 feet, as calculated by Professor John Phillips.[1]

The difference in the conditions of the two series is remarkable; for if the foldings in the more ancient strata are attributable to lateral pressure, due to subsidence, they should have occurred also, at least to some extent, in the Carboniferous rocks in which subsidence took place to the depth of nearly a mile. It is therefore necessary to search for other causes likely to effect this pressure.

Sir Charles Lyell, when commenting on the presence of the "mud lumps" at one or other of the mouths of the Mississippi, attributed their formation to "the downward pressure of the gravel, sand and sediment, accumulated during the flood season off the various mouths of the river, upon a yielding bottom of fine mud and sand. A mass of such enormous volume and weight, thrown down on a foundation of yielding mud, may well be conceived to exert a downward pressure, capable of squeezing and forcing up laterally some parts of the adjoining bottom of the gulf, so as to give rise to new shoals and islands." He further states "that railway engineers are familiar with the swelling of a peat moss, or the bed of a morass, on some adjoining part of which a new embankment has been constructed.[2] A friend who, many years ago, was engaged in superintending the erection of a fort near the mouth of the Medway, relates that the unloading of a cargo of materials to be used in its construction caused a considerable deviation from the perpendicular, and great difficulty was likewise experienced in keeping the structure erect as it progressed, on account of the muddy deposit, on which the foundations rested, giving way irregularly.

Captain C. E. Dutton, of U.S. Geological Survey, states that "wherever the load of sediment becomes heaviest, there they sink deepest, protruding the colloid magma beneath them to the adjoining areas which are less heavily weighted, forming at once both synclinals and anticlinals."[3]

Though Lyell, as has been already remarked, considered that the intense pressure by which foldings of strata have been caused, has been exerted without violence, and in the most gradual manner, he omitted to apply the phenomena, described by him as occurring at the mouth of the Mississippi, in explanation of the cause of contortions in older rocks.

[1] Report on the Probability of the Occurrence of Coal in the Vicinity of Lancaster, 1837.

[2] Principles of Geology, 10th edit. vol. i. p. 453.

[3] The Earth's Physical Evolution, The Penn Monthly, 1876, p. 424; also a resumé of the same, by Rev. O. Fisher, Geol. Mag. Dec. II. Vol. III. p. 374.

It is deserving of consideration whether, and to what extent, foldings of strata, and other concomitant phenomena, have been dependent on varying accumulations of material. A river brings down and deposits a greater quantity and coarser particles, in an estuary or bay, or in the sea, along the direction of its current, than at a distance, where the finer mud is spread out; when this occurs above an underlying muddy deposit, there would be a tendency for the heavier materials to sink down and, producing displacement, so cause lateral pressure similar to that to which these foldings have been

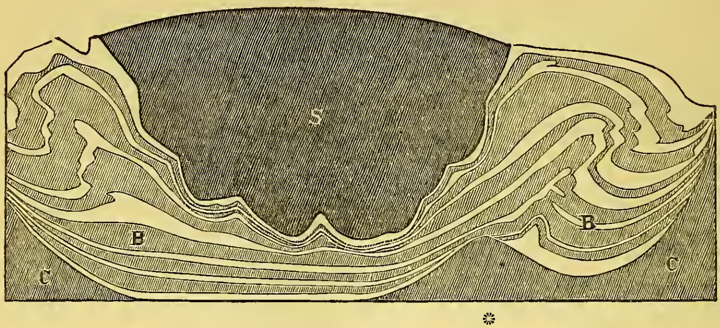


Fig. 4. C, consolidated Clay; B, layers of Clay, originally in horizontal beds, but squeezed into folds by the vertical pressure of S, sand, extra weight being applied.

attributed since the days of Sir James Hall. Effects corresponding to these suppositions can be readily induced by taking clay dried and reduced to powder and spread in consecutive layers of different colours horizontally in a box or trough. On the access of water, through holes previously made in the bottom and sides of the box rather than by pouring it on the surface (for that would prevent the free escape of the included air) the clay becomes soft and plastic; when fully saturated, by pouring sand on the clay at some special part and applying extra weight, which will be requisite in the experiment, this will not only cause the heavier substance to subside into the plastic mass of clay, but, whilst pressing downward, it will at the same time squeeze outward the clay-beds, causing the layers immediately underneath to be formed into films; these, however thin, are still continuous with those on the sides, which are rendered considerably thicker than in the original state of the beds, and are curved into folds, representing contortions similar to what are constantly met with, having been produced under circumstances analogous to what must frequently occur from natural causes (see Fig. 4).

That the form of the contortions may be greatly influenced by the contour of the solid ground is well illustrated in the effects produced by the presence of the mound (*) of consolidated clay (C) in the figured model. (The interior of the models was displayed by cutting through them, before they became solid, by means of a piece of string, previously arranged for that purpose.)

From the great thickness of certain geological strata, from the amount of deposit known by borings to occur in the Deltas of great rivers, and what may be inferred from the contour of bays, which are the submerged continuation of valleys into which rivers flow, there must be sufficient, perhaps more than sufficient, power developed, not only to account for progressive subsidence of the Earth's crust, but also to induce simultaneously, when circumstances are favourable, such lateral pressure, in the manner suggested, as would terminate in contortion and cleavage. However frequently such contortions may occur at the present time, opportunities of proving their existence must indeed be rare, for, formed beneath the surface of the water, if by any means they should become raised above the sea-level, the exposed surface of such easily disintegrated materials would be soon washed away by the waves.

The contortions which occur in metamorphic rocks must, at least in a great measure, be dependent on other causes than those which have been considered. The abrupt bendings they have sometimes undergone; the wavy wrinkled state into which they are at other times thrown, indicate that, to use an expression made to me by the Scotch chemist and mineralogist, Professor M. F. Heddle, M.D. of St. Andrews, "they must be due to some internal change." Mr. T. F. Jameson, F.G.S., "supposes that the heat from the interior of the earth gradually approached the base of the sedimentary beds and, by heating, caused them to expand and thereby become wrinkled into huge folds, as a necessary consequence of a great mass of swollen matter having to find room in the space occupied by the same matter when in a cold and contracted state.[1] Considered alone, this does not appear an altogether satisfactory explanation of the formation of such contortions as sometimes occur in metamorphic rocks. If the abrupt bendings alluded to are entirely the result of expansion from being subjected to excessive heat, it might be expected that in all cases foldings would result to a greater or less extent; or that, if so great expansion does take place, on the cooling and consequent contraction of the mass, the resulting fissures should, in gneissic and granitic rocks, have their sides separate from each other to a greater extent than is the case; the average width of which does not appear to be greater than in unaltered strata. The shrinkage of basalt and lavas forms prisms, the joints of which are in close contact with each other, though the mass in which they exist has cooled from an absolutely molten state. Mr. Charles Babbage[2] calculated, from the result of experiments by Mr. H. C. Bartlett, of the United States Engineers, that if a mass of granite, twenty-five miles in thickness, be heated to 1000°, expansion would take place to the extent of 637 feet only; that is, there would be an extension of its bulk equivalent to about $\frac{1}{207}$ of its size in a cold state. The results of other experiments, made by Mr. A. J. Adie, and by Mr. T. Mellard Reade,[3] do not greatly differ from those of Mr. Bartlett.

The expansion of rocks by increase of heat has by some been considered to be the cause of elevation of the land. Doctor James

[1] Quart. Journ. Geol. Soc. vol. xxvii. p. 105.
[2] The Ninth Bridgewater Treatise, Appendix, p. 222.
[3] Origin of Mountains, p. 109.

Hutton, in his celebrated work, states that "the power of heat for the expansion of bodies is. so far as we know, unlimited; but, by the expansion of bodies placed under the strata at the bottom of the sea, the elevation of those strata may be effected; the question to be resolved regards the actual exertion of this power of expansion, how far it is to be concluded as having been employed in the production of this earth above the level of the sea. There has been exerted an extreme degree of heat below the strata formed at the bottom of the sea, and this is precisely the action of a power required for the elevation of those heated bodies into a higher place. Therefore, if there is no other way in which we may conceive this event to have been brought about, consistent with the present state of things, or what actually appears, we shall have a right to conclude that such had been the order of procedure in natural things, and that the strata formed at the bottom of the sea had been elevated, as well as consolidated, by means of subterranean heat." [1] This coincides with the hypothesis advanced by Mr. Charles Babbage, nearly forty years subsequently, as a cause of disturbances of the earth's crust; having been suggested to him by the changes of level, proved to have occurred within a comparatively short period, at the site of the Temple of Serapis, in the Bay of Naples.[2] Mr. T. Mellard Reade considers "mountain ranges are ridgings up of the earth's crust, which take place only in areas of great sedimentation. That the existing cause of the various horizontal and vertical strains, ending in the birth of a mountain-range, is the rise of the isogeotherms and consequent increase of temperature of the new sedimentaries, and that portion of the old crust they overlie. The tendency to expand horizontally is checked by the mass of the earth's crust bounding the locally heated area, and is therefore forced to expend its energies within itself; hence arise foldings of lengthening strata, re-packing of beds, ridging up, and elevatory movements, which occur in varied forms according to the conditions present in each case." [3] He thinks "this mass of rock cannot expand laterally, for in that case it would displace the crust of the earth surrounding the affected area, nor downwards, for that would displace the foundations of the earth itself. It is only free to expand upwards." [4]

The expression, "*if there is no other way*," indicates that Hutton felt some misgiving in supposing the elevation of the strata was due to the effect of expansion from the accession of subterranean heat, and that he suggested the theory for want of a better. With respect to this proposal, as advanced by Babbage, the Rev. O. Fisher remarks that "the heat conducted upwards into the new deposits must be abstracted from the couches beneath, so that there can be no absolute increase in the amount of the heat beneath the area in question, except such as is supplied laterally." [5] It therefore follows, that there would be as great a diminution in size of the contiguous

[1] Theory of the Earth, by James Hutton, M.D., F.R S.E., 1795, vol. i. p. 123.
[2] Proc. Geol. Soc. vol. ii. p. 73; Quart. Journ. Geol. Soc. vol. iii. p. 186.
[3] Origin of Mountain Ranges, by T. Mellard Reade, C.E., F.G.S., p. 326.
[4] Page 10.
[5] Physics of the Earth's Crust, p. 82.

portion of the interior mass as would be equivalent to the increased size caused by the heat supplied to the later formed strata. Independently of this, the calculations deduced from the expansion of rocks by heat, as determined by the experiments of Bartlett, Adie and Mellard Reade, indicate that when exposed to high degrees of temperature, the enlargement is not sufficient to induce more than a fractional part of what is attributed to it.

Elevation of land does not occur where the greatest amount of accumulation is in progress; on the contrary at the mouths of great rivers, where simultaneously with, or rather, as is here contended, in consequence of the immense accretion of sediments derived from the erosion of the land, and brought down and deposited, subsidence has been proved to have taken place to a very great extent, forming conditions such as it is considered by most would render the deeply buried strata liable to be exposed to an increase of heat supplied from below. It is in those areas where the greatest amount of denudation has taken place, and the land has become lightened in the process of removal, that elevation occurs.

It is evident that where foldings occur, in what may be designated unaltered strata, they have been formed at the sea-level or at some moderate depth; if in those in which extensive chemical change has produced a re-arrangement in their constituent components, they have been buried beneath a very thick covering of strata, which has enabled them to become affected by internal heat. However high they may subsequently have become elevated, this pre-supposes the removal of this immense quantity of material before the metamorphic rock became exposed at the surface, and formed a portion of the structure of mountains.

From the examination of the geological structure of Britain it is seen that the erosion of these hard rocks, and their formation into hills and valleys, during a former period, though they may have subsequently sunk below the then sea-level, and been deeply buried beneath large accumulations of sediment, have still had a great effect in determining the present contour of the land. The flanks of buried valleys and the summits of ancient hills again become elevated and exposed by the removal of the less consolidated strata; the hardness and indestructibility which preserved them before, again enables them to stand conspicuous at a higher altitude than later deposits, and to form what has been called "the core of the mountain"; even the old valleys sometimes again serve the purpose by and for which they were originally formed; and streams run in them in the same course, often in the identical old channels.

VI.—Mr. E. T. Newton on Pterosauria.

By Dr. G. Baur, New Haven, Conn.

THE paper by Mr. E. T. Newton[1] "On the Skull of *Scaphognathus*" is one of the most important contributions to the morphology of

[1] Newton, E. T., "On the Skull, Brain, and Auditory Organ of a New Species of Pterosaurian (*Scaphognathus Purdoni*), from the Upper Lias near Whitby, Yorkshire," Philos. Trans. Lond. 1888, vol. 179, pp. 303-537, pl. 77-78.

the Pterosauria [1] which has been published. There are a few points. however, which appear to me to need correction or a fuller explanation,

1. *The "prefontals,"* Newton.

When Mr. Newton had the great kindness to show me the specimen, which he had worked out with so much skill, I suggested to him that the bones called by him "prefrontals" (*loc. cit.* p. 505) were probably parts of the nasals only. It seems to me quite probable that this view is correct, and I give the following reasons:

1. If the "prefrontals," Newton, represented these bones, they would have a position different from that in any other form of the *Monocondylia*, Haeckel, 1866 (*Sauropsida*, Huxley, 1869). They would be placed inside of the nasals.

2. They would not form a part of the orbit, a condition found in all the Monocondylia in which a prefrontal is present. As we can hardly expect such a fundamental difference between the Pterosauria and the other reptiles, this view is very improbable.

But Mr. Newton remarks, if the bones called prefrontal and nasal represent a single element, there will be no distinct prefrontal bones. In fact, the prefrontal is not free in the Pterosauria, exactly as in birds. The prefrontal probably forms the anterior and outer process of the frontals, contributing to the upper anterior border of the orbit, or it may be co-ossified with the lachrymal, as stated by Dr. Günther. The processes of the frontal, which I am inclined to consider as prefrontals, are well represented in figs. 1, 2, 3 in Mr. Newton's memoir.

The figure given by Hallmann[2] represents the relations very well. The bones called "nasals" and "prefrontals" by Mr. Newton therefore represent only one pair of bones, the nasals.

2. *The quadrato-jugal and jugal.*

The exact connection between these bones is now determined, by Mr. Newton's studies, for the first time; but the peculiar resem-

[1] I use the name *Pterosauria*, which was introduced by Kaup in 1834 in the form "Pterosaurii" (Kaup, J. J., "Versuch einer Eintheilung der Säugethiere in 6 Stämme und der Reptilen in 6 Ordnungen," Isis, 1834, p. 315.

In the same year Carus established the group "*Alata*" to contain *Pterodactylus* (Carus, Carl Gustav: Lehrbuch der vergleichenden Zootomie, 2 Aufl. Leipzig, 1834, pt. i 25).

In 1835 de Blainville called those reptiles the *Pterodactylia* (preoccupied by Latreille, 1825, for a "family of Birds," *Pterodactyli*) (de Blainville, H., "Description de quelques espèces de Reptiles de la Californie, précédée de l'analyse du système général erpétologie et d'amphibiologie," Nouv. Ann. du Musée, tome iv. p. 238, Paris, 1835). In the same paper the Ichthyosaurs are separated from the Plesiosaurs, under the names *Ichthyosauria* and *Plesiosauria*. These names antedate the *Ichthyopterygia* and *Sauropterygia* of Owen by twenty-five years. *Ornithosauri* was used by Fitzinger in 1837 (Ann. Wien Mus. Naturg. 1837, vol. ii. p. 184), and adopted by Bonaparte in 1838 (Nuovi Annali delle Scienze naturali, Bologna, 1838, vol. i. pp. 391-397). In 1841 Owen gave the name *Pterosauria* (Brit. Assoc. Rep. (1840), London, 1841).

[2] Hallmann, Eduard, "Die vergleichende Osteologie des Schläfenbeins" (Hanover, 1837), pl. ii. fig. 4.

blance between these elements and the corresponding bones in the Sauropoda [1] is not stated.

In both, the jugal has two upper processes, which form the anterior and inferior part of the orbit.

In *Diplodocus* the quadrato-jugal is connected directly with the maxillary; a condition which seems to exist in *Scaphognathus*. Newton says the maxillary "comes below the lower angle of the jugal, and seems to meet the quadrato-jugal" (p. 505). Some of the Testudinata (*Staurotypus, Aromochelys* . . .) show a similar structure.

The tendency of the quadrato-jugal in *Scaphognathus* to separate the postorbital from the jugal is very remarkable.

3. *The "supra-temporal."*

"At the outer end of each paroccipital process, and forming the hindermost angles of the skull, there seems to have been a small separate bone, which occupies the position of, and probably is the supratemporal, a bone said to be constantly present in Lizards." (Newton, p. 507.)

A supratemporal bone has not been found in any member of the group to which the Pterosauria belong. It is absent in the Phytosauria, Crocodilia, Dinosauria, and Aves. This makes it probable, that it did not exist as a free element in the *Pterosauria*. The supratemporal, Newton, may be only a part of the paroccipital or squamosal.

4. *The "basipterygoid processes."*

Mr. Newton suggests the possibility that these processes may be separate bones (p. 507), but on p. 509 he is inclined to consider these as *elongated* basipterygoid processes. It is quite evident that they cannot represent anything else.[2] In the Sauropoda they are developed in the same way.

5. *Some notes on the synopsis of genera of the Pterosauria given by Mr. E. T. Newton.*

In his "Notes on Pterodactyls"[3] Mr. Newton follows Lydekker in adopting his (Lydekker's) genus *Ptenodracon.*[4]

This name is a synonym of *Ornithocephalus*, Seeley (non Sömmering). Both Lydekker and Newton say, without apparent authority, that Zittel[5] had shown Seeley's name *Ornithocephalus* to be inadmissible. Zittel did not admit *Ornithocephalus*, Seeley,

[1] Marsh, O. C., "Principal Characters of American Jurassic Dinosaurs, part vii. On the Diplodocidæ, a new family of the Sauropoda," Amer. Journ. Sci. vol. xxvii. (Febr. 1884), pl. iii. figs. 1–3.

[2] Prof. Fraas considered these parts even as "hyoids," Palæontographica, vol. xxv.

[3] Newton, E. T., "Notes on Pterodactyls," Proc. Geologists' Assoc. vol. x. No. 8, 1888.

[4] Lydekker, Richard, "Catalogue of the Fossil Reptilia and Amphibia in the British Museum," Part i. London, 1888, p. 3.

[5] Zittel, Karl. A., "Ueber Flugsaurier aus dem lithographischen Schiefer Bayerns," Palæontographica, vol. xxix. 1882, p. 80.

because he considered it to be the same genus as *Pterodactylus*, and this was his only reason for rejecting the name.

Zittel's words are: "Die Gattung *Ornithocephalus* (Sömmering) [2] wird von Seeley folgendermaassen characterisirt: '*Ornithocephalus.*—The anterior nares are entirely separated from the middle holes of the head, both being small and the latter exceedingly small. The head is short. The neck is short. The large ischium appears to be excluded from the acetabulum, and the ilium appears to extend less far forward than in *Pterodactylus.*' Diese Diagnose stützt sich lediglich auf die ungenaue Abbildung Sömmering's. Es bedarf nur eines Blickes auf Taf. xii. fig. 3 [in Zittel's work], sowie auf die obigen Bemerkungen um sich zu überzeugen, dass die für die Gattung *Ornithocephalus* angegebenen Merkmale theils am Original garnicht vorhanden sind, theils ihre Erklärung in dem Erhaltungszustand finden. *Ornithocephalus*, Sömmering,[1] fällt somit, wie schon alle früheren Autoren annahmen, unter die Synonymik von *Pterodactylus.*"

If "*Ornithocephalus brevirostris*, Sömmering," is different from *Pterodactylus*, the name *Ornithocephalus*, restricted by Seeley to this species, has to stand, and not *Ptenodracon*, Lydekker.

The genus *Ornithopterus* (v. Meyer, 1838), of which Huxley says, "I am much inclined to suspect that the fossil upon which the genus *Ornithopterus* has been founded appertains to a true bird," is still considered by Newton as a distinct genus of the Pterodactyls. Prof. Huxley and Newton have overlooked the fact that H. v. Meyer retracted this genus in 1860, in his great work, "Reptilien aus dem lithographischen Schiefer des Jura."

H. v. Meyer,[2] after the examination of the original specimen, explained that his former statement was incorrect, and that his *Ornithopterus* could not be distinguished from *Rhamphorhynchus*, and was probably identical with *Rhamphorhynchus Gemmingi*.

REVIEWS.

I.—The Subterranean Treasures of Italy. ("I Tresori Sotterranei dell' Italia," &c., per il Cavaliére Guglielmo Jervis, Conservatore R. Mus. Indust. Ital., F.G.S., &c.) Part IV. Complete in itself. The Economic Geology of Italy. 8vo. pages xxxvi and 516. With 62 Woodcuts and Lithographs. (E. Loescher, Turin, Florence, and Rome, 1889.)

THIS fourth and last volume of Chevalier Jervis's valuable work on the underground riches of Italy treats of the topographical distribution of the stones and marbles useful for building and decoration, for architectural ornaments and sculpture; also for making lime, cement, mortar, stucco, plaster, etc. Not only are particular localities carefully described and often illustrated, but the

[1] Zittel ought to have written *Ornithocephalus* (Seeley).

[2] Meyer, Hermann v., "Reptilien aus dem lithographischen Schiefer des Jura in Deutschland und Frankreich." Frankfürt a. M. 1860, p. 141.

geology of the district and its component rocks or strata are briefly noticed in smaller type. There are, further, short historical sketches of the uses to which the materials have been applied during the course of thirty centuries, by the Etruscans and Romans, and by the Greek, Egyptian, Phœnician, and Pelasgian colonists of Southern Italy, and their several descendants down to our own times. Hence we are here shown of what stones a very considerable number of classic temples and other edifices, monuments, tombs, votive altars, and statues were constructed. Descriptive notices also are given of catacombs, aqueducts, roads, bridges, and other public works of the ancients and moderns,—all from a geological standpoint. Thus the great antiquities of Italy have been brought forward in a novel and highly intelligent and interesting manner, far beyond the reach of existing Guide-book literature; and both tourists and others can, like true students, not merely seek to collect new facts, but study known facts better.

The localities of rocks of economic value (excepting sands and clays) are indicated, that are within accessible distances from towns, roads, railways, and ports. Some of the most interesting places referred to as containing objects worthy of notice by the lithologist and geologist, as well as the antiquary, are—Volterra, Cortona, Carrara, Fivizzano, Lerravezza, Rome, Tivoli, Naples, Pozzuoli, Syracuse, and Sardinia.

Our author seems to us to have succeeded in carrying out Pliny's object, when he was striving (as he said 1800 years ago) to treat old subjects in a fresh readable light. The old Roman's opinion is given as an epigraph to the Introduction at page XXI, and may be read as follows:—"It is difficult to give novelty to ancient things and authority to new; brightness to obsolete and light to obscure things; pleasure to the fastidious and faith to the doubting; a naturalness indeed to everything and everything to its own nature."

This volume mainly consists of three parts. 1. The Alps (pp. 32–164, with 19 illustrations); 2. The Apennines and the volcanoes, both active and extinct (pp. 165–414, with 30 illustrations); 3. The Islands of Sardinia and Sicily (pp. 417–482, with 9 illustrations). These regions are treated in detail according to their hydrographic basins, provinces, and communes, which yield building-stone, marble, etc.

A list of the Illustrations is given at pp. XI–XIV, with indications of the materials used in the several buildings shown,—as, for instance, part of a Pelasgian wall at Croton (Cortona), made of great blocks of Eocene sandstone (pietra serena); part of Etruscan funereal monument, in Miocene alabaster; Etruscan mortuary tomb, of Quaternary travertine; the "cloaca maxima" at Rome, constructed of Post-pliocene volcanic tuff, of travertine from Tivoli, and of Post-pliocene peperino; Roman amphitheatre at Verona, of compact Jurassic marble; the Pantheon at Rome, with granite columns; the baker's house at Pompeii, with mill-stones of late Tertiary leucitic lava; pavement of the "Via Appia," of Post-pliocene basalt; pavement of the Roman mole of Puteoli (Pozzuoli), of Post-pliocene trachyte of the Solfatara; triumphal arch of Augustus at Susa, the cathedral of Milan, and the front of the Palazzo Madama, Turin, of white Pre-palæozoic marble; and the Railway-station at Turin, of Pre-palæozoic syenite and gneiss. The sources of the material of these and of the numerous other pictured buildings, statues, etc., are carefully given. Besides those mentioned above there are views and sketches of the mountainous districts that yield marble, of some quarries, and the rough modes of hauling the blocks by means of cruelly used bullock-teams; also of Vesuvius, Lipari, Pompeii, cement-factories, palaces, churches, bridges, statues, catacombs, cave-dwellings of Posilippo, ancient amphitheatres and temples (Roman and Greek), and of the enigmatical pre-historic buildings (Nuraghi) of Sardinia.

At page xv is a list of sixty-five authors who have described the economic stones and other such Italian materials used in construction, decoration, inlaying, etc.

The Preface and an Introduction, explaining the author's plan and intention, with a brief exposition of the bearing of Geology on the subject of his work, follow appropriately to page XXXII.

At p. XXXIII a list of the economic rocks of Italy (eighty-nine) described in this volume is given. The effects of atmospheric action on the different kinds of rock and stony materials are noted at pp. XXXIV-XXXV; and the relative composition and character of cements, mortar, and plaster, at p. XXXVI.

Page 1 commences with a catalogue of the ancient and modern names of places, the economic geology of which is mentioned in the volume. At pages 2 and 3 is a provisional or tentative Table of the chief geological formations occurring in the Italian Alps, according to the writings of accredited geologists, with indications of the different economic materials found in or made from the several rocks. At pages 4 and 5 is a similar carefully-constructed Table of the rocks and strata of the Apennines and their associated volcanoes. A similar Table for Sicily is presented at pp. 6 and 7; and one for Sardinia at p. 8. A concise list of leading Fossils for each of the above-mentioned regions is given at pp. 9 and 10. Pages 11–13 are occupied by a classified and alphabetical list of the Communes and Provinces mentioned in the Volume, with the respective numbers of the paragraphs concerned. At p. 32 is a list of fifty-five modern cities where Italian marbles, or ornamental and building stones have been used.

Not only is this volume full of matters of general interest to the educated reader, but it is a valuable repertory of useful information for provincial and communal administrations, for capitalists, technical colleges, and geologists.

Two useful and carefully compiled Indexes complete the volume. 1. An Alphabetical Index of the Communes in which the several economic materials described in the volume, and *here arranged under their lithological headings*, have been met with. 2. A simply Alphabetical Index of the Communes in which the said rocks have been found.

Vols. i.—iii. of Signor Jervis's "Subterranean Treasures of Italy" treat of the "Topographical Mineralogy" of that kingdom, under the three same geographical headings as are used in vol. iv. These three earlier parts (1873, 1874, 1881) constitute a work complete in itself (price 40 lire); and so does vol. iv. (price 15 lire). We have already[1] recommended with pleasure some of Signor Jervis's books on the fossil fuel, mineral waters, etc., of Italy; and now we again can only praise his long-continued efforts for thirty years (we believe), in gathering together and publishing in convenient form so many well-considered facts and so much information valuable for thinkers, workers, and capitalists, not only in his adopted country, but throughout the civilized world. This too is the more creditable to him, as he has not spared his private means, any more than his arduous and continuous exertions in travel and research. We hope and trust his labours will be rewarded with the honour and profit so well deserved. T. R. J.

II.—Prof. Dr. von Zittel on Palichthyology.

Karl A. von Zittel. Handbuch der Palæontologie. Palæozoologie. Band III. Lief. I. II. (R. Oldenbourg, Munich, 1887–88.)

(*Continued from page* 130.)

Dipnoi.

The chapter on Dipnoi commences with a list of the more important works relating to its recent representatives, and an interesting brief discussion of the systematic relationships of the group. To the Ctenodipterini are referred *Dipterus*, *Ctenodus*, *Palædaphus*, *Holodus*, and other more fragmentarily-known fossil forms; and a supplementary section includes *Megapleuron*, *Conchopoma*, and the problematical *Tarrasius*. *Ceratodus* is the only fossil genus of Sirenoidei; and Dr. Fritsch has recently suggested that this is wrongly thus placed, exhibiting no characters by which it can be separated from the Ctenodipterini.[2]

Ganoidei.

A long introductory section to the important group of Ganoids comprises, in addition to the usual general topics, a number of valuable, and, to a large extent, novel remarks upon the various stages of development met with in the vertebral column of these fishes, illustrated by several woodcuts. Commencing with the notochordal forms, and then referring to the false appearance of vertebræ in the Pycnodonts, Dr. v. Zittel proceeds as follows: "As a rule there first appears on the underside of the notochord an arched bony plate (hypocentrum), which in the caudal region is clasped by the inferior arches and sends upwards shorter or longer

[1] Geol. Mag. Dec. II. Vol. VII. June, 1880.
[2] Fauna der Gaskohle, vol. ii. pt. 3 (1888), p. 65.

lateral processes. Sometimes also the hypocentrum consists of two pieces, which meet together beneath the notochord. Besides the hypocentrum there is seen somewhat above on both sides a keel-shaped plate (pleurocentrum), pointed below but rounded above, by which the notochord is partly, though not completely, enclosed. In the next stage both the upwardly pointed hypocentra and the downwardly pointed pleurocentra extend so far, that a zig-zag appearance is produced laterally, and as the two pleurocentra also often unite on the dorsal aspect, the vertebra is now formed of two thin horse-shoe-shaped half-rings, completely encircling the notochord. In such half-vertebræ the upper arched pieces (pleurocentra) never partly overlap the lower pieces (hypocentra), as Heckel has erroneously stated. In the genus *Eurycormus* the vertebral column consists in its front half of about equally developed horse-shoe-shaped half-rings, while in the caudal region the attenuated ends of the hypocentra and pleurocentra unite dorsally and ventrally, thus forming two closely apposed delicate rings completely surrounding the notochord ('falsche Hohlwirbel,' Vetter). The caudal region of the recent genus *Amia* exhibits this stage, except that the ossification has proceeded further inwards and to a great extent constricted the notochord. In a number of Jurassic Lepidosteoids (*Aspidorhynchus*, *Belonostomus*, *Histionotus*, *Ophiopsis*) and Palæozoic Crossopterygians (*Rhizodopsis*, *Megalichthys*), the vertebral centrum consists of a single thin cylindrical ring with a smooth or vertically striated outer surface. That the 'Hohlwirbel' or 'Ringwirbel' results from the lateral fusion of two half-rings, is conclusively proved, for example, by *Aspidorhynchus*, for here the caudal region always consists of hollow vertebræ (Hohlwirbel), while the front abdominal region mostly consists of half-vertebræ, of which the hypo- and pleuro-centra form rings closed dorsally and ventrally, but remain completely separated by a suture laterally."

In the systematic description of the Ganoids, the doubtful fragmentary remains described by Pander from the Upper Silurian of the Island of Oesel are briefly noticed; and then follow the three problematical "orders" of Pteraspidæ, Cephalaspidæ, and Placodermi. Alth's determination of the simple shield named *Scaphaspis*, as placed ventrally beneath the more complex shields of *Pteraspis* and *Cyathaspis*, is adopted; and the restored figure of the two connected shields of *Pteraspis* is reproduced. These fossils are common in the Old Red, not of Scotland (as stated), but of Western England. We would also remark that *Palæaspis*, Claypole, so far as defined, falls in the genus *Holaspis*. A very complete synopsis of the Cephalaspidæ is given, including references to the species; and the histological remarks are illustrated by Huxley's figures of microscopical sections of the shields. Both these groups have been so well treated by Ray Lankester, that it is comparatively easy to summarize our present knowledge of their various representatives; but with the Placodermi the case is very different, and a carefully prepared digest of the existing literature of the subject shows how much revision of the typical European genera is required. Such a revision is now in progress by Dr. R. H. Traquair, and three contributions to the subject have already appeared.[1]

A few genera "incertæ sedis" succeed the Placodermi, e.g. *Menaspis*, *Oracanthus*, *Stichacanthus*, etc. Of these, *Oracanthus* is now definitely proved to be an Elasmobranch;[2] and all the associated forms, except *Menaspis*, will doubtless share the same fate when microscopically examined.

The more typical "Ganoids" are commenced with the Chondrostei, of which only two families are recognized—the Acipenseridæ and the Spatularidæ. Of the former, *Acipenser toliapicus*, Ag., is recorded from the London Clay of Sheppey, and we might add *A. ornatus*, Leidy, from the Miocene of Virginia.[3] The supposed existence of the family Spatularidæ in the Devonian age (*Macropetalichthys*) is incredible; and the recent researches of Davis[4] and Traquair[5] upon the Liassic *Chondrosteus* prove conclusively that this genus belongs to an otherwise unknown extinct family. As indicated by its generic name, *Crossopholis* possesses small pectinated scales, and these are worthy of note inasmuch as they necessitate the modification of one point in the stated family-definition.

The Acanthodidæ follow the Chondrostei, and are raised to the rank of an order, without, however, any subdivision into families. Huxley's conclusion is adopted, that these fishes are intermediate between Selachians and Ganoids; and the principal genera are briefly noticed. The order of Crossopterygidæ occupies the next eighteen pages; and the first family is typified by *Phaneropleuron*, which some authors would place in the Dipnoi. The Cœlacanthidæ are treated mainly in accordance with Reis' recent memoir;[6] and then follow the Devonian and Carboniferous genera included by Huxley in his families Saurodipterini and Glyptodipterini. The latter have been remarked upon lately by Dr. Traquair in the pages of this Magazine;[7] and the most recent information concerning Devonian Crossopterygians will be found in this article.

Polypterus naturally closes the systematic consideration of the Crossopterygian Ganoids, though no members of the Polypteridæ or Polypterini have hitherto been detected among fossils. Next are placed the Palæoniscidæ and Platysomidæ, grouped together in an order named by the author, Heterocerci, and unaccountably removed far from the Chondrostei, with which they are associated by Dr. Traquair, whose elaborate detailed researches form the basis of the chapter. It is unusual, indeed, not to place the Crossopterygians before the Actinopterygians, as being referable to a lower stage of fish-evolution; and if the definitions of "Chondrostei" and "Hetero-

[1] Geol. Mag. [3] Vol. V. (1888), pp. 508–511 (General); *ibid.* Vol. VI. (1889), pp. 1–8, pl. i. (*Homosteus*).—Ann. Mag. Nat. Hist. [6] vol. ii. (1888), pp. 485–504, pls. xvii. xviii. (Asterolepidæ).

[2] Geol. Mag. [3] Vol. V. (1888), p. 85.

[3] Rep. U.S. Geol. Surv. Territ., vol. i. pt. i. p. 350, pl. xxxii. fig. 58.

[4] Quart. Journ. Geol. Soc. vol. xliii. (1887), pp. 605-616, pl. xxiii.

[5] Geol. Mag. [3] Vol. IV. (1887), pp. 248–257, woodcuts.

[6] Palæontographica, vol. xxxv. (1888).

[7] Geol. Mag. [3] Vol. V. (1888), pp. 512–516.

cerci" had been given in uniform terms, side by side, we venture to think that the illogical nature of their separation would have become apparent. The Chondrostei are said to be destitute of scales and branchiostegal rays, while the Heterocerci are characterized by both these structures well developed; and these are the sole differences of importance recorded. Nevertheless, *Chondrosteus* is termed a Chondrostean, while the fact is omitted that its numerous large branchiostegal rays were described and figured by Egerton thirty years ago; and one of the Chondrosteans mentioned (*Crossopholis*) has the flank-scales even more developed than those of an admitted member of the Palæoniscidæ, *Phanerosteon*. Under such circumstances, Dr. v. Zittel's proposed rearrangement is far from being an emendation of Dr. Traquair's results, and must be regarded as a decidedly retrograde step.

On reaching the Order "Lepidosteidæ," the influence of the author's own researches soon becomes apparent; the Palæontological Museum of Munich containing so large a series of fine Lepidosteoids from the Bavarian Lithographic Stone. Several rearrangements of species are proposed, with one or two new genera; and there are many original figures, drawn from actual specimens, giving much precision to our knowledge of osteological characters. None of the families, however, are named from the typical genera; and in the first division (Stylodontidæ) we observe one genus (*Dictyopyge*), which, if Dinkel's original drawings are correct, contradicts one point in the ordinal definition ("Träger der unpaaren Flossen ebenso zahlreich als die gegliederten Strahlen").

The extreme forms of the Stylodontidæ are *Acentrophorus* and *Tetragonolepis*, and the family also includes *Semionotus*, *Heterolepidotus*, and *Dapedius*. The typical genus of the Sphærodontidæ is *Lepidotus*, with which are identified *Plesiodus*, *Dactylolepis*, and *Scrobodus*; and several interesting figures are given. The Muschelkalk *Colobodus* is also placed here; and likewise the Rhætic *Sargodon*. The so-called Saurodontidæ (*non* Saurodontidæ, Cope) comprise *Eugnathus*, *Platysiagum*, *Ptycholepis*, *Pholidopleurus*, *Pholidophorus*, *Ophiopsis*, *Histionotus*, *Macrosemius*, and other genera; and there is a newly determined form, *Isopholis*, separated from *Pholidophorus* on account of the less vertical elongation of the flank scales and the fact that the ventral scales are scarcely, if at all, broader than deep. There are new figures of the skull and opercular apparatus of *Pholidophorus*, *Isopholis*, and *Macrosemius*; and many species are rearranged. So far as definitions are concerned, this family is not very satisfactorily distinguished from the Stylodontidæ; and we suspect that one genus placed in the latter (*Heterolepidotus*) will ultimately prove identical with one of the present family (*Eugnathus*).

The Rhynchodontidæ are a well-marked family comprising *Aspidorhynchus* and *Belonostomus*; and interesting details are given, partly new. The Liassic *B. acutus* is deferred for consideration under *Belonorhynchus*; and to the comprehensive list of species we would only add *B. laciniatus*, lately recognized from the Chalk of

Mount Lebanon.[1] The Ginglymodi are represented in Europe solely by fragments of *Lepidosteus* from the Eocene and Oligocene; but two extinct genera are recorded from the Lower Tertiary of the United States.

In the order "Amiadæ" are arranged the three families of Microlepidoti, Cyclolepidoti, and Halecomorphi; while *Leptolepis* and *Thrissops* are treated later under the Teleostei. The first family includes *Pachycormus*, *Hypsocormus*, *Sauropsis*, *Agassizia*, and less-known genera. Of the Cyclolepidoti, the typical genus, *Caturus*, is treated at length, with several figures; *Thlattodus*, Owen, is provisionally identified with *Strobilodus*; interesting figures of the vertebræ of *Eurycormus* and *Callopterus* are inserted; and the section concludes with *Oligopleurus*, *Oenoscopus*, *Macrorhipis*, and *Aethalion*. The Halecomorphi comprise the extinct *Megalurus*; and the so-called *Cyclurus*, of the European Tertiaries, is identified with the existing *Amia*.

The order "Pycnodontidæ" is not subdivided into families, and concludes the Ganoidei, with the exception of a brief appendix upon the problematical *Dorypterus*. A new figure of the head of *Gyrodus* is important, and several interesting details are illustrated in separate woodcuts. *Cleithrolepis* is placed with hesitation after *Gyrodus*, and has recently proved to be a Dapedioid.[2] A detailed description of *Microdon* follows, with five figures. *Cœlodus* is made to include most of the so-called species of *Pycnodus* and *Gyrodus* from the Cretaceous; and the genus *Pycnodus* proper is confined to the Eocene.

A new and much improved figure of *Dorypterus* is given; but further specimens are still required before its systematic position can be determined. A. S. W.

(*To be continued.*)

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—Annual General Meeting, February 15, 1889.—Dr. W. T. Blanford, F.R.S., President, in the Chair.

The Secretaries read the Reports of the Council and of the Library and Museum Committee for the year 1888. The Council stated that they had once more to congratulate the Fellows upon the prosperous state of the Society's affairs, although, from various circumstances, there was a considerable falling off in the total number of Fellows. The number elected during the year was 68, and the total accession 54; but owing partly to the results of an inquiry into the list of Fellows whose addresses were unknown, and partly to greater strictness in the application of the Bye-Laws relating to the non-payment of subscriptions, the total loss on the year was much greater than usual, amounting to 97, and thus producing an actual decrease of 43

[1] Geol. Mag. [3] Vol. V. (1888), p. 472.
[2] Quart. Journ. Geol. Soc., vol. xliv. (1888), pp. 141–143, pl. vi. figs. 6, 7.

in the total number of Fellows. The numbers of contributing Fellows was reduced by 8. The Balance-sheet showed receipts to the amount of £2866 16*s.* 10*d.*, and a total expenditure of £2739 16*s.* 1*d.*, including a sum of £159 9*s.* 2*d.* expended in the purchase of stock. The actual excess of receipts over expenditure was £127 0*s.* 9*d.*, and the balance in favour of the Society was £248 12*s.* 5*d.* The Report also mentioned the proceedings taken during the year in connexion with the proposed revision of the Bye-Laws, and briefly noticed the Meeting of the International Geological Congress in London in September. In conclusion it announced the awards of the various Medals and of the proceeds of the Donation Funds in the gift of the Society.

The Report of the Library and Museum Committee, after enumerating the additions made to the Society's Library and Collections during 1888, referred briefly to the work done in the Museum, in the way of cleaning and putting it in order.

In presenting the Wollaston Gold Medal to Prof. T. G. Bonney, D.Sc., F.R.S., the President addressed him as follows:

Professor Bonney,—A Medal that was instituted to promote researches concerning the mineral structure of the earth cannot be more appropriately awarded than for petrological studies. That the method of research has changed since Wollaston's time is largely due to the improvement of modern instruments; the work carried on by yourself and others with the microscope is in direct continuation of that done by Wollaston, his contemporaries and many of his followers with the goniometer, the test-tube, and the balance. In your hands the microscope has been a valuable adjunct to field-observation, and has been chiefly applied to detect the secrets of those rocks which, possessing no organic remains to betray the tale of their origin, have hitherto succeeded in baffling the curiosity of geologists as to their early history. In many parts of the British Islands, throughout the Alps, and in Canada, especially where ancient and obscure formations presented puzzles yet unsolved, you have been occupied in adding to our knowledge. Nor has your attention been confined to Archæan and Plutonic rocks; you were a leader of the opposition to the prevalent, but perhaps somewhat exaggerated view of the powers of glacial erosion, and you have applied the same key that had admitted you to the inner mysteries of metamorphic formations to unlock the history of British sedimentary rocks.

In conferring upon you the chief mark of distinction in its gift, the Council desires to evince its appreciation of your scientific researches, and the Fellows of the Society will, I feel sure, heartily endorse the presentation of the Wollaston Medal to you, who have served so long and so successfully as one of their principal officers.

Prof. Bonney, in reply, said:—Mr. President,—It is difficult for me adequately to express my gratitude to the Council for the great honour which they have conferred upon me, and to you for the terms in which you have spoken of my work. Of this, the defects to myself seem more conspicuous than the merits. I can only plead in excuse for those, that my work has been carried on under many difficulties on which I will not now enlarge. It has been incomplete and preparatory, often destructive rather than constructive, that of a seeker after truths to which another generation will attain. If, indeed, there be any good in it, this is because throughout I have studied nature more than books, I have sought for reasons rather than for authorities, and in so doing have endeavoured to apply the principles of induction which I learnt years ago at Cambridge in the study of mathematics. Still, I am conscious that for this crowning honour I am indebted more to the kindly feeling of others than to my own merits, and can only promise that, if time for scientific work yet remain, I will try to become more worthy of the distinction which has been awarded to me.

In handing the Murchison Medal to Mr. William Topley, F.R.S., for transmission to Professor James Geikie, LL.D., F.R.S., F.G.S., the President addressed him as follows:

Mr. Topley,—The Council has awarded the Murchison Medal to Professor James Geikie in acknowledgment of his important contributions to the Geology of North Britain, and especially of his investigation of glacial phenomena. His 'Great Ice-age' contained a full, careful, and admirably written summary of the observations made up to 1874, and the interest excited by the work was proved by a second edition being required in 1877. Professor Geikie has besides published numerous papers, not the least important of which were two that appeared in the Society's Quarterly Journal containing his observations "On the Glacial Phenomena of the Long Island or Outer Hebrides."

Mr. Topley, in reply, said:—Mr. President,—On behalf of Prof. James Geikie, who is detained in Scotland, I beg most heartily to thank the Council of the Geological Society of London, for the honour conferred upon him in the Award of the Murchison Medal. A prize founded by and continued in honour of his old chief, will, I am sure, have for Prof. James Geikie an especial value. He has desired me to communicate to you the following remarks:—"I feel sure that my fellow-geologists will fully agree with me when I say that the prosecution of our favourite science is its own great reward. The charms that first took our fancy do not lose any of their attractions after we have become confirmed devotees. On the contrary, as years pass, our interest only deepens, and we are so absorbed that happily we escape much of the fret and fever of these bustling times. But a geologist, after all, is human, and he would be less so if he did not warmly appreciate the sympathy of his fellow-hammerers. I need hardly say, therefore, that I am extremely gratified to find that I have gained the sympathy of so representative a body of geologists as the Council of this Society. The distinction which they have been so good as to confer upon me I shall cherish not only as a mark of their appreciation of the little I have done, but as an additional incentive to continued work."

The President then presented the Lyell Medal to Prof. W. Boyd Dawkins, F.R.S., F.G.S., and addressed him as follows:

Professor Boyd Dawkins,—In awarding to you the Lyell Medal for the present year, the Council of the Geological Society wishes to mark its recognition of the importance of your palæontological researches, and especially of the additions made by you to our knowledge of the mammalia found in the later Tertiary and particularly in the Pleistocene deposits of this country. Your researches have extended over a considerable number of years, and amongst the earliest of the papers published by you were those on British fossil oxen and on the dentition of certain extinct species of Rhinoceros, all of which appeared in the Society's Quarterly Journal. Your attention has especially been directed to primæval man, his implements, and the mammals that were his contemporaries, and in your works on 'Cave Hunting' and 'Early Man in Britain' you have done much to disseminate a knowledge of scientific discoveries amongst readers whom more technical works would have repelled.

Prof. Boyd Dawkins, in reply, said:—Mr. President,—I thank you, from my heart, for the kind words which you have spoken in awarding to me the honour of the Lyell Medal. I feel, Sir, on looking back on the work of the last 25 years, how little I have been able to do compared with what I proposed to do, and I console myself with the knowledge that this is the common experience of all workers in all subjects. My main work has been in that field of Geological inquiry which looks towards history, in which Sir Charles Lyell, the founder of the Medal, rejoiced to labour, and its results have for the most part been published in the Journal of this Society. I feel therefore peculiar gratification in receiving in the name of this Society this medal for work done in Sir Charles Lyell's favourite field. If I may speak of the future, I would say that I shall work all the harder through this mark of approbation of the Society, and that I hope to be able to do a little, in the time that is left to me, to fill up the blank which lies between our science and history.

In presenting the Bigsby Medal to Mr. J. J. Harris Teall, F.G.S., the President said:

Mr. Teall,—Your contributions to the Petrology of the British Islands have had a great influence on the views of British geologists. In your papers on the dykes of Northern England and Scotland you have added much to our previous knowledge, and in your description of the metamorphosis of dolerite into hornblende-schist you succeeded in proving what had certainly been suspected, but probably never so clearly demonstrated before, the production of foliated rocks by the action of mechanical forces on igneous formations. Your 'British Petrography,' the concluding part of which has recently appeared, contains many original observations, and well maintains the scientific character of your previous writings, whilst it supplies a much-needed desideratum to the geologists of this country. The Council of this Society, whilst awarding to you the Bigsby Medal in token of the esteem in which they hold your work, hope your 'British Petrography' may be the precursor of other equally valuable additions to our science.

Mr. Teall, in reply, said:—I beg to offer my sincere thanks to the Council for the honour they have conferred upon me, and to you, Sir, for the kind way in which you have referred to my work There is an accidental circumstance which adds to the pleasure I feel on this occasion; it is that I receive the Bigsby Medal on the day that my earliest instructor receives the highest award which this Society can give. I should not be standing here to-day if it had not been my good fortune to come in contact with Prof. Bonney at Cambridge.

The President next presented to Mr. A. Smith Woodward, F.G.S., the Balance of the Proceeds of the Wollaston Fund, and said:

Mr. Smith Woodward,—In presenting to you the Balance of the Wollaston Fund, the Council of the Geological Society recognize the value of your contributions to the knowledge of fossil fishes and fossil reptiles. Your publications on these classes of animals are carefully written, and show an extensive acquaintance with the rather intricate literature of the subject. I hope that the award now handed to you will be an incentive to further researches and an assistance in prosecuting them.

Mr. Smith-Woodward, in reply, said:—Mr. President,—I beg to express my best thanks to the Council of the Geological Society for the honour they have done me in making this award, and also to yourself, Sir, for the kind manner in which you have spoken of my slight attempts to extend the boundaries of one small department of our Science. It has always been my greatest pleasure to devote my leisure hours to the study of Natural History; and it is very gratifying to feel that the circumstances of the last few years have enabled me to follow these pursuits in a manner that is deemed worthy of recognition by this Society. Continual access to a collection like that of the British Museum affords exceptional facilities for palæontological research; and the experience gained when assisting my late senior colleague, Mr. William Davies, in the arrangement of the unique series of Fossil Fishes, has pointed out to me a wide field for investigation among the lower extinct Vertebrates. The highly-valued encouragement received to-day will incite me to renewed efforts, and I shall still strive to make the best use of the advantages resulting from my official position.

In presenting the Balance of the Murchison Geological Fund to Mr. Grenville A. J. Cole, F.G.S., the President said:

Mr. Grenville Cole,—In the course of the last few years you have published several interesting papers on petrological subjects, and especially on spherulitic and perlitic structure, and on volcanic glasses. The Council of the Geological Society has presented you with the Balance of the Murchison Fund in recognition of your contributions to Petrology, and as a means of aiding you in extending your investigations.

Mr. Cole, in reply, said:—Mr. President,—This award, granted by the Council of the Geological Society, is all the more pleasant to me because so completely unexpected. It is to me but another evidence of the generous encouragement that is extended by the master-craftsmen to the apprentices in geological work. To deal with rocks from a purely mineralogical standpoint would be to ignore the broad principles of geology marked out by the founders of the science, and it will always be my earnest endeavour, stimulated by the fellowship of this Society, to connect the minuter researches of the laboratory with the study of earth-structure in the field.

The President lastly presented to M. Louis Dollo the Balance of the Proceeds of the Lyell Geological Fund, and addressed him as follows:

M. Dollo,—The Reptilian and Batrachian Faunas of the Upper Secondary and the Tertiary strata of Belgium have only of late years become generally known to geologists. That the scientific world is now better informed concerning the wonderful remains of Cretaceous Dinosaurs, Mosasaurs, and Crocodiles, and both Cretaceous and Tertiary Chelonia from the Belgian beds is in great part due to your descriptions. In awarding to you the Balance of the Lyell Fund the Council of the Geological Society hope to aid you in prosecuting further researches.

M. Dollo, in reply, said:—Mr. President,—I beg to express my acknowledgments for the honour which has been bestowed upon me by the Geological Society. This encouragement will stimulate my energies in the field of palæontology, and my greatest and sincere desire is that I may, on any occasion, render myself useful to the Geological Society of London, and fully deserving of the favour which it has been pleased to confer upon me. The nature of the researches to which I have devoted these last years has afforded me the advantage of frequent intercourse with many of the palæontologists in this country; and I wish on this occasion to express to them my indebtedness for the many encouragements I have received.

The President then read his Anniversary Address, in which, after giving obituary notices of Mr. W. Hellier Baily, Prof. H. Carvill Lewis, Vice-Admiral T. A. B. Spratt, Viscount Eversley, Mr. John Brown, Mr. W. Ogilby, and other deceased Fellows, together with notices of the Foreign Members and Correspondents of the Society who have died since the last Anniversary Meeting (Prof. Gerhard Vom Rath, Prof. T. Kjerulf, Prof. Giuseppe Meneghini, and Prof. Giuseppe Seguenza), he noticed the papers which had been published by the Society during the past year. The remainder of the Address consisted chiefly of a discussion of the work of the International Congress from its commencement to the last Meeting in London in 1888, and dwelt upon the influence which such meetings exercise upon the progress of geological science, quite apart from any formal resolutions which may be arrived at by the Members.

The Ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year:—*President:* W. T. Blanford, LL.D., F.R.S. *Vice-Presidents:* John Evans, D.C.L., LL.D., F.R.S.; Prof. T. M'Kenny Hughes, M.A.; Prof. J. W. Judd, F.R.S.; Prof. J. Prestwich, M.A., F.R.S. *Secretaries:* W. H. Hudleston, Esq., M.A., F.R.S.; J. E. Marr, Esq., M.A. *Foreign Secretary:* Sir Warington W. Smyth, M.A., F.R.S. *Treasurer:* Prof. T. Wiltshire, M.A., F.L.S. *Council:* Prof. J. F. Blake, M.A.; W. T. Blanford, LL.D., F.R.S.; Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; James Carter, Esq.; John Evans, D.C.L., LL.D., F.R.S.; L. Fletcher, Esq., M.A.; A. Geikie, LL.D., F.R.S.; Prof. A. H. Green, M.A., F.R.S.; Rev. Edwin Hill, M.A.; W. H. Hudleston, Esq., M.A., F.R.S.; Prof. T. M'Kenny Hughes. M.A.; Prof. J. W. Judd, F.R.S.; Major-Gen. C. A. McMahon; J. E. Marr, Esq., M.A.; E. T. Newton, Esq.; Prof. J. Prestwich, M.A., F.R.S.; F. W. Rudler, Esq.; Prof. H. G. Seeley, F.R.S.; Sir Warington W. Smyth, M.A., F.R.S.; W. Topley, Esq., F.R.S.; Rev. G. F. Whidborne, M.A.; Prof. T. Wiltshire, M.A., F.L.S.; Rev. H. H. Winwood, M.A.

II.—February 20, 1889.—W. T. Blanford, LL.D., F.R S., President, in the Chair.—The following communications were read:

1. "On the Cotteswold, Midford, and Yeovil Sands, and the division between Lias and Oolite." By S. S. Buckman, Esq., F.G.S.

After giving a short sketch of the work and opinions of other writers, the author proceeded with the evidence on which his own views are based. He described a series of sections of the typical exposures of "Sands" and contiguous strata, commencing near Stroud and terminating on the Dorset coast. Dividing the series into *seven* horizons, characterized by their distinctive Ammonites, viz. *Amm. communis, variabilis, striatulus, dispansus,* the genus *Dumortieria, Amm. Moorei* and *opalinus,* and taking the *striatulus*-beds as a fixed starting-point, the author demonstrated how the strata varied in regard to that horizon. The Cotteswold Sands, containing the *variabilis*- and part of the *communis*-horizons, were below the *striatulus*-beds; the Midford Sands, containing the *dispansus*-horizon, were above. *Gramm. striatulum* occupying a thin bed at the base; the Yeovil Sands, containing the *Moorei*- and *Dumortieria*-horizon, and were consequently still later deposits.

Since the different sands were deposited not on a horizontal plane, in point of time, but, as it were, obliquely, the deposit of Cotteswold, Sands having ceased before that of Yeovil Sands commenced, it was incorrect to lump all the "Sands" from the Cotteswolds to the Dorset coast under the single local name "Midford Sands," thereby implying a contemporaneity which did not exist, while the use of the present restricted local names was defended.

The Ammonites were apparently uninfluenced by changes in the character of the deposit, since the same species are found in Limestone in the Cotteswolds, in Sands at Midford, and in argillaceous Marl at Ilminster. The change from argillaceous to arenaceous or calcareous deposits has been looked upon as so distinct a feature, that it has been utilized as a great argument in favour of drawing the line between Lias and Oolite at that point; but if this be done, the line is always drawn at different horizons in different districts.

If lithology furnishes no reason for a dividing-line at this point, it was shown that neither did palæontology. It was also shown that the Ammonite family Hilderoceratidæ dominated the period from the *Falcifer*- to the *Concavus*-zones, and that with the close of the latter zone they died out with singular abruptness, and that, furthermore, there exists, both in England and upon the continent, a marked hiatus at the same point due to the absence of a zone or a number of zones.

On account of these facts the proposal was put forward that d'Orbigny's term "Toarcien" should be employed to designate the strata from the *Falcifer*-zone to the *Concavus*-zone inclusive, that this term should not be used in the sense of merely an extended "Upper Lias," but to mark an entirely distinct transition-formation,—a definite part of the Jurassic period,—separating the typical Lias from the mass of thoroughly Oolitic strata.

2. "On some Nodular Felstones of the Lleyn Peninsula." By Miss Catherine A. Raisin, B.Sc. Communicated by Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

This paper dealt with two small masses of rock forming the headlands of Pen-y-chain and Careg-y-defaid, a few miles from Pwellheli. They consist of old lava-flows, once glassy, now devitrified and, at the former place, associated with interbedded agglomeratic and ashy strata. The lithological characters, as well as other slight evidence obtained, would fully support the identification by the Survey of the surrounding beds as of Bala age.

The rocks exhibit evidence of alteration and of silicification, suggesting that the district may have passed through a Solfatara stage, and that its condition may have been not far removed from that of a geyser region. Perlitic structure is common. and is often found in connection with spherulitic growth, of which there are many gradations, and specially marked and large examples are presented in the agate nodules.

Some nodules seem to result from spheroidal fracture, others to be masses of flow-brecciation; but the majority have a spherulitic crust, often surrounding an interior occupied by secondary quartz or chalcedony. Similar specimens were described and compared, which had been received from Boulay Bay, through the kindness of Professor Bonney. The evidence of these and of the Lleyn examples appears to be strongly in favour of the view that the spherulite is the least altered and most durable part of the mass. Other considerations were brought forward by the author, which would offer some further difficulties in accepting the decomposition-theory to account for the origin of the interior of the nodules. Some of the specimens described present certain special characteristics, and, at one locality in the Lleyn, what seem to be quartzose amygdaloids occur, in close relation to agate nodules. On the whole, although the mode of origin is difficult or impossible definitely to prove, the evidence appears to suggest that in these nodules a spherulitic crust has formed around an originally vesicular nucleus.

3. "On the Action of Pure Water, and of Water saturated with Carbonic-acid Gas, on the Minerals of the Mica Family." By Alexander Johnstone, Esq., F.G.S.

Two muscovite fragments were suspended for a year, one in distilled water, the other in water saturated with carbonic anhydride. A good deal of mica-dust was detached from each, but no material had been dissolved, the only chemical change being hydration, accompanied by physical alteration, producing a mineral chemically and physically similar to a natural hydromuscovite.

When biotite was similarly treated, the mineral suspended in the distilled water became a hydrobiotite, whilst that in the water saturated with carbonic anhydride underwent chemical change, and was converted into hydromuscovite by loss of magnesia and iron, which were dissolved in the water.

Lepidomelane in pure water became hydrated, but in carbonated water also sustained a loss of iron.

The author has ascertained that when anhydrous micas become hydrated, or lower hydrated ones more highly hydrated, they increase in bulk.

Royal Geological Society of Ireland.

THE Annual General Meeting for the election of officers took place at the rooms of the Royal Dublin Society on the 20th of February. Mr. A. B. Wynne, F.G.S., was elected President and addressed the meeting, taking two of the most important questions recently brought under the notice of geologists, as his subject, namely, the evidences of enormous earth-movements and horizontal displacement in the Highlands. And secondly the arguments in support of a Palæozoic, or Carboniferous to Permian, Glacial period. With regard to the former, the revelations announced by the officers of the Geological Survey as to transplacement, metamorphism, and deformation of the rocks, were brought to notice, and amongst theoretical or other observations bearing upon the question of how the rock-masses were afforded room to move, the late observations by Dr. Ricketts in the GEOLOGICAL MAGAZINE were referred to; also Mr. J. R. Kilroe's suggestions, which would go far to afford a solution of the question. These suggestions, now for the first time advanced, indicated that where areas of locally reduced vertical pressure came into existence, by bulging of the crust, in consequence of contraction in cooling or other cause, the greater vertical pressure on each side of such an area (possibly increased by the deposition of denuded materials from the elevated part) would produce attenuation of the underlying rocks. The pressed-out substance of these flowing —after the manner described by Tresca and Daubrée—towards the space beneath the area of least pressure, crumpling and folding of beds, in this position, would result. This need not necessarily be accompanied in such situations by metamorphism, but beneath regions of extreme superincumbent pressure, once the cosmical equilibrium was disturbed and motion originated, metamorphism would proceed actively till equilibrium was restored. Repeated action of this kind would produce alternating zones of greater or less, or no, metamorphism, and where the vertical pressure and consequent movement on each side of an elevated area of least pressure differed in amount, the tangential thrust of the rock-masses, moving in opposite directions towards each other, would vary, the most powerful thrust tending to pass over the other with a more and less upward inclination towards the place of least pressure and least resistance at the surface of the elevated area. Development of these actions where the scene of the elevation had changed to a previously altered region, would account for most of the phenomena which form the key to the latest published interpretations of Highland geology.

Regarding the second subject, the address pointed out that since the time when the Rev. Dr. Haughton recorded, thirty-eight years ago, the occurrence of glacial boulders of granite in the Carboniferous limestone of Dublin, a great number of writers, including Dr. Blanford, President of the Geological Society of London, had advocated the existence of glacial features in connexion with Permian or Carboniferous boulder-beds. Amongst these writers was Sir A. C. Ramsay, who recognized first the glacial character of certain Permian deposits in England, but numerous other writers had maintained the same character for beds in India, Afghanistan, South Africa and East Australia, regions supposed to have been once united by Sclater and Haeckel's lost continent of 'Lemuria.' Attention was called to the latest contribution to the geological literature of the subject by Dr. Waagen of Prague, who contends that the ancient Carboniferous Ice Age prevailed over the whole earth except South America, and the evidence for his deductions was discussed, it being thought improbable that these would be at once or entirely accepted. The expanding field of geological investigation as the science progressed, was alluded to, fresh and important discoveries ever rewarding those who laboured to complete the history of the earth.

A vote of thanks for the Address was proposed by Dr. Hull and seconded by the Rev. Dr. Haughton, who observed that for thirty years he had taught the geology of the past, and now contemplating the geology of the present, he shrunk from conjecturing what might be that of the future. He was glad to find the discoveries of the late Prof. Tresca, of Turin, as to viscous fluidity from pressure, occurring in the case of solids and metals like silver, lead and gold, applied in explanation of geological structure. And in this connexion he was reminded of the deposit of gypsum cut through in forming the St. Gothard tunnel, which under great pressure flowed into the tunnel and stopped the works. The Carboniferous Ice-age possessed considerable interest to him from his having been the first to record glacial boulders of that period. He was much pleased with the Address and felicitated the Society upon the election which had taken place.

CORRESPONDENCE.

DYKE IN THE LIZARD SERPENTINE.[1]

Sir,—In reference to Mr. Somervail's answer (last month) to my letter indicating two inaccuracies in his article on a dyke in the Lizard Serpentine, permit me to state that I did not mistake the south for the north end of Pentreath Beach, or the locality of which he wrote. It is not my custom to criticise without using all pains to ascertain what an author has said or (if possible) what he means. As to this dyke, I believe (though to be quite sure I should have to revisit the locality) that in my diary I have a sketch of and a note on part of it; but at any rate I know its situation. On the theoretical and hypothetical views put forward in the article and the letter I do not presume to comment. Mr. Somervail has doubtless discovered some quicker and surer way to a conclusion than the laborious route on which I have been obliged to plod.

23, Denning Road, Hampstead, N.W., T. G. Bonney.
February 2, 1889.

SCIENTIFIC BIBLIOGRAPHY.[1]

Sir,—All workers will most cordially endorse the remarks of Mr. S. S. Buckman (Geol. Mag. N.S. Dec. III. Vol. VI. No. II. p. 94. London, Feb. 1889). But surely the Societies are not to blame for sins of omission in "Authors' Copies." It is always open to the author of a paper, when ordering his separate copies, to order at the same time a title-page or printed cover which shall give all necessary details. It is not to the advantage of a Society to permit an author to issue his paper as though it were an independent publication:

[1] The Editor regrets that Prof. Bonney's and Mr. Bather's letters were omitted from the last number of the Magazine from want of space. – Edit. G.M.

this however is the effect produced when no reference to the Society is made when the pagination is altered, and the type partially reset. All parties would be benefited if the Society would prohibit such unnecessary and confusing changes. But there is no inducement to a Society to consult the wishes of those who break up odd volumes of their Proceedings, while a careful worker or a good bookseller will take care to copy the information before the original covers are destroyed. Should public-spirit ever lead a Society to move in this matter in the direction of convenience to specialists, then the suggestions of Mr. Buckman would be admirable. One might further suggest that a fresh paper should always begin on a fresh leaf; the extra expense would be small, the convenience to book-breakers great. In some German and American magazines each paper begins a fresh "Section": so excellent an arrangement might well be adopted by our leading Societies.

As to authors, they would further benefit their readers by attention to two points. First, by giving definite and descriptive instead of vague and unsatisfying titles to their papers. Secondly, by publishing some address at which letters or papers would find them: one often wishes to communicate with a fellow-worker in one's special field, but is deterred by the absence of any information as to his whereabouts, and one often hesitates to make the hardworked Editor a general postman. The chief gainers by this would, however, be the authors themselves.

In referring to a paper it is very advisable to give its title, as well as that of the publication in which it appeared: for the possessors of a separate copy are often unable to recognize it when merely referred to by a string of letters and figures, especially when the proper information has not been given with the authors' copies.

BRIT. MUS. (NAT. HIST.), S.W. F. A. BATHER.

THE OLENELLUS ZONE IN N. W. EUROPE.

SIR,—It has been pointed out to me that the original discovery of the *Olenellus zone* on the European side of the Atlantic was not made by the late Dr. Linnarsson, as indicated in my recent "*Note on the Discovery of the Olenellus Fauna in Britain*,"[1] but was the work of my friend Dr. A. G. Nathorst, of Stockholm. In the year 1868 Dr. Nathorst detected and described a new and distinct horizon below the "*Paradoxides Beds*" at Andrarum (Scania), containing annelide trails and examples of *Lingula*.[2] In the following year he discovered in the same horizon a *Paradoxides-like* form, together with examples of *Ellipsocephalus*, and a species of *Arionellus*. Dr. Torell, to whom he communicated this discovery, gave the *Paradoxides*-form the provisional title of "*Paradoxides Wahlenbergi*," and named the containing beds the "*Paradoxides Wahlenbergi strata*;"[3] but he did not describe or figure the new form.

Linnarsson made his own discovery of *Olenellus* (*Paradoxides*)

[1] GEOL. MAG., Nov. 1888. p. 484.

[2] Öfvers. Kongl. Vetens. Akad. Förhandlinger, Stockholm, 1869, p. 64.

[3] Torell, Petrefacta suecana Formationis Cambrica, 1869–70.

Kjerulfi in Norway in 1870. He published an account of this discovery in 1871, naming the characteristic Trilobite *Paradoxides Kjerulfi*,[1] and figuring it. The identity of this species with the previously named *Paradoxides Wahlenbergi* of Dr. Torell was distinctly acknowledged by Linnarsson in the year 1876.[2] Thus, while it must be admitted that Linnarsson's specific title of *Paradoxides* (*Olenellus*) *Kjerulfi* must be retained as that of the first Trilobite *figured* and described from the *Olenellus Zone* in Europe; yet the actual credit of the original detection of this *Olenellus* zone belongs unquestionably to Dr. Nathorst, who made known its stratigraphical position in Sweden at least two years before Linnarsson detected and described the species of the *Olenellus* zone from Norway.

Chas. Lapworth.

A WOODEN DINOSAUR.[3]

Sir,—Frequent protests have been entered against the hastiness with which new species or even genera are founded upon fragmentary materials. But all previous blunders in this line are thrown into the shade by the recent restoration of a new genus of Dinosaurs, *Aachenosaurus*, from two fragments which, on microscopical examination, prove to be nothing but masses of silicified wood. The contributions to this subject, quoted below, not being easily procurable, we think the readers of this Journal may be interested by the following analysis.

In two notes published in Belgium, Abbé G. Smets describes a fossil obtained by him from the sands of Aix-la-Chapelle, in a quarry at Moresnet, Belgium, between Verviers and Aix-la-Chapelle, sands in which, according to the most competent local authorities, no vertebrate remains have as yet come to light. This fossil has been described as a portion of the right dentary bone, "to which joins another fragment, very probably of the coronoid," of a new Dinosaur of the family Hadrosauridæ. The author declared he had tested the bony nature of this fossil by means of the lens and the microscope, without, however, making any sections; while some incrustations were identified by him as teeth. A plate, so rudely executed as to be utterly worthless, accompanies his second paper, which concludes with an attempt at a restoration of this marvellous Dinosaur, which is supposed to have been biped, to have attained a length of 4 to 5 metres, to have been provided with a spatulate mandible, to have fed on succulent plants, while its hide was probably furnished with an armour of dermal spines.

M. Dollo having obtained leave to examine and make micro-

[1] Linnarsson, Öfvers. af Kongl. Vetens. Akad. Förhand. 1871, p. 784.

[2] *Ibid*, Brachiopoda of Swedish Paradoxides beds. Bihang. Kong. Swensk. Vet. Akad. Handlingar. 1876, p. 5.

[3] G. Smets. Un Reptile nouveau des Sables d'Aix-la-Chapelle. Muséon (Louvain), vi. 1887, pp. 133, *et seq.*

G. Smets. *Aachenosaurus multidens*, Reptile fossile des Sables d'Aix-la-Chapelle (Mémoire présenté au congrès des savants catholiques à Paris et lu dans la séance du 9 avril, 1888). Hasselt, 1888, 8vo. 23 pp., 1 pl.

L. Dollo. *Aachenosaurus multidens*, Bull. Soc. Belge Géol. ii. 1888, p. 300.

G. Smets. Un mot de réponse à M. L. Dollo. Hasselt, 1889, 8vo. 13 pp.

scopical sections of the fragments, has come to the conclusion that they are merely masses of fossil wood, a view in which he is supported by a well-known botanist, Dr. M. Hovelacque.

This demolishing of the new Dinosaur has brought upon M. Dollo a would-be crushing retort from its founder. The tone of the reply is, however, not of a kind to raise its author in the opinion of the scientific, or, indeed, for that matter, of any other world. He seems indeed to have followed the Old Bailey maxim, that when you have no case, the only thing left is to abuse the plaintiff and all connected with him. We were, however, especially concerned to find our own names dragged into this unseemly controversy, on the ground that we have seen reason to differ in certain respects from M. Dollo's views as to the serial position or specific distinction of some of the Wealden Reptiles of Belgium. To make such differences of opinion the grounds of a deliberate impeachment of M. Dollo's capacity as a palæontologist is, on the face of it, too absurd for serious notice. We believe, indeed, that scarcely any two palæontologists can be found who will agree with one another in all respects as to the affinity of a totally extinct type of animal; and when the type specimens are in the fragmentary condition in which some of the allied English forms were found, there is no wonder that M. Dollo failed to recognize their identity or kinship with the Belgian examples. In one instance, indeed, one of the undersigned has since agreed with M. Dollo in regarding the Belgian Crocodile *Bernissartia* as generically distinct from the English *Hylæochampsa*.

We are well assured, in conclusion, that no words of ours are needed to express the high estimation in which M. Dollo's palæontological work is held, not only in this country, but wherever the science is cultivated; and we look forward with keen hope to the appearance of fully illustrated monographs from his hand, which will worthily proclaim to the world the priceless treasures preserved in the Brussels Museum.

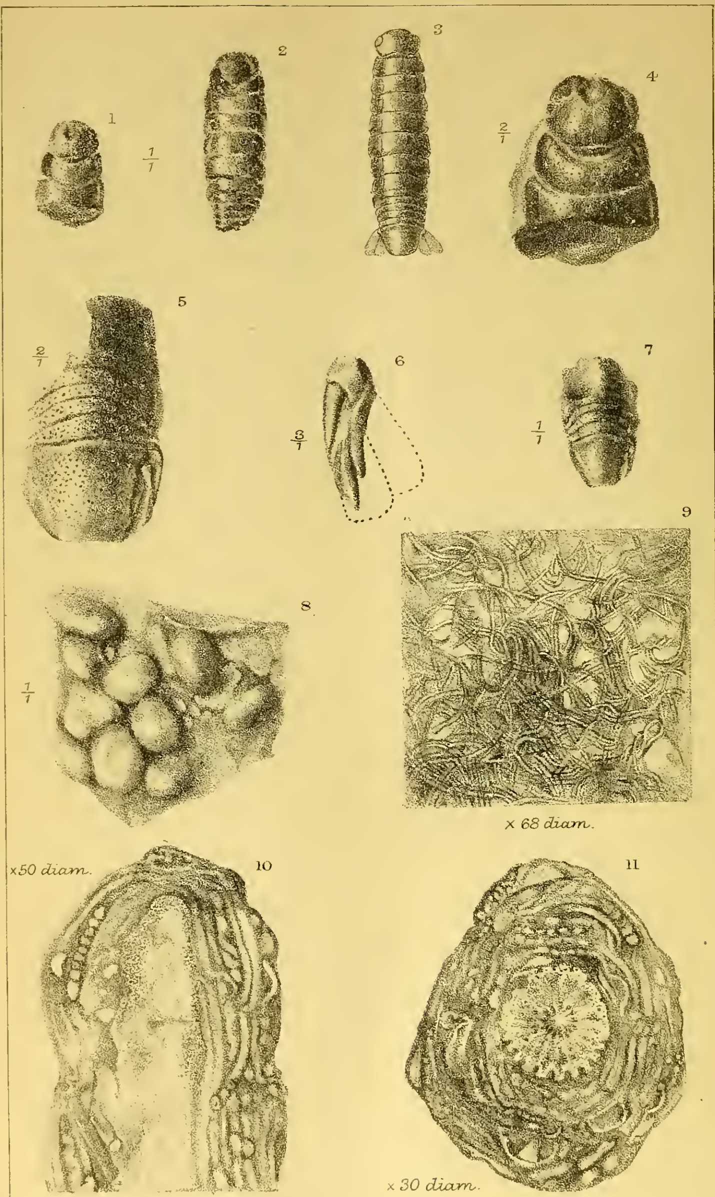
G. A. Boulenger,
R. Lydekker.

British Museum, 20 *March*, 1889.

MISCELLANEOUS.

Human Relics and Bones of Mastodon found in Association. —Mr. J. M. Clarke reports to Dr. James Hall, State-Geologist, Albany, N.Y., that in the village of Attica, Wyoming Co., N.Y., some bones of Mastodon (or possibly Elephant) and of Elk (?), together with charcoal, have been found at a depth of about six feet, in a natural sink-hole or bog-hole in the shale of that place; and that some ancient pottery and charcoal were found in a neighbouring bog-hole, about 40 feet distant, and at a depth of a foot lower than in the other pit. The two holes or pits were once connected by a small watercourse. The hole with the bones and charcoal was at top about 30 feet, and that with the pottery and charcoal about 75 feet in diameter. Both narrowed downwards, and contained "black muck and mucky clay"; one is under the street and the other in a pasture.

T. R. J.



E. C. Woodward lith. ad nat. West, Newman & Co. imp.

Figs. 1 to 7. To illustrate Mr. Carter's paper.
Figs. 8 to 11. To illustrate Mr. Wethered's paper.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. VI.

No. V.—MAY, 1889.

ORIGINAL ARTICLES.

I.—On Fossil Isopods, with a Description of a New Species.

By James Carter, F.G.S.

(PLATE VI. Figs. 1—7.)

THE recent discovery in the Woodwardian Museum of an undescribed species of Isopod from the Upper Greensand of Cambridge affords an opportunity for the revision of the entire list of that class of fossils. The total number of species which have hitherto been described as occurring in a fossil state is inconsiderable,—probably scarcely thirty—including both foreign and British. To what extent this small number expresses the variety of specific form of this tribe of Crustaceans, which actually existed during the period of deposition of the several rocks in which their remains occur, it is impossible to determine, as doubtless by far the greater proportion of the individuals perished by reason of the delicacy of their tissues—the larger and thick-shelled species only having been preserved—the small, thin-shelled kinds not admitting of recognizable "fossilization." Specimens of Jurassic and Cretaceous Isopods are very rare both as to variety and individual number, and it may be inferred that this rarity of occurrence results from the more or less turbulent conditions under which these marine deposits were formed. The Tertiary estuarine and freshwater species, buried under more tranquil conditions, are much better preserved, and occur in some localities in innumerable abundance—*Sphæroma, Archæoniscus*, etc.

The succession and geological distribution of Isopods, so far as has yet been ascertained, is indicated by the following list:—

	One species has been obtained form		the Old Red Sandstone.
?	One ,,	,,	the Triassic rocks.
	Five ,,	,,	the Jurassic ,,
	Three ,,	,,	the Cretaceous ,,
	Eighteen	,,	the Tertiary ,,

About three-fourths of the forms enumerated are foreign, and seven species have been recorded by Dr. Woodward as occurring in this country:—

Præarcturus gigas, H. Woodw.	Old Red Sandstone, Hereford.
Archæoniscus Brodiei, Milne Edwards	Purbeck Beds, Vale of Wardour.
,, *Edwardsii*, H. Woodw.	,, ,,
Palæga Carteri, H. Woodw.	Grey Chalk, Dover.
Bopyrus sp. (parasitic)	Greensand, Cambridge.
Eosphæroma fluviatile, H. Woodw....	U. Eocene, Isle of Wight.
,, *Smithii*, H. Woodw.	,, ,,

To this list may be added *Palæga McCoyi*, the new Cretaceous form described in this paper, thus making a total of eight species as representing the fossil Isopods in Britain. In Phillips's Geology of Oxford and Valley of the Thames, p. 122 (1871 ed.), the genus *Æga* is mentioned in a list of Liassic fossils, but no specific name, figure or description is given.

In investigating a tribe of genera it is obviously desirable not only to consider each genus separately and distinctly, isolated from its allies, but also to consider it with reference to other forms, so as to determine its relationship and phylogeny, and the precise zoological position which it occupies. To do this at all completely is as difficult as it is interesting, even with reference to living organisms; but with regard to those which occur only in a fossil, and consequently in a more or less imperfect, condition, the difficulty is increased; and in the case of the Isopods—as indeed in that of the innumerable host of perishable organisms which doubtless existed in geological periods—it is well-nigh hopeless to attempt such an enquiry, inasmuch as the supply of material in the shape of specimens is so extremely limited. It may, however, be useful to give collectively a brief epitome of the publications of the few palæontologists who have written upon the subject up to the present date.

In 1879 Dr. H. Woodward, who is well known to have long given special attention to, and to have contributed so largely towards a knowledge of, fossil carcinology generally, made a valuable communication to the Geological Society (Q.J.G.S. vol. xxxv.), in which he has given a list of described species of Isopoda, including the seven already alluded to as being British, and seven foreign; and has added copious notes and observations.

Dr. Ludwig von Ammon, of Munich, has published an able and exhaustive paper—"Ein Beitrag zur Kenntniss der fossilen Asseln" (Sitzungsber. d. Math.-Phys. Classe der k. k. Akad. d. Wissensch. 1882, Heft iv.), in which he has described a new species of *Palæga* (*P. scrobiculata*), and critically reviewed, with abundant bibliographical references, the contributions of various authors who have written upon Isopods. He has also compiled a table, systematically and stratigraphically arranged, of all the species which he regards as true Isopods, including those which Dr. Woodward had previously enumerated, and adding the ten following:—

Isopodites triassicus, Picard, Trias. (A doubtful form.)
Urda rostrata, Münst. Solenhofen.
,, *punctata*, ,, ,,
Ægites Kunthi, v. Ammon ,,
Palæga scrobiculata, v. Ammon, Tertiary.
From the "Unter oligocaen," Tyrol; a large species very nearly allied to *Palæga Carteri*, Woodw.
Oniscus convexus, Koch und Berendt, Tertiary (in Amber).
Trichoniscus asper, Menge, ,,
Porcellio notatus, Koch und Berendt, ,,
,, *granulatus*, Menge, ,,
,, *cyclophorus*, Menge, ,,

The five last mentioned are terrestrial Oniscidæ, of small size, and nearly allied to recent forms. A new Mexican species of

Sphæroma (*S. Burkartii*, Barc.), is described by M. Barcena (Geological Record, 1875, p. 297). The Geological Magazine for April, 1887 (Vol. IV. p. 189), contains a notice of a paper "On New Neogene Isopoda," by N. Andrussow, in which mention is made of the following:—

Cymodocea Sarmatica, Andr. A marine genus of the Sphæromidæ.
Palæga Anconitana, Andr.
Sphæroma Catullii, Zigno.
,, *exsors*, Eichw. Bull. de Moscou, 1863.
Cymatoga Jazykowii, Eichw. Cretaceous, Bull. de Moscou, 1863.

Lastly, let me add that Prof. K. A. von Zittel (Handbuch der Palæontologie, 1885, pp. 666—670) gives, besides the foregoing:—

Arthropleura ornata, Jordan, Coal-M. Saarbrücken.
Archæosphæroma Frici, Novak, U. Miocene, Bohemia.
Sphæroma faveolatum, Costa, Post-Tertiary, Calabria.
Armadillo molassicus, H. v. Meyer, U. Miocene, Oeningen in Baden.

On *Palæga McCoyi*, sp. nov. Plate VI. Figs. 1—7.

The species about to be described is represented by three specimens from the Cambridge Upper Greensand, one of which exhibits the cephalon and first two segments of the pereion, another is tolerably complete except the telson, the third consists of portions of the pereion, the pleon, and the telson, with traces of the caudal appendages. As is the case with so many of the fossils from the same prolific bed, the specimens occur as phosphatic casts only, no portion of the test having been preserved: these casts are, however, so sharp as to afford characters with quite sufficient distinctness to be available for specific description. As specimens of Isopods occur so rarely, and are usually so imperfect, the distinction of a new species by means of mutilated examples seems justifiable.

Description.—General form slender, moderately convex transversely; lateral margins of pereion approximately parallel; cephalon about three-fourths as wide as the first segment of the pereion, rather wider than long, rounded in front, posterior border with a median condyloid prominence. Eyes large, reniform, widely separated, directed obliquely outwards and forwards; extending backwards beyond the transverse mid-line of the cephalon. The three anterior segments of the pereion rather shorter than the succeeding four; a sharp sulcus marks off a large epimeron on each segment. The pleon is about half the length of the pereion, and rather narrower; it consists of five equal, short segments, the last of which is lodged in the sinus of the fourth. The telson constitutes the posterior half of the pleon, and is as wide anteriorly as the segment which supports it: it narrows posteriorly and has apparently no carina. The surface of all the segments may be seen under the lens to be pitted by large, widely separated, puncta (see Pl. VI. Figs. 4 & 5). The matrix in which the specimen is embedded shows a sharp cast of the uropodite, the basal joint of which has the inner distal angle prolonged into a spine more than half as long as the endopodite—a character which occurs in many *Ægidæ*: the endo- and exo-podite are broken; they were probably of moderate and of equal size.

Total length from 30 to 35 millimetres; width from 8 to 9 mm. Upper Greensand, Cambridge; Woodwardian Museum.

To one of the specimens (Figs. 5 and 7) Prof. Seeley attached as a MS. label *Squilla McCoyi*, and this name is quoted by Mr. Jukes Browne in the list of fossils contained in his paper 'On the Cambridge Gault and Upper Greensand' (Q. J. G. S. May, 1875). The subsequent occurrence of two other specimens has enabled me to determine that the fossil so named is the pleon of the Isopod now described.

Palæga McCoyi is quite distinct from all other described fossil Isopods, although it bears considerable resemblance to several recent forms. I have provisionally referred it to the genus *Palæga*, established by Dr. H. Woodward (Geol. Mag. 1870, p. 495). Some characters suggest a reference to the recent genus *Cirolana*, but the tribe to which it really belongs cannot be determined until the details of the cephalic and abdominal appendages are known; in the absence of this knowledge it is not possible to decide whether it should be referred to the Ægidæ proper, or to the Cymothoidæ.

With reference to these tribes, as regards living species, a most valuable and exhaustive series of articles, illustrated by numerous plates, have been published in Naturhistorisk Tidsskrift (Copenhag.), Bd. xii. xiii. xiv. 1879–84, 'Symbolæ ad Monographiam Cymothoarum,' by J. C. Schiœdte and Fr. Meinert. These authors also publish a paper in the same series, 'De Cirolanis Ægas simulantibus commentatio brevis,' Bd. xii. 1879–80.

DESCRIPTION OF PLATE VI. Figs. 1—7.

Fig. 2.	*Palæga McCoyi*, Carter.	Showing the cephalon (crushed), the pereion, and the anterior segments of the pleon. nat. size.
,, 1.	,, ,, ,,	Cephalon, first, and portion of second segment of pereion. nat. size.
,, 4.	,, ,, ,,	The same specimen as Fig. 1, but enlarged.
,, 7.	,, ,, ,,	Posterior portion of pereion, the pleon and the telson, with impression in the matrix of uropodite. nat. size.
,, 5.	,, ,, ,,	The same specimen as Fig. 7, but enlarged.
,, 6.	,, ,, ,,	Uropodite. enlarged.
,, 3.	,, ,, ,,	Restoration of entire form.

II.—On the Microscopic Structure of the Jurassic Pisolite.

By E. Wethered, F.G.S., F.C.S., F.R.M.S.

(PLATE VI. Figs. 8—11.)

The specimens of pisolite which I have examined were obtained from two horizons, namely, the Coralline Oolite and base of the Inferior Oolite near Cheltenham. The pisolites are well known and have frequently been referred to by authors as fine types of oolitic granules, and in proof of this I may quote from Mr. H. B. Woodward's last edition of his Geology of England and Wales. Speaking of oolite granules the author says (p. 281), "When these particles approach the size of a pea or bean, the rock is termed Pisolite, Pisolitic Limestone, or Pea-grit."

The Coralline Pisolite.

For the specimens which I have examined from the Coralline Oolite and for information descriptive of the beds, I am indebted to Mr. H. B. Woodward, F.G.S., to whom I return my cordial thanks. The first specimens sent me were collected at Osmington, near Weymouth, from a bed 1 foot thick, and occurring 6 or 7 feet from the base of the Coralline division, named "Osmington Oolite" by Blake and Hudleston.[1] The specimens consisted of dark brown calcareous spherules about the size of peas. They were loosely embedded in an argillaceous matrix in which there were also oolitic granules of the ordinary size and type.

The sections of the spherules show a nucleus in each, but the structure of the surrounding material can only be studied through a microscope. Viewed through a low power the nucleus is observed to be enclosed by rudely concentric layers of innumerable minute tubuli. Examined by a half-inch object glass the tubuli are clearly defined. They measure about $\frac{1}{4000}$ of an inch in diameter, and are remarkable for the extraordinary vermiform twistings and turnings which they exhibit, Fig. 9, Pl. VI. They appear to make up the whole mass; no skeleton fibre can be made out, and what spaces there are between the tubuli are filled with crystalline calcite. The only system exhibited by the tubuli, if system it can be called, is that they appear in aggregations, having a concentric tendency around an unoccupied space in the centre of each aggregation, and that the latter seem to interlace one with the other. The other specimens sent me by Mr. Woodward were collected at Sturminster Newton, from the bed No. 6a. mentioned by Blake and Hudleston.[2] The horizon is the same as the Osmington pisolite, and the bed is described as consisting of "loose pisolite of large flattened concretions, 1 foot thick." In shape and size the spherules are similar to those from Osmington, but they are lighter in colour. The microscopic structure is generally well preserved and coincides with the description given of the Osmington pisolite.

Pisolite, or Pea-grit, from the Inferior Oolite. Pl. VI. Fig. 8.

After examining the specimens of pisolite from the Coralline Oolite I turned to the Pea-grit, so well known as occurring at the bottom of the Inferior Oolite in the Northern Cotteswolds. The greatest development is in the neighbourhood of Cheltenham, and the stratigraphical features of these interesting beds have been frequently referred to by geologists; among whom I may mention Sir R. Murchison, Mr. Strickland, Dr. Wright, Professor Hull, Mr. Lycett, Professor Buckman, Mr. Witchell, Mr. Etheridge and Mr. Lucy.

[1] Quart. Journ. Geol. Soc. vol. xxxiii. p. 265.
[2] *Loc. cit.* p. 276.

Dr. Wright[1] divided the beds as they occur at Leckhampton near Cheltenham as follows, in descending order:

"A. Brown, coarse, rubbly oolite, full of flattened concretions, cemented together by a calcareous matrix.	12 feet
"B. A hard cream-coloured pisolite rock made up of flattened concretions of about the thickness of those in A.	10 ,,
"C. A coarse, brown, ferruginous rock composed of large oolitic grains	20 ,,
Total	42 feet"

Commencing the microscopic examination at the beds marked C by Dr. Wright, we see a limestone made up of granules and fragments of organisms, the spaces between being filled in with crystalline calcite. The organic fragments consist of spines of Echini, Polyzoa, Crinoids, shells of Mollusca and Foraminifera, those of the Crinoids and Echini are by far the most numerous. All the granules show a nucleus, but in some instances the original has become converted into crystalline calcite. The nuclei vary, indeed all the fragmentary remains of organisms mentioned as occurring in the rock may be said to serve. When the nucleus is a portion of a spine, then the shape is less spherical and is somewhat elongated.

The granules are of two types; first the true oolitic granule distinguished by the concentric layers; second, spherules which vary in size from that of ordinary oolitic granules to that of a pea. In this latter type of spherule the nucleus is not surrounded by concentric layers of carbonate of lime, but by vermiform tubuli averaging about $\frac{1}{500}$ of an inch in diameter (Figs. 10-11), but in some instances they are larger. The tubuli may be said to be arranged in layers or bands which are concentric with the nucleus. In some instances the tubes turn and twist about in a very remarkable manner, sometimes assuming a flat spiral form.

Passing to the succeeding series of beds, marked B by Dr. Wright, we find the pisolite spherules[2] as large as peas (Fig. 8, Plate VI.), but often flattened. The typical Pea-grit is confined to one bed which averages about 4 feet 6 inches thick, and is best studied at Cleeve Hill. It is a mass of the spherules, which are firmly cemented in the matrix. On exposure to the action of the atmosphere the matrix is removed and the spherules then stand out in relief and after a time become detached. On examining some of these with a magnifying glass a vermiform structure may be noticed in some instances.

Thin sections made from this typical bed show the nucleus in the spherules to be surrounded by the same tubuli as represented in Figs. 10 and 11, but if anything they are more vermiform. Some of these spherules, however, show layers and spaces not occupied by that type of tubuli, and when these are not filled with crystalline material, minute tubuli are seen which correspond with those in the pisolite from the Coralline Oolite.

[1] Quart. Journ. Geol. Soc. vol. xvi. p. 7, 1860.

[2] I use the term spherule for the pisolites and granule for the ordinary oolitic forms.

Inference.

I now come to the inference which is to be drawn from the observations I have made. The first conclusion, which cannot be disputed, is, that we can no longer regard the pisolites as a form of concretionary oolitic structure. The so-called pisolite granules are really formed by the growth of an organism around a nucleus. As to the determination of that organism the similarity to the genus *Girvanella* is at once suggested. This organism was first described by Professor A. Nicholson and Mr. R. Etheridge, jun.,[1] and has since been more fully referred to by Professor Nicholson.[2] He remarks, "This curious fossil occurs in great numbers in the lime-formation of the rock," the Ordovician limestone, "and presents itself in the form of small rounded or irregular nodules which vary in diameter from less than a millimetre to more than a centimetre. The larger examples show a distinctly concentric structure, visible even to the naked eye, but the most powerful lens fails to show any obvious internal structure in fractured or weathered surfaces. Examined microscopically the nodules of *Girvanella* are seen to consist of exceedingly minute circular tubes, endlessly contorted and bent, and twisted together in loosely reticulated or vermiculate aggregations." This description of the microscopic structure of *Girvanella problematica*, the one species of the genus mentioned by Professor Nicholson and Mr. Etheridge, jun., corresponds very closely with the structure of the Coralline pisolites, and with the minute tubuli in some of the Pea-grit spherules at the base of the Inferior Oolite. A comparison of actual specimens confirms the similarity, and I have no hesitation in referring the Coralline pisolites to the genus *Girvanella*. Nor do I find sufficient evidence to warrant me in making a new species. It is true that the majority of the tubes are smaller than those in *G. problematica*, and that Professor Nicholson makes no reference to a nucleus around which they congregate. Now, the first portion of a Jurassic *Girvanella* spherule to undergo change is the nucleus. In some specimens we find simply crystalline calcite into which the original nucleus has been converted. The Silurian rocks, in which *Girvanella* was first discovered, are so much older than the Jurassic Oolite that it is not surprising to find the original nucleus changed into crystalline calcite. In the specimens which I have examined of *G. problematica* there seems to me to be undoubted signs of a nucleus, and I therefore do not see my way to make the absence of a clearly defined nucleus in the Silurian forms the reason for proposing another species of those in the Coralline Oolite, but it is possible that at some future time evidence may be obtained which would warrant that course being taken for reasons apart from the nucleus.

With some of the spherules of the Pea-grit the matter is different. The larger well-defined tubuli represented in Figs. 10 and 11 are wanting in the Coralline forms, and I therefore propose to give them the name of *Girvanella pisolitica*. It is a question whether

[1] Mon. Sil. Foss. Girvan, pp. 22-3. pl. ix.
[2] Geol. Mag. N.S. Dec. III. Vol. V. p. 22, 1888.

two species should not be made out of the Pea-grit forms, on account of both the minute tubuli and the larger type occurring in the same spherule. For the present, however, I do not see my way clear, as it may be that the two forms are associated together in the same spherule.

As to what known organisms *Girvanella* should be referred is a matter which seems to me to be one of considerable difficulty. Professor Nicholson and Mr. R. Etheridge, jun., referred it to the *Rhizopoda* and regarded it as related to the arenaceous *Foraminifera*. From this view Professor Nicholson, in his later communication, sees no reason to depart (*loc. cit.* p. 23).

Girvanella pisolitica (new species), Plate VI. Figs. 10 and 11.

This species occurs in the form of flattened spherules varying in size from 1 to $\frac{5}{12}$ of an inch in greatest diameter (Fig. 8, Plate VI.). In the centre of each spherule there is a nucleus which is surrounded by calcareous tubuli (Figs. 10 and 11) with well-defined walls, and averaging about $\frac{1}{500}$ of an inch in diameter, though some are smaller. In some instances, more especially in the larger spherules, the tubes bend and twist about in a truly vermiform manner, often assuming the form of a flattened coil. It differs from *G. problematica* inasmuch as the tubes do not occur in aggregations, and are more concentric around the nucleus. The tubes are also branching and are larger than those of *G. problematica*.

DESCRIPTION OF PLATE VI. Figs. 8—11.

Fig. 8. Spherules of *Girvanella pisolitica* from the Pea-grit near the base of the Inferior Oolite, Cheltenham. Natural size.

Fig. 9. Portion of *Girvanella problematica* from a Coralline Oolite spherule. × 68 diam.

Fig. 10. *Girvanella pisolitica*, shown in section, from near the base of the Inferior Oolite near Cheltenham. × 40 diam. (not 50 diam. as erroneously marked on the plate).

Fig. 11. Another spherule of *Girvanella pisolitica* from the Pea-grit near Cheltenham. × 30 diam. Shows a joint of a Crinoid as a nucleus.

III.—On Jurassic Ammonites.

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

Ammonites serpentinus (Reinecke), and Ammonites Strangewaysi, Sowerby.

In a former communication (Geol. Mag. Dec. III. Vol. IV. No. 9, p. 396, 1887), when pointing out how Reinecke's *Amm. serpentinus* had been misunderstood, I gave as a synonym, but with a query, Sowerby's *Amm. Strangewaysi*. As I have, since then, examined the type-specimen of the latter species contained in the collection of the Natural History Museum, and as Mr. E. Walford kindly forwarded me for my determination a capital specimen from Byfield, I have been able to satisfactorily settle the identity of these forms. Except being evolute carinate Ammonites, the two species have hardly a feature in common.

Harpoceras Strangewaysi (Sowerby).

1822. *Ammonites Strangewaysi*, Sow. Min. Conch. pl. 254, figs. 1 and 3.
1885. *Harpoceras serpentinum*, Thompson (non Reinecke), Upper Lias; Journ. Northampt. Nat. Hist. Soc. vol. iii. p. 309, pl. 1, fig. 1.

Discoidal, compressed, hollow-carinate. Whorls flattened, ornamented with genuine sickle-shaped ribs, which, though less conspicuous in size on the body-chamber, are there more distinctly bent. Ventral area marked by the prolonged forward sweep of the ribs, and surmounted by a well-marked hollow-carina. Inner margin almost upright, neither concave nor convex. Umbilicus shallow and open. Inclusion, with the body-chamber present, one-third. Termination of mouth-border partly visible, showing that it is plain, and curved like the ribbing. Aperture, oblong.

The above, taken from Mr. Walford's specimen, differs in some particulars from Sowerby's description; but then neither Sowerby's figure, nor his description, agree with the original specimen. The umbilicus is drawn considerably too large; the inner margin—"oblique flattened surface which forms the inner edges of the whorls"—which Sowerby emphasizes so particularly, is by no means slanting, but is nearly upright, and the sectional view which he gives is quite incorrect. The ribs, too, are not drawn with sufficient bend; they are truly of the shape of a sickle, with the inner portion quite straight and a marked bend at the middle. The indications of suture-lines are correct enough in Sowerby's figure, and his specimen shows that the lobes are exactly those of *Harpoceras*, as I described these in my former communication (p. 397).

Harpoceras Strangewaysi differs from *Harp. falciferum* by its umbilicus being much more open—about one-fourth larger—its ribs not quite so strongly bent, and its inner margin almost upright instead of being undercut. Individual specimens of this species seem to differ in the coarseness of their ribbing. Sowerby's example is more coarsely ribbed than his drawing would lead us to expect.

Mr. Walford's specimen came from the "Fish-bed, Upper Lias, Byfield"; Mr. Thompson sent me a specimen from Bugbrook; and I have a poor example from Trent near Yeovil; Sowerby's specimen came from Ilminster. The species seems to be unknown on the Continent.

Hildoceras serpentinum (Reinecke).

1818. *Argonauta serpentinus*, Reinecke, Maris protogæi, figs. 74, 75.
1867. *Ammonites serpentinus*, Meneghini, Monogr. calc. rouge; Paléont. Lombarde, 4e série. Plate iii. fig. 1.
1885. *Hildoceras serpentinum*, Haug, Beitr. Mon. Harpoceras; Neues Jahrbuch für Mineral. Beil.-Bd. iii. p. 643.

I discussed this species in my previous communication (p. 396), pointing out wherein it differed from a species to which this name had been erroneously applied. I was uncertain, then, as to its genus, because I had not a specimen; and *Am. Strangewaysi* being given as a synonym misled me.

The suture-line[1] of this species differs entirely from *Harp. Strangewaysi*; it lacks all the florid ornamentation, the large accessory lobe, and the auxiliary lobe; in fact, the suture-line is an almost exact copy of what belongs to *Hildoceras bifrons*. The ribs incline more to a sigmoidal curve, the inner margin is actually obliquely-truncated, and inclining to be concave; the carina is solid and bounded by two slight furrows (which, however, disappear on the body-chamber); the inclusion is almost nil, and the whorls are consequently narrow. The difference betwen the suture-line of *Harp. Strangewaysi* and *Hildoceras serpentinum* is so striking that any one who has seen the two species together would never mistake them.

Hild. serpentinum is very like *Hild. bifrons* in all respects, but lacks the longitudinal furrow; while it has smaller ventral channels, and its ribs are visible on the inner area.

The species is evidently extremely scarce both in England and on the Continent. I have searched both the Natural History and Jermyn Street Museums without success; and the only specimen I know is the one in my own collection from South Petherton, probably from the *Falciferum*-zone.

Neither this nor the previous species were figured in Wright's monograph.

Ammonites Murchisonæ, Amm. corrugatus, Amm. læviusculus Sowerby; Harpoceras amaltheiforme, Vacek.

The first three species have usually been united under the name *Amm. Murchisonæ*; but this arose from the fact that the two species suppressed had never been correctly identified. I was soon able to satisfy myself concerning the species to which Sowerby had given the name *Amm. læviusculus*; but the little shell figured as *Amm. corrugatus* proved a most difficult subject. It has in fact taken me five years to find the truth, even though I was often able to compare Sowerby's original with my own specimens.[2] Three years ago I imagined that it agreed with the young of Vacek's species; but there was a very slight discrepancy in the curvature of the ribs upon the ventral area, and therefore I was not absolutely satisfied. Last summer I obtained some specimens from Dundry; and during a recent visit to the Natural History Museum, I was able to satisfy myself concerning what Sowerby's *corrugatus* really was.

I have already treated of *Ludwigia Murchisonæ*, Sowerby sp., in my Monograph, pt. i., and have nothing further to add thereto; but I will define the other species.

Sonninia corrugata (Sowerby).

1825. *Ammonites corrugatus*, Sowerby, Min. Conch. pl. 451, fig. 3.
1867. ——— *patella*, Waagen, Geogn. Pal. Beitr. (Zone *Amm. Sowerbyi*) pl. 25, fig. 2, 3.

[1] Hitherto unknown (*Haug*). It agrees almost exactly with my fig. 28, pl. A. (Monogr. *Ammonites*, 1889, part iii.), but the inferior lateral lobe is a little larger and is nearer the edge.

[2] I take the opportunity of thanking the officers of the Natural History and Jermyn Street Museums for their kindness and courtesy.

Non *Ludwigia corrugata*, Douvillé.

When young, this species possesses coarse ribs, more or less joined towards the inner margin, and projected forwards on the ventral area; it has a small keel sunk between two furrows; and the preceding whorl is covered about one-half by the next. It soon loses its furrows, obtains a large hollow carina, and at a later date loses its ribs; its envelopment is now two-thirds, quickly decreasing again to one-half at the mouth.

When adult, the species reaches a diameter of 11 inches, is quite smooth, and is then the *Amm. patella*, Waagen, whose name must now give way to Sowerby's. It occurs in the "Ironshot Oolite" of Dundry, Somerset; and I have a large specimen from Sherborne, Dorset. Its horizon is either the *Humphriesianum* or *Sauzei*-zone.

Witchellia læviuscula (Sowerby).

1825. *Ammonites læviusculus*, Sowerby, Min. Conch. pl. 451, fig. 1, 2.
1885. *Harpoceras læviusculum*, Haug, Beitr. Mon. Harpoceras; Neues Jahrbuch für Mineral. etc. Beil.-Bd. iii. pl. xii. fig. 6.

Sowerby's figures of this species are very truthful. They do not, however, show one peculiarity belonging to this species, and in fact to this genus, namely, that when the test is absent, the ventral area carries two deep furrows each side of a carina; when the test is present, the furrows are not observable, while the carina is much raised, and is of the hollow type. The species occurs plentifully at Oborne in the *Sauzei*-zone, and also at Dundry in the Ironshot Oolite, but not so frequently. I have proposed the genus *Witchellia* for species which have the peculiarity of a furrowed core and a hollow carina, compressed sides, coarse irregular ribs with a long ventral projection, and a suture-line which possesses the characteristics of that of *Sonninia*, but is by no means so ornate. The genus begins with the evolute *W. Sutneri* (Branco), and gradually developing ends with the involute W. *læviuscula.*

Hammatoceras amaltheiforme (Vacek).

1886. *Harpoceras amaltheiforme*, Vacek, Oolithe Cap. San. Vigilio. Abh. k. k. geol. Reichsanstalt, Bd. iii. pl. ix. fig. 1 only.

In youth almost exactly similar to *Sonninia corrugata*; but the ribs meet the carina with only an extremely slight forward projection. When adult, the species is entirely different; it is much thicker, and still possesses its coarse ribs. The suture-line is quite different to that of *Sonninia*; the inner lobes crossing the inner area in such an oblique direction—much dependent—are characteristic of the genus *Hammatoceras.*

I possess a whole series showing the evolution of this species from *Hamm. insigne* (Schubler); nor does the development of the genus end here, for a species with a smaller, almost closed, umbilicus is evolved.

This species occurs in the *Concavum*-zone of Bradford Abbas, but is scarce.

IV.—Comparison of the Principal Forms of Dinosauria of Europe and America.[1]

By Professor O. C. Marsh, Ph.D., LL.D., F.G.S.

THE remains of Dinosaurian reptiles are very abundant in the Rocky Mountain region, especially in deposits of Jurassic age, and during the past ten years the author has made extensive collections of these fossils, as a basis for investigating the entire group. The results of this work will be included in several volumes, two of which are now well advanced towards completion, and will soon be published by the United States Geological Survey.

In the study of these reptiles, it was necessary to examine the European forms, and the author has now seen nearly every known specimen of importance. The object of the present paper is to give, in few words, some of the more obvious results of a comparison between these forms and those of America which he has investigated.

With this purpose in view, it will not be necessary to discuss here the classification of the *Dinosauria*, their affinities, or their origin. These topics will be treated fully in the volumes in preparation. For the sake of convenience, however, the ordinal names proposed by the author, and now in general use, will be employed.

Sauropoda.

The great group which the author has called *Sauropoda*, and which is represented in America by at least three well-marked families, appears to be rare in Europe. Nearly all the remains hitherto discovered there have been found in England, and most of them in a fragmentary condition. The skull is represented only by a single fragment of a lower jaw and various isolated teeth, and, although numerous portions of the skeleton are known, in but few cases have characteristic bones of the same individual been secured.

Quite a number of generic names have been proposed for the remains found in England, and several are still in use, but the absence of the skull, and the fact that most of the type specimens pertain to different parts of the skeleton, render it difficult, if not impossible, to determine the forms described.

In the large collections of *Sauropoda* secured by the author in America, which include the remains of more than one hundred individuals, both the skull and skeleton are well represented. On this material, his classification of three families, *Atlantosauridæ*, *Morosauridæ*, and *Diplodocidæ*, has been based. The *Pleurocœlidæ*, also, appear to be distinct, but the remains at present known are less numerous and characteristic than those pertaining to the other divisions of this group.

In examining the European *Sauropoda* with some care, the author was soon impressed by three prominent features in the specimens investigated:—

1. The apparent absence of any characteristic remains of the *Atlantosauridæ*, which embrace the most gigantic of American forms.

[1] Abstract of a paper read before Section C, of the British Association for the Advancement of Science, at the Bath Meeting, Sept. 8th, 1888.

2. The comparative abundance of another family (*Cetiosauridæ*), nearly allied to the *Morosauridæ*, but, as a rule, less specialized.

3. The absence, apparently, of all remains of the *Diplodocidæ*.

A number of isolated teeth and a few vertebræ of one immature individual appeared to be closely related to *Pleurocœlidæ*, but this, for the present, must be left in doubt.

Among the American forms of *Sauropoda*, the skull is now comparatively well known in the principal families and genera. *Brontosaurus*, *Morosaurus*, and *Diplodocus*, typical of their respective families, are each represented by several skulls, some of which are nearly complete, and characteristic portions are known of the skulls of other genera.

The vertebræ, also, and especially the pelvic arch, afford distinctive characters. By the latter alone, the *Atlantosauridæ* and *Morosauridæ* may be readily distinguished. In the absence of the skull, this is a point of importance in a comparison of European with American forms.

In the *Atlantosauridæ*, the ischia are nearly straight, and when in position, extend downward and inward, meeting on the median line by a symphysis of the two ends, as in Crocodiles. In the *Morosauridæ*, the ischia are twisted, and extend inward and backward, with the inner margins alone meeting each other on the median line, the ends being free.[1]

All the ischia of *Sauropoda* known from Europe appear to be of the latter type, although proportionally broader and more massive than those of the corresponding American forms. The ilia and pubes associated with these ischia agree in their main features with those of the American genus *Morosaurus*, so that there can be little doubt that the same general form is represented in both countries.

A striking difference between the *Cetiosauridæ* and the allied American forms is that, in the former, the fore and hind limbs appear to be more nearly of the same length, indicating a more primitive or generalized type. Nearly all the American *Sauropoda*, indeed, show a higher degree of specialization than those of Europe, both in this feature and in some other respects.

The identity of any of the generic forms of European *Sauropoda* with those of America is at present doubtful. In one or two instances, it is impossible, from the remains now known, to separate closely allied forms from the two countries. Portions of one animal from the Wealden, referred by Mantell to *Pelorosaurus* under the name of *P. Becklesii*,[2] are certainly very similar to some of the smaller forms of *Morosaurus*, especially in the proportions of the fore limbs which are unusually short. This fact would distinguish them at once from *Pelorosaurus*, and until the skull and more of the skeleton are known they cannot be separated from *Morosaurus*, and should be known as *Morosaurus Becklesii*. During the examination of this specimen, which is in the collection of its discoverer, Mr. S. H. Beckles, of St. Leonards, England, the author found, attached

[1] Diagrams showing typical ischia in these families and in the *Cetiosauridæ* were exhibited by the author when the paper was read.

[2] Morris's Catalogue of British Fossils, p. 351, 1854.

to the humerus, portions of the osseous dermal covering, the first detected in the *Sauropoda*, and known only in the present specimen.

A dozen or more generic names have been proposed for the European forms of *Sauropoda*, and of these *Cetiosaurus*, Owen, 1841, is the earliest, and must be retained. The remains on which this genus was based are from the Great Oolite, or Lower Jurassic. *Cardiodon*, Owen, 1845,[1] is from nearly the same horizon, and there appears no evidence that the two forms are not identical. *Pelorosaurus*, Mantell, 1850, is from the Wealden, and may be distinct, but, at present, the proof is wanting. *Oplosaurus*, Gervais, 1852, also from the Wealden of England, cannot well be separated from *Pelorosaurus*. *Gigantosaurus*, Seeley, 1869, from the Kimmeridge of the Upper Jurassic, may prove to be different from the above, but the type specimens alone do not indicate it. *Bothriospondylus*, Owen, 1875, is also from the Kimmeridge, and, although the type specimen pertains to a very young, if not fœtal individual, it seems to be distinct, and may be nearly allied to the American genus *Pleurocœlus*. The author failed to find conclusive evidence in the type specimens themselves for the use of the other generic names proposed, namely: *Ornithopsis*, Seeley, 1870, from the Wealden; *Eucamerotus*, Hulke, 1872, Wealden; *Ischyrosaurus* (preoccupied), Hulke, 1874, Kimmeridge; and *Chondrosteosaurus*, Owen, 1876, Wealden.

Æpyosaurus, Gervais, 1852; *Macrurosaurus*, Seeley, 1876; and *Dinodocus*, Owen, 1884, all represent forms from the Cretaceous, but their relations to each other cannot yet be determined.

Discoveries of more nearly perfect specimens may establish the fact that the forms in the different geological horizons are distinct, but so long as the known remains are so isolated and fragmentary, this point must be left in doubt.

The European *Sauropoda* at present known are from deposits more recent than the Lias, and none have been found above the Upper Greensand. In America, this group apparently has representatives in the Trias, was very abundant in the Jurassic, but, so far as now known, did not extend into the Cretaceous.

Stegosauria.

Another group of Dinosaurian reptiles, which the author has called the *Stegosauria*, from the typical American genus *Stegosaurus*, is well represented in European deposits. The remains already discovered are more numerous, and in better preservation, than those of the *Sauropoda*, and the number of distinct generic forms is much larger. The geological range, also, is greater, the oldest forms known being from the Lias, and the latest from the Cretaceous.

These reptiles, although very large, were less gigantic in size than the *Sauropoda*, and were widely different from them in their most important features. Their nearest allies were the *Ornithopoda*, to which they were closely related.

[1] *Cardiodon* dates from 1841 and *Cetiosaurus* also from 1841. See Introduction, Part 2, p. x, of Catalogue Fossil Reptilia, by R. Lydekker (May, 1889).—Edit.

All the known members of the group appear to have had an osseous dermal armour, more or less complete.

One of the best preserved specimens of the *Stegosauria* in Europe was described by Owen, in 1875, as *Omosaurus armatus*, and the type specimen is in the British Museum. It is from the Kimmeridge Clay (Upper Jurassic), of Swindon, England. The skull is wanting, but the more important parts of the skeleton are preserved. Various portions of the skeleton of several other individuals have also been found in England, but the skull and teeth still remain unknown.

A recent examination of these specimens by the author disclosed no characters of sufficient importance to separate them from the genus *Stegosaurus*, and, as the name *Omosaurus* is preoccupied, they should, for the present, at least, be referred to *Stegosaurus*. The discovery of the skull and the dermal armour may not unlikely prove them to be distinct, but the parts now available for comparison do not alone authorize their separation.

The type specimen of *Anthodon serrarius*, Owen, a fragment of a jaw from South Africa, and now in the British Museum, has teeth so very similar to the American forms of *Stegosaurus*, that, judging from these alone, it would naturally be referred to that genus. *Hylæosaurus*, Mantell, from the Wealden, has teeth of the same general type, but most of those referred to it, by Mantell and others, pertain to the *Sauropoda*. This genus, as well as *Polacanthus*, Hulke, from the same formation, *Acanthopholis*, Huxley, from the Cretaceous, and *Scelidosaurus*, Owen, from the Lias, are known from English specimens, but have not yet been found on the Continent. No American forms of these genera have yet been discovered.

An interesting Cretaceous member of this group is the *Struthiosaurus*, Bunzel, 1871, apparently identical with *Danubiosaurus* of the same author, 1871, and *Cratæomus*, Seeley, 1881. It is from the Gosau formation of Austria. Although only fragments of the skeleton and dermal armour are known, some of these are very characteristic. One specimen of the latter, figured by Seeley, and regarded as a dermal plate, bearing a horn-like spine "exactly like the horn-core of an ox,"[1] is very similar in form to some problematical fossils from America, the exact horizon of which is in doubt.[2]

Palæoscincus, Leidy, 1856, from the Cretaceous, and *Priconodon* of the author, 1888, from the Potomac formation, are, perhaps, allied forms of the *Stegosauria*, but, until additional remains are found, their exact affinities cannot be determined. Apparently, the oldest known member of this group in America is the *Dystrophæus*, Cope, 1877, from the Trias of Arizona. In Europe, none have yet been

[1] Quart. Journ. Geol. Soc. of London, vol. xxxvii. pl. xxviii. fig. 4, 1881.

[2] Additional remains secured during the past season prove conclusively that some of these "horn-cores," if not all, were attached to the skull in pairs, and one specimen found in place has since been described by the author as *Ceratops montanus* (Silliman's Journal, vol. xxxvi. p. 477, December, 1888). It is from the Laramie formation of Montana. Others have been found in Colorado and in Wyoming. These are all much larger than the European specimens.

found below the Jurassic. The *Euskelesaurus* of Huxley, 1867, from the Trias of South Africa, is apparently a member of this group.

Ornithopoda.

The great group which the author has called the *Ornithopoda* is well represented in Europe by *Iguanodon* and its allies. The remarkable discoveries in the Wealden of Belgium, of a score or more skeletons of *Iguanodon*, have furnished material for an accurate study of the genus which they represent, and, indirectly, of the family. The genus *Iguanodon*, founded by Mantell in 1824, is now the best known of European forms, and need not here be discussed. *Hypsilophodon*, Huxley, 1870, from the Wealden, is likewise well represented, and its most important characters fully determined. The other genera of this group, among which are *Mochlodon*, Bunzel, 1871, *Vectisaurus*, Hulke, 1879, *Orthomerus*, Seeley, 1888, and *Sphenospondylus*, Seeley, 1883, are described from less perfect material, and further discoveries must decide their distinctive characters.

None of these genera are known from America, but allied forms are not wanting. A distinct family, the *Hadrosauridæ*, is especially abundant in the Cretaceous, and another, the *Camptosauridæ*, includes most of the Jurassic species. The latter are the American representatives of the *Iguanodontidæ*. The nearest allied genera are, apparently, *Iguanodon* and *Camptosaurus* for the larger forms, and *Hypsilophodon* and *Laosaurus* for those of small size. A few isolated teeth from each country suggest that more nearly related forms may at any time be brought to light.

Many generic names have been proposed for members of this group found in America and in Europe, but, in most cases, they are based on fragmentary, detached specimens, which must await future discoveries before they can be assigned to their true place in the order.

As a whole, the European *Ornithopoda* now known seem to be less specialized than those of America, but additional discoveries may modify this opinion. The geological range of this group, so far as known, is essentially the same on each continent, being confined to the Jurassic and Cretaceous. There is some evidence, from footprints, at least, that, in America, the order was represented in the Trias.

Theropoda.

The carnivorous *Dinosauria* have all been included, by the author, in one order, *Theropoda*, although there are two or three suborders quite distinct from each other. This great group is well represented both in Europe and America in the Trias, is especially abundant in the Jurassic, and diminishes in the Cretaceous, at the close of which, it apparently becomes extinct.

The typical genus is *Megalosaurus*, Buckland, 1824, the type of which was the first Dinosaurian reptile described. Although its remains are comparatively abundant in Europe, they have been found only in a fragmentary condition, and many important points in the structure of the skull and skeleton are still in doubt.

The oldest representatives of this group in Europe are *Thecodontosaurus*, Riley and Stutchbury, 1836, and *Plateosaurus*, von Meyer, 1837, both from the Trias. The former genus is from the lower horizon, near Bristol, England; the latter, from the Keuper of Germany. *Zanclodon*, Plieninger, 1846, is from the same horizon as *Plateosaurus*, and appears to be the same thing. *Massospondylus*, Owen, 1854, from the Trias of South Africa, is apparently a form allied to *Thecodontosaurus*. The nearest American genus is *Anchisaurus*, two species of which are known from the Connecticut River sandstone.

The most interesting member of the *Theropoda* known in Europe is the diminutive specimen described by Wagner, in 1861, as *Compsognathus longipes*. The type specimen, the only one known, is from the lithographic slates of Solenhofen, Bavaria, and is now preserved in the Museum in Munich. Fortunately, the skull and nearly all the skeleton are preserved, and as it has been studied by many anatomists, its more important characters have been made out. It is regarded as representing a distinct suborder, and no nearly related forms are known in Europe. Its nearest ally is probably the specimen from Colorado, described by the author, in 1881, as *Hallopus victor*. This animal was about the same size as *Compsognathus*, and resembles it in some important features. It is probably from nearly the same geological horizon, but may be somewhat older. Each of these specimens appears to be unique, and until a careful comparison of the two is made, their relations to each other can only be conjectured.

The American representative of *Megalosaurus* is apparently *Allosaurus*, a genus established by the author, in 1877. The type specimen is from Colorado, from a higher horizon in the Jurassic than that of *Megalosaurus*. Nearly every part of the skeleton of this genus is now known, and the more important portions have been described and figured by the author. *Creosaurus*, also from the Jurassic, is an allied form, and *Dryptosaurus*, from the Cretaceous, is, perhaps, also closely related. A very distinct form in the Jurassic is *Labrosaurus*, described by the author, in 1879. It is known from detached specimens only, but these, especially the jaws, edentulous in front, show it to represent a distinct family.

The most perfectly known of American *Theropoda*, and by far the most interesting, is the genus *Ceratosaurus*, founded by the author, in 1884. This is the representative of a very peculiar family, which differs in some important respects from all other known Dinosaurs. The skull and nearly all the various parts of the skeleton are known. When found, they were entire, and in the position in which the animal died. The skull and some of the more interesting parts of the skeleton have been figured by the author, and all will soon be fully described.

The skull bears a large elevated horn-core on the median line of the nasals. The cervical vertebræ differ in type from those of any other known reptiles, having the centra plano-concave. All behind the axis have the anterior end of each centrum perfectly flat, while the posterior end is deeply cupped. This genus, moreover, differs from all known Dinosaurs in having the elements of the pelvis (ilium, pubis, and ischium) coössified, as in all existing birds. The metatarsals, also, are firmly united, as in birds. No representatives of the *Ceratosauridæ* are known in Europe.

In conclusion, it may safely be said that the four great groups of *Dinosauria* are each well represented both in Europe and America. Some of the families, also, of each order have representatives in the two regions, and future discoveries will doubtless prove that others occur in both.

No genera common to the two continents are known with certainty, although a few are so closely allied, that they cannot be distinguished from each other by the fragmentary specimens that now represent them. It must be remembered that the great majority of genera have been named from portions of skeletons, of which the skull was unknown, and until the latter is found, and definitely associated with the remains described, the characters and affinities of the genus can be only a matter of conjecture, more or less definite, in proportion to the perfection of the type specimens.

From Asia and Africa, also, a few remains of Dinosaurs have been described, and the latter continent promises to yield many interesting forms. Characteristic specimens, representing two genera, one apparently belonging to the *Stegosauria*, and one to the *Theropoda*, are already known from South Africa, from the region so rich in other extinct Reptilia.

From Australia, no *Dinosauria* have as yet been recorded, but they will undoubtedly be found there, as this great group of Reptiles were the dominant land animals of the earth, during all Mesozoic time.

V.—Second Note on *Stenotheca*.

By G. F. Matthew, M.A., F.R.S., Canada.

SOME three years ago the writer communicated to this Magazine a "Note on the Genus *Stenotheca*" of Hicks,[1] stating that from the appearance of the species, which on this (western) side of the Atlantic had been referred to it, it did not seem to belong to the Pteropoda, but more probably to the Gasteropoda. I also stated that there were two distinct types of shells which had been referred to *Stenotheca*, one of which by its internal muscular scar and position of the umbo might be compared to *Parmophorus*, etc.; while the other, represented by a number of minute species, appeared to correspond to the original *Stenotheca* of Dr. Hicks.

Collections of these smaller fossils, made subsequently to 1885, led the writer to think that they were the shells of Crustaceans, and he applied to Dr. Hicks for an authentic example of his *Stenotheca*; this Dr. Hicks kindly sent, and the example proved to be congeneric with the smaller shells of the St. John Group which had been referred to *Stenotheca*, and which had been found to be those of Crustaceans.

[1] See Geol. Mag. Decade III. Vol. II. 1885, p. 425.

But the larger shells, which by Billings, Walcott, and the writer have been referred to *Stenotheca*, are Gasteropods allied to *Metoptoma*. They are not, however, of this genus, which has been described as having a truncated apex, whereas the beak of the Cambrian shells is arched and acuminate at the apex.

The minute shells, of which *S. concentrica* is the type, and which alone are properly of the genus *Stenotheca*, show, when magnified, a chasing of waving or chevron lines visible both on the outside and inside of the crust, and these lines *are much more distinct on the inside.* There is no suture along the back, the folded carapace having been irregularly cracked where the sides have been crushed together in the shale. No nuchal piece has been observed, so it appears to have had a minute carapace of one piece only. These fossils are not very plentiful, but occasionally they are found in considerable numbers on layers of the fine dark shales which are equivalent to the Menevian shales of St. David's in Wales.

St. John, N.B., Canada.

VI.—Glaciation of Eastern Canada.

By Robert Chalmers, Esq.,
Of the Canadian Geological Survey.

A PAPER on the Glaciation of Eastern Canada by the writer will shortly appear in the Canadian *Record of Science*, Montreal. It is intended to be a condensed statement of the principal facts hitherto collected on this interesting subject, with references to the reports and publications in which details are given. The following is an abstract which I send to the Geological Magazine in advance. The subject is regarded as an important one, and has occupied the attention of geologists for many years, as Eastern Canada is the battle ground, so to speak, of the advocates of the rival theories of continental glaciation and floating ice. The results thus far obtained from a somewhat careful study of its glacial phenomena, however, point to conclusions which are at variance with those held by extreme glacialists, and show that the theory of local glaciers upon the more elevated portions of the country and icebergs or floating ice striating the lower coastal areas during the Post-Tertiary submergence of these, as maintained by Sir William Dawson, will serve to explain all the observed phenomena. The term 'local glacier' I define as an ice-sheet limited in extent, that is, confined to one valley or hydrographic basin, whether large or small, and influenced in its movements by local topographic features, such as mountains, water-sheds, hills, or the valleys of the larger rivers. The data have been collected chiefly by the staff of the Geological Survey; but Sir William Dawson, who has long studied this region, and others have done much valuable work in glacial geology here.

In reference to the origin and movements of local glaciers, it may be stated, that the main facts pertaining to each centre of dispersion, when correlated, show that these glaciers were independent bodies which had large gathering grounds upon the higher parts of the country where snow fields and *névé*-ice must have existed. Whenever motion began this snow or *névé*-ice became converted into glacier-ice. Upon areas where they never underwent change into ice no striation of the rocks took place. In their movements the glaciers, generally speaking, followed the slopes of the land or the present drainage channels. Some of them seem to have been quite large, and those from adjacent drainage areas may have coalesced on the lower grounds and become confluent. At all events, the slopes and coastal tracts are usually more glaciated than the interior and higher grounds.

In Nova Scotia there was a shedding of ice from the Cobequid Mountains northward and southward, and the South Mountain appears also to have sent glaciers down its slopes, on either side. Sir William Dawson, Dr. Honeyman, Mr. H. Fletcher, Dr. R. W. Ells, and others have made numerous observations showing many divergent courses of striæ, which are explicable only on the theory of local glaciers and icebergs.

The main water-shed of New Brunswick, which traverses the province from north-west to south-east, sent off glaciers in nearly opposite directions, or north-eastward towards the Baie des Chaleurs and Gulf of St. Lawrence on the northern slope, and south-eastward towards the Bay of Fundy on the southern slope. This is abundantly proved by data collected by the writer and others.[1]

Considerable areas in the interior of this province, where centres of dispersion for local glaciers existed, are unglaciated, no ice-action whatever nor Boulder-clay being seen, and the loose materials consisting largely of rock debris *in situ*. These were probably snow-fields and gathering grounds for the ice during the Glacial period. The glaciers on the southern slope appear to have been much larger than on the northern. But even upon the former they had numerous local and divergent movements, as the evidence shows.

The Shickshock or Notre Dame Mountains in South-Eastern Quebec and their continuation south-westward had also large gathering grounds for snow and ice on their summits and shed glaciers south-eastward into the Baie des Chaleurs and the valleys of the Restigouche and St. John rivers, and north-westward into the St. Lawrence valley, the estuarine portion of which must then have been open to receive them.[2] The valleys of tributary rivers and the subordinate ridges and hills caused, however, many local deflections in the ice-currents.

The glacial phenomena of the Archæan area north of the St. Lawrence and great lakes have also been investigated to some extent. The general parallelism of the Laurentian slope, north of the St. Lawrence, to that of the Notre Dame Range, caused the striæ observed on it to have nearly the same course as those on both slopes of the latter, the ice flowing down the slopes at about right

[1] Annual Report, Geol. Surv. Canada, 1885, vol. i. part GG.
[2] Annual Report, Geol. Surv. Canada, 1886, parts I. and M.

angles to the main axes of the mountains.[1] This fact has been made use of to support the theory of a massive ice-sheet moving from the Laurentides across the St. Lawrence valley over the summits of the Appalachians and down the New England slope to the Atlantic. But as will be seen the evidence at hand does not support this view. The Archæan area has, however, sent sheets of ice down its slopes in all directions around its circumference. In the central part, on the east side of Hudson Bay, they moved directly westward into its basin. In Hudson Strait, according to Bell, the ice had a north-eastward and eastward flow. Whether the whole Archæan area was covered by glaciers flowing outwardly from the centre towards the circumference, or with snow fields forming the *névé* of local glaciers, as seems more probable, is a question to be decided by future investigation. Areas of unglaciated rock surface, doubtless, occur there as well as upon other elevated portions of Eastern Canada where decomposed rock lies undisturbed except from subaerial action.

The extent and thickness of the glaciers cannot as yet be satisfactorily determined; but they seem to have been largest on the southern slopes of the Appalachians and Laurentides. The cause of this is not evident; but as regards those of the first-mentioned mountains, which are in a part of the country with which the writer is most familiar, it may be owing in some measure at least to the difference in the steepness of the slopes on either side of it. The south-east slope is long, much broken, and has numerous comparatively level areas upon it. As the rate of motion would be slower on this slope, the ice would necessarily accumulate in larger sheets in depressions and on the level tracts. On the shorter and steeper slope of the St. Lawrence the motion of the ice would be more rapid, and it would more readily debouch into the estuary or sea.

Evidences of the action of icebergs or floating ice are found in the St. Lawrence valley and on the Baie des Chaleurs coast, also in a number of other places around the shores of the Gulf of St. Lawrence. So far as the writer has observed, they are met with only on ledges below the 200 to 350 feet contour-line above sea-level. Floating ice seems to have played an important part in transporting boulders over the submerged areas.

The views here briefly outlined will doubtless undergo some modification, as this region, especially when that part of it known as the great Archæan area, comes to be studied in greater detail. I think, however, the main conclusions herein advanced will stand.

Newfoundland, although not forming part of Canada, is geographically connected with it, and its glacial phenomena may therefore be referred to in this connection. The late Alex. Murray, C.M.G., Director of the Geological Survey for many years, states that its surface is everywhere glaciated.[2] He held the theory of a continental

[1] Geology of Canada, 1863, pp. 890–92; Notes on the Post-Pliocene Geology of Canada, 'Canadian Naturalist,' 1872; Annual Report, Geol. Surv. Canada, 1886, parts I. and M.

[2] Transactions of the Roy. Soc. of Canada, 1882, sec. iv., paper on the Glaciation of Newfoundland.

ice-sheet, however; but his facts show that the striæ are quite divergent, following depressions and valleys in different directions. It seems probable, therefore, that here, as in Eastern Canada, local glaciers produce the chief striation observed, as pointed out by the late Captain Kerr, R.N.[1] But from its insular position, and lying as it does in the track of the Arctic currents, the coast areas must have been intensely eroded from icebergs and floating ice.

OTTAWA, CANADA.

VII.—ON THE OCCURRENCE OF OTTRELITE IN THE PHYLLITES OF NORTH CORNWALL.

By W. MAYNARD HUTCHINGS, Esq.

THE mineral ottrelite, which has received so much attention elsewhere, especially in the Ardennes, and which is of considerable interest in connection with the metamorphism of certain rocks, has not, up to now, ever been reported as occurring anywhere in Great Britain.

I am able to state that I have discovered it in considerable amount in a certain roofing-slate of North Cornwall.

The slate in question is one of a series of specimens of the phyllites of the district collected by me during two successive summer holidays at Tintagel. This series includes most of the roofing-slates of the neighbouring quarries, together with many other slates and slaty rocks, which, while closely of the same general nature as the roofing-slates, differ from them in not having sufficient hardness and fissility to render them fit for quarrying. I have long studied some of these rocks under the microscope, and latterly have been supplied, by the kindness of Mr. Teall, with material from the Ardennes for comparison, as well as with the principal original literature concerning them from the pens of Rénard, Renard and Vallée-Poussin, and Gosselet. The resemblance in many essential points between some of the Cornish rocks and some of the occurrences described by these petrologists, is very interesting, and leads me to think that some account of the Cornish ottrelite-slate and its neighbours may be of some little value.

I will first describe somewhat in detail the slate in which the ottrelite occurs, and the characteristics here shown by that mineral and by which it was identified. Owing to the close general resemblance between all the phyllitic rocks of the district, it will afterwards be a very simple matter to point out the few details of variation.

The ottrelite-slate in question is quarried in the cliffs near to Tintagel Church, the quarry being owned and worked by the Reverend Prebendary Kinsman, Vicar of Tintagel, to whom I am much indebted for the trouble he has kindly taken in forwarding more specimens, and in giving me information since my personal visit to the place.

[1] *Ibid.* p. 68.

The slate is of a greenish-grey colour, close and hard in texture, with a silky lustre rather inclining to resinous in the best kinds. Moderately thin flakes of it are translucent on the edges. It splits easily into very thin sheets, which are strong and sonorous; and appears to be a really first-class roofing-material, equal in every way to the best products of the celebrated quarries at Old Delabole, a few miles inland.

It is fossiliferous, apparently as much so as the Delabole slate so well known in that respect, and Mr. Kinsman informs me that the fossils from the two localities are identical in nature.

There are two quarries at Tintagel very near together, but it is only in the slates from the "New Quarry," nearest to the church, that I have found ottrelite.

Macroscopically, nothing of its mineralogical composition can be made out except that it is more or less speckled over with pyrites, and stained here and there with ferric oxide due to the oxidation of that mineral.

When very thin sections of it are examined under the microscope, it is seen that the main constituent is sericitic mica. By far the greater part of this sericite lies flat in the plane of cleavage of the slate, the flakes overlapping and felted together to an aggregate which, between crossed Nicols, forms a dimly-polarizing, blue-grey base in which the other minerals are set. A great many flakes of sericite, however, are not arranged parallel to the cleavage, but lie in all directions, polarizing in brilliant colours.

The two other principal constituents of the rock are ilmenite and ottrelite;—it might be best described as being a sericite-ottrelite-ilmenite phyllite.

The ottrelite is very abundant. It occurs entirely as quite irregular and indefinitely-bounded, mostly more or less ragged flakes, dispersed pretty uniformly throughout the rock.

The arrangement of the flakes bears no definite relationship to the plane of cleavage of the slate; they lie flat in this plane, vertical to it and at every intermediate degree of inclination. The size is very variable, but as a whole it is very much less than in the well-known rocks of Ottrez, Serpont, and other places in the Ardennes. The largest flakes are usually oblong in shape, the long diameter seldom exceeding $\frac{1}{50}$ inch, and reaching this only in the minority of cases. A usual average, especially in the more rounded forms, is close around $\frac{1}{100}$ inch; but there is ample evidence that the mineral has been much torn and broken up since its formation, and lesser flakes exist down to exceedingly small fragments. The thickness is as variable as the other dimensions. It does not exceed $\frac{1}{1000}$ inch, and most of the flakes are very much less, down to $\frac{1}{3000}$ inch, which seems to be the thickness of a large proportion of the fairly thin ones measured.

The characteristic secondary cleavages, intersecting on the basal plane, are largely developed, though in many flakes they are considerably distorted, and are also frequently much masked by irregular cracks and ruptures, these effects being due to the stress the mineral has undergone during rock-movements. These cleavages are best studied on flakes isolated from the rock and separately mounted. The two most important of these secondary cleavages intersect on the basal plane at an angle of 120° or an approximation to it. Many measurements give that angle exactly, while many more vary but little from it, though some diverge more markedly. Rosenbusch states that there is a third cleavage, less well developed, bisecting the obtuse angle of the other two. Cracks answering to this description may be seen in some flakes of the Cornish mineral, but they are few and not very marked. The French writers speak of a cleavage approximately vertical to one of those intersecting at 120°, and many cracks corresponding to this may also be seen in the mineral now under consideration. But it really does not seem possible to say that either is really a definite cleavage, or to be in any way certain concerning any third line of cleavage observable on the basal plane. The cleavage-cracks are nearly all quite vertical to the basal plane, and are seen on the lath-shaped cross-sections of the flakes as lines nearly always at right angles to the lateral boundaries, obliquity being rare and very slight.

Most of the ottrelite flakes are intergrown with crystals of white mica, so that nearly all the narrow lath-shaped sections are seen to be united with one, or usually with two, flakes of the mica, one on each side, the individuals lying perfectly parallel, and in cases where the ottrelite is so cut that it extinguishes parallel to its length, the whole combination extinguishes together. The petrologists who have described the rocks of the Ardennes do not appear to have observed a similar intergrowth of ottrelite and mica.

Gosselet considers (Etudes sur l'Origine de l'Ottrélite, Annales de la Société géologique du Nord, tome xv. p. 85) that in the rocks he studied the ottrelite was formed at a time after the phyllites were already fully developed as such. This appears to be equally the case in these Cornish slates, and it is quite evident on observation of structure and arrangement, that the white mica with which the ottrelite is intergrown was formed at the same time. It is in larger and much more definitely-bounded individuals than the main sericite of the rock. There are also crystals, apparently of the same generation, but not intergrown with ottrelite. The dimensions of some of these average about $\frac{1}{150}$ inch in length by half that width, in sections vertical to the base.

This intergrowth with mica renders much of the optic examination of the ottrelite impossible in the slate direct. By pulverizing some of the rock moderately fine, a number of the thicker flakes may easily be detached from the mica, and are then easily separated out by means of a Sonstadt solution of sp.g. of about 3, most of the thinner flakes remaining suspended attached to mica. Material so separated is suited for optic examination, and, as above stated, for study of the cleavages, much of it being in sharply-bounded cleavage-fragments.

In colour the Cornish mineral is more inclined to blue than the ottrelite of Ottrez. The characteristic pleochroism is strongly developed. The scheme is a=yellowish green, β=blue, γ=pale greenish yellow.

Examined between crossed Nicols a large proportion of the lath-shaped cross-sections are seen to be twinned, but this twinning does not seem to be as pronounced as in some of the other occurrences of the mineral, there being mostly only two lamellæ even in the thicker bits, and many flakes being quite untwinned.

Many of these sections extinguish quite parallel to their length, but the greater number show an angle, which reaches as high as 20 degrees and over in some cases, though about 12 degrees is a more usual figure.

The examination of selected, sufficiently thick, and untwinned fragments from the isolated material in convergent polarized light shows the emergence of a positive bisectrix on the principal cleavage-face of the mineral. The angle of optic axes is rather large. The optic-axial plain bisects the obtuse angle formed by the two best-developed secondary cleavages.

As usual, the ottrelite is rich in inclosures, but is very much less crowded than in most other occurrences. The principal mineral inclosed is rutile, in perfectly formed crystals for the most part, many being twinned both as "knees" and "hearts." The largest crystals measure $\frac{1}{2000}$ inch, and they pass from this into the merest specks through all intermediate sizes. Other included matter is very small in amount, and mostly quite indeterminable in nature, with the exception of white mica which is frequent, and which is in many cases seen to occupy cracks and seams in the ottrelite. Many bits are also full of cavities of all shapes and sizes.

Gosselet states that he was able to observe, around the individuals of ottrelite, zones which were very much less rich in microlites than the rest of the rock. This is not the case in the Tintagel slate. The whole rock is very rich in minute rutile crystals; but though the ottrelite contains them in far greater abundance than does the sericite, there is no sign that it has impoverished the space just around it.

No quantitative analysis has been made of the isolated material, but it has been tested as to its resistance to acids, and has been qualitatively analyzed, the results of these examinations confirming the optical and other evidence that the mineral is ottrelite. Specimens of the rock have been submitted to authorities in this country and on the continent, who also recognize the mineral as ottrelite.

No doubt it will be found in other similar slates when search is made, as well as at Tintagel.

The ilmenite of this rock is well worthy of remark. It is present in considerable amount in nearly all the phyllites examined, but is perhaps more abundant in this ottrelite-slate than in any other. It is pretty evenly diffused in little flakes and tablets. Some of it is in the form of the thinnest "micaceous ilmenite," perfectly transparent, with rich brown colour, and there is every gradation of thickness and translucency up to tablets which are perfectly opaque. The thinner and medium-thick flakes are all more or less ragged, but many of the thicker tablets show more definite boundaries, and indications of crystal faces at the edges. The average diameter of the flakes is about $\frac{1}{500}$ inch, and the thickness of the opaque ones ranges between $\frac{1}{2000}$ and $\frac{1}{4000}$ inch.

Like the ottrelite, the ilmenite lies in all directions with regard to the cleavage of the slate, but a considerable majority of the flakes are approximately parallel to it.

A large part of this ilmenite is reticulated, in varying degree, with sagenitic rutile. Among the thinner transparent flakes all degrees may be seen, from such as show a wholly unbroken brown colour, to others which are so finely meshed with delicate interlacing lines of rutile, that only a high power suffices to display the structure; and there are, finally, bits of sagenite in the network of which no trace of ilmenite is seen. Thicker plates of ilmenite also often show a development of sagenite, while many show only a line here and there. Such of them as are still thin enough to be at all translucent frequently show indications, in strong light and under high power, that a little thinning would expose complete reticulations.

Rénard has devoted considerable study to similar occurrences of ilmenite in rocks of the Ardennes. In a paper published in 1884 (Recherches sur la Composition et la Structure des Phyllades Ardennais, Bulletin du Musée Royal de l'histoire naturelle de Belgique, tome iii. pp. 231–268) he described in detail, and figures the "phyllade à ilménite des Forges de la Commune." The occurrence in this case is clearly of the same nature as in the Cornish slate, this being borne out by sections of the Belgian rock which I have examined; the difference being that in the latter the flakes are a good deal larger, while the amount present is very much less, as is also the proportion of it which is transparent or in which sagenite is developed. Rénard was at great pains to isolate some of the mineral and prove chemically that it is ilmenite. In the Cornish rock, in face of the large amount of transparent brown flakes, such chemical proof would scarcely be called for; but it is all the better that Rénard carried it out, inasmuch as it does not seem practicable to isolate the much smaller flakes and tablets of the Tintagel slate.

No better material could be desired than these North Cornish phyllites for the study of these highly interesting microscopic sagenites and their combinations with ilmenite; and in view of the large amount of very thin, thoroughly transparent flakes so combined, I have been in hopes that by careful study of them some light might be thrown on the question as to how the combination ought to be regarded; whether the sagenite is a secondary product resulting from the decomposition of the ilmenite; whether the two have been originally formed together as now seen; or whether, in any cases, the intervening ilmenite has resulted from an alteration of the rutile, the occurrence of alterations of rutile into ilmenite having been demonstrated by V. Lasaulx.

The first of these alternatives is that which most readily suggests itself on first examination of the minerals; and it might seem to derive some support from Cathrein's observation that ilmenite dissolved in acid frequently leaves a residue of extremely minute needles of rutile. In the course of an investigation of the ilmenite and leucoxene of certain schists from Wildschönau in the Tyrol (Zeitschrift für Krystallographie u. Mineralogie, Band 6, pp. 244–256) he found that ilmenite, which was perfectly homogeneous and opaque under the microscope, left a considerable amount of such residue on solution. By using hydrochloric acid for this purpose, he was able to detect combinations of the most delicate needles of rutile in networks and "gratings" of sagenite.

He does not say whether he himself came to any conclusion as to the primary or secondary nature of these interpositions, which appear to correspond with what is so well seen in the thin ilmenite flakes of the Cornish slate; neither does Rénard, so far as I am aware, express any opinion on this point, nor do I know of any other authority who has done so.

After long and careful examination of these forms I do not find it possible to say that there is much evidence one way or other, but consider that on the whole it appears most probable that it is a case of original inter-crystallization.

The study, under high powers, of the thinnest, most transparent flakes in every degree of reticulation, seems to show that in all cases the rutile of the sagenite is so very sharply marked off from the ilmenite that the idea of a chemical change going on between the two is not easily entertained.

The whole question as to the mode of origin of these ilmenite flakes is one of great interest. It seems clear, from the manner of occurrence in the rock, that like the ottrelite they were produced at some period posterior to the formation of the sericite-phyllite as such, and there is much evidence that they also have been much torn and broken up at a still later period.

Calcite is present in this slate in noticeable amount in the form of grains and small patches irregularly diffused all through it.

There are a few small patches of pale chlorite, of which it is to be remarked that they are quite free from the microlites of rutile, so abundant in the rest of the rock. Tourmaline in perfect hemihedral crystals is well represented, these crystals measuring in most cases $\frac{1}{500}$ inch in length. They appear all to lie with their long axes parallel to the plane of cleavage of the slate.

This slate is so completely metamorphosed that nothing whatever can be detected which could be referred to the original clastic material out of which it has been formed, except a few crystals and rounded grains of zircon.

Roofing-slates from other quarries of the district all resemble that just described in general structure and composition, though, with the exception of the fundamental basis of sericite, the amounts of the various minerals present vary a good deal. Thus ilmenite is much more abundant in some than in others, and in some cases does not show any sagenite. The latter is present in numerous and fine examples, however, in the Delabole slates.

Garnets are plentiful in some slates, as at Delabole.

The other phyllites, not fit for roofing-slates, show rather more variety of composition. Chlorite is much more abundant in some of them. Ilmenite is almost universal, and in many cases is as abundant and as full of sagenite as is the ottrelite-slate. Garnet is very abundant in some cases, and most of all in specimens taken from near the contact with one or other of the igneous rocks described in a recent paper.

This garnet is all colourless, or very nearly so. It is in the form of very small irregular grains with only here and there a solitary case of any crystal-form.

Tourmaline is much increased in amount near the contacts, and is in some cases the main constituent after the sericite.

Rutile is present in large amount in all the phyllites of the district, as minute crystals, and, in some cases, also in large grains and tablets.

In none of the many specimens examined by me, have I come across any ottrelite, except in the one case described. It is hardly likely that it is limited to the one particular quarry, but I have not been so fortunate as to find it anywhere else.

There are several beds of black, shaly rock in among the sericite phyllites at various points. They are almost wholly siliceous in nature, very fine-grained quartzites cemented and veined with infiltrated silica and permeated through and through by fine carbonaceous matter. These rocks contain but little of any other minerals, and do not present any special interest.

VIII.—On the Secular Straining of the Earth. I.[1]

By Charles Davison, M.A.,

Mathematical Master at King Edward's High School, Birmingham.

As early as the times of Descartes (1668) and Newton (1681), the "settling and shrinking of the whole globe after the upper regions or surface began to be hard,"[2] was held a sufficient cause for the formation of mountain-chains. Following the growth of our knowledge of mountain-structure, the contraction theory has been rediscovered several times in the present century. It has been worked out in great detail by Élie de Beaumont, Prevost, Delabeche and others; but, above all, by J. D. Dana, the real founder of the theory, in an admirable series of papers extending over the last forty-two years.

[1] Read before the Birmingham Philosophical Society on Feb. 14, 1889. In this paper I have attempted to give an account of part of a paper "On the Distribution of Strain in the Earth's Crust resulting from Secular Cooling, etc.," read before the Royal Society on May 5, 1887 (Phil. Trans. 1887, A. pp. 231-242). The reasoning in ch. xi. of Mr. T. Mellard Reade's work on "The Origin of Mountain Ranges" (1886) shows that he had previously perceived the existence of a surface of zero-strain in the earth's crust, separating an outer region of crushing from an inner region of stretching. In his well-known paper, "On the Formation of Alpine Valleys and Alpine Lakes" (Phil. Mag., Feb. 1863, 4th ser. vol. xxv. p. 97), Mr. John Ball arrived at the conclusion that folding by lateral pressure diminishes as the depth from the surface of the earth increases, until it becomes insensible.

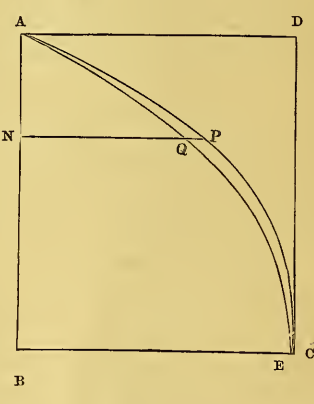
[2] Brewster's "Memoirs of Sir Isaac Newton," vol. ii. Appendix 4; Nature, vol. xxxviii. p. 30.

Leaving its details out of account, the fundamental idea in the contraction theory may be stated as follows: The whole earth was originally at a high temperature throughout, its present distribution of temperature being the result of cooling since the initial epoch. The surface of the earth has now practically ceased to cool, and the interior at and below a depth of two or three hundred miles has not yet begun sensibly to lose its heat. The intermediate layer in cooling contracts, and the outermost crust, being deprived of its support, is crushed and folded by the tremendous pressures thus brought into action. The ridges and wrinkles, into which the crust is thrown, constitute our mountain-chains.

It is curious that, until recently, attention has been wholly concentrated on the behaviour of the outer crust with respect to the cooling layer beneath it, and that the behaviour of the cooling layer itself with respect to the uncooled nucleus within has passed unnoticed. Taking this latter relation into account, however, it will be found that new light is thrown upon several points of the theory, and especially on the comparatively superficial nature of the mountain-making forces.

I shall assume in this paper the truth of the doctrine, which recent researches agree in indicating with a high degree of probability, that the earth is practically a solid body; also of Sir W. Thomson's celebrated investigation on the secular cooling of the earth. Further, in order to simplify the problem, I shall suppose the earth to be a sphere and its surface perfectly smooth.

Taking the initial temperature of the earth at 7000° F., and the average rate near the surface at which the temperature increases with the depth at 1° F. for every 51 feet, Sir W. Thomson shows that the date at which the earth solidified cannot have been less than 20 million, nor more than 400 million, years ago, that it was probably not far from 100 million years ago. In his well-known paper, he gives a curve which represents the temperature at different depths, and which is reproduced in the accompanying figure. The depths from the surface are represented by lengths measured from A along the line AB. The temperature at the depth AN is represented by the length of the line NP drawn at right angles to AB. If lines like NP be drawn from every point in AB, and if each line be made proportional in length to the temperature at the corresponding depth, the other ends will all lie on the curve APC. At the depth represented by AB, about 150 miles, the temperature is very nearly the same as it must be in the entire mass below.



At a subsequent date, every point, through cooling, is at a lower temperature. The state of temperature may then on the same scale be represented by the curve AQE. The temperature corresponding to the depth AN is now represented by the line NQ instead of NP, so that the amount of heat lost in the interval is represented by the length of the line QP. If we now suppose the line NQP to start from AD and to move downwards, keeping parallel to itself, the part QP, at first zero increases for a certain distance, until it becomes a maximum, and then it decreases until the line NQP reaches the position BEC, where it is practically again zero. Since the rate of cooling is proportional to the amount of heat lost in a given time, it follows that this rate is zero at the surface, that it increases as the depth from the surface of the earth increases, until it is a maximum, after which it decreases, becoming insensible at a depth of two or three hundred miles. If the time since the earth solidified be 100 million years, Prof. G. H. Darwin has shown[1] that the depth at which the rate of cooling is greatest is about 53 miles. He has shown also that this depth increases in proportion to the square root of the time, that is, at four hundred million years the depth will be twice as great as this, three times as great at nine hundred million years, and so on. At the initial epoch, it coincided with the surface of the earth.

If a sphere, having the same centre as the earth, pass through the point at which the rate of cooling ceases to be sensible, it will include within it the whole mass of the earth which has not yet begun to lose its heat, the "uncooled nucleus," as it has been called above. The rest of the earth, constituting the "cooling layer," may be supposed to be divided up into a very great number of very thin shells by spherical surfaces all having the same centre as the earth. Each shell must be imagined so thin that the rate of cooling varies by an infinitely small amount between the inner and outer surfaces of the shell.

Let us now consider the consequences of the method of cooling described above; and, first, in the lowest shell of the cooling layer, that next to, and surrounding, the uncooled nucleus. In a given time, this shell loses a definite, though small, amount of heat, in consequence of which it must contract in volume. If the shell were isolated, it would also contract in radius, by an amount proportional to the loss of heat. But this is prevented by the presence of the nucleus within. The contraction can therefore be accomplished only by the shell stretching over the nucleus, at the same time diminishing in thickness.

The next succeeding shell is stretched in a similar manner. If the loss of heat were the same as in the first shell, both shells would be stretched by very nearly the same amount. But it loses more heat in the same time, for the rate of cooling at first increases from the nucleus outwards. The second shell is therefore stretched more than the first. In like manner, the third is stretched more than the second; and this is the case with every shell to very nearly as far as the surface where the rate of cooling is greatest.

[1] Nature, vol. xix. p. 313.

Above this surface a change takes place. In this part of the earth's crust each shell in a given time loses less heat than the shell below it, and consequently undergoes less stretching. The stretching thus decreases gradually and continuously towards the surface of the earth; and it may be shown that at a certain point it vanishes altogether.

To do this, we must consider the shells close to the surface of the earth. The outermost shell of all is not losing any heat. The layer between it and the nucleus, by cooling and contracting, is diminished in thickness, and tends to leave the shell unsupported. But, immediately this takes place, enormous lateral pressures are developed by the attraction of all the earth's mass within; and the outermost shell is crushed and wrinkled until it rests completely on the mass below. In the same way, the shell next below the outermost is crushed and folded, but not to so great an extent, for it does lose a certain small amount of heat, and the contraction due to this brings it a little nearer the mass on which it is obliged to rest. In the shell below this, the loss of heat is still greater (for the rate of cooling increases from the surface downwards), and the amount of folding still less, and so on. Thus the folding and crushing of the shells gradually and continuously diminish as the depth from the surface increases.

We have now the following state of things. From the surface of greatest rate of cooling, stretching gradually diminishes outwards. From the surface of the earth, crushing and folding gradually diminish inwards. At some point between the surface of the earth and the surface of greatest rate of cooling, there must be a shell which is being neither stretched nor crushed. We may call it therefore the "surface of zero-strain."

This surface plays an important part in the physical history of the earth. If the contraction theory be true, our loftiest mountain-ranges must be formed principally, perhaps entirely, of the material in the comparatively thin layer of rock outside it. Our earthquakes and volcanic eruptions probably originate at points above the surface of zero-strain.

It would therefore be an interesting and important problem to determine, if we could, the depth of the surface of zero-strain; but, in the present state of our knowledge, it is impossible to do this accurately. Assuming, however, that the coefficient of dilatation and the rate of conductivity are the same at all temperatures, that the surface of the earth is a sphere, and that the stretching or folding of any shell is uniform all over that shell, I found, by an approximate method which it is hardly necessary to describe, that the surface of zero-strain was, or more probably will be, at a depth of five miles after an interval of 174,240,000 years since the earth solidified.[1] This depth, on account of the method of calculation employed, is too great by a fraction of a mile, but we shall probably be well within the limits of error if we put it at between four and five miles.

[1] This period was adopted in order to simplify the calculations, and is well within the limits given by Sir W. Thomson.

At the same time and on the same assumptions, the depth of the surface at which stretching is greatest would be about 72 miles, this surface being less than a mile below the surface of greatest rate of cooling.

We may sum up the results obtained for this period as follows, assuming the surface of the earth to be smooth and spherical: Folding by lateral pressure is greatest at the surface. It diminishes as the depth increases until, at a depth between four and five miles, it vanishes. Below this depth, folding by lateral pressure gives place to stretching by lateral tension, and the stretching increases as the depth increases until it is a maximum at a depth of about 72 miles. Below this, again, the stretching begins to decrease, and it continues decreasing, until it practically vanishes at a depth of about 200 miles.

If the contraction theory be true, the most important evidence which the surface of zero-strain gives us is that relating to the extremely superficial nature of the forces which produce our mountain-ranges. Some geologists have regarded the slight depth of the surface as a strong argument against the theory. It seems to me that they are somewhat hasty in coming to this conclusion, that they do not take sufficiently into account our utter ignorance on many important points. It cannot be denied that the theory is surrounded with great and serious difficulties, but I submit that there is a difference between objections which cannot be met and difficulties which have not yet been solved; and I cannot help thinking that these difficulties, if treated as subjects for future investigation, will sooner or later be removed. The contraction theory is attractive not only from its beauty and its simple grandeur. It explains so many phenomena in the evolution of mountain-chains; so many apparently unconnected facts are grouped together by its guidance; that the reasons must be weighty indeed which shall lead us to reject it.

IX.—An Exposure of Middle and Newer Pleistocene Boulder Clay in Derby.

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

SOME very interesting deposits of Pleistocene age have lately been exposed on the Burton Road, Derby. The road rises on the north side of Mill Hill, and near the top, at the height of 260 feet, cuts into a mass of Boulder-clay, which is, or was, well shown in the cuttings for the new roads leading into Byron Street. Another outlier of the same clay is exposed in Littleover Lane to the south-west. The main mass of the deposit cut into on the Burton Road is a red morainic clay with boulders; apparently a subaerial moraine subsequently modified by the passage over it of land ice. Unlike the tough, silty, red and blue aqueous Boulder Clays so plentifully spread over the Midland counties, it shows little or no signs of aqueous action. Sometimes it has a banded or streaked appearance, but this seems to be due rather to a crushing or pressing-out action than to original conditions of deposition. In this respect it much resembles many of the morainic deposits of the Lake District and North Wales. Although the matrix is chiefly finely broken up Keuper Marl and Coal-measure rock, there are occasional beds of what appears to be torrential sand and gravel much disturbed by subsequent ice action. Large boulders of Upper Carboniferous rocks, together with quartzite pebbles, probably derived from the Bunter Pebble Beds, are abundant, but Carboniferous Limestone is rather scarce. Flints are numerous and sometimes of large size. They are scattered throughout the whole depth of the deposit, not merely intruded into the surface portions.

I have elsewhere pointed out[1] that in the Midlands flints are absent from the thick deposits of Older Pleistocene Boulder Clay and sand, but appear in great abundance in the clays and sands of Middle Pleistocene age. Associated with the Older Pleistocene Boulder Clays there occurs a thick deposit of sand, the Quartzose Sand, the false bedding of which indicates powerful currents from the north-west and south-west. The absence of flint from these deposits has a peculiarly interesting bearing upon the question of where the flints in the clays and sands of Wales, Cheshire, and Lancashire came from, and also when they were carried to the positions they now occupy. In Older Pleistocene times, when, as we have seen, the currents were favourable for the transport of flints from Ireland, flints were certainly not brought in any quantity into the Trent Valley. At least I have only found them in deposits of this age near the surface, into which they have no doubt been subsequently introduced. In Middle Pleistocene times, when the ice-flow was from the East or N.N.E., great quantities of flint and chalk were carried into the Trent Valley; for flints form a considerable proportion of the Chalky Sand even in the extreme north-westerly portion of the area; indeed they may be found in the Chalky Sand where it passes through the Biddulph Pass into the Cheshire Plain; but the nearer we approach the hypothetical Irish source, the more scarce they become. I do not mean to assert that no flints have crossed over from Ireland; but the weight of evidence points strongly to the conclusion that the vast majority of the flints in the Boulder Clays and sands of North and South Wales came from the east of England during the Middle Pleistocene epoch.

The presence of flint in the Burton Road and Littleover Boulder Clay, therefore, favours the assumption that the deposit is either of Middle or Newer Pleistocene age. Fortunately a deep excavation in the road, after passing through the red morainic clay, entered a couple of feet of blue silty clay full of rounded grains and pebbles of chalk. This deposit, which was clearly typical Chalky Boulder Clay, rested directly upon Keuper Marl, and was separated by a sharp line from the red clay above. Another shaft close by passed through clean-bedded Middle Pleistocene sand. Both the lithological and stratigraphical evidence, therefore, points to the conclusion that the upper clay is the Later Pennine Boulder Clay.[2]

[1] Q. J. G. S. Nov. 1886.

[2] That Mr. A. J. Jukes-Browne has misunderstood my argument concerning the

As I have recorded the presence of this deposit in many places in the neighbourhood of Derby, it is very satisfactory to find it resting in considerable masses upon, and separated by a sharp line of demarcation from, the Chalky Boulder Clay. It is evident from the great quantity of flint which exists in the Newer Pleistocene Boulder Clay and River Gravels of the Derwent Valley, at and below Derby, that the small patch of Chalky Boulder Clay on the side of Mill Hill is merely a remnant of a great mass of the same deposit which once partly choked up the Derwent, Trent, and other valleys, outliers of which are to be seen at Chellaston, Doveridge, and Hanbury Wood End.

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NOTICES OF MEMOIRS.

I.—The Mineral Wealth of Queensland. By R. L. Jack, F.G.S., F.R.G.S., Government Geologist. Brisbane, 1888. 8vo. pp. 71. With Map showing position of the Mineral Fields.

THIS book, written at the request of the Hon. the Minister for Mines and Works, gives a resumé of the mining statistics of the Colony, with an account of the mineral fields that have been or are being worked, of the geological formations in which they occur, the methods of working and of reducing them where the latter is done on the spot, as well as a list of the minerals associated with them, and a table of localities where minerals yet undeveloped are known to exist.

In 1887 about 400,000 oz. of gold were raised, of which less than 25,000 were of alluvial origin, the remainder being obtained by crushing stone containing from one to two ounces to the ton.

The wealthiest gold field is the Charters Towers, for which the returns given for 1887 are alluvial 317 oz., reef 151,060 oz. obtained by crushing 83,292 tons of quartz. The gold here is associated with pyrites, galena, and zinc-blende, and the yield per ton shows a slight increase at the deepest levels, the lowest of which is now 1400 ft.

Gold occurs in most parts of the Colony, but as far as at present known only in paying quantities near the coast in the southern half, while in the northern or tropical divison in the interior as well.

The most remarkable mine is that of Mount Morgan in the Rockhampton District. The Mount is a dome-shaped hill 1500 ft. above sea-level and 500 above the surrounding table-land, of which the

Newer Pleistocene Boulder Clays of Lincolnshire is evident from the following passage in his letter, which I quote. Referring to my short paper in the Geol. Magazine for October, 1888, he says, "He suggests, however, that some of the clays classed by me as Newer Glacial may really be older than the Chalky Boulder Clay, and he apparently finds great difficulty in accepting the occurrence of such Newer Glacial beds at elevations approaching 400 feet." My greatest difficulty, distinctly stated, was the supposed "*marine* aspect of the high level, brown, Boulder Clays." All Boulder Clays are certainly not marine, frequently not even aqueous.

rocks belong to the Carbonifero-Permian series, and are intersected in every direction by dykes of dolerite, rhyolite, etc. "The upper portion of Mount Morgan consists of a deposit varying from red and brown hæmatite on the one hand to a frothy, spongy cellular siliceous sinter on the other. Fine gold is disseminated throughout the mass," it has averaged of late 7 oz. to the ton, is *absolutely free from silver.* The mining operations are simply quarrying, and the gold is extracted by chlorination. The mine is estimated to be worth £16,000,000, while Messrs. Morgan Bros., the original proprietors, who gave their name to the Mount, are said to have sold the 640 acres it covers for less than £300.

The amount of silver obtained in 1887 was over £120,000 in value, chiefly from galena, though in the Ravenswood silver-field the surface yielded lead carbonate giving as much as 300 oz. of silver to the ton, lower levels of galena giving 2 oz., while at a depth of 650 ft. "the shaft bottomed on an antimony and copper ore somewhat resembling tetrahedrite in composition, but containing from 500 to 5000 oz. silver to the ton."

The tin, produced chiefly by mining and crushing porphyry, quartzite and chlorite dykes, though a considerable quantity is obtained from alluvial deposits, was valued at over £220,000 in 1887.

Copper is not worked to any great extent, though there are lodes of oxides, carbonates and sulphides, the latter containing in some cases both gold and silver in considerable quantities, which, to quote the author, "would be payable under favourable conditions," meaning, we presume, proper facilities for carriage, for in one place he instances freight to England £1 per ton of ore, while the carriage to the port of shipment was £4 per ton.

The other metals are mercury and cobalt, the ores of the latter are very rich, and promise to be very productive when the workings are extended. Antimony has been mined to a small extent.

The Coal-fields extend over thirty thousand square miles, occurring in the Carbonifero-Permian and Jurassic systems. The quality is good in some of the seams, but in others the percentage of ash is high. The workings at present are few, in fact only 230,000 tons were raised in 1887.

REVIEWS.

I.—Prof. Dr. von Zittel on Palichthyology.

Karl A. von Zittel, Handbuch der Palæontologie. Palæozoologie. Band III. Lief. I. II. (R. Oldenbourg, Munich, 1887–88.)

(*Concluded from page* 181.)

Teleostei.

THE only modern synopsis of the Palæontology of the Teleostean fishes, previous to the publication of Dr. v. Zittel's work, is to be found in Dr. Günther's "Study of Fishes" (1880); and as this is merely an outline, without details or references, the present

"Handbuch" supplies an important desideratum in Ichthyological literature. The description of the "subclass" occupies pp. 252–316, and is illustrated by 58 woodcuts.

After an enumeration of the more general works upon the subject, and a preliminary definition, the six "orders" of Johannes Müller are adopted, and the extinct representatives of each noticed in succession from the Lophobranchii to the Anacanthini.

The known fossil Lophobranchs are but few in number, and restricted to the Tertiaries. Of the Solenostomidæ an extinct representative (*Solenorhynchus*) occurs in the Eocene of Monte Postale; and the common surviving pipe-fish (*Syngnathus*) is met with in the Oligocene of Monte Bolca and Croatia, and in the Miocene of Licata, Sicily. A *Hippocampus*-like fish with a caudal fin (*Calamostoma*) has also been described by Agassiz from Monte Bolca.

The Plectognathi have a scarcely more satisfactory palæontological record, and only a few types, closely related to living genera, have hitherto been detected in the Tertiaries. Of the sun-fish (*Orthagoriscus*) Dr. v. Zittel rightly casts doubt upon Dixon's supposed fossil jaw from the Chalk, which now proves to be the dentary bone of a turtle;[1] but reference might have been made to the undoubted mandibles of *Orthagoriscus* discovered in the Oligocene of Belgium.[2] *Diodon* has a wide range from the Oligocene upwards, and there are some indications of closely-allied extinct genera in the Lower Tertiaries of Egypt, the Gironde, and Monte Postale. *Ostracion* occurs at Monte Bolca; and *Balistes* is supposed to be represented upon the same horizon by the extinct *Protobalistum*. Following Baron de Zigno, the author assigns two species to the latter genus, but Dr. Theodore Gill[3] has lately pointed out that a rearrangement is required, and that the so-called *P. Ombonii* forms the type of a very distinct genus to be henceforth termed *Protacanthodes*. *Acanthoderma* and *Acanthopleurus* are the well-known Sclerodermis described by Agassiz from the black slates of the Canton Glarus; and, in default of a more certain position, the pharyngeal teeth named *Ancistrodon* (first determined as such by Dr. W. Dames) are provisionally placed as an appendix to the same group.

The great order of Physostomi commences with the family of Siluridæ, and the earliest undoubted representatives of this remarkable division are recorded from the Eocene. One extinct genus (*Bucklandium*) has lately been noticed in the London Clay of the Isle of Sheppey;[4] and a recent discovery of a nearly complete skull in the Barton Clay[5] has confirmed the occurrence of the recent genus *Arius* in the English Middle and Upper Eocenes. The genera from the Pliocene of the Siwalik Hills, India, and from the Lower Tertiary of Padang, Sumatra, are also satisfactorily determined; but the so-called *Pimelodus* from the Miocene of Hungary is based upon fin-

[1] Proc. Geol. Assoc. vol. x. p. 276.
[2] P. J. Van Beneden, Bull. Acad. roy. Belg. [3] vol. vi. (1883), p. 132.
[3] Amer. Nat. 1888, pp. 446–448.
[4] Geol. Mag. [3] Vol. V. p. 471; and Proc. Zool. Soc. April 2nd, 1889.
[5] E. T. Newton, Proc. Zool. Soc. April 2nd, 1889.

rays which appear quite indeterminable, and probably do not belong even to the Siluroid family.

Following the Siluridæ are the three typically-Cretaceous families of "Saurocephalidæ" (Saurodontidæ of Cope), Hoplopleuridæ, and Stratodontidæ. These, however, can only be regarded as provisionally defined, and the precise relationships even of the best-known genera are at present very doubtful. *Portheus*, *Ichthyodectes*, and *Saurocephalus* are typical representatives of the Saurocephalidæ: but, as Cope has already recognized,[1] it is impossible to place *Protosphyræna* with these. The stated definition of the Hoplopleuridæ contradicts one point ("Wirbelsäule verknöchert") in the diagnosis of the "subclass Teleostei" on p. 252; and this contradiction is introduced to admit of the association of the early Mesozoic genera, *Belonorhynchus* and *Saurichthys*, with *Dercetis* and its allies of the Chalk. Such an association appears to the present writer most unnatural and unjustifiable; for it must be remembered that in the dorsal and anal fins of *Belonorhynchus* the interspinous bones are very much fewer in number than the dermal rays[2]—a character unknown in any fishes higher than Crossopterygians and Acipenseroids—while the maxilla of *Saurichthys* has lately proved to exhibit a palatal extension such as has hitherto been met with only in the Crossopterygian *Polypterus*.[3] The Neocomian *Saurorhamphus*, it is true, is said to have possessed a persistent notochord, but more information is required concerning this fish. *Leptotrachelus* is probably a synonym of *Dercetis*, or at least is not separated by the usual diagnosis;[4] and in whatever family *Eurypholis* is placed, *Enchodus* must follow. *Eurygnathus* (Davis) is a synonym of the latter,[5] and the recent discovery of complete skulls has proved the stout bones so long described as premaxillæ (and thus named by Dr. v. Zittel) to be truly the palatine elements.[6] The amended "*Hypsodon*" is identical with *Pachyrhizodus*;[7] and next to *Cimolichthys* we might add *Pomognathus*,[8] removing it from p. 279.

The Esocidæ have few extinct representatives, so far as known, though there is much in their anatomy to suggest close alliance with some of the earlier Physostomi. The Notopteridæ and Chirocentridæ also have no fossil representatives of importance; but the enumeration of the succeeding Clupeidæ occupies nearly nine pages. Here Dr. v. Zittel places the typically Jurassic *Thrissops* and *Leptolepis*, adopting a subfamily Thrissopina, and then three others—the Clupeina, Chanina, and Elopina. A fine new figure of the head, opercular apparatus, and pectoral arch of *Leptolepis* is given; and there is some interesting information concerning the mandible both of this genus and of *Thrissops*. W. von der Marck's wide separation of *Sardinioides* from *Osmeroides* is accepted; *Scombroclupea* follows

[1] Bull. U.S. Geol. Surv. Territ. vol. iii. (1887), pp. 821–823.
[2] W. Deecke, Palæontogr. vol. xxxv. (1889), p. 129.
[3] Ann. and Mag. Nat. Hist. [6], vol. iii. 1889, p. 302.
[4] Proc. Geol. Assoc. vol. x. p. 319.
[5] Geol. Mag. [3], Vol. V. 1888, p. 472.
[6] Proc. Geol. Assoc. vol. x. p. 315, pl. i. figs. 5, 6.
[7] *Ibid.* p. 311. [8] *Ibid.* p. 317.

Clupea; and *Diplomystus* is recorded, but only from the Green River Shales of Wyoming. The latter genus is now known also from the Cretaceous of Brazil[1] and Mount Lebanon,[2] besides from the Oligocene of the Isle of Wight.[3]

The fossil Salmonidæ are little known, and to the author's account we would only add that the remarkable nodular concretions with *Mallotus villosus*, so well known from Greenland, are also met with in the Glacial Clays on the banks of the Ottawa River in Canada. The palæontological history of the Scopelidæ and Osteoglossidæ is likewise scanty; and the only point of much interest in that of the Cyprinodontidæ is the occurrence of the now-existing tropical American genus *Pœcilia*, in the Oeningen beds of Switzerland. Many representatives of the Cyprinidæ occur in freshwater Tertiary formations, but the majority are referable to existing genera; and *Notogoneus*, from the Green River shales of Wyoming, is the sole recognized fossil genus of Gonorhynchidæ (misprinted Ganorhynchidæ). The Murænidæ occur first in the Upper Cretaceous of Mount Lebanon; and the Scombresocidæ, which conclude the Physostomous order, are considered by Dr. v. Zittel to be also probably represented in the Cretaceous by *Istieus* and *Rhinellus*.

The order of Pharyngognathi comprises three families with fossil representatives—the Pomacentridæ, Labridæ, and Chromidæ. To the first are assigned two extinct genera, *Odonteus* from Monte Bolca; and *Priscacara* from the Green River Shales of Wyoming; and in the last are placed the Cretaceous genera *Pycnosterinx*, *Omosoma*, and doubtfully *Imogaster*. The Labridæ are represented chiefly by detached examples of the pharyngeal dentition in the Tertiaries; and in addition to typical forms like *Labrus* and *Nummopalatus*, Dr. v. Zittel places here the remarkable Eocene *Phyllodus* and *Egertonia*. The latter are also recorded from the Cretaceous, but *Phyllodus cretaceus*, Reuss, is not founded upon satisfactory evidence; and *Egertonia gaultina*, Cornuel, from the French Gault, is very doubtfully related to the Eocene fossils, and may perhaps be more satisfactorily compared with the palatine dentition of the Elopine *Protelops* from the Turonian of Bohemia.

The order Acanthopteri commences with the Berycidæ, having many extinct representatives. In addition to the ordinary species, *Beryx* includes numerous detached scales described under five or six generic names from the Plänerkalk of Saxony and Bohemia; and we would only remark that the English Chalk species mentioned (*B. lewesiensis*) now proves to be referable to *Hoplopteryx*.[4] In the last-named genus must also be placed the so-called *B. Zippei*, of the dorsal fin of which the figure copied from Fritsch scarcely gives a correct impression.[5] The Lebanon fossil named *Homonotus pulcher*

[1] E. D. Cope, Proc. Amer. Phil. Soc. vol. xxiii. (1886), p. 3.
[2] Ann. and Mag. Nat. Hist. [6] vol. ii. (1888), p. 134.
[3] *Clupea vectensis*, E. T. Newton, Quart. Journ. Geol. Soc. vol. xlv. (1889), pp. 112–117, pl. iv.
[4] Proc. Geol. Assoc. vol. x. p. 327.
[5] *Cf.* L. Agassiz, Poiss. Foss. vol. iv. pl. xv. fig. 2.

is probably a *Pycnosterinx*;[1] and *Platycormus* appears to have more affinity with the Squamipinnes than with the Berycidæ.

Like the last family, the Percidæ are also represented by many extinct species and a few extinct genera, but these appear to be restricted to Tertiary formations. The Glarus fossil, *Acanus*, is placed here as the result of Wettstein's researches; and the recent genus *Serranus* ranges downwards to the Eocene of Monte Bolca. Of freshwater genera, the common *Perca* has a wide range in the European Tertiaries; and *Smerdis* is a common extinct form in the Eocene and Miocene. The Pristipomatidæ are separated from the Percidæ, and the London Clay *Sciænurus* is assigned a place in this family.

Dr. v. Zittel's account of the Sparidæ is an interesting palæontological lesson; for the variation in the teeth of these fishes has led to the publication of innumerable names, which the ichthyologist soon recognizes as worthless and arising from ignorance of recent genera. *Capitodus*, Münster, is shown to be partly founded upon the anterior teeth of *Chrysophrys*, and partly upon the pharyngeal teeth of Cyprinoid fishes; most of the crushing teeth of *Chrysophrys* have been named *Sphærodus* and *Sparoides* by fossil collectors; and *Trigonodon*, Sismonda, is shown to be a synonym of *Sargus*. A new genus, *Stephanodus*, is founded upon broad cutting teeth with denticulated edges, from the Upper Chalk of the Sahara; and associated with these fossils are round crushing teeth, which seem to demonstrate the Sparoid affinities of the original fish. The Squamipinnes, Scorpænidæ, and Teuthididæ, are not of much palæontological interest; and, as Dr. v. Zittel remarks, the published information concerning the fossil Xiphiidæ is somewhat doubtful.[2] The Palæorhynchidæ form an entirely extinct family of older Tertiary age, and the author considers that *Hemirhynchus* is a synonym of *Palæorhynchus*, being originally founded upon an imperfect specimen. It is satisfactory, at last, to find no mention of *Enchodus* in a palæontological account of the Trichiuridæ; and Wettstein's determination of the identity of *Anenchelum* with *Lepidopus* is adopted, thus extending the range of this recent genus to the horizon of the Swiss Glarus slates.

Of the Acronuridæ the recent genera *Acanthurus* and *Naseus* are determined from Monte Bolca; and the little *Calamostoma* (Steindachner) from the same horizon requires a new name, not being the *Calamostoma* of Agassiz (p. 256).

The Carangidæ are represented by extinct species of the principal recent genera in the Tertiaries; and a few (e.g. *Platax*) also occur in the uppermost Cretaceous. Of the Cyttidæ, *Zeus* has been found in the Miocene of Licata, Sicily, and there is an extinct genus, *Cyttoides* (Wettstein), in the Glarus slates. A good figure of the well-known *Mene* (*Gasteronemus*) *rhombeus* is given under the Coryphænidæ; and the succeeding list of Scombridæ and Trachinidæ does not present much of interest, except the occurrence of the specialized

[1] Proc. Geol. Assoc. vol. x. p. 329.
[2] See Proc. Geol. Assoc. vol. x. p. 321.

Echeneis in the Glarus slates, as discovered by Wettstein. The Pediculati or Lophiidæ are still only known, among fossils, in the Eocene of Monte Bolca; and the Cottidæ, Cataphracti, Gobiidæ, and Blenniidæ, are soon enumerated, the only striking forms being the problematical *Petalopteryx* and *Cheirothrix* from Mount Lebanon. Among the Mugiliformes, the so-called *Sphyræna Amici*, of Mount Lebanon, is rightly omitted; but it may be added that both *Calamopleurus* and *Cladocyclus* are well known from the English Chalk,[1] and *Dictyodus* does not pertain to this family, but to the Scombridæ.[2] There is also some doubt concerning *Apsopelix*, Cope, for it is mentioned both here and in the Stratodontidæ (p. 269). The Blochiidæ, with the single remarkable extinct genus, *Blochius*, from Monte Bolca, follow the Mugiliformes; and the Aulostomi close the Acanthopteran series.

Of the important modern order Anacanthini, so few extinct forms are known that less than two pages suffice for their consideration. Both the Gadidæ and Pleuronectidæ range from the Eocene upwards, but much yet remains to be discovered concerning their ancestry and precise relationships.

In conclusion, Dr. v. Zittel devotes twenty pages to a general summary of our knowledge of the distribution of fossil fishes in space and time; and this unique work of reference is thus made available for the Stratigraphical Geologist equally with the systematic Ichthyologist. A. Smith Woodward.

II.—Brachiospongidæ: A Memoir on a Group of Silurian Sponges. With Six Plates. By Charles Emerson Beecher. Memoirs of the Peabody Museum of Yale University, Vol. ii. pt. i. (New Haven, Conn., 1889. Imp. 4to. 28 pp.)

THE peculiar sponges to which Prof. O. C. Marsh gave the name of *Brachiospongia* have been described and figured since 1838, but hitherto their structural characters have been unknown. Mr. Beecher has carefully studied the specimens obtained by Prof. Marsh, and, aided by this gentleman's liberality, has brought out the present beautifully illustrated Memoir, in which the real nature of these sponges is satisfactorily shown. The sponges themselves—which sometimes reach to a foot in diameter—consist of an open cup-shaped, central body, from which a number of curved, tubular finger-like processes project. The sponge-wall is built up of spicules of the hexactinellid type, which do not appear to be cemented together, with the exception of those forming the dermal layer, which are apparently fused into an irregular quadrate mesh. There is considerable variety in the outer form and the number of the projecting arms in different specimens, but Mr. Beecher has done wisely in regarding them as belonging to a single species, *B. digitata*, D. D. Owen, sp. Another hexactinellid sponge having a peculiar lobate or tuberous form and a stout wisp or rope of anchoring spicules is placed in a new genus *Strobilospongia*. These sponges have been

[1] Proc. Geol. Assoc. vol. x. pp. 324, 325.
[2] Dollo and Storms, Zool. Anzeiger, No. 279 (1888).

for the most part obtained in Kentucky and Tennessee, in passage-beds between the Trenton and Hudson River formations, apparently on the horizon of the Utica Shale, which in these States is not distinctively developed as a bituminous shale, the same as in New York and Canada. There is a definite horizon in Franklin County, Kentucky, in which they are associated with beds of cherty limestone, the chert being restricted to the bands in which the sponges occur. Their condition of preservation is as a rule unfavourable, and much credit is due to Mr. Beecher for having finally determined their structural characters.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—March 6, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Subdivisions of the Speeton Clay." By G. W. Lamplugh, Esq. Communicated by Clement Reid, Esq., F.G.S.

This paper gave the results of a long series of observations made during favourable opportunities at the cliff-foot and on the beach at Speeton from 1880 to 1889. The chief points brought forward by the author were as follows:—

The sandy blue shales now seen in the cliff near Filey are not in place, but are erratics in the Drift, and most, if not all, of them are derived from the Lias.

The bituminous shales with *Belemnites Owenii*, classified as Upper Kimeridge, extend upwards to the Coprolite-bed and the beds described as Portlandian by Prof. Judd, having been wrongly placed in this part of the section. No unconformity is traceable at the Coprolite-bed, or at any other horizon, between the Jurassic and Cretaceous portions of the clays.

The clays may be most conveniently divided into zones by reference to the Belemnites, as follows:—

Marly shales below the Red Chalk = zone of *B. minimus* and allies.

Upper division of the "Neocomian," including the "Cement-beds," and part of the Middle Neocomian of Judd = zone of *B. semicanaliculatus* and allies.

Lower division of the Neocomian from the top of the *Pecten cinctus* zone down to the base of the supposed Lower Neocomian zone of *Ammonites noricus* = zone of *B. jaculum.*

From the base of the *noricus*-zone to the Coprolite-bed = zone of *B. lateralis* (zone of *Amm. Astierianus* of Judd).

The bituminous shales below the Coprolite-bed = zone of *B. Owenii* and varieties.

The clays of the zone of *Bel. lateralis* have strongly marked Jurassic affinities, and it is from this zone that the coronated Ammonites were obtained, these being the beds supposed by Leckenby to be of Portlandian age. A very well-marked band of nodules, with some scattered coprolitic pebbles, caps the *lateralis*-beds, and this band constituted the "Coprolite-bed" of Leckenby.

The thickness of the clays above the coprolites has been over-estimated; it is probably not more than 300 feet.

The ranges which have been assigned to some of the characteristic fossils, especially *Ammonites Astierianus*, *Amm. speetonensis*, and *Toxaster complanatus*, need to be revised and altered.

The term "Middle Neocomian," as applied in the Speeton section, is unnecessary and misleading, seeing that a "Lower Neocomian" fauna occurs both above and below the beds with Middle Neocomian types; and, as stated by Meyer, marly shales exist between the Red Chalk and the Neocomian clays, strongly suggestive of a passage from the one to the other, and these beds contain many Gault forms. Thus there is probably at Speeton a continuous series of clays from the Jurassic to the Upper Cretaceous, and the deposition of these beds appears to have gone on contemporaneously with the erosion of the beds inland.

2. "Notes on the Geology of Madagascar." By the Rev. R. Baron. Communicated by the Director-General of the Geological Survey. With an Appendix on some Fossils from Madagascar, by R. Bullen Newton, Esq., F.G.S.

The central highlands of Madagascar consist of gneiss and other crystalline rocks, the general strike of which is parallel with the main axis of the island, and also, roughly, with that of the crystalline rocks of the mainland. The gneiss is frequently hornblendic; its orthoclase is often pink; triclinic felspar also occurs in places; biotite is the most common mica, but muscovite is not uncommon; magnetite is generally present, often in considerable quantities. The gneiss is often decayed to great depths, forming a red soil, and the loosened rock is deeply eaten into by streams. The harder masses of gneiss, having resisted decay, stand out in blocks, and have been mistaken for travelled boulders of glacial origin. Other more or less crystalline rocks are mica-schists, chlorite-schists, crystalline limestone, quartzite (with which graphite is often associated), and clay-slate.

Bosses of intrusive granite rise through the gneiss. That east of the capital contains porphyritic crystals of felspar which near the northern edge of the granite are arranged roughly in a linear direction; here also the granite contains angular fragments of gneiss. For the most part the granite of Madagascar is clearly intrusive, but this may not always be the case.

The volcanic rocks are of much interest. The highest mountains, those lying to the S.W. of the capital, consist in their higher parts, of a mass of lava, for the most part basaltic, but with some sanidine-trachyte. The lava-streams are sometimes 25 miles long, and successive flows, up to 500 feet in thickness, are exposed by the valleys, From the great denudation which this area has undergone, and from the fact that no cones now remain, we may assume that this volcanic series is of some antiquity. Of the newer volcanic series there are numerous very perfect cones, dotting the surface of the gneiss in many places. No active volcano now exists in the island, but the occasional emission of carbonic-acid gas, the occurrence of numerous hot springs and deposits of siliceous sinter, and the frequency of small earthquake-shocks, seem to show that volcanic forces are only dormant and not entirely extinct.

The ashes generally lie most thickly on the side of the cone between north and west; this is accounted for by the prevalence of the south-east trade-winds. The volcanic areas are ranged roughly in a linear direction, corresponding with the longer axis of the island.

Sedimentary rocks occur mainly on the western and southern sides of the island. The relations of these to each other have not yet been determined; but from the fossils (referred to the European standard) it seems that the following formations are represented:—Eocene, Upper Cretaceous, Neocomian, Oxfordian, Lower Oolites, Lias. Possibly some of the slaty beds may turn out to be Silurian or Cambrian. The crystalline schists, etc., are probably, for the most part at least, Archæan. Recent deposits fringe the coasts and are largely developed on the southern part of the island.

East of the central line of watershed there is a long depression containing a wide alluvial deposit, probably an old lake-bed. Terraces fringe its sides in many places. The lagoons of the eastern coast are due to alluvial deposits.

The paper concluded with some remarks on the geological antiquity of the island, its separation dating from early Pliocene times, if not earlier. This is the conclusion arrived at by Wallace from its fauna; the author's detailed researches into its flora, recently described before the Linnean Society, show that while about five-sixths of its *genera* of plants are also found elsewhere, chiefly in tropical countries, at least four-fifths of its *species* are peculiar to Madagascar.

The Appendix, drawn up by Mr. R. Bullen Newton, F.G.S., consisted of Notes upon the fossils collected by the author, with tables, and descriptions of two new species, namely, *Astarte* (?) *Baroni* and *Sphæra madagascariensis*, both from deposits of Lower-Oolitic age.

3. "Notes on the Petrographical Characters of some Rocks collected in Madagascar by the Rev. R. Baron." By F. H. Hatch, Ph.D., F.G.S.

This paper was divided into two parts, the first treating of the petrographical characters of the older crystalline rocks of the eastern and mountainous part of the island, the second of the nature of the lavas that have been erupted from volcanic vents situated mainly in the same portion of the island.

i. *The Older Crystalline Rocks* are represented in Mr. Baron's collection partly by foliated specimens, partly by rocks showing no parallel structure in the hand-specimen.

The foliated specimens have, with few exceptions, the structure and composition of *gneiss*. The author subdivided them into an acid and a basic series. The acid series, which embraces rocks composed of abundant quartz with orthoclase as the dominant felspar, he terms *granitite-gneiss*; the basic series, which consists of rocks containing little quartz and much plagioclase felspar, *tonalite-gneiss.*

The unfoliated specimens comprise *granite, gabbro* or *norite, pyroxene-granulite,* and *pyroxenite.*

The majority of the granites are of the *granitite*-type—*i.e.* they are *granites with one mica*; but *granites with two micas* are also represented.

The remainder of the rocks are of a basic type. They are interesting, in the first place, on account of the striking combinations of fresh and beautiful minerals they present, as for example:—plagioclase, hypersthene, olivine, brown hornblende and green spinel, in an *olivine-norite*; or, plagioclase, green pyroxene (omphacite or diallage), hypersthene, hornblende, garnet and iron-ore, in *pyroxene-granulite*; or, again, diallage and hypersthene in *pyroxenite.*

But of greater interest is the fact that these basic types, which are so well known in other territories of old crystalline rocks—Saxony, Brittany, Scandinavia, Scotland, the Hudson River, etc.—constitute in Madagascar, as they do at Kilima-njaro on the adjacent mainland, a large part of the ancient platform on the submerged portions of which the sedimentary rocks have accumulated, and through which the volcanic lavas were erupted.

ii. *The Volcanic Rocks.*—In composition these are acid, intermediate and basic, mainly the latter. The acid and intermediate types are described are *sanidine-trachyte* and *hornblende-augite-andesite.* The basic rocks consist of various types of *basalt.* They vary with respect to the presence or absence of corroded quartz-grains, olivine, porphyritic hornblende, and biotite. In one interesting type the hornblende appears in small idiomorphic crystals as a constituent of the ground-mass. A felspar-free variety, or *magma-basalt,* is also represented. This rock contains only a small quantity of olivine, and is therefore intermediate between Rosenbusch's *Limburgite* and Dölter's *augitite.*

II.—March 20, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "Supplementary Note to a Paper on the Rocks of the Atlantic Coast of Canada." By Sir J. W. Dawson, K.C.M.G., F.R.S., F.G.S.

In a paper in the "Journal" for November, 1888, the author referred to the *Olenellus*-fauna as characterizing the Middle Cambrian. The fauna, he has no doubt, from the recently published observations of Walcott and Matthew, should be regarded as characteristic of the Upper Member of the Lower Cambrian. From this arises a new view of the physical geography of the period, namely, that the Lower Cambrian was, in America, a period of continental depression, and the Middle Cambrian a period of continental elevation, leading to the important conclusion that a time of elevation intervened between the Huronian and the early Cambrian, which may represent the apparent gap between these systems in Eastern America. He thinks that this new view deserves a special mention in connection with the probability that the Huronian and Kewenian beds are of littoral origin.

2. "The Occurrence of Colloid Silica in the Lower Chalk of Berkshire and Wiltshire." By W. Hill, Esq., F.G.S., and A. J. Jukes-Browne, Esq., F.G.S.

In the Lower Chalk of Berks and Wilts are beds which contain a large amount of disseminated colloid silica; these are comparable in general structure to the Malmstones of the Upper Greensand. Dr. Hinde's study of the latter led him to believe that the globular colloid silica which they contain was directly derived from the remains of siliceous sponges, and the authors' studies of the Chalk specimens have confirmed this conclusion by adding several important pieces of evidence.

They found that the amount of free disseminated silica increases in proportion to the number of spicules and calcite-casts of spicules which occur in the rock, and observed that the great similarity between the siliceous chalk and the Malmstone was heightened by the occurrence of similar siliceous concretions in both rocks, the material of which might be described as siliceous chalk, indurated by a cement of chalcedonic silica. The conditions in which the silica was found in the Lower Chalk were described, in examples varying from those containing least to those which held most silica; in the latter the amount of colloid silica was estimated at 12·61 per cent. by weight. After noticing the vast amount of silica present in rocks with a maximum thickness of 70–80 feet, the authors discussed the difficulty of accounting for this, and drew attention to Prof. Sollas's statement that many living siliceous sponges constantly shed some of their spicules.

A further question arose as to whether the formation and accumulation of globular silica went on contemporaneously with the deposition of the calcareous material upon the sea-floor, or whether the conversion of the spicules into such silica took place after the consolidation of the rock, and the authors gave reasons for supposing that the latter was the case, the change having occurred when the rock was in a sufficiently oozy condition to admit of easy molecular distribution. Reasons were given for supposing that the disseminated colloid silica had not been derived directly from the disintegration of spicules in which a globular structure had been previously developed, but that the globular silica was precipitated from solution whilst the beds were still permeated by sea-water.

The precipitation of the chalcedonic silica was regarded by the authors as a secondary and subsequent operation. They were disposed to regard all nodular concretions resembling flints and phosphatic nodules as growths, which were more or less contemporaneous with the deposition of the materials of the enclosing rock, and in conclusion they offered some comments upon the problem of the formation of flints.

3. "Note on the Pelvis of *Ornithopsis*." By Prof. H. G. Seeley, F.R.S., F.G.S.

The remains preserved in Mr. Leeds's collection at Eyebury, and described by Mr. Hulke, are the largest and most perfect pelvic bones of a Saurischian known in this country. An examination showed that the bones of the right and left sides were united in the median line almost throughout their length by a median suture, and that they formed a saddle-shaped surface internally from front to back. After giving a detailed description of the pubis and ischium, the author stated that he was not aware that this type of pelvis had been previously observed. He noted that the antero-posterior concavity between the anterior symphysis of the pubic bones and the posterior symphysis of the ischia was a well-marked characteristic of Saurischian reptiles, but that it remained to be determined to what extent the median union of the pubic bones was developed in the group.

It was impossible to judge of the form of the ilium from the imperfect fragment preserved, but it did not make any recognizable approximation to the bone in those American genera which offered the closest resemblance of form to the pubis and ischium.

There were several minor differences of proportion between the bones from the Oxford Clay and those from the Wealden of the Isle of Wight, and the former differed in ways pointed out from *Morosaurus*, *Diplodocus*, and *Brontosaurus*, though there were resemblances.

III.—April 3, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.

The President announced that according to a circular lately received from the "Sociéte Géologique de France," that Society proposed to hold its Extraordinary Meeting this year in Paris, the date being fixed for the 18th August next. Meetings will be held in Paris, the collections in that city will be visited, and there will be a series of excursions to places of interest within easy reach of Paris, on successive days of the week devoted to the Meeting. These are specified on the circular; and in the week following the Meeting, excursions will be made to more distant localities, of which the Auvergne and Brittany are particularly mentioned, that to the former district under the guidance of M. Michel-Lévy, and that to Brittany conducted by M. C. Barrois. Arrangements will be made with the railway authorities for a reduction of 50 per cent. upon the fares; but in order to secure this advantage the names of persons intending to attend must be sent to the Secretaries of the Society before the 1st July, 1889. British Geologists, and especially Fellows of the Society, are cordially invited to be present.

The following communications were read:—

1. "The Elvans and Volcanic Rocks of Dartmoor." By R. N. Worth, Esq., F.G.S.

The object of this paper was to give reasons for the belief that the present granite of Dartmoor passed upward into felsitic and volcanic rocks, remnants of which are to be found in the Triassic conglomerate of Devon, in the detritus of the bottom lands of the moor itself. on the beaches of the channel, and in ancient river-gravels and pebble-beds; to indicate the wide range of character taken by the felsites of the Dartmoor district; and to point out some of the evidence which exists in the *in-situ* elvans for the development of the most varied of these forms from a common magma.

Special opportunities for the study of two of the elvanite dykes in the neighbourhood of Tavistock have lately presented themselves. The Shillamill elvan exhibits a centre composed of quartzose felspar-porphyry graduating laterally through numerous varieties into "claystone porphyry"; whilst the Grenofen elvan retains the same structure in breadth, but changes in length from a rock containing so little felsitic matter that it is essentially a fine-grained porphyritic granite, to one with a compact semivitreous ground-mass, in which felspars, quartz, mica are porphyritically developed.

As evidence afforded of the existence of distinctly volcanic rocks, mention is made of a deposit of water-borne and water-worn detritus, indicating a Dartmoor origin for a large portion of its constituents, along with rolled flints and pebbles of Carboniferous, Liassic, and Cretaceous limestone, with which were associated typical andesites and specimens of volcanic grit such as arise from denudation of volcanic cones. This occurs on the limestone at Cattedown near Plymouth, and bears testimony to a very ancient denudation.

2. The "Basals of Eugeniacrinidæ." By F. A. Bather, Esq., B.A., F.G.S.

Although Professors Beyrich and v. Zittel had alluded to certain specimens of *Eugeniacrinus* as proving, by the course of the axial canals, that in this genus the basals had passed up into the radials, yet the two chief authorities who subsequently discussed the subject practically ignored this argument. M. de Loriol contented himself with denying any trace of basals, while Dr. P. H. Carpenter maintained that the top stem-joint represented a fused basal ring. In a previous paper the author had argued in favour of Prof. v. Zittel's view without convincing Dr. Carpenter of its correctness. Such scepticism was, no doubt, warranted by the lack of detailed description and of figures. The object of the present note was to set the matter at rest by describing and figuring certain dorsal cups of *Eug. caryophyllatus* kindly lent to the author by Prof. von Zittel.

Owing to the mode of fossilization the canal system is plainly seen. The axial canal passes up into the radial circlet and gradually widens; at a short distance below the floor of the calycal cavity it gives off five interradial branches; these soon bifurcate, and the adjacent radial branches converge. Before they meet, each radial branch gives off a very short branch; this connects the radial branch with the ring-canal that contained the interradial and intra-radial commissures.

The evidence of all other Crinoids that have these canals shows that the basals always contain the interradial branches. And in *Eugeniacrinus*, since the interradial branches have their origin in the middle of the radials, the basals must have passed up in between the radials.

3. "On some Polyzoa from the Inferior Oolite of Shipton Gorge, Dorset." By E. A. Walford, Esq , F.G.S.

The author referred to the little attention the Jurassic Polyzoa have received in England, a few scattered papers comprising the whole of the literature of the subject. This may be accounted for, in part, by the rare occurrence of conditions favourable to the preservation of the delicate features necessary for their true study, and in part, also, by the difficulties into which the classification has drifted.

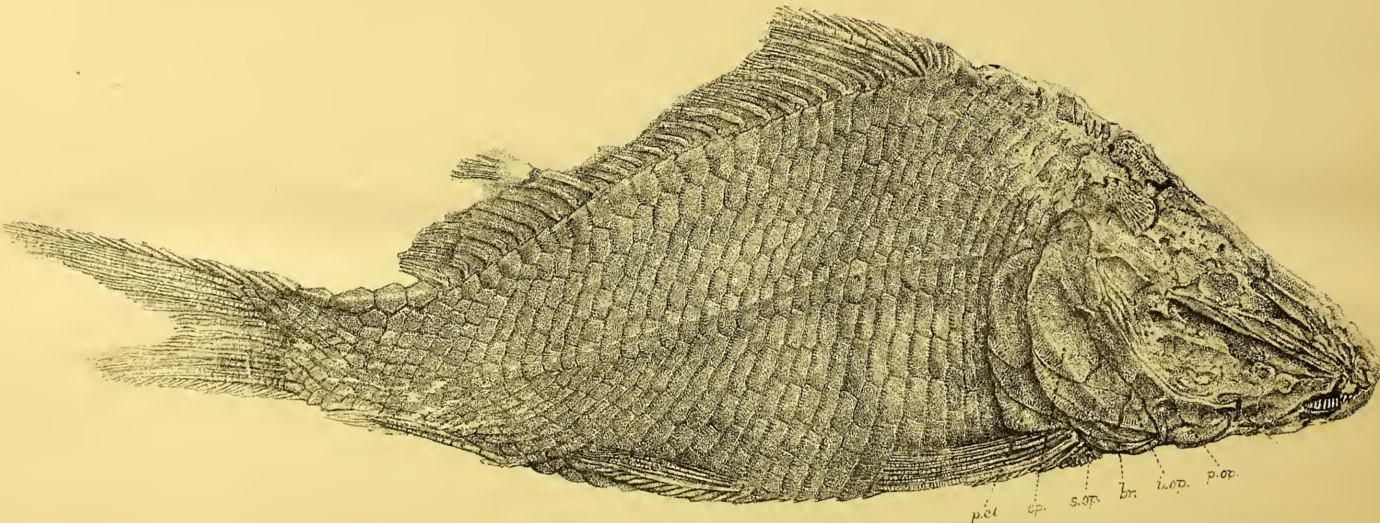
The series dealt with has been collected from the Inferior Oolite, zone of *Ammonites Parkinsoni*, at Shipton Gorge, Dorset, and the number of forms from the single horizon and locality was stated to be equal to the whole of those described by Jules Haime from the Lias to the Kimeridge Clay. Associated with the Polyzoa are *Crania Moorei*, and sp., *Thecidea*, sp., *Rhynchonella senticosa*, *Terebratula Phillipsii*, *Ammonites Martinsii*, some Echinoderms, and a large series of sponges. The tranquil conditions prevailing during the deposition of the beds are indicated by the presence of many slender and arborescent forms of Polyzoa, and the little abrasion they have suffered, as well as by the presence of numerous sponges.

The author, in briefly reviewing the Cyclostomata, adopts the simple divisions of Mr. Waters, the Parallelata and Rectangulata, based upon the Hincksian system. The disregard of zoarial growth, in any great degree, as a means of classification, would lead to confusion under the present modes of grouping; neither, however, can any great constancy be found in the form of the zoœcia or in the shape of the aperture.

In the group *Stomatopora* six species are recognized, of which two are new. Amongst the *Proboscinæ* is a species described in that stage of growth as *Proboscina spatiosa*, which passes into both Tubuliporoid and Diastoporoid forms, and also in the latter phase throws off erect Entalophoroid branches. The author has used the same specific name for each form, though describing them under different generic names. Considerable variation in size and shape of cell occurs in each stage. The *Idmoneæ* are represented by two new species and two new varieties; *Bisidmonea* by one form only. Though the latter has much the appearance of *Entalophora*, the character of the ovicell is so definitely that of the associated *Idmonea* as to decide its relationship, and it has also the cell-type of *Idmonea*. In the group *Entalophora* d'Orbigny's Cretaceous species *Entalophora raripora* and *E. subgracilis* are quoted, the latter, however, under a varietal form. *E. anomala*, Manz., *E. richmondiensis*, Vine, and one new species, *E. magnipora*, complete the list so far.

MISCELLANEOUS.

Western Australia.—From Reports received, it appears that the Gold-fields of this Colony are likely to prove as rich as those of Eastern Australia. But we are still more glad to learn that the Coal-seams on the Irwin River, noticed by Gregory in 1863, are now being successfully worked, and promise excellent results. Western Australia has already 450 miles of railroad, and if coal can be obtained close to the northern terminus at Geraldton, it will be of the highest value.



Berjeau & Highley, del. et lith. West, Newman & Co. imp.

Histionotus angularis, *Egerton.*

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VI.

No. VI.—JUNE, 1889.

ORIGINAL ARTICLES.

I.—On a New Specimen of *Histionotus angularis*, Egerton.

By J. C. Mansel-Pleydell, F.L.S., F.G.S.

(PLATE VII.)

HISTIONOTUS ANGULARIS, was first described and figured by the late Sir Philip de M. Grey Egerton, Bart., F.R.S., in Decade viii. of the Memoirs of the Geological Survey, 1853. The uninterrupted dorsal fin, extending from near the occiput to the tail, suggested the generic name of *Histionotus*,[1] and in this feature it re-resembles *Ophiopsis*. It has the characters also of other genera, for instance, *Pholidophorus* in its scales, *Semionotus* in the shape of its body, and *Lepidotus* in the shape of its head. Sir Philip Egerton, misled by the imperfect preservation of the posterior end of his specimen, thought the caudal-fin to be also similar to that of *Lepidotus*. By a singular coincidence, a fine specimen of *Lepidotus minor* lies side by side on the same slab with the subject of this note (Pl. VII.), and the caudal fin of each is well exposed, showing that of *Lepidotus* to be comparatively short and truncate, while that of *Histionotus* is deeply forked. In its crushed condition, the upper lobe in *Histionotus* is longer and larger than the lower lobe; but this is proved to be a deceptive appearance by another example of the genus I have since met with from the same quarry which displays the symmetry of the tail-fin, the lobes being beautifully shown of equal length.

The outline of the upper portion of the body is triangular, rising abruptly from the snout to a distance of 20 millim. beyond the base of the occiput along the dorsal ridge, and then descending by a less abrupt gradient from this culminating point to the base of the caudal fin, a distance of 85 millim. The depth of the body at the most elevated part of the dorsal ridge to the pectoral fin is 65 mm., to the shoulder-girdle 33 mm.

The anterior margin of the first ray of the dorsal fin, which is stouter than the others, is furnished with a series of fulcral rays. The remaining rays, of which there are more than twenty, bifurcate about half-way from the base, and the distal halves are again bifurcated and cleft. The pectoral fin consists of seven rays, of which the first is the longest and stoutest, and all are bifurcate

[1] ἱστίος, a sail, νῶτος, a back.

and split. Each ventral fin, which is 20 mm. long, has only four rays, the first exceedingly stout and furnished with a series of large marginal fulcra; and all the rays are transversely articulated or jointed beyond the point of bifurcation. The anal fin has four rays also, and is the smallest of all; the length of the largest ray being 15 mm. The caudal fin consists of eight rays in each lobe, the upper lobe appearing 40 mm. long, whereas the lower is only 25 mm. The margins of the upper ray of the larger lobe and of the lower ray of the smaller are furnished with a series of large fulcra which probably increased the locomotive power of the tail.

The depth of the shoulder-girdle is 25 mm., and the breadth of the post-clavicular plates (*p. cl.*) 5 mm. The opercular apparatus is well preserved, showing distinctly the operculum (*op.*), sub-operculum (*s. op.*), interoperculum (*i. op.*), and preoperculum (*p. op.*), besides a few branchiostegal rays (*br.*). These, like the post-clavicular plates of the shoulder-girdle, are all enamelled.

The bones of the head are much crushed. The maxillæ, although perfect, are displaced; and a portion of the right premaxilla is preserved, showing seven teeth, with part of the eighth. These teeth are styliform, slender, straight, and smooth, and appear to decrease in size from front to back. The largest is 2 mm. in length. The vomerine bones are hidden, which unfortunately prevents our ascertaining whether or not the roof of the mouth is armed with teeth. The orbit is obliterated by the intrusion of the underlying skull-bones.

The scales of the body are small as compared with those of *Lepidotus*, and are not so lustrous. Those of the flank measure 6 mm. in depth and 2 mm. in breadth. They are rhomboidal in shape, finely pectinated on the posterior exposed margin, arranged obliquely in rows from the dorsal to the ventral region, twelve in a series. The lateral line from head to tail extends along the middle of the flank. Between the last ray of the dorsal fin and the base of the caudal, are three double-cone-shaped lustrous ridge-scales, which may have served to strengthen this attenuated part of the body, enabling it to resist the strain upon it when the caudal fin was in action.

Length of body	1·80 m.
,, tail, upper lobe	0·50 m.
,, ,, lower lobe	0·30 m.
,, head	0·46 m.
Breadth of head	0·40 m.

EXPLANATION OF PLATE VII.

Histionotus angularis, Egerton; right lateral aspect of fish, nat. size. Middle Purbeck Beds, Swanage, Dorsetshire. *br.* branchiostegal rays. *i. op.* interoperculum. *op.* operculum. *p. cl.* post-clavicular plates. *p. op.* preoperculum. *s. op.* suboperculum.

The specimen from which the above description is taken, and which is figured in the accompanying plate, was procured by me from a quarry at Herston, near Swanage, Middle Purbeck. It is now preserved in the Dorset County Museum, Dorchester.

Whatcombe, Blandford, Dorsetshire.

II.—On Statical and Dynamical Metamorphism.

By Prof. John W. Judd, F.R.S.

It has long been recognized by geologists that rock-masses which have undergone movement, and have thereby been subjected to internal stresses, exhibit, as the consequence of the action upon them of such mechanical forces, unmistakeable evidences of having been greatly modified, alike in their mineralogical and in their structural characters. That the most complete and striking examples of such changes are to be found in the rock-masses which constitute mountain-chains—rock-masses which have actually been made to "flow," and in so doing have been subjected to shearing movements of the most intense character—was clearly pointed out by Scrope, Darwin, Sharpe, Naumann, and Dana; all of whom referred the foliated structure exhibited by such rock-masses to this cause.

The careful study, in recent years, of the actual processes involved in bringing about such changes, has rendered necessary the adoption of certain terms, to define the nature of the action in particular cases. In 1869, Lossen proposed to call the changes produced during rock-movements "dislocation-metamorphism" (dislocationsmetamorphismus);[1] while four year later Baltzer invented the term "mechanical metamorphism" (mechanischer metamorphismus);[2] in 1884 Gosselet suggested the term "friction-metamorphism" (métamorphisme par friction);[3] and in the following year Gümbel employed the name "compression-metamorphism" (stauungsmetamorphose);[4] while in 1886 Bonney proposed to use the term "pressure-metamorphism."[5]

Rosenbusch, in the same year, seeking to bring clearly into view the consideration that the special kind of metamorphism referred to is only produced when the mechanical forces effect movement, and thus do work, suggested the term *Dynamical metamorphism* or *dynamometamorphism*;[6] and this term, if not absolutely free from objections, is so convenient that it bids fair to be generally adopted.

There is perhaps at the present time a tendency to exaggerate the results of this particular agency of dynamical metamorphism, and to overlook or minimize the importance of other contributory causes to the alteration of rock-masses. I desire in this note to call especial attention to the remarkable effects which result from the chemical and crystallizing processes which certainly go on at great depths, and under enormous pressures, *even when the rock-masses do not yield to the pressures* and thus become subjected to the movements which

[1] Zeitschr. d. d. geol. Gesellsch. Bd. xxi. pp. 282–340.
[2] Der Glärnisch (1873), p. 58.
[3] Ann. Soc. Géol. du Nord, xi. (1884), p. 188.
[4] Geol. von Bayern, i. p. 379.
[5] Ann. Address Geol. Soc. Q J.G.S. vol. xlii. (1886), p. 62.
[6] Der Massige Gesteine, 2nd ed. 1886.

result in dynamometamorphic action. Such changes, resulting from pressures that do not effect movements in the rock-masses, may be appropriately called "statical metamorphism."

The researches of modern physicists are beginning to enable us to realize what are the chief factors in these processes which go on at great depths within the earth's crust. The striking experiments of Guthrie have shown that there is a perfect gradation between the states of fusion and solution, and have enabled us to realise the important part played by even small quantities of water or other liquids held under great pressure in the deeper and highly heated masses of the earth's interior.[1] The researches of Spring, van't Hoff, Reicher, and others have shown the effects of pressure in bringing the molecules of solid bodies sufficiently close to one another for chemical affinity to operate between them; and especially significant to the geologist is a recent conclusion arrived at by the first-mentioned physicist, that when the particles of a solid are brought into juxtaposition by the action of mechanical force, the chemical processes may go on even after the pressure is removed. Time, it is thus shown, may become an important factor in such changes.[2] And, lastly, Van der Waals in his remarkable essay on "The Continuity of the Gaseous and Fluid States" has shown that "*all bodies can mix with one another when the pressure exceeds a certain value.*"[3]

That at great depths and under the enormous pressures within the earth's crust, *the whole substance* of solid rocks—crystallized minerals and glassy groundmass alike—may be traversed by various liquids and gases, I think it is impossible to doubt. In various papers in which I have endeavoured to establish and illustrate the theory of "Schillerization,"[4] I have shown that rocks, which at any point of their history have been deep-seated, have undergone very remarkable changes—their minerals having been metamorphosed and transformed, and their original structure sometimes completely altered; these changes, which have taken place quite independently of any movement that the rock-masses may have been subjected to, can therefore be spoken of as *statical* metamorphism. A striking illustration of the truth of the conclusions arrived at by Van der Waals is afforded by the fact, that in the interior of rock-forming crystals, we find cavities (indisputably formed by solvent action long subsequently to the formation of the minerals themselves), containing at the same time, various supersaturated aqueous solutions and also carbon-dioxide retained in the liquid condition by pressure.

It may be of interest at the present time to draw a comparison

[1] The bearings of Dr. Guthrie's researches on geological problems have been already pointed out. See this MAGAZINE, Dec. III. Vol. V. p. 1, 1888.

[2] Amer. Journ. Sc. 3rd ser. vol. xxxvi. (1888), p. 288.

[3] I am indebted to my colleague Prof. Rücker, F.R.S., for calling my attention to the valuable researches of Van der Waals, which have had such an important influence on the views of physicists. His essay, which was translated from the original Dutch into German in 1881, is now about to be issued in English form by the Physical Society.

[4] Quart. Journ. Geol. Soc. vol. xli. (1885), pp. 374–389; Mineralogical Magazine, vol. vii. (1886), p. 81.

between the effects of statical and dynamical metamorphism respectively.

Setting aside the more purely mechanical effects which may precede or accompany dynamical metamorphism—such as cleavage, jointing, the crushing or deformation of included fragments, the stretching of rocks, and the production of "mylonitic" bands—the results of this agency may be classified as follows:—

First.—The inducement of metamorphoses in the constituent minerals of a rock. That minerals are capable, without losing their identity, of undergoing remarkable metamorphoses, whereby their chemical, crystallographical, optical and other physical properties may be modified within certain—though often indeed very wide—limits, is now beginning to be recognized by both mineralogists and geologists. The production of twin-lamellation in many minerals by internal and external stresses, and the deformation of crystals by these means, so that they assume not only the external angles, but the internal structure and the optical properties of complex twins belonging to a system of lower symmetry than their own, are now well-recognized facts. An admirable illustration of this action is afforded by the production of microcline from orthoclase. The beautiful experiments of Des Cloizeaux, Dufet and Bücking on this same mineral species, orthoclase, have shown that both by heating and by pressure the position of the optic-axial plane, and the angle between the axes may undergo temporary changes; while, if the temperature or pressure pass beyond a certain limit, these changes become permanent. The study of the minerals of the enstatite-group has shown that as certain chemical changes go on within their crystals, these, while retaining their orthorhombic symmetry, may undergo the most remarkable modifications, not only in their colour, pleochroism, and absorption, but also in their index of refraction, in the sign and intensity of their double refraction, in the position of their optic-axial plane and in the angle between their axes; and further, that, changes in specific gravity, in hardness and in fusibility may accompany these several modifications.

That the form and position of the ellipsoid of elasticity in a crystal may be altered temporarily and even permanently by the action of heat, pressure, or chemical agencies, is a phenomenon for which we ought to be fully prepared; and it is upon the form and position of this ellipsoid that the so-called optical "constants" of a mineral depend.

That the metamorphoses which have been more or less fully investigated in the case of a few species, like orthoclase, enstatite, selenite, etc., are not confined to those species must be clear to all who have been in the habit of studying the so-called "optical anomalies" of minerals; and such "anomalies" are especially frequent in the case of the common rock-forming species. When we remember the nature of the forces to which the constituent minerals of rocks must have necessarily been subjected in many cases, we shall cease to wonder at this result.

Secondly. As there must be, in every case, a limit beyond which a mineral cannot change without losing its identity, the final result of the internal stresses set up in a rock-mass is that the constituent minerals are gradually transformed into totally different ones. This transformation may take place in two different ways :—First, *paramorphic*, or change into a new mineral species crystallizing in the same or a different system, but having the same chemical composition; or secondly, *metachemic* (to use Dana's convenient term)[1] when, in consequence of the addition or subtraction of materials, or of both of those processes combined, the chemical composition as well as the crystallographical characters of the substance undergoes complete alteration.

Thirdly.—This change in the mineralogical constitution of a rock may be accompanied by a modification, more or less complete, in its structure. The structures which usually result from the action of *dynamical* metamorphism are the *granulitic*, and the *foliated* or *schistose*. It must be remembered that while these changes in structure may undoubtedly take place in rock-masses which have long since acquired the solid condition, they are also liable to arise in masses which are still in a plastic or viscous condition, and as the result of a primary rather than of a secondary crystallization when the mass is under the influence of internal stresses and movements. I have shown how completely the granulitic structure may be developed on the sides of great intrusive masses of gabbro; and General McMahon has well illustrated the production of foliation in intrusive granite-veins. Even in hypocrystalline rocks, like the more acid lavas, as Scrope and Darwin so admirably proved, the shearing movements in a slowly moving, viscous mass give rise to phenomena having the most striking resemblance to the foliation of the crystalline schists.

Let us now direct our attention to the class of changes which take place in rocks which are subjected to great pressure, but in which this pressure has not produced differential movement resulting in shearing. In these cases the most potent agency by which change is effected consists in the penetration of the whole mass of the rock by various liquid or gaseous solvents. It is for the whole group of such changes—of which "schillerization" is a conspicuous example —that I propose to employ the term *statical* metamorphism. Such statical metamorphism can often be shown to have taken place in the same rock-masses which have undergone dynamical metamorphism —the statical metamorphism either preceding or following the dynamical metamorphism.

The effects of statical metamorphism may be conveniently classed under the same three headings which we have employed in considering the results which are produced by dynamical metamorphism.

First.—The metamorphoses of the constituent minerals in a rock. We cannot perhaps better illustrate the nature and variety of the changes which take place in minerals subjected to great pressures

[1] Amer. Journ. Sci. (1886), vol. xxxii. p. 69–71.

than by referring again to the very widely distributed species orthoclase. This mineral, according as it has been formed near the surface or at great depths, assumes the special crystallographic habit, the lustre, density and other properties which characterize *sanidine* and *adularia* respectively. But, subsequently to their formation, the crystals may have their optical characters completely altered either by heat or pressure, so that the position of the optic-axial plane and the angle between the axes change to those of *anomalous orthoclase* (orthose deformé). On the other hand, the great mechanical stresses, to which rock-forming orthoclases have in some cases been subjected, has frequently caused them to assume the external angles, the internal structure and the optical properties characteristic of *microcline.*

But there are a number of other changes that orthoclase-crystals are subject to, which, though they have certainly been produced only in crystals that have existed in deep-seated rock-masses, yet cannot be referred to any process of dynamic metamorphism.

Almost universally, the crystals of orthoclase in such deep-seated rock-masses are found to have lost their transparency and vitreous lustre, and to have acquired the opacity and pearly lustre, often with the red, pink, grey or green tints distinctive of *common orthoclase.*

Sometimes the separation by chemical agencies of minute particles in the transparent mass has gone on in such a manner as to give rise to the scattering of light which results in "opalescence." We have thus produced the *opalescent orthoclase,* some forms of which are known as "moonstone."

If the change results in the formation and infilling by foreign deposits of negative crystals lying in their solution planes, then the result is an *avanturine* or *schiller orthoclase,* to which some of the so-called "sunstones" must be referred.

If the structures developed in the crystals by these agencies be of ultramicroscopical dimensions, we may have the beautiful interference phenomena produced, which are characteristic of *iridescent orthoclase.* The important researches of Stokes and Madan, and especially those recently undertaken by Lord Rayleigh, upon the artificially formed iridescent crystals of chlorate of potash, promise to throw much new light upon the obscure question of the theory of such a play of colours as exhibited by certain minerals.

The chemical changes which take place along certain definite planes within a crystal of orthoclase may result, not only in developing a particular lustre along these planes, but also in giving rise to a tendency to division along them (pseudo-cleavage), and we thus get the beautiful variety known as *Murchisonite.*

Lastly, the crystal after having undergone any or all of the changes above indicated, may, in consequence probably of changes of temperature, break up more or less regularly along certain planes ("contraction-rifts"); and, in the clefts thus produced, secondary deposits of albite or some other form of felspar may be deposited giving rise to the varieties known as *Perthite* and *Microperthite.*

Similar series of changes may be traced in the case of many—

perhaps of all—the rock-forming minerals, which have been subjected to deep-seated chemical action within the earth's crust.

Secondly.—The mineral (often greatly altered in its chemical constitution by one or other of the processes above described) may undergo complete transformation—either paramorphic or metachemic. Thus orthoclase, according to the nature of the solvents and the conditions under which they operate, may be converted wholly or in part into a zeolite, into muscovite or some hydrous mica, into epidote, into a kaolinite, or into some other type of mineral.

It may be interesting to illustrate in a tabular form the chief metamorphoses to which the species orthoclase appears to be subject, and the complete transformations of which it is ultimately susceptible :

A. *Forms dependent upon the conditions under which the crystals were originally produced.*

Adularia.	Sanidine.

B. *Forms resulting from physical or chemical changes, induced by statical or dynamical metamorphism.*

Anomalous Orthoclase (Othose deformé).	Common Orthoclase.
Microcline.	Opalescent Orthoclase.
	Avanturine Orthoclase.
	Iridescent Orthoclase.
	Murchisonite.
	Perthite.

C. *New minerals resulting from the further alteration of Orthoclase.*

Zeolites.	Micas.
Epidotes, etc.	Kaolinites, etc.

Thirdly.—Statical metamorphism, by giving rise to the development of new minerals in a rock or to the growth of old ones, may lead to a complete change in the structure of a rock. Holocrystalline rocks are those in which the whole of the materials have acquired the crystalline character without interruption, the time before their complete solidification having been sufficient for the prevention of any imperfectly crystallized residue being left. Such rocks may be regarded as being in the most stable condition. But with the hypocrystalline rocks the case is otherwise. We have a stable portion produced by the uninterrupted action, up to a certain point, of crystallization, and an unstable portion produced during the more sudden solidification of the residue. In such a rock, when subjected to the process of statical metamorphism, the stable crystals may grow at the expense of their unstable surroundings, and, as I have recently shown, many new and remarkable rock-structures may result from this process.[1]

It is very difficult to define any *limits* to the processes of statical metamorphism. The effects of such operations can be best studied in the case of igneous rocks—especially those belonging to a late period in the earth's history—that have been situated near volcanic centres and afterwards exposed to our study through denudation. In such cases the phenomena which have to be investigated are less liable

[1] Quart. Journ. Geol. Soc. vol. xlv. pp. 175-186 (1889).

to be complicated and obscured by the results of other processes of change, than in older rock-masses of similar origin. Around volcanic centres, too, the rate of the rise of the temperature with descent is probably more rapid, and the solvent agents are more abundant than elsewhere; and it is also more easy to trace the effects of these agents upon the definite minerals making up the plutonic rocks, than in other cases. But all rocks at great depths must be subjected to high temperatures, to enormous pressures, and to some solvent agents; and it may well be that at such depths a condition approaching to fusion or to solution may be reached, which permits of perfect re-crystallization of the rock materials; such a state of things would seem to be advocated by Dr. A. C. Lawson and Dr. G. Dawson, as having probably occurred in the case of the rocks which cover so large an area in Canada.

I cannot perhaps better illustrate the complicated results of the joint action of statical and dynamical metamorphism than by referring, as briefly as possible, to the cycle of changes which can be shown to have occurred in the case of a particular rock.

The so-called Apatit-bringer of Oedegarden, near Bamle, in Norway, is a rock consisting essentially of hornblende and scapolite, which, as shown by the beautiful experiments of Fouqué and Michel Lévy, can, by fusion and slow cooling, be converted into an aggregate pyroxene and felspar. That the rock was originally a pyroxene-felspar-rock which has been metamorphosed into a hornblende-scapolite one, the observations of Sjögren and others sufficiently indicate, and we are now able to show the exact series of processes by which the transformation has been effected.[1]

In certain specimens the pyroxene (an enstatite) may be seen to have acquired, through a process of *statical* metamorphism, the peculiar characters of bronzite; and, by the same means, layers of cavities are developed along the twin-planes of the felspars, which cavities are filled with supersaturated solutions of sodic chloride.

Statical metamorphism having carried the change thus far, *dynamical* metamorphism has next come into play, and the bronzite has been converted into hornblende and the mixture of felspar and sodic chloride into scapolite; the former by a paramorphic, the latter by a metachemic transformation. At the same time the structure of the rock has been changed from a granitic to a granulitic one.

This particular case is one of more than ordinary interest from our being able to study all the stages in the complete cycle of change, from a pyroxene-felspar rock to a hornblende-scapolite one, and back again to the former. But there are many other instances in which careful study may enable us to follow many of the successive steps by which very similar changes have been gradually effected.

[1] Mineralogical Magazine, vol. viii. p. 186.

III.—A Week's Geological Excursion to the Swiss Alps.

By Capt. Marshall Hall, F.G.S., F.C.S., etc.

THE following notes were drawn up by the writer some years since as a sketch for an excursion by members of the Geologists' Association to the Alps, and it may perhaps still prove acceptable to geologists who this year intend to visit Switzerland for the first time.

Leaving London any morning and proceeding onwards by the night-train from Paris, we may breakfast at Lausanne railway-station on the following morning.

Take steamer from Lausanne (Ouchy) for Villeneuve, where we have a good example of an anticlinal valley—that of la Tinière. Thence by rail to Vernayaz, where sleep. I need hardly summarize the geology round Lake Leman; in the train from Villeneuve remark the wave-crest form characteristic of the Jura seen from north, and the rock-fall at Roche; on the right the great one near Vouvry. The Triassic rocks are all interesting; and on the left after leaving Aigle are the fine marble quarries of St. Triphon. As you approach Bex you will observe the monticule called le Montet, which is principally a mass of gypsum. Bex with its salt mines would be well worth half a day's exploration.

Between that and St. Maurice we are in the Cretaceous formation. At the Baths of Lavey (left hand) we enter the Carboniferous region, consisting here of metamorphic schists. Remark any number of "roches moutonnées" and glacier-worn rocks. Of the picturesque nature of our route I say nothing—is it not recorded in many excellent guide-books?

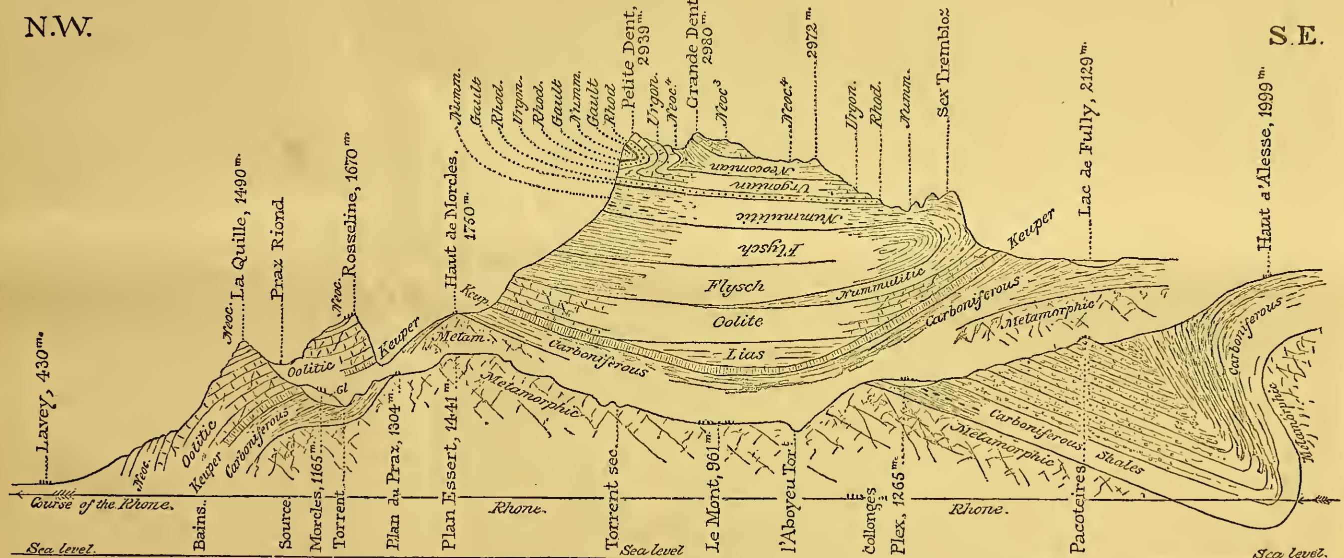
Next morning visit the Gorges du Trient, and thence the Pissevache, whence a rough zigzag leads over schists and by slate quarries to a point half-way up the carriage road to Salvan. This road winds up an interesting gorge, with a repetition on each side of slates at the bottom, Carboniferous grits, anthracitic and mica-schists and metamorphic schists, and grits. The heights above are gneiss.

Salvan is an hour and a quarter's fair walk from Vernayaz, up a good char road, but with a pitiless series of, I think, fifty-two zigzags, and, once fairly out of them, a gentle hill. Some ten minutes before reaching Salvan and five minutes off the road to the south-east are some very remarkable "marmites des Géants," *i.e.* the ancient pot-holes of glacial times, worn by water falling through "moulins." They show the pestle and mortar action, their centres rising in the form of cones.

On the opposite side of the valley of the Rhone the Dents de Morcles rising more than 10,000 feet have been growing more and more grand, and the replications of the strata, of which a sketch after that by Professor E. Renevier is given (see Pl. VIII. p. 251, opposite), are very specially remarkable, and, even at that distance, quite evident.

The geological map of the "Alpes Vaudoises," by the same geologist, marks "Poudingues de Valorsine" at Salvan.

One charming walk, scarcely known to the Cockney tourist, is a



Geological Section of the Dents de Morcles, by Prof. E. Renevier.

(Scale 1·50,000 for distances and altitudes.)

[Two sections combined and re-drawn from the originals by G. C. Crick, F.G.S.]

couple of hours up to La Creuse, whence is a splendid view of Mont Blanc. And I think the approach to the valley of Chamounix by this side of the valley far more interesting than that by the Tête Noire. The upper portions are gneiss. M. Renevier maps them as "schistes et grès metamorphiques," differing in this from the late Professor Studer, as the latter mentioned to me in several conversations.

The traveller should return to Vernayaz, or go on to Martigny, by the south-east side of the Trient, by the bridge of La Taillat and the hamlet of Guéroz. Thence he will take rail to Visp. The geological interest of the Valais increases, and its scenery is much under-appreciated. The Jurassic crags, peaks and precipices on the north side after reaching Saxon, are very grand and wild. The tendency of the Jurassic rocks to slope up like a heavy swell at sea, from the north, and, so to speak, break like the crests of waves in stormy weather on the south, is well exemplified. On the south side at the base of the mountains we have a different series, lowest are anthracitic schists, then a long strip of dolomite, extending to beyond Sierre, then banks of quartzite, and high up micaceous and other schists.

The flat valley, filled with old and recent alluvium, with the old Castles at Sion perched upon their craggy islands, the old moraines, especially about Sierre, would be excuse enough for the geologist to delay his journey at many points.

On arriving at Visp we start at right angles to the Rhone valley, ascending through the Schistes lustrés of Triassic age; then through some quartzite, and subsequently an occurrence of dolomite, then serpentine, which on the west side forms a not inconsiderable height. We then come upon mica and some chlorite schists, and, crossing a highly picturesque bridge, reach Stalden in less than two hours from Visp. Here we pass the night, well above the flies, queer odours, and generally doubtfully salubrious air of the Valais plain. Near Stalden are some notable stone-capped pillars and glacial detritus, resembling the well-known earth-columns of Botzen.

Leaving the valley of S. Niklaus to the right, next morning we begin to mount the actual Saas-Thal, to the south-east. Mark the blocks of gneiss perched on the hill-side, and study the water-worn gorge, with its wooden bridges and torrent roaring at great depths. We come to a level with the bed of the stream, and find therein a considerable variety of pebbles of schists, gneiss, serpentine, gabbros, etc. In four hours we reach Saas-im-Grund, and again come, in the valley sides, upon a bank of dolomite, between the older metamorphic schists and the gneiss of the central mountain mass. I have seen sections well showing the contact metamorphisms of this dolomite. I should be much obliged if any geologist having the time would kindly examine the relations of these occurrences of dolomite to the other rocks. Saas-im-Grund itself is upon the edge of schists and gneiss just mentioned, and it is worth while to spend the rest of the day in this field-work, and in walking forty minutes up the west side of the valley to Saas-Fée (where there is a good hotel), for the sake of the grand views of the Fletschorn and other noble peaks to the east, and of the great Fée glacier and surrounding heights behind the village. In such case, and with a competent guide, it is not difficult to substitute a very interesting glacier walk for what I am about to describe as the next day's work, by making across the Fée glacier towards the Allalinhorn, and working one's way to Point 3150 mètres on the map, and so down to the Mattmark inn.

But if pressed for time, the traveller should walk or ride another three hours. In the bed of the torrents are beautiful specimens of the rocks of the country, in profusion. The rocks are schistose and gneissic on each side the valley. But on the west the Egginerhorn is of serpentine. Near Almagel is a gorge with waterfalls of great picturesqueness. As we advance, the forests become more and more scanty, and the scene grows wilder. The path, near a small roadside chapel, brings you almost within reach of the end of the Allalin glacier. I remember that in the year 1848 or 1849, the ice was far over the existing track, and the old path was above the present one in consequence. The plain has scanty herbage, moraine gravel and streams wandering where I remember the Mattmark-see (now an insignificant sheet), which could then boast the dignity of a small lake. Blocks of serpentine become more and more abundant, close to the Mattmark inn is one which I roughly guessed to weigh some 5000 tons or more, called the Blauen-Stein. This characteristic upper valley, surrounded with precipices and glaciers, with a frowning desolate aspect, will much strike the traveller. The rough inn, with its ingeniously varied dinners out of scanty resources, and warm welcome, is at a height of 7000 feet above the Mediterranean, and well placed for mountaineering and field-work. It is also only some couple of hours or so from the Col of Monte Moro, and as horses or mules can be taken all the way from the railroad at Visp to Thäliboden, that is, one hour from the top, one of the sublimest views in all Europe is attainable without difficulty or fatigue. I know nothing in the range of the Alps, after some forty years of devotion to them, which in its way is more imposing, grander or more instructive than the view which bursts upon the traveller, of the cirque of precipices and glaciers of the Monte Rosa chain—to say nothing of blue Italy. But a *very* early arrival is generally necessary to enjoy this in completeness.

Professor Bonney has written so much and well upon the Western Alps that I will not dwell upon their structure. But I will mention an exceedingly interesting day, or more, of work best done from the Mattmark inn. Although it is not actually in the considerable districts of serpentine which lie principally to the S.E. and S.W., the neighbouring heights are outliers of this mass. Also a rock of euphotide gabbro occurs within a morning's walk, which has I think supplied most of the erratic stones of this rock which occur on the north side of Lake Leman, and at the junction of the Rhone and Arve, below the town of Geneva, whilst, as regards the gabbros found on the south side of Lake Leman, as, for instance, about Evian, I take it the mountains at the head of the Val d'Herens were their source, the widening Rhone glacier of old having spread out as it advanced. I come to these conclusions from microscopical examination of rocks, erratic and not in situ.[1]

If we leave the inn betimes on a fine morning, we shall find the torrent at its lowest, and, crossing it by a wooden bridge of the roughest construction, we traverse a meadow, and at once begin to ascend a steepish zigzag up a ridge partly of rock, partly of old moraine. Chalets some 1000 feet above the valley would give shelter at a pinch, and milk when inhabited. An hour more up the Schwartzberg brings us to the Aeusser Thurm, which, as also the Inner Thurm a little further on, overhangs the Schwartzenberg Glacier on the S.E. side, and on the N.W. joins the Névé of the Allalin Glacier. We cross the latter, but, as it is in this part treacherous (owing to concealed crevasses), though not steep, we must either be three in number, roped, and experienced, or have a guide (and always a rope). In half an hour we shall reach the foot of a rock marked in the Swiss map 3150 mètres (10,333 feet), and this is our mountain of euphotide. A climb without difficulty, but requiring caution, will in half an hour place us on its summit, and amongst its innumerable detached blocks we shall have found a 'quantum sufficit' of gabbros. Chloritic schists and serpentines characterize its surroundings, and the mass itself is far from being altogether euphotide. Now a geologist having started early and exploring the adjacent ridge, which leads up to the Allalinhorn, would fulfil the errand which took me there, but which I was unable to carry out from the rocks being concealed by an unusual quantity of snow in 1880.

I was especially desirous to ascertain the exact relations of the presumably intrusive euphotide with the serpentine and other rocks surrounding it, and also to observe the effects of its contact with its neighbours. I failed ignominiously, though in other respects my scramble was delightful and its results satisfactory. There is another point—in the large Swiss map, a rock in the middle of the Allalin Glacier is marked 3368 mètres. In that snowy year I think it must have been covered, or the glacier itself have previously increased in volume, for I could see nothing of it—the whole seemed névé. Now I much wish to know its nature, and should be grateful for specimens of it, and of the ridges leading up to the Allalinhorn and from the Inner Thurm to the Strahlhorn.

Let the geologist be cautious as to falling stones, and bear in mind that serpentine, though a good solid rock, is perfectly awful to slip upon.

In this skeleton of a tour the only occasions upon which a guide is at all necessary—though an intelligent mountaineer is always a useful and agreeable companion—is the scramble just described, and its alternative route from Fée. For these, and all walks in big mountains, a guide is a matter of prudence. I have now climbed for forty years, and still hold this mountaineering dogma.

[1] Vide Mineralogical Magazine, June, 1883.

I have now briefly indicated a few of the innumerable matters of interest most prominent during a course up part of the great Rhone valley and across the various schists and other formations to the centre of the Western Alpine mass. I could go on, could keep my unfortunate geologist hard at work, week after week, over this hastily surveyed ground. But I should be writing a book!

With regard to fossil remains. Switzerland is so bad a hunting ground that, unless a specialist wishing for details of a particular formation, the palæontologist will grow discontented. But for the history of mountain formation, and—pace Heim—metamorphism, not a spot in this wonderful country but tells its story of one or other.

And now I basely desert my traveller! If a scrambler, I advise him either to take the Weiss-Thor pass and sleep at the Riffel Hotel, or descend by the new Weiss-Thor pass which I first found in 1849, to Macugnaga. Whence, should the proposed excursion of the Geologists' Association to Naples take place, he might join those who may have crossed the Simplon at Vogogna. If no mountaineer, he must even ride or walk down to Stalden by the way he came. Somehow or other he will I trust get home after much enjoyment.

The geologist will find excellent official geological maps with memoirs and a large scale ordinary map (Siegfried) $\frac{1}{50000}$ at Mon. Rouge's, a leading bookseller in Lausanne. But it would avoid possible delay to bespeak them.

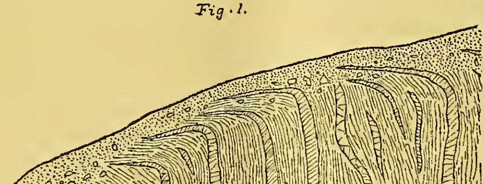
IV.—On the Creeping of the Soilcap through the Action of Frost.

By Charles Davison, M.A.,

Mathematical Master at King Edward's High School, Birmingham.

1. The object of this paper is to show how the soilcap, or its upper portion, may creep down an inclined surface through the action of frost. The subject has also been discussed by Mr. W. C. Kerr in a valuable memoir, "On the action of frost in the arrangement of superficial earthy material,"[1] published in May, 1881. I

Fig. 1.



reproduce here one of the figures given by Mr. Kerr, as I cannot better describe the nature of the phenomenon which it is the aim of this paper to consider.

"During the Centennial Exhibition [at Philadelphia], Market Street was extended westward . . . . . and a hill of some twenty

[1] American Journal of Science, 3rd ser. vol. xxi. pp. 345-358.

feet was brought to grade in the process. . . . . . The rock is gneiss and mica-schist with hornblendic and chloritic strata, inclined at a high angle, and decomposed, for the most part, the entire depth of the cut [not more than three to four feet in the portion sketched], presenting a banded section of variously-coloured earths. The most striking and novel peculiarity of this section is shown in the sketch (Fig. 1, *ante*, p. 255), viz. the gradual drawing out,—attenuation of these coloured bands, as the parts of them in succession were moved down the slope" (p. 353).

After remarking on the great depth of frozen soil in Canada and Labrador during their present winters, and on the still greater depth to which it must have penetrated during the Glacial period, Mr. Kerr says: "The alternate freezing and thawing of the saturated mass of decayed rocks . . . . would of necessity produce just the movement and settling which are described above. That is, this freezing and thawing would give rise to precisely the same movements of the mass, and of the particles *inter se*, as are seen to occur in the true glacier, *differing only in amount*. In other words, these masses were *earth glaciers*, and these deposits may be denominated *frost drift*, as distinguished from proper glacial drift" (p. 352). The majority of these deposits Mr. Kerr refers to glacial age; but, considering the small thickness of that illustrated in Fig. 1, he remarks that "the probability is strong that it is of recent (*present*) origin, the existing climate of Philadelphia being equal to the production of such effects" (p. 353).

It is not clear from this description how Mr. Kerr supposes the freezing and thawing to have acted in producing this movement of the soilcap. My first impression after reading his paper was that the water in freezing would, by its expansion, force the mass of loose earth bodily down the slope. This may be the case in certain parts of the mass, but that the explanation cannot be generally true will, I think, be evident after I have described the way in which I believe the movement must as a rule take place, together with some of the experiments made to test the theory.

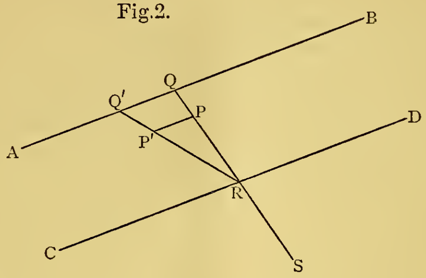
2. Imagine a layer of damp earth resting on an inclined surface, and exposed to the action of frost. The water in the interstitial pores will be frozen to a depth depending on the intensity and duration of the frost. If the particles of soil be not closely packed, the water will, in freezing, expand into the spaces between them, and the relative position of the particles may not be altered in consequence. But this cannot often be the case, for freshly-turned earth is soon rendered close and compact by a few showers of rain. The distances between the separate particles will thus as a rule be increased when the water between them is frozen. Now, the soil being compact and, except near the edges of the mass, continuous, the only direction in which expansion can readily take place is outwards and perpendicular to the surface. Every particle of soil in the frozen layer will therefore be displaced from its original position along the line of the normal (or perpendicular) to the surface of the soil; and, if the water be equally diffused throughout, the amount of the displacement will be proportional to the

distance of the particle from the surface to which freezing extends. The more intense and lasting the frost, the thicker will be the frozen layer, and the greater the displacement of the surface particles.

On the recurrence of warmer weather, the interstitial ice will be melted, and in melting will contract, and the particles will return, not, as they came, along the normal to the surface, but in a direction nearly vertically downwards owing to their weight; not quite vertically, however, because the adherence of each particle to its neighbours, by reason of the water between them, tends to bring it back towards its old position. The particles will thus after every frost and thaw occupy a lower position down the slope than they did before; and the whole outer layer of the soilcap will in this way creep slightly downwards, the creeping being greatest at the surface, and diminishing downwards to zero at the greatest depth to which freezing extended.

3. If all the particles descend vertically during the thaw, or at any rate in the same direction, it may be shown that a series of particles lying in a straight line will, after a single frost and thaw, continue to lie in a straight line, inclined, however, at a different

Fig.2.



angle to the horizon. Let A B (Fig. 2) represent the surface of the soil, C D the surface to which freezing extends. Let P be any particle of soil on the straight line Q R. Its normal displacement, and therefore also its creep, P P′, will be proportional to the distance of P from C D, and therefore to P R. Hence, the series of particles originally lying along the straight line Q R, will, after the frost and thaw, lie along the straight line Q′R; and the effect of the creeping will be to bend the line Q R S into the form Q′R S.

4. But, since during any winter or series of winters, there must be numerous frosts of different degrees of intensity and duration, and therefore penetrating to different depths, and since the surface layers of soil are affected by every frost, however slight, and in any one frost are more displaced than those below them, it follows that after any given time (including many changes of temperature across the freezing-point), particles lying originally on a straight line will in the end lie on a curved line with its concavity facing downwards.

If the different frosts be of different degrees of intensity and duration, the resulting line will be curved throughout its whole length, down to the lowest depth to which freezing has extended. But if, as in colder countries than ours, the frost last through nearly the whole winter, and in different winters do not vary greatly in its depth of penetration, then the resulting line will exhibit a more or less sharp bend at the average depth to which the frosts are felt, and above the bend they will be fairly straight. Mr. Kerr's section (Fig. 1) seems to me to agree remarkably with this latter deduction; and it will be observed also that the bends are all at nearly the same depth, which ought to be the case when the surface is not very uneven.

5. The experimental evidence that I have been able to obtain, though less varied and complete than it might have been made in a colder country, is decidedly confirmatory of the above theory. The experiments were made in boxes inclined to the horizon, and in this respect the conditions were not quite natural, for the sides and bottom of the boxes, as well as the surface of the soil, were exposed to the cold. But the movements of the surface-particles near the middle of the boxes would not be affected by this. The method adopted, moreover, possesses several advantages, not the least being that the effects are more marked than they would be naturally, owing to the greater depth of frozen soil.

Two boxes, differing in form, were filled with damp, fairly compact, soil. The first (A) is, internally, $2\frac{1}{16}$ inches wide, $2\frac{7}{8}$ inches deep, and, at the surface, 13 inches long; the lower end is horizontal, the upper vertical; and the inclination of the bottom of the box and the surface of the soil is 32°. A straight bar of wood is firmly screwed to upright supports at either end of the box, so that its lower edge is parallel to the surface of the soil and at a distance of $1\frac{1}{8}$ inches from it. The other box (B), rectangular in form, is, internally, $15\frac{1}{4}$ inches long, six inches wide, and $6\frac{5}{8}$ inches deep; and is inclined at an angle of 27°. A straight bar of wood is also fixed to the box, with its lower edge parallel to the surface of the soil and one inch from it. Fine pencil-lines are ruled on both bars in several places, perpendicular and parallel to the lower edges; and serve as reference-lines for the measurement of the displacements. I will now give an example of the experiments made with each box.

6. *Experiment* 1.—(Box A). The index used to register the motion of the soil consists of a slab of sheet-lead, $\frac{7}{8}$ inch square, on two opposite sides of which are arms, one inch long and $\frac{1}{4}$ inch wide. These are bent towards the centre of the slab, and, when they meet, bent again so as to be perpendicular to the slab. Part of a stout needle, $1\frac{5}{16}$ inches long, is bound tightly with strong silk between the projecting arms. The whole index weighs a little over three-fifths of an ounce.

The index was placed so that the surface of the soil was level with the upper surface of the slab, and the soil was pressed closely all round it, so that there was no gap between the soil and the edges of the slab. It was then left some days, and afterwards placed outside on the window-sill of an unused room, on the evening of January 3, 1889; and the distances of the needle-point from the lower edge of the bar and one of the lines perpendicular to it were carefully measured with the aid of a pair of bow-compasses.[1]

The minimum temperature during the following night was 27° F. and the soil was evidently frozen through by the next morning. The needle-point had risen $1\frac{1}{2}$ mm. in a line almost exactly perpendicular to the surface of the soil; and it remained in this position until the night of Jan. 7–8, when a thaw set in, by which the ice in the soil was entirely melted in about twelve hours. During this interval the position of the index was recorded several times; and the displacements measured, though very small, showed that the needle-point descended in practically a straight line, so as to end at the same distance from the lower edge of the bar as at starting, but $\frac{3}{8}$ mm. further down the slope. The direction of descent was therefore not quite vertical, but approximately bisected the angle between the vertical and the normal to the surface of the soil. Also, the normal rise of the surface-particles was about $\frac{1}{48}$ of the depth of the frozen soil, and their creep downwards about $\frac{1}{192}$ of the same depth.

At first sight, it seems possible that this creep may have been only apparent, and due to the weight of the index, which is of course much greater than that of an equal volume of soil. But I noticed carefully that, after the thaw, there was no gap between the lead slab and the surrounding soil; and this could hardly have been the case if the movement of the surface-particles had been very different from that of the index. The following experiment, however, appears to me to remove this objection, if it be one.

7. *Experiment* 2.—(Box B). An index, similar to that used in the preceding experiment, was placed on the surface of the soil, in order to measure its normal rise. Two fine grains, half a millimetre in diameter, of very hard red drawing-chalk were also inserted into very small holes made in the soil to receive them. One of these was exactly in a line with the edge of a long pin (a lady's hat-pin) fixed at right angles to the bar, and penetrating the soil. The other was just underneath the point of a similar pin constrained to slide in a straight groove perpendicular to the lower edge of the bar. Before the soil was frozen, the point of the pin was drawn up a short distance, and brought close down to the soil at the end of the frost and again after the thaw.

The box was put outside on February 9th, and by the 12th inst. the soil was frozen through. The needle point of the index had risen normally $3\frac{3}{8}$ mm., and the two red grains had also risen normally, and probably the same distance. Later on Feb. 12th the thaw began, and the interstitial ice was quite melted the next day. After the thaw, the needle-point of the index was found at $\frac{1}{8}$ mm. above its original distance from the lower edge of the bar, and 1 mm.

[1] The measurements thus made are probably correct to one-eighth of a millimetre.

further down the slope. One of the red grains had crept $\frac{3}{4}$ mm., and the other 1 mm. down the slope. The soil particles must therefore have descended along a line inclined at an angle of about 17° to the normal to the surface of the soil. The normal rise of the surface particles was about $\frac{1}{49}$ of the depth of the frozen soil, and their creep about $\frac{1}{165}$ of the same depth.

8. Now, if the creeping of the soilcap through the action of frost were due to the expansive force of the freezing water urging the mass down the slope, it is clear that the downward movement should take place during the frost and not during the thaw; but the experiments just described show that this is not the case, unless it be along the edges of the mass of frozen earth. Again, if this explanation were the correct one, the whole frozen layer at any point would be displaced equally throughout its depth, and there would be a rupture of continuity between the frozen and unfrozen parts of the soilcap. Hence, any line inclined to the surface would, after a succession of frosts of different degrees of intensity and duration, exhibit a series of breaks forming miniature faults parallel to the surface of the ground. And, if the principal frosts of every season penetrated to approximately the same depth, then, at that depth, the fault-displacement would be greatest. It need hardly be said that this inference is not supported by Mr. Kerr's section given in Fig. 1. Both reasoning and experiment are in favour of the view that creeping takes place by a normal rise during the frost and a more or less vertical descent during the thaw.

9. It would be interesting to determine, if we could, the length of time required for the production of the effects illustrated in Fig. 1, but the data are too imperfect to enable us to form more than a very rough estimate. Judging from the figure, the creep near the surface is on an average about three times the depth of the bends. If the amount of creeping of the surface particles be the mean of the values given by the experiments recorded above, namely, $\frac{1}{177}$ of the depth of frozen soil, and if there be only one important frost and thaw every winter, then the time required may have been about 531 years. But the assumptions involved in making this estimate are too great to allow us to place any reliance whatever upon its accuracy. It is just possible, however, that it may indicate the order of magnitude of the real interval of time.

10. Lastly, the conditions which are most effective in producing the creeping here considered are neither those of a temperate climate, in which there may be many alternations of frost and thaw in one winter, nor those of an arctic or glacial climate; though probably nearer those of the latter than of the former. Other conditions being the same, the amount of creeping (measured by the product of the volume of soil moved into the average displacement down the slope) varies as the square of the depth to which the frost penetrates. Thus, if in one place, the soil be frozen to a depth of one foot, and, in another, to a depth of three feet, the creeping of the surface-particles in the latter will be three times as great as in the former, and the volume of soil affected also three times as great: hence the

amount of creeping in the second place will be nine times that in the first. And it seems hardly possible that there should in any country be nine separate frosts in one winter each penetrating to the depth of one foot.

On the other hand, in arctic countries, the soil is permanently frozen at a certain depth, and the amount of creeping then depends on the depth to which the soil is thawed during a comparatively short summer. We may conclude, therefore, that the amount of creeping will be greatest in that place in which the soil frozen in winter, and also thawed in the following summer, attains its maximum depth.

V.—Notes on the Wicklow Greenstones.

By Frederick H. Hatch, Ph.D., F.G.S.

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

The Wicklow greenstones occur in sheets and dykes intrusive in the Lower Silurian slates (the equivalent of the Bala beds of Wales) that lie to the east of the main chain of the Leinster granite. Like the Welsh greenstones, they are associated with acid lavas (felsites and keratophyres) and felspathic tuffs, although of slightly later origin than these.

In a petrographical appendix to the memoir on Sheets 138 and 139 of the Map of the Irish Geological Survey, I have given some notes on the microscopical characters of the more important types. These notes were based on sections made from rocks collected in June of last year. In November and December I had another opportunity of visiting the ground, in company with my colleagues Messrs. Cruise and Clark; and this visit threw fresh light on certain points not cleared up on the first occasion, especially with regard to the mechanically deformed greenstones, and also furnished me with an additional supply of material for microscopical investigation. As the publication of the memoir could not be delayed until this fresh material had been thoroughly worked out, perhaps I may be permitted to communicate in this place my results, coupled with a brief abstract of what has already appeared in the memoir.

The Wicklow greenstones have this advantage over those of many other areas, that they present a greater variety in structure and composition. Offering this attraction it is somewhat surprising that they have received such scant attention at the hands of the microscopist. The literature on the subject is indeed meagre, and may be disposed of in a very few lines.[1] Prof. von. Lasaulx,[2] during a short visit to Ireland in 1876, collected some specimens which he described as diabase, diorite, and mica-diorite. The Allport collection in the British Museum contains a few sections of Wicklow greenstones. These have been described by Mr. Teall in his British Petrography.[3]

[1] Professor Haughton gave a brief description, with two analyses, of the West-aston greenstone as early as 1859 (Trans. Roy. Irish Acad. vol. xxiii. p. 619); but I am referring to microscopical work.

[2] "Petrographische Skizzen aus Irland," Tschermak's Min. u. Pet. Mitth. vol. i. 1878, p. 441.

[3] 1888, pp. 249 and 266.

In the notes appended to the memoir referred to above, the greenstones there described are arranged in the following categories:—*a.* Quartz-mica-diorite; *b.* Quartz-diorite and diorite; *c.* Augite-diorite; *d.* Dolerite (diabase); *e.* Epidiorite (passing into hornblende-schist); and *f.* Serpentine.

(*a*) *Quartz-mica-diorite* (the Tonalite of vom Rath).—A fine example of this rock occurs as an irregular boss, extending from Carrigmore to Westaston, 4 miles E. of Rathdrum (Sheet 130). The central portion of the mass is traversed by the road going from Rathdrum to Kilboy Bridge. The rock is remarkable for its granitoid appearance, the grain being moderately coarse and the colour light. Some parts of the mass are spangled over with lustrous six-sided plates of dark mica; while in others the mica is replaced by chlorite. At Carrigmore the mica occurs in thin bronze-coloured films, covering irregular patches of the rock's surface. Under the microscope these patches appear as ophitic plates of a bright reddish brown colour.

The component minerals of the rock are quartz, felspar (mostly plagioclase, but with a small quantity of orthoclase), biotite, a pale green hornblende, a few grains of colourless augite (malacolite), chlorite, and apatite.

The quartz is abundant. It was evidently the last mineral to separate, since it fills the interspaces between the idiomorphic crystals of the earlier-formed minerals. Apatite is also present in considerable quantity; and its six-sided acicular microlites are found penetrating all the remaining minerals. The chlorite has resulted from the alteration of the mica, the plates of which are sometimes surrounded by a border of chlorite, sometimes altered almost completely into that mineral.

(*b*) *Quartz-diorite* and *diorite.*—An excellent example of quartz-diorite occurs at Bologh Lower, three miles E. of Rathdrum. The rock is a medium-grained granitic aggregate mainly of felspar and quartz, but with some green hornblende and chlorite. Both monoclinic and triclinic felspar are present, the former being fresher than the latter.

The interspaces between the felspar-crystals are filled by clear quartz. Green hornblende occurs, sometimes in idiomorphic crystals that are evidently original, sometimes in granules and needles, imbedded in patches of chlorite, and then perhaps of secondary origin.

In structure and composition the rock much resembles a hornblende-granitite; but mode of occurrence and association show that it belongs to the greenstone rather than the granite family.

Similar rocks, but with less abundant quartz, occur near Cummer Place, six miles E. of Shillelagh. These are true diorites.

In all of them the effects of dynamic metamorphism are occasionally met with, in the shape of finely-granulated patches — the so-called "quartz-felspar-mosaic" — resulting from a molecular rearrangement of the original felspar.

(*c.*) *Augite-diorite.*—This type is very common among the Wicklow greenstones. It consists essentially of plagioclase felspar and a pale variety of augite (salite or malacolite). Interstitial quartz is sometimes present; and there is a complete absence of ophitic structure, the augite occurring in isolated and often well-contoured crystals: both, points of distinction from dolerite. The felspar occurs in crystals giving lath-shaped sections and exhibiting the twin-striation characteristic of plagioclase. It is sometimes enveloped by patches of clear quartz, somewhat in the same way that felspar-lathes are enveloped by augite in the dolerites.

Rocks of this character occur abundantly in the neighbourhood of Kilpatrick House, N. of Arklow. The exact localities are given in the memoir.

(*d.*) *Dolerite* (*diabase* of the Germans).—The rocks considered under this head are composed essentially of plagioclase and augite, with a well-marked ophitic structure. The Wicklow type is entirely free from olivine, and passes by the addition of quartz, accompanied by a change in the nature and structure of the augite, into augite-diorite, to which it is naturally closely allied.

The best representatives of this group occur in the neighbourhood of Arklow Head, where they are quarried for road-metal by Mr. Parnell.

The dolerites pass readily into epidiorite; and even when the rock, examined under the microscope, appears, at first sight, to be quite unaltered, a narrow zone of secondary hornblende will, on nearer examination, sometimes be found fringing the augite-patches. But the more detailed discussion of these changes is reserved for the next section.

(*e.*) *Epidiorite.*—The rocks embraced under this head are dolerites that have undergone alteration under the influence of dynamic metamorphism. Originally they were plagioclase-augite rocks; but, as a result of the metamorphism, the augite has been more or less completely converted to hornblende. This mineral occurs in ragged patches, which in most cases still present the ophitic structure of the augite which it has replaced. Other new-formed minerals are chlorite, epidote, leucoxene, sphene and calcite. The leucoxene often presents elongated streaky forms, suggesting linear extension. Further evidence of mechanical metamorphism is to be found in the cataclastic structure frequently presented by the felspar; in such cases the mineral loses its homogeneity and appears as a minutely granular mass, giving aggregate-polarization (*"felspar-quartz-mosaic"*). In places where the movements have been great, the rock assumes a highly schistose character, and in such places a considerable proportion of the hornblende is often replaced by chlorite.

All degrees in the mechanical metamorphism of a greenstone can be well studied in the Aughrim Valley, between Woodenbridge and Coatsbridge (Sheet 139). The altered rocks occur here in sheets, intercalated between the Lower Silurian beds, and are correctly represented on the Survey Map as a series of lenticular bands, striking N.E. and S.W. At the time when this ground was surveyed, however, the effects of dynamic metamorphism had not yet been recognized, consequently the schistose character of these rocks caused them not unnaturally to be regarded and mapped as tuffs ("greenstone-ash").[1] In the smaller sheets the foliation is very striking, the whole of the rock being converted into schist; the thicker bands, however, are foliated only at the margin, *i.e.* near the junction with the slates.

About one mile and a half west of Woodenbridge one of these larger bands has been well opened out by a quarry; and the successive stages of alteration admit there of easy study. The central portion of the sheet is not foliated. It is composed of a granular aggregate mainly of plagioclase, and hornblende, secondary after augite. The hornblende is the ordinary green variety (actinolite), and shows pleochroism in bluish-green and yellowish-green tints. It occurs in patches, which, though often compact towards the centre, are usually bordered by a fibrous fringe. These patches are penetrated by needles and prisms of turbid felspar, thus indicating the ophitic structure of the original augite. In rare instances a nucleus of augite still remains, thus removing all doubt as to the secondary nature of the hornblende. The presence of isolated patches of chlorite shows that hornblende does not represent the final stage of alteration; for the chlorite appears to be derived from the hornblende, and thus to bear only a tertiary relation to the augite. Other secondary minerals are epidote, in granular aggregates, leucoxene, in white turbid grains after ilmenite, and calcite. The epidote is derived mainly from the felspar, the original crystals of which are replaced by a mosaic of minute granules of secondary felspar, doubtless a variety less rich in lime—such as albite, or oligoclase.

A fibrous asbestos is developed between the slickensided joint-faces.

Near the junction with the slates the rock assumes a marked foliated character. In thin sections made from this portion of the rock the hornblende appears in narrow fibrous bands, alternating with layers of a cryptocrystalline aggregate of felspar together with grains of original felspar. Secondary quartz is associated with the new-formed felspar, and chlorite with the hornblende. The chlorite increases in proportion to the amount of alteration, until finally we get a highly fissile lustrous schist, in which chlorite greatly predominates.[2]

Some specimens of these highly altered schistose rocks, for instance one from a band two miles west of Woodenbridge, contain abundant grains of sphene, and it seems probable that this mineral has been produced by a molecular reconstruction of the turbid leucoxene derived from ilmenite.

Some of the greenstone-bands that cross the Aughrim Valley are

[1] According to Mr. W. M. Hutchings (this Magazine for February, 1889, p. 53) the same error has been committed in Cornwall, De la Beche having held certain "schistose trappean rocks," which Mr. Hutchings has proved to be mechanically metamorphosed greenstones," for altered ash.

[2] Similar alterations are described by Mr. Hutchings in the Tintagel rock (*loc. cit.*), and by Mr. Teall in a greenstone occurring at Garth near Portmadoc (Brit. Petrog. p. 216).

prolonged in a south-westerly direction towards Croghan Kinshelagh. A specimen, collected from a spot one mile north of the summit of this mountain, proved, on examination with the microscope, to be a typical epidiorite. The rock forming the summit itself has undergone more alteration. It has a marked foliated character, and consists mainly of chlorite and "felspar-mosaic." Sphene is also present in abundant grains.

Specimens of epidiorite were also collected about a mile N. of Wicklow, on the S.W. side of Croghan Kinshelagh, and from a small patch of greenstone two miles east of Kilcavan House, to the east of Shillelagh (Sheet 138).

(*f.*)—In only one case was the occurrence of a serpentinous greenstone noted. My attention was drawn to this rock by Mr. Kinahan. A small patch of it occurs about half a mile west of the patch of epidiorite referred to above, two miles east of Kilcavan House, near Shillelagh. Unfortunately I was prevented by lack of time from visiting the locality myself, and the specimen examined was collected by Mr. Clark. The rock is of a variable green colour, and has the characteristically soapy "feel" of a serpentinous rock. A microscopic section discloses the serpentine in colourless layers, associated with grains of opaque iron-ore and a finely granular substance resembling calcite or dolomite. The powdered rock, treated with hydrochloric acid, effervesces only on warming; it contains, therefore, as we should expect, the magnesian carbonate.

The texture of the serpentine is well brought out between crossed nicols. It has rather the "netted" or "bladed" structure of serpentine derived from augite than the "lattice"-structure peculiar to that mineral when produced by the alteration of hornblende.

Whatever may be the nature of the alteration, there can be little doubt that we have here the final product of the alteration of a greenstone (dolerite). As we have seen above, the usual course of the metamorphism of the Wicklow dolerites is, first, the formation of a hornblendic rock (epidiorite, hornblende-schist) and, finally, a chlorite-schist; but the case in point indicates that there are exceptions to this rule.

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VI.—Devonian Greenstones and Chlorite Schists of South Devon.

By Miss C. A. Raisin, B.Sc.

In a paper published in the Devonshire Transactions for 1888 (p. 215), Mr. Somervail suggests the identity of the chlorite schists of South Devon with certain rocks to the northward. As this hypothesis (could it be established) would have a most important bearing on subjects of controversy, I took the opportunity in a few days this winter, to visit and collect from these localities, including the dyke nearest to Torcross. I was not rewarded by finding any striking similarity to the metamorphic rocks of the south. In that series, the chlorite schists consist of clear and definite crystalline grains, among which I find felspar to be rare and have not yet certainly identified augite—while these northern greenstones are full of broken crystals of both minerals, together with viridite, dust resulting from the crushing, and a small amount of minute secondary hornblende and sericite (?), chlorite being generally rare, and often absent. The one rock is a true schist, the other nothing more than a schalstein. If Mr. Somervail ascribes the marked difference in character to more intense pressure, a very obvious difficulty would have to be met. As pointed out by Prof. Bonney, the chlorite schist exhibits at places not only a well-defined mineral banding, but also a cleavage cutting transversely across it, which appears to be in close relation with the general cleavage of Devonshire.[1] If, therefore, pressure metamorphism be invoked to account for the origin of the chlorite schist and its banding, the force must be relegated to an earlier period, and thus the rocks affected by it, even if originally igneous, cannot be of Devonian age.

Of themselves, however, these schistose rocks afford interesting study, as in the case of other west-country greenstones.[2] One type[3] (from the coast near Redlap, and also from a quarry for road metal N.W. of Stoke Fleming), is clearly an ophitic dolerite,[4] but exhibits changes which have resulted from the crushing of the rock. Much of the augite is still very fresh and clear, but it seems to have been brittle, and to have broken along cleavage planes, forming fragments with sharp straight boundaries. Often there is a border of a hornblendic mineral, partly an alteration product,[5] although some is not unlike the serrate fringe of 'secondary enlargement' described by Van Hise,[6] having cleavage planes continuous with those of the original crystal. A fibrous hornblende, which is probably asbestiform, also seems to have formed at places, where a fragment of augite has been drawn out in the shearing of the rock. Elsewhere, as Professor Bonney suggested to me, strands of a very pale viridite seem to be connected with remnants of augite crystals,[7] and, in some cases, the viridite encloses small pieces, fragmental in outline, now converted into fibrous actinolite, which very probably have resulted from the crushing of a crystal of the pyroxene. Professor Bonney sug-

[1] Q.J.G.S. 1884, vol. xl. p. 8, fig. 4, p. 22.

[2] Q.J.G.S. 1876, vol. xxxii. p. 407, S. Allport. Q.J.G.S. 1876, vol. xxxii. p. 155, and 1878, vol. xxxiv. p. 471, J. A. Phillips. Q.J.G.S. 1880, vol. xxxvi. p. 285, and 1886, vol. xlii. p. 392, F. Rutley. Brit. Petrogr. J. J. H. Teall, p. 228.

[3] Somewhat like the Carlion rock (No. 7) of Mr. Rutley, Q.J.G.S. 1886, p. 397. The augite resembles that of fig. 2, p. 398.

[4] *Cf.* Mr. Allport, Q.J.G.S. 1876, p. 419.

[5] As, for example, in the Lizard gabbro and basalt. Q.J.G.S. 1877, vol. xxxiii. pp. 904, 907, Prof. Bonney, "On the Serpentine and Associated Rocks of the Lizard." See also Q J.G.S. 1885, vol. xli. p. 520, "On the so-called Diorite of Little Knott," and Q.J.G.S. 1883, vol. xxxix. p. 256, "On Hornblende Picrite from Anglesey," Prof. Bonney. Also Q.J.G.S. 1878, p. 493, J. A. Phillips. "Perimorphic" hornblende of Mr. Harker, Q.J.G.S. 1888, vol. xliv. p. 452.

[6] Amer. Journ. Science, 1887, vol. xxxiii. p. 388, fig. 3; also U. S. Geol. Survey, 5th Rep. 1883-4.

[7] *Cf.* Brit. Petrogr. J. J. H. Teall, pp. 216, 230.

gested that this difference, in the results of the transformed augite, might be due to an admixture of the constituents of felspar obtained in the crushing, either from ophitic plates or from the surrounding mass. The felspar in the slide has been completely decomposed, and the ophitic plates can be identified mainly by their sharp outlines, preserved within the surrounding augite. Rarely a granular crystalline aggregation seems to mark a former felspar now replaced. Thus this rock is actually in a condition of transformation, and seems to point out what may result from the crushing of an ophitic dolerite. Planes of schistosity have been formed, characterized by streaks of viridite, probably derived mainly from the pyroxenic constituent, and the larger films may mark the loci of what were once augite crystals. Secondary hornblende has formed by recrystallization, along the exterior of original crystals, or from the shearing, possibly of an unmixed augite. A dusty and granular ground-mass, partly kaolinitic, has resulted from the powdering up of other constituents, including the greater part of the felspar.

A slide from rock of a second type is crowded with plagioclase felspars, exceptionally well preserved, although they have been much broken and snapped by strains acting on the mass. Crystals of iron oxide are abundant, some being clearly ilmenite. The structure of this rock is difficult to interpret, but the felspars seem to have occurred as porphyritic crystals, and not to be pyroclastic. Professor Bonney has suggested to me, that the ground-mass might be that of a crushed glassy rock, possibly andesitic, and that the greenish mineral, which is abundant in it, might perhaps be best classed as a variety of palagonite. Mr. Rutley describes and figures certain rocks from Cant Hill, near St. Minver, which he believes have been derived from what was once a rather basic glass, and this slide from Redlap seems to have a ground-mass something like that of fig. 1—with broken felspar similar to that of fig. 3.[1] I have not, however, recognized in these Devonshire specimens the vesicular structure, which the other rocks exhibited.

In a third type of rock, the ground-mass seems to have been felspathic, sometimes crowded with well-defined felspars, which are now altered to a filmy mineral (? sericite). Porphyritic crystals can be traced, which have undergone an aggregate replacement. Other groups in the slide, consisting possibly of an intergrowth of quartz and felspar, with some calcite, might represent a similar porphyritic mineral, or they are possibly amygdaloidal, like that figured by Mr. Phillips.[2] Sometimes associated with these, but distorted in form, are certain viridite or serpentinous strands, which may be examples of the crushed amygdaloids noted by Mr. Rutley, or possibly only the infilling of secondary cracks. They form the green films, which may be noticed on many of the schistose surfaces near Redlap, and in my specimens from that locality I searched in vain for any of the well-defined chlorite of the southern schists, with which mineral

[1] Q.J.G.S. 1886, vol. xlii. p. 393, pl. xii. figs. 1, 3.
[2] Q.J.G.S. 1878, vol. xxxiv. p. 483, pl. xx. fig. 2.

the rocks are said to be charged.[1] Mr. Somervail may, however, allude to some other specimens from these cliffs (since I did not attempt to make an exhaustive examination of the place). But, even if chlorite occurs, as it does, although not to a large extent, in the dyke further south, its presence is a rather slender argument for the identification of the schist and the diabase, since it is one of the commonest secondary products in basic igneous rocks of any age or locality.

I examined the associated sedimentary rocks at Redlap, and they are genuine phyllites of the ordinary Devonian character, with only the usual crystalline development of minute films along the lamination.[2] If the greenstones were the equivalents of the chlorite rock of the south, it would be strange, that these associated phyllites should present such wide and well-marked differences from the mica schists. They exhibit effects of pressure metamorphism, even more strongly than the phyllites just north of the fault, which bounds the crystalline series, and yet they are totally unlike the mica schists in that series. In one of the phyllites near Redlap, the laminæ are puckered up into undulations, across which at places extends a succession of small brown films. These appear to have formed from a ferruginous infiltration, inserting itself and accumulating between the laminæ, along the steeper slope of the waves. Just at this part, rupture has often taken place, thus forming an incipient strain-slip cleavage, marked only by a darker staining. The steeper slope of the undulations is almost universally in the same relative position —doubtless on that side towards which the thrust of the rocks was directed.

I must thank Mr. Somervail, for calling my attention to the deserted quarry of chlorite schist to the north of the Hall Sands streamlet, in consequence of which the boundary-line must be marked at that part of the valley as north of the stream.[3] It is to be regretted, however, that Mr. Somervail does not withdraw his former untenable assertion, but attempts to renew it, by confusing together the correct indication of the boundary given by Professor Bonney on the coast, and any slight modification which I have to make in the direction I traced inland. The position *on the coast* would not be affected by the occurrence of the chlorite schist south of the valley, nor by this chlorite schist north of the valley. The hypothesis of a straight east-to-west line for the fault is quite gratuitous, since no

[1] Trans. Devon Assoc. 1888, p. 224.

[2] Thus these rocks in the direction of their micaceous constituent would agree with the phyllites described by Professor Bonney from near Morlaix, Q.J.G.S. 1888, vol. xliv. p. 13, and would differ from those near Torcross, Q.J.G.S. 1884, vol. xl. p. 17.

[3] See map Q.J.G.S. 1887, vol. xliii. p. 715. The dotted line marking the junction of phyllites and metamorphic rocks should probably cross the stream about east of the *l* of Muckwell, before bending south-eastward or E.S.E. to the coast. This alteration does not, however, disprove the possibility that the fault may have determined the lower course of the valley, since there are no exposures which we can trust along the 400 yards between the quarry and the beach; and also in a continued erosion along a fault, a portion of one rock may often be left adhering at some spot to the mass against which it was faulted.

one attempts to draw such—how could the line in that case reach on the Salcombe estuary a position, which is considerably to the north of a line drawn due west from Hall Sands?

In connection, also, with the suggestion, that the chloritic rock near the fault-line was a "buffer, checking the northward spread of metamorphism," [1] I should like to ask, why was this duty neglected by the much larger and more extensive mass near Prawle Point, and that overlooking The Barr?—to the northward of which, in both cases, lie well-marked mica-schists. I might take exception to many other statements, but I should not be justified in thus occupying space, for they are matters of detail, compared with the suggested identification of the two series of rocks. These may have some resemblance to each other—though I should have thought it so superficial as not to mislead any practised observer; but even if there be a vague resemblance, due to their having had the same origin, they cannot, as I have shown, have been manufactured at the same epoch.

VII.—On some Ostracoda from the Mabou Coal-field, Inverness Co., Cape Breton (Nova Scotia).

By Prof. T. Rupert Jones, F.R.S., and J. W. Kirkby, Esq.

THIRTEEN specimens of black shale, crowded with Ostracoda, besides fish-scales, Anthracomyæ (?), and other small fossils, were sent in 1886 by Mr. J. F. Whiteaves, F.G.S., Palæontologist of the Geological Survey of Canada, for examination. They had been collected by Mr. A. H. Foord, F.G.S., of that Survey, in 1881.

In these coal-shales the Ostracoda are very numerous as individuals, but belong apparently to very few species of one genus. They are in a great degree similar to those mentioned in the Geol. Mag. Dec. II. Vol. VIII. 1881, p. 95, and Dec. III. Vol. I. 1884, p. 358, etc., as occurring in the black coal-shales of the South Joggins, Nova Scotia.

In the Mabou coal-fields we find:—

1. *Carbonia fabulina*, J. and K., very abundant. It is of rather smaller size than the Scottish forms figured and described in the Ann. Mag. Nat. Hist. ser. 5, vol. iv. (1879), p. 31, pl. 2, figs. 1–10. The innumerable minute Ostracoda imbedded throughout the shale seem to be small individuals of *C. fabulina*.

2. Among the foregoing is a variety larger than the Scotch specimens referred to, rather more oblong in outline, and with stronger marginal overlap, and a somewhat coarser punctation of the surface. It may be termed var. *altilis* (well-nourished).

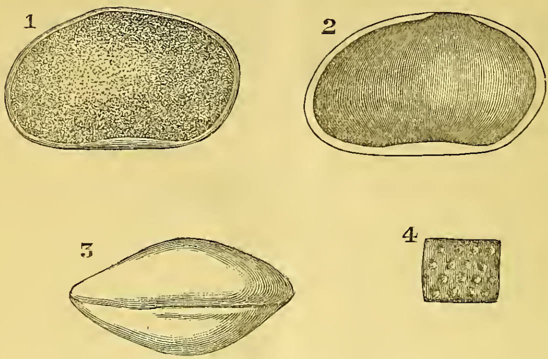
3. *Carbonia* (?) *bairdioides*, J. and K., also occurs, but far less abundantly than *C. fabulina*. The specimens more closely resemble fig. 24, pl. 3, "A. M. N. H." ser. 5, vol. iv. p. 38, than fig. 8, pl. 12 of the Geol. Mag., Dec. III. Vol. I. p. 359.

Carbonia fabulina is abundant in the Upper and the Lower Carboniferous formations of Britain, wherever the conditions had been

[1] Trans. Dev. Assoc. 1888, vol. xx. p. 217.

favourable for the formation of Coal-shales,[1] especially in the Lower Carboniferous series of Scotland. *C. bairdioides* occurs more rarely, but in strata similar to the above, in Scotland and Staffordshire. They both occur at the Joggins, on the shore of the Cumberland Basin, Cumberland Co., Nova Scotia, as noticed above.

The geological features of Inverness County (Cape Breton), Nova Scotia, and the relationships of the strata are described in detail in the Geological and Natural-History Survey of Canada: Report of Progress, 1885; and Reports and Maps of Investigations and Surveys, 1882–83–84; including Report (H) on the Geology of Northern Cape-Breton, by Hugh Fletcher, 1884.



Figs. 1–4. *Carbonia fabulina*, J. & K. Var. *altilis*, nov.

Fig. 1. Carapace, showing the left valve, overlapped by the other valve at the margin. × 25.

Fig. 2. Inside of the right valve. × 25.

Fig. 3. Dorsal view of the carapace. Not set quite upright, but sloping a little. × 25.

Fig. 4. Punctation of the surface; highly magnified.

The Inverness Coal-field is treated of at p. 53 H; and the Mabou Coal-basin at p. 61 H. This is referred to as belonging to the "Lower Carboniferous" series at p. 53 H and on the Map (No. 14, 1884), accompanying Mr. Fletcher's Report. At p. 6 of the Report H, however, it is referred to the "Middle Carboniferous," which consists of "Conglomerate and Coal-measures" in that locality.

The strata containing the specimens under notice are indicated in Mr. Fletcher's Map (No. 14) as at the place where Mr. Foord collected fossils in 1881, on the shore about one mile and a half south of Cape Mabou,[2] and about one mile north of the spot marked "Mabou Coal-mines" on the same map.

The "Black Shales" of the Mabou Coal-measures are mentioned in the list of strata at p. 70 H, thus—

"12. Dark-bluish-grey, thin-bedded, calcareo-bituminous shale;

[1] See Quart. Journ. Geol. Soc. vol. xxxv. 1879, pp. 30 and 38; and Geol. Mag. Dec. III. Vol. I. 1884, p. 360.

[2] The post-town called "Cape Mabou" is three miles east (inland) of Cape Mabou.

fish scales, teeth, coprolites, and spines, *Cythere, Naiadites, Spirorbis.* —2 feet.

"13. Dark-bluish-grey, flaggy, concretionary, calcareous rock, with the same fossils.—2 ft. 6 inches." There follow (14–29) other shales and shaley beds, more or less bituminous. At p. 71.H it is stated—"The black shales are those from which an interesting collection of fossils was made by Mr. Foord, of the Geological Survey, in the summer of 1881. In this collection the following forms have been determined by Mr. Whiteaves:—*Naiadites* (*Anthracoptera*) *carbonaria*, Dawson; *N.* (*Anthracomya*) *elongata*, Dawson; Entomostraca; *Rhizodus lancifer*, Newberry (scales); *Cœlacanthus* (jugular plates); scales of two genera of Ganoid Fishes; also jaws and teeth of Fishes undetermined."

VIII.—On the Discovery of *Turrilepas* in the Utica Formation (Ordovician) of Ottawa, Canada.

By Henry Woodward, LL.D., F.R.S., F.G.S.

Mr. Ami's interesting discovery has already been announced in a letter addressed to Mr. A. H. Foord, F.G.S., published in this Magazine (October, 1888). Mr. Ami now supplies a "Note" on the precise geological position of the beds in which the *Turrilepas* was found. Want of space, however, precludes us from giving the whole of his detailed observations, which are accompanied by a sketch section, here reproduced:—

The following is a summary of Mr. Ami's "Note."

The *Turrilepas* was found in a band of bituminous limestone cropping out on the right bank of the Rideau River, at the Rifle Range, near Ottawa. The precise position of the beds (Lower Utica = about the lower part of the Bala Series),[1] was ascertained by means of their fossil contents, which include an interesting Brachiopod—*Siphonotreta Scotica*, identified and named by the late Dr. T. Davidson, F.R.S.

The calcareous and shaly measures characterizing the Lower Utica in this district, as exposed on the Rideau River, have a south-by-west dip of about 4°, and exhibit a portion of the south-western limb of a low, denuded anticlinal, which, however, affects the physical aspect of the country to a very small extent.

The accompanying sketch is a diagram section of the rocks cropping out at the Rifle Range rapids. The depth of section is about 22 feet.

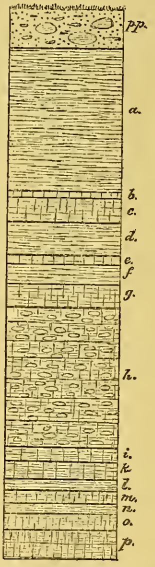


Diagram-section of rocks at Rifle Range near Ottawa.

[1] Mr. Ami regards them as equivalent to the Llandeilo of Craighead, Ayrshire.

(*pp.*) There are resting unconformably upon the Utica beds between 1 and 2 feet of Post-Tertiary sands and gravels, débris from the glacial clays or "till," the "Leda clay," and overlying sands of the Rideau Valley, a valley of denudation.

(*a.*) These upper measures consist of thin-bedded, soft, at times hardened, black or dark brown, bituminous shales, holding crinoidal fragments associated with *Lingula progne, Orthis testudinaria, Trocholites ammonius, Endoceras proteiforme, Triarthrus Becki, Asaphus Canadensis,* etc.

(*b.*) Thin *Conularia*-band, consisting of dark grey impure limestone, with *Orthis testudinaria, Leptæna sericea, Conularia Trentonensis,* etc.

(*c.*) Zone of *Siphonotreta scotica,* Davidson. Band of black bituminous limestone, often shaly in character, and containing numerous fossils, including *Lingula elongata, Discina Pelopea, Leptæna sericea, Zygospira Headi, Conularia Trentonensis, Calymene senaria, Beyrichia oculifera,* and *Turrilepas Canadensis.*

(*d, e, f, g.*) Thin bands of black, grey, or dark brown calcareous and bituminous shales, highly fossiliferous, except (*g*), which is "apparently destitute of fossils."

(*h.*) Light yellowish, grey weathering, argillaceous limestone bands, with shaly partings between the divisional planes of stratification, distinctly nodular in character and structure, disintegrating rapidly under atmospheric influence. Fossils :—*Monticuliporidæ,* Brachiopoda, Orthocerata, *Bucania expansa.* 5 feet 5 inches.

(*i, k, l.*) Thin bands of bituminous limestones and shales, from 3 to 10 inches in thickness, the last (*l*) holding *Orthis testudinaria, Leptæna sericea, Calymene senaria.*

(*m.*) Dark grey, bituminous, crinoidal limestone band with *Leptæna sericea,* etc. This stratum dips north and south, being on the axis of the anticlinal referred to above. Thickness varying from 4 to 6 inches.

(*n.*) Thin shaly parting, with *Asaphus Canadensis.*

(*o.*) Hard, compact, light-weathering, dark grey limestone band, holding *Orthis testudinaria, Leptæna sericea, Calymene senaria, Asaphus Canadensis, Conularia Trentonensis.*

(*p.*) Compact, dark grey, impure limestone, bituminous and fossiliferous, holding *Asaphus,* sp. indt., crinoidal fragments, etc., preserved in a light, yellowish-brown, ferruginous matrix. Thickness, 8 inches.

At a meeting of the Geological Society of London on June 7th, 1865, I described a new genus of Cirripedia from the Wenlock Limestone and Shale of Dudley, which I named *Turrilepas* (see Quart. Journ. Geol. Soc. vol. xxi. pp. 486–489, pl. xiv. figs. 1*a*–*l*).

This Cirripede (or part of a Cirripede) had as many as four rows of asymmetrical plates, with more than eight plates in each row; the surface of each plate had a uniform sculpturing of fine, slightly waving, delicate, raised lines similar to those seen on the opercular valves of *Balanus* or of *Pollicipes.* As many as three or four different forms of plates are known, these are arranged in linear series of similar plates, each series being strongly imbricate from below upwards, and so disposed that the edges of the contiguous series are alternate in position, and partially cover one another laterally.

In the Supplement to vol. i. of Barrande's great work "Système Silurien du Centre de la Bohême," part i. 1872, p. 565, the author describes a similar form under the generic name *Plumulites*, of which he records ten species, based on detached plates from beds in various localities in Bohemia, from D 1=Lingula Flags, to E 2=Wenlock Limestone.

Several of these plates closely resemble those from the Wenlock Limestone of Dudley; the others, whilst agreeing in their ornamentation, have the apex of the plates obtuse, and the ornamental lines near the summit circular and fenestrated. These may possibly have been terminal or opercular plates, the more pointed forms being the peduncular plates (see Q. J. G. S. 1865, p. 488).

In their "Monograph of the Silurian Fossils of the Girvan District in Ayrshire," etc., H. A. Nicholson, and Robert Etheridge, jun. (vol. i. 1880, fasc. ii. pl. xiv. figs. 22–27, pp. 213–215, and fasc. iii. pp. 299–302, pl. xx. figs. 8–10) describe two new species of *Turrilepas*, namely, *T. Peachii*, Eth. and Nich., and *T. Scotica*, R. E., jun., from the Silurian of Girvan, Ayrshire.

In their observations on *Turrilepas* one of these authors writes (p. 213) as follows:—"The genus *Turrilepas* was established by Dr. H. Woodward for certain peculiar ovate-triangular plates from the Dudley Limestone, previously known under the name of *Chiton Wrightianus*, de Koninck. Dr. Woodward satisfactorily showed that these plates were more properly referable to a form of Cirripede allied to *Loricula* (and for which he proposed the name *Turrilepas*) than to *Chiton*, or to any other Mollusc.

"Priority is claimed by M. Barrande for his term (*Plumulites*) on the plea of previous publication. For my own part, I hardly think the facts support M. Barrande's claim. Dr. Woodward's name was both proposed and published in 1865; and although the genus was certainly not defined in so many words, it was nevertheless founded on a well-known and perfectly defined fossil, and, what is more, was copiously illustrated. I take this to be satisfactory publication. It appears that M. Barrande had discovered similar plates in the Silurian rocks of Bohemia, and applied to them the name *Plumulites*, —a fact which was communicated (orally) by Prof. Reuss to the Imperial Academy of Science of Vienna, 18th February, 1864, and the name was published in a paper of the latter,[1] but unaccompanied either by description or figure. So far as I understand the question, no description or figure was furnished by Barrande until the appearance in 1872 of the supplement to the first volume of his magnificent work on the Silurian System of Bohemia (already quoted).

"I think, under these circumstances, that strict impartiality requires the adoption of Dr. Woodward's name *Turrilepas*. Again, Messrs. Hall and Whitfield adopt *Plumulites* in preference to

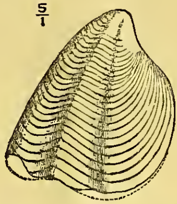
[1] Sitz. Berichte d. k. k. Akad. Wissensch. vol. xlix. p. 215.

Turrilepas, on the ground that the latter was never characterized; but my previous remarks equally apply in this case." (Nicholson and Etheridge, Girvan District, p. 214.)

In Messrs. James Hall and John M. Clarke's Geological Survey of the State of New York, Palæontology, Albany, N.Y. 1888 (4to. pp. 215–220, pl. xxxvi. figs. 1–19), the authors give figures and descriptions of eight species of *Turrilepas* from the Upper Helderberg and Hamilton groups=Devonian, Ontario and Ohio. One or two of these plates resemble somewhat Barrande's Bohemian species and also plates figured by the writer from the Wenlock Shale, Dudley, but they are apparently all specifically distinct from the European forms, but with the same persistent ornamentation in which they all agree.[1]

The discovery by Mr. Ami of a new specimen of *Turrilepas* in so low an horizon as the Utica series, equivalent to our Llandeilo Flags, is particularly interesting, as the species recorded by Messrs. Hall and Clarke in Ontario are all from the much later Devonian formation.

$\frac{5}{1}$



Turrilepas Canadensis, sp. nov., discovered by Mr. Ami in the Lower Utica series = Llandeilo, right bank of the Rideau River, Rifle Range, near Ottawa, Canada.

Description of the Ottawa specimen :—

Valve roughly triangular, right-hand border very broadly-rounded, but contracting inwards towards the apex; lower border sinuous in outline; left-hand margin nearly straight, curving slightly towards the apex, which is deflected a little towards the right side; the striæ, which are slightly raised, are about 30 in number, very delicate and regular, and all follow the undulations of the lower border; the carina dividing the right and left sides of the valve is very much nearer to the left-hand margin, with which it is also parallel nearly to the apex, the left side being only about one-third as wide as the right side; at about a third of the distance between the carina and the right-hand border of the valve and parallel to the carina is another *apparent* ridge (marked in the woodcut by a line of shading); this is really a flexure in the lines of growth and ornamentation, which is further emphasized by a fracture in the matrix containing the specimen exactly on this line.

The valve of *Turrilepas Canadensis* measures six millimetres in height and five millimetres in breadth.

In general form the Ottawa specimen agrees somewhat closely with

[1] This ornamentation, as I have pointed out (see Geol. Mag. 1880, Dec. II. Vol. VII. p. 197) occurs also on the body-plates of the anomalous Cystidean, *Ateleocystites*, which is found in the same Wenlock Limestone of Dudley, and in the Trenton Limestone of Ottawa.

one of those figured by the writer in 1865 (see Quart. Journ. Geol. Soc. vol. xxi. pl. xiv. fig. 1*i*); but the Wenlock specimen is broader in proportion to its length, and the keel of the valve is straighter, and the general outline more angular than is the case with the Ottawa specimen.

I propose for this new form the trivial name of *Canadensis*, and trust that before long, through the researches of Mr. Ami, we may become aquainted with many more examples of the valves of this very interesting and widely-distributed fossil.

IX.—Remarks on Mr. Davison's Paper on Secular Straining of the Earth.

By Rev. O. Fisher, M.A., F.G.S.

A VERY important discovery was made independently by Mr. Davison, and somewhat earlier by Mr. T. Mellard Reade, when they demonstrated that, on the hypothesis of the earth having cooled as a solid body, there is within it a certain level, which is called by Mr. Davison the "surface of zero-strain," and for which Mr. Reade has adopted the term "level of no strain." At this level compression ceases, and for a certain distance beneath it extension, or stretching of the layers of the globe, takes the place of compression.

There are one or two points in Mr. Davison's paper which invite remark, because they have an important bearing upon the geological aspect of the subject. He states that he has come to the conclusion that, after an interval of 174,240,000 years since the earth solidified, the depth of the surface, or level, of no strain "was or more probably will be" five miles. But for geological purposes what we want to know is, what the depth of this level may be at the present time. Now, on the assumption that the earth has cooled as a solid, this is easily calculated, without the need of any knowledge either of the length of time since solidification, or of the conductivity of the materials of which the crust of the earth is composed.

The formula which gives the depth of the level of no strain within a few hundred feet is simple. It is:

$$\textit{Depth of level of no strain} = \frac{6}{3{\cdot}1416}\left(\frac{\textit{temperature of solidification}}{\textit{temperature gradient}}\right)^2 \div \textit{radius}.$$

The temperature gradient at present is known to be $\frac{1}{51}$ of a degree Fahr. per foot. The only quantity to be guessed at is the temperature of solidification, which Mr. Davison, following Sir Wm. Thomson, puts at 7000° Fahr. The radius of the earth in feet is 20,900,800.

Working out the sum we then find that the depth of the level of no strain, on this hypothesis respecting the temperature, is at the present time 11,645 feet, or 2·2 miles.

But 7000° Fahr. seems to be an excessive temperature for solidification; and if we put it at 4000°, which seems more probable, the depth of this level at the present time would only be a little over half a mile. It must be remembered that the depth of this level increases as time goes on, so that it is deeper down now than ever it has been before.

It is obvious that the amount of compression which can be got out of a superficial shell certainly not more than two miles thick, and probably much less, the compression gradually diminishing and coming to an end at that depth, can have produced scarcely any appreciable folding. We must therefore look in some other direction for the cause of rock folding, thrust planes, and other phenomena of that nature. The probability is that the theory of the earth being solid throughout is incorrect.

NOTICES OF MEMOIRS.

I.—Records of the Geological Survey of New South Wales. Vol. I. Part I. Department of Mines, Sydney, 1889. 8vo. 31 pp. and Plates i.—iv.

As a significant indication of the increasing interest in geological science in New South Wales, it gives us pleasure to call attention to the first part of a new periodical, issued under the auspices of the Geological Survey of that colony, in which it is intended to record the discoveries and observations in the geology, palæontology and the mineral deposits of the country. The part just issued contains seven papers on a great variety of subjects, amongst which may be noticed 'Notes on the Geology of the Barrier Ranges District and Mount Browne and Tibooburra Goldfields, by C. S. Wilkinson, F.G.S., Geological Surveyor in charge'; 'Report on the Discovery of Human Remains in the Sand and Pumice Bed at Long Bay, near Botany,' by T. E. David, F.G.S., and Robt. Etheridge, jun., and 'On a Coral intermediate in structure between the Genera *Lonsdaleia* and *Spongophyllum*, etc.,' by R. Etheridge, jun.

G. J. H.

II.—Faune du Calcaire D'Erbray (Loire inférieure). Par Charles Barrois. Contribution à l'étude du Terrain Dévonien de l'Ouest de la France. Extrait des Mémoires de la Société géologique du Nord, tome iii. Avril, 1889. pp. 384, pls. i.-xvii.

From the beds of limestone quarried near the small town of Erbray (Loire inférieure) a comparatively rich fauna was obtained by M. Cailliaud in 1861, who compared it with that of the Bohemian étage F., the so-called third Silurian Fauna of Barrande, and it has since been regarded as the sole representative of this particular division in France. This conclusion is now called in question by Dr. C. Barrois, who has made an exhaustive study of the fossils from these rocks, and described and illustrated them very fully in the present memoir. The limestones yielding the fossils occur as discontinuous lenticular masses in a series of fine argillaceous schists, which are unfossiliferous and estimated to be from 800 to 1000 mètres in thickness. Dr. Barrois recognizes three distinct levels in the limestones, each marked by particular lithological characters, corresponding to as many palæontological zones. Some of the beds are largely crinoidal; the fauna on the whole is very varied, and the number of species described is about 200, of which 57 are considered as new. Amongst the corals simple forms of *Cyathophyllum, Zaphrentis* and *Amplexus* predominate. A new genus, *Briantia,* is proposed for simple corals allied to *Cyathophyllum,* but with a solid external zone of considerable width. New species of *Striatopora, Cœnites,* and *Acervularia* are likewise described; *Heliolites, Favosites, Beaumontia,* and *Alveolites* are also represented, but no forms of *Stromatopora* have been recognized. The Brachiopoda are very numerous; the principal genera are *Rhynchonella,* with two new species; *Orthis, Meristella, Athyris, Spirifer,* and *Centronella*? each with three new species; examples of *Strophomena, Atrypa* and *Pentamerus* are also present. Of the Lamellibranchs, the genus *Conocardium* is the most numerously represented. The Gasteropods all belong to the Holostoma, the principal forms are included in the genera *Pleurotomaria, Murchisonia, Bellerophon, Strophostylus,* and especially *Platyceras,* of which there are no fewer than 12 new species. The Cephalopods are mostly included in the subgenus *Jovellania,* and the Trilobites belong to *Calymene, Phacops, Dalmanites, Proetus, Harpes, Cheirurus* and *Bronteus.*

The fauna of the Erbray limestones bears a great resemblance to the Hercynian fauna of the Harz, and to that of the Étages F. G. H. of Barrande. It is referred by the author to the Étage Gedinnian, which is at the base of the Devonian in the West of Europe, and it likewise corresponds to the Oriskany sandstone and the Upper Helderberg of North America and the limestones of the Carinthian Alps and of the Urals. It is a distinctly lower stage than that of the Coblenzian, which by many authors is still regarded as the base of the Devonian. G. J. H.

REVIEWS.

I.—The Probable Cause of the Displacement of Beach-lines. An Attempt to Compute Geological Epochs. By A. Blytt.

[*Printed in English,* Christiania Videnskabs-Selskabs Forhandlinger, 1889, No. 1. With two Supplementary Notes.]

ON first thoughts it seems impossible to divine any connection between layers of septaria or bands of ironstone, and the eccentricity of the earth's orbit. Yet those who have read with attention a previous communication by the same author, "On Variations of Climate in the Course of Time,"[1] will perhaps not be surprised at the latest evolution of his doctrines.

A study of the Recent and Post-Pliocene deposits of Norway and Denmark furnished the author with evidence "that climate is subject to periodical alterations." He was also led to conclude that alter-

[1] Reprinted in "Nature," July 8th and 13th, 1886.

nations of strata, formed under different physical conditions, could not, as a rule, be attributed to local pheuomena, but are rather due to general and more permanent causes.

Thus in cold and dry periods, the rivers which are nourished mainly by springs, are rich in soluble substances, and from their comparatively small volume, they carry little detrital matter. In rainy periods, the rivers, then poor in soluble matter, transport much clay, sand, and gravel. Hence dry periods should be marked by chemical deposits; rainy periods by mechanically-formed sediment.

Admitting that layers formed chemically and mechanically will be accumulated at all times, the author observes that they will be deposited in different places according to the variable amount of rainfall. When, however, clay alternates with limestone; when thick beds of sand alternate with sandstone cemented chemically by salts of iron and lime, or by silica; when clay alternates with layers of septaria, etc.: then (in the author's opinion) do the first-named beds date from periods with warmer ocean-waters and greater rainfall, than attend the formation of the latter.

The author is indeed unfortunate in his examples. If he had omitted all mention of septaria, which were formed since the deposition of the strata in which they are embedded, and which frequently enclose organisms identical with those found in the clay above and below them; and if he had taken no notice of sands which may be hardened by chemical agency long subsequent to original deposition, and which indeed are compacted at various horizons—then indeed we might pass on to consider his general conclusions with less misgiving than we do now; but our faith in his geological knowledge is sorely tried.

Other alternations of strata are considered to be due to "a rise and fall of the sea in relation to the land," the result being "an alternation of deep-sea formations with littoral formations or freshwater beds."

Of the two explanations thus given of alternations of strata, both causes in the author's opinion are periodically active. In the one case climatic causes are repeated at somewhat regular intervals; in the other, the changes in the relative level of land and water are repeated at longer and less regular intervals.

Periodical variations of climate, explained by comparatively small fluctuations in the extremes of temperature and rainfall, are attributed to periodical changes in the strength of ocean-currents. From ocean-currents the author turns to prevailing winds, to changes in atmospheric pressure, and finally to the precession of the equinoxes and the eccentricity of the earth's orbit as originating periodical variations of climate.

Thus alternately in the northern and southern hemispheres, the precession of the equinoxes causes the summer to be, for about 10,500 years, longer than the winter, but in the subsequent 10,500 years to be shorter. The author considers that although the periodical changes of climate were not great, yet they were sufficient to imprint themselves on the strata, in the alternation of beds, and in the formation of beach-lines, terraces, and moraines. To each period of precession there corresponds one alternation of strata.

In order to illustrate this portion of the subject, the author institutes a comparison between astronomical periods and the different series of geological strata. We may pass briefly over this portion of the subject. Suffice it to say that calculations have been made of the curves of the eccentricity of the earth's orbit. These curves or fluctuations are repeated once in about every $1\frac{1}{2}$ million years. The eccentricity has been calculated for a period of $4\frac{1}{2}$ million years, with the result that three curves are indicated. In each of these cycles of $1\frac{1}{2}$ million years, the author finds 16 arcs of the curve, which correspond with certain oscillations in the eccentricity of the earth's orbit.

The change in the tidal-wave caused by the variation of the eccentricity is presumed to be sufficiently great to explain the displacement of beach-lines. Each arc of the curve before mentioned corresponds to one oscillation of the sea. For every considerable oscillation of the beach-lines there is a corresponding geological stage. In these stages there will be found a certain number of alternations of strata, as many in fact as there are periods of procession in the corresponding arc.

The author remarks that the oscillation of beach-lines, corresponding to an arc, cannot be pointed out everywhere, but only in those geological basins where the forces at the time exerted their effect. In the Hampshire and Paris Basins he finds the total number of alternations in the strata to be about the same; and he endeavours to illustrate this by noting the number of alternations he finds in the different subdivisions of the Tertiary strata. One quotation will suffice to illustrate the method of the author. He remarks:—"The Upper Eocene Barton Clay has 5 layers of septaria. It is synchronous with the Grès de Beauchamp of the Paris basin, and it must consequently, like this, correspond to the arc 14 of the curve. This arc represents 100,000 years, and, consequently, about 5 periods of precession."

We must confess our utter disagreement with the author in his interpretation of geological facts.

As before mentioned, septaria afford no clue to changes in the physical conditions attending deposition. Again, the author remarks that "between the Eocene and the Oligocene a great break exists in the Isle of Wight," and he proceeds to remark that this may represent about 200,000 years. Now as a matter of fact there is no physical break between these divisions in the Isle of Wight. Moreover, the Tertiary strata are for the most part so variable in character, that it is not always possible to correlate particular layers exposed in the cliffs on the east side of the island with those seen on the west. What, then, is the value of the author's contention that the Eocene period appears to have had 16 oscillations, and should correspond to the first cycle, extending from 3,250,000 till 1,810,000 years before the present time? We fear the only verdict that can be given is, that the author's conclusions are of no geological value. At the same time we can but admire his enthusiasm, and admit that many of his remarks are exceedingly suggestive.

We have yet to consider the author's views of the "rise and fall of the sea in relation to the land." While he believes that beach-lines oscillate periodically backwards and forwards, he accepts the view that the great ocean depths and the great continents have, in all essential respects, retained their original relations to each other from the remotest times. When, however, he comes to discuss the form of the earth and the possible changes it has undergone, he finds that the cooling and contraction of the body of the globe are insufficient to account for all the phenomena. He believes that the lengthening of the sidereal day has had much influence on the form of the solid globe. The tidal wave which rises and falls, in some measure, with the eccentricity of the earth's orbit, is considered the most powerful agent in altering the sidereal day and in lengthening it; and as the centrifugal force diminishes during the lengthening of the sidereal day by tidal friction, strain accumulates in the solid earth, until the limit of resistance is reached. Hence arose vertical displacements of beach-lines.

The author remarks that most earthquakes are caused by dislocations, and that in countries where the inner strain has been relieved by great displacements in recent periods, earthquakes will probably be rare, and less destructive than in countries where there is still a great strain in reserve. Thus he concludes that great upheavals and subsidences are caused by strains, which have accumulated through very long periods.

He considers that the shore-lines in higher latitudes may be brought to recede, either by the rising of the land in the same region, or by the subsidence of the sea-bottom in lower latitudes. During the Tertiary period each oscillation did not exceed a few metres. Those who desire fully to understand the arguments of the author must consult his papers. For our own part we feel that very many of the geological facts to which he appeals lend no real support to his hypotheses; and that while his contention that precession has left its imprints on the strata is in itself plausible, yet the particular conclusions he draws on the means of measuring geological time rest on too oscillating a foundation to have any permanent value.

H. B. W.

II.—Die Stämme des Thierreiches; von M. Neumayr. Wirbellose Thiere. Erster Band, mit 192 Textbildern. Royal 8vo. pp. 603. (Wien u. Prag, Tempsky, 1889.)

The aim of this work is to trace out the descent-relationship of the various forms of animal life so far as they can be ascertained from geological and palæontological sources. Firmly impressed with the idea that the Darwinian theory of descent affords a reasonable interpretation of the phenomena of the succession of life as shown in the rocks, Prof. Neumayr set before himself the arduous task of working out the history and relationships of each of the divisions of the animal kingdom from its first appearance in the geological series, through each successive stage, until its extinction or its continuance in the organisms still existent, with the view of representing in one work the different steps in the course of its development. It is, in reality, an attempt to co-ordinate the facts of palæontology with the theory of descent in the same way as has been successfully done with those of embryology and comparative anatomy.

In an introductory chapter, the nature of the evidence to be derived from palæontology, and its application to the theory of descent, are treated at considerable length. In contrast to that afforded by the study of living organisms, in which every structural detail can be determined, only the hard parts of fossils have been preserved, and these often in scattered fragments, with their original condition modified in varying degrees by fossilization, so that satisfactory conclusions as to the characters of fossil organisms can only be made by those investigators who, in addition to a thorough knowledge of the anatomy and development of existing animals, have acquired experience in interpreting the relations of mere fragments, and these often masked and distorted. The difficulties are also increased by the fact of the important differences between existing and extinct forms of life, the greater in proportion as we go back in time; and as some of the oldest forms differ altogether from any now existing, their characters must always remain enigmatical.

It cannot be said that we have any satisfactory knowledge of the *beginnings* of life from the facts of palæontology. In the oldest known fossiliferous rocks of the Cambrian period there is already a great variety of different forms of life; and if these really represented the oldest types, it would be strong evidence against the theory of descent. We can only suppose that long before Cambrian times, organic life may have existed through immeasurable periods of time, and this supposition is supported by the presence of graphite, anthracite, bitumen, and limestones—substances which are regarded as having an organic derivation—in the Archæan rocks. The form known as *Eozoon*, however, is of too doubtful a character to be accepted as a proof of organic life.

Not only are the earliest types of organic life missing, but throughout the geological series there are undoubtedly great gaps in the succession. The number of species in the existing animal kingdom approaches to 300,000, whilst there are only from 70,000 to 80,000 fossil species. This great preponderance of existing forms is largely owing to the number of insect species, which constitute three-fourths of the total, whilst they are relatively rare as fossils. Of organisms inhabiting water, there are more fossil species known than recent; but, on the other hand, the existing species of land-dwellers are more numerous than those preserved as fossil. As an indication of the vast army of forms which in all probability have been wholly obliterated from our knowledge, the author states that there is good evidence to show that the marine life of the Jurassic seas was as various and abundant as that now existing; that during this period more than thirty distinct zones, each with its own peculiar fauna, can be distinguished; and making sufficient allowance for forms common to more than a single zone, the number of species which may have existed during the whole Jurassic period can hardly have been fewer than from 500,000 to 750,000. And yet the total number of marine fossil species from all the Jurassic beds only mount up to about 10,000, a very insignificant proportion in comparison with the above estimate. If such deficiencies exist where the geological series is fairly continuous, still greater ones may be presumed where there are breaks in the succession like those between the Tertiary and Mesozoic, and the Mesozoic and Palæozoic groups.

In view of the above it is useless to expect that a complete succession of fossils could be found in which all the varieties intermediate between different species were represented; but nevertheless fairly distinct lines of descent can be shown in the case of certain Brachiopods, Corals and Crinoids from the Palæozoic strata; in the Mesozoic Ammonites and the Molluscan genera *Pholadomya*, *Inoceramus* and *Halobia*, and in many Tertiary forms. As good examples of a gradually changing series of forms may be cited the fresh-water *Paludinas* from the Lower Pliocene of Sclavonia, in which the individuals at the beginning vary so much from those of the higher end of the series, that they might be taken for distinct genera if it were not for the numerous intermediate connecting forms.

The causes which have led to the extinction of species are to the palæontologist of as great interest as those relating to their origin. A great number of species have become extinct in historical times, some mainly through man's influence. It can hardly be said that species become extinct because they have outlived their capacity to vary, for we find still existing genera, such as *Rhynchonella*, *Lingula*, and *Discina*, which have varied but very little since their first appearance in the Palæozoic era; whilst on the other hand such forms as *Ammonites* and *Rudistes* exhibit remarkable variations shortly before they became extinct. The complete extinction of many groups of organisms which existed through long geological periods in great numbers and in manifold variety, as, for instance, the Trilobites, is difficult to account for; but there is nothing to support the theory that this or any other group of animals inhabiting widely-separated localities became contemporaneously extinct; for so far as it can be traced, the extinction of a species is not sudden, but rather a gradual process. In certain instances it is possible to connect the disappearance of a predominant group with the gradual increase and subsequent supremacy of another group which thus supplants it, and furnishes an instance of the 'survival of the fittest'; but in other cases, such as the Carboniferous *Fusulina* and the Tertiary *Nummulites*, there is no evidence of extinction from such a cause.

The next five chapters of the work are devoted to the consideration of the following invertebrate groups: I. Protozoa; II. Cœlenterata; III. Echinodermata; IV. Annelida; and V. Molluscoidea. As a preliminary introduction to each group, the most important of its structural details are given with figures of the typical forms.

Protozoa.—In this group are included the Foraminifera and Radiolaria. As regards the former, the author points out the comparative scarcity of their remains in the older Palæozoic rocks and their comparatively sudden appearance in great variety in Carboniferous strata, in which some highly organized forms, as *Nummulites*, *Fusulina*, etc., are associated with *Nodosaria*, *Textularia* and *Astrorhizida*, etc. The forms with calcareous shells are all regarded as derived from those with agglutinated tests, and these again have probably sprung from types with extremely simple and irregular tests like those of the Astrorhizidæ.

In the brief notice given of the Radiolaria, it is mentioned that the forms recently discovered in Jurassic and Triassic strata show but small differences from those of Tertiary and recent seas, and afford no clue to the natural relationships of the various divisions.

In the Cœlenterate division are embraced the Sponges, Corals, Hydrozoa, and Graptolites. As regards the Sponges, the author adopts with certain modifications the views of Zittel, and concludes with diffidence that the siliceous forms are probably derived from some more ancient type, in which the elementary spicule of the skeleton was irregularly polyaxile.

The Corals are treated very fully, and due importance is given to the fresh light thrown upon their characters by the microscopic observations of recent students. The Rugosa or Tetracorallia are regarded as a sharply defined group characterized by the symmetrically bilateral arrangement of their septa, and they are believed to be restricted to Palæozoic strata. Attempts are made to show that the forms from Mesozoic rocks which have been relegated to this group do not really belong to it, and conversely that Palæozoic Corals which have been placed with the Hexacorallia should really be included with the Rugosa. Some of the statements respecting the sharp division between the Rugosa and the so-termed Hexacorallia, namely, that the young forms of the former group are always symmetrically bilateral, and that in the latter the septal skeleton is purely radial and at the commencement with six septa, are too comprehensive and can hardly be substantiated. The genus *Calostylis* from Silurian strata, which, by Lindström, Nicholson and other excellent observers, is considered to be an undoubted member of the Perforata, is cast out of this division by Neumayr on the suspicion that it possesses bilateral symmetry, and that it is thus a Perforate Rugose Coral; but it is probable that the objection to ranking it with the normal Perforate Corals mainly depends on its occurrence in the Palæozoic rocks. The Palæozoic Favositoid Corals are regarded as forming an independent group, on the ground that the perforations in their walls are morphologically entirely different from those in normal Perforate Corals, and we think the objection a good one. The genera *Heliolites* and *Halysites* are, on the grounds of their possessing twelve true septa, indicating a corresponding number of true mesenteries and tentacles, considered as nearly related to the Fistuliporidæ and without any real affinity to the Alcyonarian genus *Heliopora*, with which they have been associated by Moseley and subsequent authors. Neumayr concludes that the great mass of the Palæozoic Tabulate Corals, distinguished as Favositidæ, Chætetidæ and Heliolitidæ, form a natural group, whose individual members are connected by intermediate forms. The relations between these Tabulate and the other leading groups of the Rugosa and the Hexacorallia cannot, in the present state of our knowledge, be determined.

The descriptions given by Nicholson of the structure and relations of the Stromatoporoidea are adopted by Neumayr. The true position of the Graptolites is regarded as doubtful; whilst some of their structural features indicate relationship to certain Hydrozoa, others point to a connection with Bryozoa, and the possibility is not excluded that they form an extinct group which has left no descendants.

The Echinodermata are very fully treated, and the structural features which link together the members of each of its divisions are carefully traced. There are, however, no indications in the fossil forms of the kind of animal from which the class has been developed. The Cystoidea are considered to be the central group from which connecting threads of relationship run to the other orders. The Sea-urchins are connected through *Cystocidaris*, and the Sea-stars through *Palæodiscus*, with those Cystideans whose test is irregular, and consists of numerous plates; whilst the Cystideans, with a test of a small number of fairly regular plates, approach the Crinoids through *Porocrinus* and *Hybocystites*, and the Blastoids through *Codonaster* and *Asteroblastus*. The relation between the groups may be graphically represented thus:

Ophiuro-Asteroidea ╲ ╱ Blastoidea
Cystidea
Echinoidea ╱ ╲ Crinoidea.

The Annelids or Worms, though so important a group zoologically in the consideration of the theory of descent, are but little adapted for preservation in the fossil state, and the traces they have left in the rocks throw scarcely any light on the characters of the early types. With regard to the genus *Tentaculites*, Neumayr states that probably it belongs to the Tubicola, and that there is not the slightest ground for ranging it with the Pteropoda.

The last division treated in the present volume is the Brachiopoda, in which a new arrangement is proposed varying in many respects from that at present adopted. In this the two main divisions are named Ecardines and Testicardines, corresponding generally to the Inarticulata and the Articulata. The Testicardines are subdivided into Eleuterobranchiata, without calcified free arm-supports, and Pegmatobranchiata, with free arm-supports. Forms in which the arm-supports consist of a loop, or of two free lamellæ only, are grouped as Campylopegmata, and those in which the supports are the well-known conical spirals, as Helicopegmata. Whilst it is possible to indicate the descent-relationships between many of the members of each subdivision, there is much uncertainty as to the relationship between these groups, and forms like *Atrypa* and *Retzia* may prove to be nearer related to *Rhynchonella* and *Wald-*

heimia respectively than to the other members of the Helicopegmata with which they are included.

The above notes afford but a very imperfect indication of the contents of this work, which is destined to exercise considerable influence in the advance of the science of palæontology. It is very generally thought that this science embraces nothing beyond dry descriptions of fossil species, but Prof. Neumayr shows that these are but the raw materials which, in skilled hands, yield conclusions of far-reaching interest and importance. It has been inevitable that the early stages of the science should have been devoted to the accumulation of the raw materials for future use; but in going over the pages of this work, we yet find numerous reminders of the deficiency in this respect. Much of the elementary work of the past has been of too superficial a character to be of service in solving such problems as that of descent; but there is every prospect that the more thorough modes of investigation, by means of thin sections and the microscope, which palæontologists now adopt, will in time clear up many of the difficulties which have confronted Prof. Neumayr in his present task.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—April 17, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Production of Secondary Minerals at Shear-zones in the Crystalline Rocks of the Malvern Hills." By Charles Callaway, Esq., M.A., D.Sc., F.G.S.

In a previous communication the author had contended that many of the schists of the Malvern Hills were of igneous origin. Thus, mica-gneiss had been formed from granite, hornblende-gneiss from diorite, mica-schist from felsite, and injection-schists from veined complexes which had been subjected to compression. As a further instalment towards the elucidation of the genesis of the Malvern schists, it was now proposed to discuss the changes which the respective minerals of the massive rocks had undergone in the process of schist-making.

The schistosity was usually in zones, striking obliquely across the ridge, varying in breadth from a few inches to many yards, and separated from each other by very irregular intervals. Within the zones bands of maximum schistosity alternated with seams in which the original structure had been less completely obliterated. The new structure was connected with a shearing movement, by which the rigid mass was often sliced into countless parallel laminæ or flakes. In a more advanced stage of alteration, the planes of movement were obliterated, and a sound clear gneiss or schist was formed. These foliated bands were called "shear-zones."

The most important shear-zones were those in which diorite was interlaced with granite-veins. The following changes were noticed in tracing the massive rocks into the zones. The hornblende might suffer excessive corrosion, or it might become "reedy" and break up along the cleavages into numerous fragments, which were drawn away from each other in the direction of foliation, or might pass into chlorite, or chlorite and epidote. The chlorite thus formed often passed into biotite, and sometimes the biotite was changed to white mica. Where shearing was excessive, chlorite sometimes passed directly into white mica.

Soda-lime felspar was altered to epidote or zoisite, and often to calcite. A more important result was the production of muscovite in the plagioclase. Much of this felspar was reconstructed in small clear crystals or granules. Quartz also was abundantly produced. Diorite might thus be converted either into a gneiss with two micas, or into a gneissoid quartzite. The granite of the veins passed through the usual changes in muscovite-gneiss.

Other secondary minerals were actinolite (from augite), sphene (from ilmenite), and garnet.

It was contended that the granite-veins were exogenous, because they appeared as apophyses from large masses, they had the same coarse texture in different varieties of diorite, and they produced contact-effects similar to those of intrusive veins, including the phenomena of aggregation and enlargement in the minerals of the encasing rock.

Foreign minerals were often introduced by infiltration. Thus, the hornblende of a diorite was decomposed into chlorite and iron-oxide, which passed for a considerable distance along the shear-planes of an adjacent granite, giving rise to a chlorite-gneiss, and the chlorite was partially changed to biotite. Epidote might be introduced in the same way.

Both the diorite and the granite of shear-zones tended by loss of bases to become progressively silicified. Most of the liberated bases could be accounted for. Analyses showed there was an interchange of alkaline bases, soda going to the granite, and potash to the diorite. Thus, some of the latter contained almost twice as much potash as soda.

The evidence collected seemed to prove that the schist-making had taken place subsequently to consolidation; but it was clear, especially where the rock was heavily sheared, that the constituents had been re-dissolved and reconstructed. Thus, as we followed a diorite into the core of a shear-zone, we could see the gradual disappearance of shear-planes and other mechanical effects, as well as the progressive results of chemical synthesis.

The secondary origin of the micas and of part of the felspar was proved by the fact that they were moulded on decomposition-products, such as chlorite and epidote, and upon fragments of hornblende crystals, which had been crushed during the shearing, and carried away from each other. The mineral changes as here described resulted from contact-action *plus* mechanical force.

2. "The Northern Slopes of Cader Idris." By Grenville A. J. Cole, Esq., F.G.S., and A. V. Jennings, Esq., F.L.S.

From the publication of Mr. Aikin's paper in the Transactions of the Geological Survey in 1829 to the second edition of the Survey Memoir on North Wales, the relations of the geological and physical features of Cader Idris have been pointed out in some detail. The present paper dealt with the nature of the eruptions that took place in this area and the characters of their products at successive stratigraphical horizons. The best exposures occur, as is well known, upon the northern slopes.

The lowest evidence of contemporaneous volcanic activity is to be found at the Penrhyn-gwyn slate-quarry, where a somewhat coarse bed of tuff, with slate-fragments and abundant felspar-crystals, occurs above an andesitic sheet. Similar slate-tuffs are repeated up to the base of the great cliff of Cader Idris, with intervening layers of normal clayey sediment. On the whole, the tuffs and ashes become more highly silicated as the upper levels are reached, and they terminate on the southern slopes in beds with fragments of perlitic and devitrified obsidian, such as are found under Craig-y Llam. On Mynydd-y-Gader the intrusive dolerites have altered the ashes into hornstones; in places, moreover, they have become jointed into distinct columns. Fragments of andesitic glass as well as trachyte are recorded.

The "pisolitic iron-ore" of the Arenig beds appears to have resulted from the metamorphism of an oolitic limestone, as in the case of the Cleveland ore described by Mr. Sorby, and that of Northampton described by Prof. Judd. The grains still give evidence under crossed Nicols of their having been built up of successively deposited concentric layers. The calcite so freely developed in the hollows of the underlying rocks may have been largely derived, during metamorphic action, from the destruction of similar thin limestone seams. No true lava-flows occur among these tuffs and sediments, a fact that implies comparative remoteness from the volcanic centre; and the important masses of intrusive matter represented upon the maps are themselves largely composed of the products of explosive action. The numerous sheets of ophitic dolerite, aphanite, and altered andesite, that lie, seemingly interbedded, on the northern slopes, were probably intruded when the associated rocks were already weighed down by much superincumbent sediment. A common character of these basic sheets is the development of small colourless crystals of epidote.

The most striking mass upon the mountain is the main "felstone" (eurite) of the wall, which proves to be minutely "granophyric," and of very uniform grain throughout. An analysis by Mr. T. H. Holland shows 73 per cent. of silica. This vast intrusive sheet is regarded as perhaps of no later date than the Llandeilo lavas of Craig-y-Llam, and as a forerunner of the volcanic conditions that prevailed in Bala times throughout North Wales.

The stratigraphical horizons, as shown on published sections, would throw a great part of the tuffs and ashes described into the Tremadoc beds, or even lower, in contradiction to the generally accepted statement that volcanic activity began in Arenig times. While this point can only be settled by detailed mapping on the basis of the new six-inch survey, the authors incline to the belief that the eruptions in this area broke out in the Cambrian rather than the Ordovician period.

CORRESPONDENCE.

OCCURRENCE OF SODA-FELSITES (KERATOPHYRES) IN IRELAND.

SIR,—In the February Number of this MAGAZINE I gave some account of the occurrence of soda-felsites or keratophyres in Co. Wicklow, at the conclusion of which I expressed the opinion that they would also be found to occur among the felsites that crop out in such abundance on the Waterford coast between Tramore and Ballyvoyle Head. Since the publication of this paper my attention has been drawn to some analyses of the Waterford felsites which were made by the late Mr. John Arthur Phillips and published in the Philosophical Magazine for January, 1870 (vol. xxxix. p. 12). As these analyses do not appear to be generally known,[1] and as they are interesting as confirming my surmise as to the probable occurrence of soda-felsites among the Lower Palæozoic rocks of Co. Waterford, I venture to bring them to the notice of the readers of the GEOLOGICAL MAGAZINE.

No. 1 was collected at the sea-cliff east of the village of Knockmahon. It is described as an elvanite. It is a compact rock "of bluish grey colour, which, when freshly broken, shows imbedded crystals of quartz and felspar in an amorphous matrix." The felspar is supposed by the author to be oligoclase.

No. 2 is a "flesh-coloured felsite obtained from a very broad band of this rock seen in the cliff near the village of Annstown, and immediately west of a copper-vein in which some explorations are being made. Under the microscope this was found to consist of a colourless and generally amorphous matrix enclosing a few crystals of dodecahedral quartz and some small crystals of felspar."

	I.	II.
SiO_2	72·33	80·50
Al_2O_3	9·02	8·33
Fe_2O_3	6·34	3·44
FeO	1·06	·96
CaO	1·92	1·21
MgO	trace	trace
K_2O	1·46	1·89
Na_2O	5·83	2·12
H_2O	1·83	1·38
	99·79	99·83
Sp. G.	2·66	2·64

28, JERMYN STREET. FREDERICK H. HATCH.

STENOTHECA, SALTER.

SIR,—In the note by Mr. G. F. Matthew, in the GEOL. MAG. for May, on *Stenotheca* (p. 210), it is assumed that the name was suggested first by me. This is not correct, as the MS. name was given by Mr. Salter, and afterwards adopted by me in my paper "On some undescribed Fossils from the Menevian Group" (Q. J. G. S. vol. xxviii. p. 180). The species is there given as "*Stenotheca cornucopia*, Salter."

May 3, 1889. HENRY HICKS.

ERRATUM.—In the April Number, p. 172, line 22 should read: "or it may be co-ossified with the lachrymal, as in *Sphenodon*, which bone is not free, as stated by Dr. Günther."

NEW HAVEN, Conn., U.S. DR. G. BAUR.

[1] They are not mentioned, for instance, in Teall's British Petrography.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. VI.

No. VII.—JULY, 1889.

ORIGINAL ARTICLES.

I.—Subaërial Deposits of the Arid Region of North America.

By Israel C. Russell,
of the United States Geological Survey; Washington D.C., U.S.A.

Part I.

Introduction.

THE subaërial deposits now accumulating in the arid portion of the United States may be divided into four classes: 1, Eolian Sands; 2, Talus Slopes; 3, Alluvial Cones; and 4, Calcareous Clays to which no specific name has been applied, but which, for reasons stated below, will be called "adobe" in this paper.

Eolian Sands.—Rounded hills of blown sands termed dunes give variety to the landscape in many portions of the arid region. These are local accumulations, but they sometimes have an extent of many square miles, and may attain a thickness of several hundred feet. They occur most frequently in sheltered valleys or in bay-like recesses of large valleys, where topographic conditions favoured the accumulation of wind-borne particles. They are usually composed of quartz grains, which show by their rounded and worn appearance, when examined under the microscope, that they have travelled far during their uncertain wanderings. Dunes are constantly changing their forms, each wind that blows being busy in remodelling the contours of their rounded domes. Their internal structure is extremely irregular, frequently showing cross-bedding and intricate contortions. Their surfaces are wind-rippled and many times covered with footprints.

In some instances, especially on the Carson Desert, Nev., small-sized dunes may be seen which are formed of the cases of minute Crustaceans (*Cypris*) which have been gathered by the wind from the surface of the desert and accumulated in piles in the same manner as in the formation of ordinary sand dunes.

Near Fillmore, Utah, another exceptional variety of dunes occurs, formed of small crystals of gypsum, which have been swept from a neighbouring desiccated lake-basin and accumulated in conspicuous white hills.

The dunes of arid regions have the same characteristic forms as those occurring in more humid climates. They are steep on the leeward side and slope much more gently in the direction from which the prevailing winds blow. The sources from which they are supplied are usually less easily determined, however, than in the case of sand hills which accumulate along the borders of oceans, lakes and rivers.

Talus Slopes.—These occur in abundance at the bases of nearly all rock escarpments, and are usually composed of coarse angular material. They owe their accumulation to the falling of detached blocks from the faces of rocky cliffs. Their surface slopes are usually high, depending on the angle of stability of the material of which they are composed, and are much greater than the corresponding slopes of alluvial cones, next to be described. Unlike alluvial cones, too, they occur quite uniformly along the bases of steep mountains instead of being confined to the mouths of cañons.

The talus slopes of arid regions are of essentially the same character as those occurring in humid climates, and farther notice of them at this time seems unnecessary.

Alluvial Cones.—The smooth, even slopes of these deposits are a noticeable feature about the bases of all the principal mountains in the Far West. They are formed of both coarse and fine material which has been swept out of gorges in the mountains and deposited in the valleys. In many instances they have a great superficial extent, and where the conditions for their formation are most favourable, may be hundreds and possibly thousands of feet in thickness.

The alluvial cones of the region of interior drainage in the western part of the United States, known as the Great Basin, have been described by Mr. G. K. Gilbert,[1] and we cannot do better than quote his description :—

"The sculpture of a mountain by rain is a twofold process; on the one hand destructive, on the other constructive, The upper parts are eaten away in gorges and amphitheatres until the intervening remnants are reduced to sharp-edged spurs and crests, and all the detritus thus produced is swept outward and downward by the flowing waters, and deposited beyond the mouths of the mountain gorges. A large share of it remains at the foot of the mountain mass, being built into a smooth sloping pediment. If the outward flow of the water were equal in all directions, this pediment would be uniform upon all sides; but there is a principle of concentration involved, whereby rill joins with rill, creek with creek, and gorge with gorge, so that when the water leaves the margin of the rocky mass, it is always united into a comparatively small number of streams, and it is by these that the entire volume of detritus is discharged. About the mouth of each gorge a symmetric heap of alluvium is produced—a conical mass of low slope, descending equally in all directions from the point of issue; and the base of each mountain exhibits a series of such alluvial cones, each with its apex at the mouth of a gorge, and with its broad base resting upon the adjacent plain or valley. Rarely these cones stand so far apart as to be completely individual and distinct, but usually the parent gorges are so thickly set along the mountain front that the

[1] Contributions to the History of Lake Bonneville, in Second Ann. Rept. U. S. Geol. Surv. 1880–81, p. 183.

cones are more or less united and give to the contours of the mountain base a scalloped outline."

Alluvial cones when best developed extend out from the mountains to a distance in many instances of several miles. Not infrequently the deposits on opposite sides of the valley unite along the centre of the depression, so that its profile is an unbroken curve; or, more accurately, is a combination of two curves, for each alluvial cone has a concave surface.

The material forming alluvial cones varies in size from the finest powder to angular rock weighing many tons. It exhibits no regular bedding or stratification, but coarse and fine debris are mingled in endless variety. There is a well-marked gradation, however, to be seen as one travels from the apex of an alluvial cone towards its periphery. At the apex it is composed mostly of coarse, angular material, with fine silt-like clays filling the interspaces. Toward the periphery the fine material predominates, and in many instances forms a homogeneous unstratified deposit, without stones or pebbles. At other times coarse material occurs at certain horizons in the fine silt, thus recording periods of unusual precipitation, when the gravels from the mountains were swept out into the valleys to a greater distance than under ordinary conditions. At the lowest limits to which the debris is carried in large valleys it is always fine, and has a much smaller surface slope than the upper portions of the alluvial cones with which it is associated.

The climatic conditions favouring the formation of alluvial cones might be discussed; but as deposits of this nature are not the special subject of this paper, their further consideration will be postponed.

Calcareous Clays (*Adobe*).—Widely distributed throughout the valleys of the more arid portion of the United States there occurs a peculiar calcareous clay which is used largely by the Indians, Mexicans and others for the manufacture of sun-dried bricks, known by the Spanish name "adobe." The earth from which these bricks are made is also designated by the same name. We have therefore adopted it, with some extension of its popular meaning, as a convenient term by which to designate the fine subaërial accumulations in general, exclusive of eolian sands, which occur in the region just referred to.

I.—Adobe.

Distribution.—The area over which adobe forms a large part of the surface has not been accurately mapped, but enough is known to indicate that it is essentially co-extensive with the more arid portions of this country. In a very general way it may be considered as being limited to the region in which the mean annual rainfall is less than twenty inches. It forms the surface over large portions of Colorado, New Mexico, Western Texas, Arizona, Southern California, Nevada, Utah, Southern Oregon, Southern Idaho, and Wyoming. In this paper the great area here designated is termed the Arid Region. Adobe occurs also in Mexico and may there reach a greater development than in the United States, but observations concerning it south of the Rio Grande are wanting.

In the United States it occurs from near the sea-level in Arizona, and even below sea-level in Southern California, up to an elevation of at least six or eight thousand feet, along the eastern border of the Rocky Mountains, and in the elevated valleys of New Mexico, Colorado and Wyoming. It occupies depressions of all sizes up to valleys having an area of hundreds of square miles. Although occurring throughout the Arid Region, it can be studied to best advantage in the drainless and lakeless basins at Nevada, Utah, and Arizona.

Thickness.—The maximum thickness of the adobe is always difficult to determine, for the reason that it is still accumulating, and has not been sufficiently dissected by erosion to expose sections of any considerable depth. That it not infrequently has a depth of many hundreds of feet is apparent to one who traverses the valley in which it occurs. The profiles of very many of these valleys indicate that they have probably been filled to a depth of at least two or three thousand feet. In the larger valleys there are rocky crests, called "lost mountains," which project above the broad level desert surface, and are in reality the summits of precipitous mountains that have been almost completely buried beneath recent accumulations. These qualitative observations are supported by a few quantitative measurements.

At Sandy, about six miles south of Salt Lake City, Utah, and at a distance of two or three miles west of the west base of the Wasatch Mountains, a well was bored a few years since, in search of artesian water, which penetrated fine yellow earth with occasional layers of sand, gravel and clay, to a depth of about 1500 feet, without reaching the rock-bottom of the basin. The material taken from near the bottom of this well was of the same character as that occurring at the surface over a large number of valleys throughout the Arid Region.

The boring at Sandy is in the basin of Lake Bonneville (Quaternary), but the entire depth of material penetrated cannot be referred to the deposits of that lake. Older lakes, in which sands and clays must have been accumulated, probably existed in the same basin in pre-Bonneville times, and the depression must also have been filled by purely subaërial deposits. It is impossible to determine whether the comminuted material brought up from the well was deposited under water or not, but the precise manner in which its accumulation took place does not concern us so much at present as the evidence which the well affords of the great depth of superficial material occurring in Great Salt Lake Valley, and, it is to be presumed, in adjacent valleys as well.

A second well over 1300 feet deep was bored a few years since near Humboldt Lake, Nev., which penetrated material of the same general character as that brought up from the well near Salt Lake City, and, as in the former instance, did not reach the true rock-bottom of the basin in which it was bored. This well was located in a valley once occupied by the waters of Lake Lahontan (Quaternary), but only the extreme upper portion of the material penetrated can be referred to the sediment of that lake.

A large number of wells have been bored in the Great Valley of California, which penetrate alternating layers of unconsolidated sand, gravel and clay, to depths varying from a few hundred to 2300 feet without reaching bed rock.[1] The deepest of these is situated in the northern part of the San Joaquin Valley, as I have been informed by Wm. Ham. Hall, State Engineer of California.

With these measurements before us, it does not seem that an estimate of three thousand feet or more, for the thickness of the superficial deposits in many of the valleys of the Arid Region, is too great. My confidence in this conclusion has been increased by finding that the depth of superficial material in the valley of Great Salt Lake has been estimated by G. K. Gilbert[2] at 5000 or 6000 feet.

Physical Characters.—Typical examples of adobe may be seen in thousands of places in the Arid Region, where sun-dried bricks are being made. In every Indian and Mexican village of Arizona and New Mexico there are excavations where material has been obtained for this purpose. Many times the bricks used in the construction of a building are made from the earth removed in digging its foundations. At these and many other localities where the adobe is open to view, it appears as a fine-grained porous earth, varying in colour through many shades of grey and yellow, which crumbles between the fingers, but separates most readily in a vertical direction. The coherency of the material is so great that vertical scarps will stand for many years without forming a noticeable talus slope. The sun-dried bricks made from it are more durable than the escarpments of natural earth, and when built into walls are capable of standing the atmospheric conditions to which they are subjected for scores of years. There are buildings now in use in Santa Fé, N.M., built of sun-dried bricks, which, I have been assured on good authority, have been standing for more than a century.

Adobe is frequently exposed in the sides of arroyos or dry water-courses, especially in the valleys along the eastern base of the Rocky Mountains from Wyoming to Mexico. At Cañon City, Colorado, exposures of this character are abundant, and sections from fifteen to twenty feet in height may be examined in detail. Wells dug in the same region have penetrated the adobe to a depth of forty feet without reaching its lower limit. At these and at numerous other localities that have been examined no lines of stratification could be distinguished, but the deposits were homogeneous throughout, except at times when lines of pebbles marked more or less definite horizons. Pebbles are most abundant near the mountains, and become less and less frequent as one recedes from them. At a few localities the adobe was seen to be traversed by small vertical tubes, some of which branched downward. In samples collected at Santa Fé, N.M., the tubes have a diameter ranging from a fiftieth to a hundredth of

[1] Physical Data and Statistics of California, Sacramento, 1886.

[2] Report on the Geology of Portions of Nevada, Utah, California and Arizona, in Report of Geographical and Geological Explorations and Surveys West of the 100th Meridian, Washington, 1875, vol. iii. p. 66.

an inch. In no instance could a definite lining to the tubes be distinguished.

The adobe used for brick-making is usually light grey in colour, but this is not always the case. It is frequently light yellow, and has varying tints according to locality. Sometimes it has a reddish tint, caused by the prevailing colour of the surrounding rocks from which it was in large part derived. The grey colour of the adobe commonly seen in buildings is due in many, and probably in all cases, to an admixture of organic matter. Its characteristic colour, when free from organic matter, is light yellow. In alluvial cones, and generally throughout the drainless valleys of the Arid Region, this is the prevailing tint. The organic matter which darkens the adobe in many instances may have been contained in the rocks from which it was derived; this is certainly the case near Cañon City, Col., where the adobe is formed principally from the wash of grey Jurassic shales. At other times the colour seems to have originated from the decay of vegetable matter buried in the deposit.

When examined under the microscope, the adobe is seen to be composed of irregular, unassorted flakes and grains, principally quartz, but fragments of other minerals are also present. An exhaustive microscopic study has not been made, but the samples examined from widely-separated localites were very similar. The principal characteristics observed were the extreme angularity of the particles composing the deposit and the undecomposed condition of the various minerals entering into its composition. It is to be inferred from this that the material was not exposed even to a very moderate degree of friction, and had not undergone subaërial decay before being deposited. Adobe collected at typical localities is so fine in texture that no grit can be felt when it is rubbed between the fingers; in other instances it contains angular rock fragments of appreciable size, and, as we have stated in speaking of alluvial cones, may be intimately associated with rock-masses many tons in weight. When the rocks overlooking adobe-filled valleys are of easily eroded sandstone, the deposit in the valley below is sometimes so sandy that the distinctive features of adobe are lost. Other changes in colour and texture have been observed, depending on the character of the rocks from which the deposit was derived.

Chemical Characters.—Analyses of several samples of adobe are given in the following table, which show that it not only has a varied composition, but differs in its chemical characteristics in different localities.

The diversity of composition, as shown in the table, indicates that the deposits which we have classed under the same name on account of their physical and other characteristics vary widely in constituents. These analyses show that adobe is very distinct from residual clays, as is also proven by its appearance under the microscope. The table of analyses of residual clays from the Southern Appalachian region is here introduced for convenience of comparison. Residual clays are composed essentially of ferruginous silicate of alumina, and are remarkably free from substances which

ANALYSES OF ADOBE BY L. G. EAKINS.

Constituents.	No. 1. Santa Fé, N.M.	No. 2. Fort Wingate, N.M.	No. 3. Humboldt, Nev.	No. 4. Salt Lake City, Utah.
SiO_2	66·69	26·67	44·64	19·24
Al_2O_3	14·16	·91	13·19	3·26
Fe_2O_3	4·38	·64	5·12	1·09
MnO	·09	trace	·13	trace
CaO	2·49	36·40	13·91	38·94
MgO	1·28	·51	2·96	2·75
K_2O	1·21	trace	1·71	trace
Na_2O	·67	trace	·59	trace
CO_2	·77	25·84	8·55	29·57
P_2O_5	·29	·75	·94	·23
SO_3	·41	·82	·64	·53
Cl	·34	·07	·14	·11
H_2O	4·94	2·26	3·84	1·67
Organic matter	2·00	5·10	3·43	2·96
	99·72	99·97	99·84	100·35

are readily soluble in ordinary surface waters. Adobe, on the other hand, has a complex composition, and carries many substances which on exposure to percolating waters would be dissolved out. This difference is shown especially by the absence of calcium from residual clays and its abundance in adobe. Correlated with those differences in chemical composition are marked contrasts of colour. The prevailing and characteristic colour of residual clays is dark red; the adobe when not affected by organic matter is light yellow.

ANALYSES OF RESIDUAL CLAYS FROM THE SOUTHERN APPALACHIAN REGION.[1]

Constituents.	No. 1.	No. 2.	No. 3.
SiO_2	13·26	43·07	55·42
Al_2O_3	28·76	25·37	22·17
Fe_2O_3	16·80	15·16	8·30
FeO	—	—	trace
TiO_2	·64	—	—
P_2O_5	·10	—	—
Na_2O	—	1·20	·17
Ca_2O_3	trace	—	—
K_2O	—	2·50	2·32
MnO	trace	—	—
CaO	·37	·63	·15
MgO	·59	·03	1·45
H_2O (by ignition)	13·26	12·98	9·86
	100·07	100·64	99·84

No. 1, Residual clay resulting from the subaërial decay of trap rock from Wadesborough, N.C.

No. 2, Residual clay resulting from the subaërial decay of Trenton limestone, from Lexington, Va.

No. 3, Residual clay resulting from the subaërial decay of Knox Dolomite, from Morrisville, Ala.

[1] From U. S. Geol. Surv. Bulletins, No. 52.

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

II.—The Lias Marlstone of Tilton, Leicestershire.

By E. Wilson, F.G.S., and W. D. Crick,
With Palæontological Notes by E. Wilson, F.G.S.

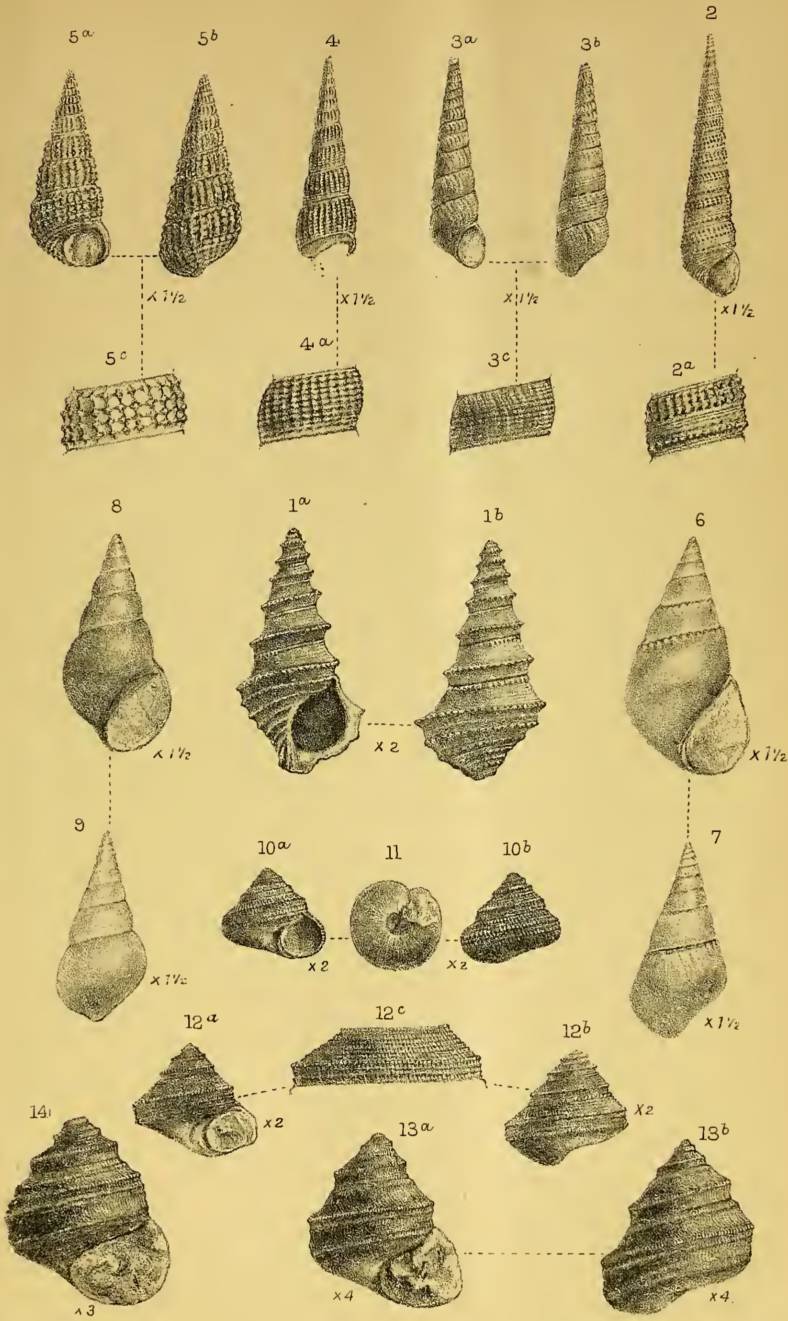
(PLATE IX.)

WHEN the new railway from Nottingham to Market Harborough was made, several instructive sections in the Upper and Middle Lias series were opened out between the latter place and Tilton. Most of these are now covered up and grass-grown, but one of the best is still partially laid bare in the deep cutting at Tilton Station. This Tilton section has become one of considerable interest to the geologists of the Midland district, from the complete and characteristic exposure which it gives of the Marlstone Rock of Leicestershire in its fully developed and unweathered form, and also on account of the rich fauna which that rock, and in particular its top or 'Transition Bed,' has here yielded.

The main purpose of this note is to present a list of these fossils with a detailed description of a few of them which are either new to the British Lias, or which have not hitherto received an adequate description. Before entering upon this part of our task, a very brief account of the stratigraphy of the district referred to will be desirable. A little to the south of Tilton Station the following section is exposed:—

	Ft.	in.
Upper Lias Shales: concealed in grass-grown slopes of the cutting, yielding a few fossils, e.g. *Harpoceras serpentinum*, *Stephanoceras crassum*, *Turbo Theodori*, *Trochus Northamptonensis*, *Leda ovum*, and *Belemnites* ... about	30	0
Middle Lias: *Marlstone Rock.*		
"Transition Bed" (Middle to Upper Lias); flaggy limestone, containing *Harpoceras acutum*, *Amaltheus spinatus*, *Stephanoceras commune*, *St. annulatum*, etc., *Nautilus truncatus*, *Belemnites elongatus*, *B. paxillosus*, etc., *Lima pectinoides*, *Pecten æquivalvis*, etc., many Gasteropods, *Pleurotomaria rustica*, *Cryptænia expansa*, *Trochus lineatus*, *Tr. ariel*, *Cerithium* (?) *confusum*, *C. ferreum*, etc. *Rhynchonella tetrahedra* var. *Northamptonensis*, *Terebratula punctata*, and fragments of fossil wood	0 9 to 0	6
Bluish-green ferruginous limestone, finely oolitic; *Harpoceras acutum*, *Stephanoceras commune*, *Pecten æquivalvis*, *P. lunularis*, *Terebratula punctata*, and *Belemnites*, in two blocks	4	3
Bluish-green finely oolitic ferruginous limestone with irregular seams of encrinital fragments; *Pecten æquivalvis*, *P. lunularis*, and *Belemnites*, in three blocks	4	2
Bluish-green rock, becoming locally a "jack"; [1] *Pecten æquivalvis*, *Rh. tetrahedra*, *T. punctata* and *Belemnites*	1	6
Greenish arenaceous rock with a "jack" in upper portion and nodular below; *Rh. tetrahedra*, *T. punctata* and *Belemnites*	4	6
Greenish arenaceous rock with "jack" in upper half, and nodular below; *Amaltheus margaritatus*, *Gresslya lunulata*, *G. intermedia*, *Pleuromya* sp., *Rh. tetrahedra*, and *T. punctata*	3	6
	18	5
Middle Lias Shales with bands of sandstone and scattered limestone nodules, etc., *Am. margaritatus*, *Protocardium truncatum*, *Monotis cygnipes*, *Avicula inæquivalvis* and *Leda complanata*, etc. ... about 13 feet exposed, increasing, as the beds rise, to the north.	13	0

[1] "Jack," a quarryman's term for a bed of marlstone made up of an agglomeration of the shells of *Rhynchonella tetrahedra* and *Terebratula punctata*.



A. S. Foord del. et lith.

West, Newman imp.

Lias Marlstone Rock, Transition-Bed & Upper Lias Gasteropoda.

Tilton, Leicestershire

The Marlstone Rock in the Tilton railway-cutting, lying beneath a thick capping of Upper Lias Shales, is a hard massively-bedded grey ferruginous limestone, in appearance something like the Marlstone Ironstone of the Cleveland district of Yorkshire, but more finely-grained and duller looking, and containing also a much less percentage of iron. The rock is traversed by numerous joints, and along these and also along the bedding-planes to the depth of a few inches on either side the carbonate of iron has been changed, under the influence of percolating waters, into the hydrated ferric oxide. Coincidently with this chemical change the greenish-grey stone has assumed a rusty-brown colour, so that, when first opened out, the face of the rock presented a very prettily checked appearance. A few years' exposure to the atmosphere, however, has gone far towards toning down this variegation and covering the whole face of the Marlstone Rock with a uniform dull brown tint.

So far as the Leicestershire area is concerned, the "Transition Bed," at the top of the Marlstone Rock, appears to be confined to this single locality. This bed is remarkable for the numerous and varied organisms which it contains. Of these *Harpoceras acutum* is especially abundant, and characteristic of this horizon. Several Ammonites usually confined to the Upper Lias are here found associated with other forms characteristic of the Middle Lias, so that palæontologically the "Transition Bed" must be considered as really transitional between those two series, notwithstanding that it possesses the mineral characters of, and is welded to the Marlstone Rock. We have not therefore hesitated to apply to this bed the name given by Mr. E. A. Walford [1] and Mr. B. Thompson [2] to a similar bed which lies at the top of the Marlstone Rock in Oxford and Northamptonshire. It is mainly, if not solely, from this thin stratum that the Ammonites, as well as the Gasteropods, which are so numerous at Tilton, have been obtained. The "Transition Bed" may be examined *in situ* on a narrow ledge which projects a little from beneath the Upper Lias shales on the west side of the railway-cutting, and the best way to work it is to turn over and break up the slabs with a pick in wet weather, when the stone is softer and works much more readily. A small dip—about 1° S.E.—carries this bed and the Marlstone Rock beneath the line towards the south end of the cutting.

The material taken from the Tilton cutting has been used to construct the embankment at East Norton, about three miles to the south. Here blocks of the Tilton Marlstone lie about in great numbers. Under the action of the weather during the ten or twelve years which have elapsed since the line was made, the hard grey Marlstone Rock has been changed superficially into a comparatively soft brownish arenaceous ironstone, a change of the same kind, if not carried to the same degree, as that which, in the course of ages,

[1] "On some Middle and Upper Lias Beds in the Neighbourhood of Banbury," by Edwin A. Walford, F.G.S., Proc. Warwick Nat. and Arch. Field Club, 1878.

[2] "Notes on Local Geology," by B. Thompson, F.G.S., part x. "The Junction Beds of the Middle and Upper Lias," Journal Northants. Nat. Hist. Soc. vol. ii, p. 239, 1883.

has converted this dense grey ferruginous limestone into a porous and friable rusty brown ironstone over such large areas, where it forms the surface rock, in Leicestershire and Rutland.[1] This softening process has made it possible to extract a large number of fossils in a fairly complete state of preservation.

The list of Tilton fossils here given is in large measure founded upon specimens thus obtained. It is therefore in many cases impossible to say with absolute certainty from what part of the Tilton section these fossils came; but as we find that the chief repository for the cephalous mollusca, at any rate, at Tilton, is the top or "Transition Bed," we shall probably be pretty safe in assuming that most if not all of the similar organisms found in the Marlstone blocks of the East Norton embankment have been derived from that horizon.

Going south from Tilton, the Marlstone Rock rapidly dies away. In the railway-cutting near East Norton Station it can still be traced as a concretionary bed two or three feet in thickness, whilst between Keythorpe and Hallaton it is less than one foot thick; and nearing Market Harborough, it locally disappears altogether.

In the East Norton railway-cutting the grey clays of the "Communis zone" of the Upper Lias are exposed, and have yielded the following characteristic Upper Lias fossils:—

Stephanoceras commune, Sow.
,, *crassum*, Y. & B.
Harpoceras bifrons, Brug.
Belemnites subtenuis, Simpson.
Nortonia (*Purpurina*) *Patroclus*, d'Orb.
Inoceramus dubius, Sow.
Nucula Hammeri, Defrance.
,, *claviformis*, Sow.
Serpula tricristata, Goldfuss.

Palæontological Notes, by E. Wilson, F.G.S.

Although it has fallen to my lot to undertake the critical palæontology connected with the subject, I have to acknowledge very considerable assistance from my colleague in this department of our joint work. Mr. Crick has not only collected the great majority of the fossils mentioned in the Appendix, but he has also identified the whole of them, with the exception of the Gasteropoda and the species which I have described. The success attending Mr. Crick's researches in the neighbourhood of Tilton will be understood when I mention the fact that five years ago the total number of species which had been derived from the Marlstone Rock of the Leicestershire district, including Rutland and S.W. Leicestershire, did not exceed sixty, and that it is chiefly through his labours that this total has been increased to one hundred and ten.[2] Seeing that scarcely anything has been found in the Leicestershire district which has not also been found at Tilton, the Marlstone fauna of this single locality may be considered to fully represent that of the larger area referred to.

[1] As an illustration of the effect of atmospheric action in producing this change, it may be mentioned, that under the railway bridges where the Marlstone ballast has been protected from the rain, the rock remains in practically the same hard state as that in which it was first quarried.

[2] We are indebted to Mr. B. Thompson, F.G.S., of Northampton, for the privilege of inspecting his collection, and also for the loan of some of the most interesting of the fossils here described.

Without further preface I proceed to the consideration of certain of these fossils which are either new to science, or to the British Lias, or which call for more complete description or revised nomenclature. These fossils have all been derived from the Marlstone Rock of Tilton, Leicestershire, with the exception of the remarkable form first noticed, which is from the Upper Lias of East Norton, Rutland, and the peculiar interest of which must be my apology for noticing it in an essay not strictly dealing with Upper Lias palæontology.

NORTONIA (PURPURINA) PATROCLUS, D'Orbigny, 1847, Plate IX. Figs. 1*a*, 1*b*.

1847. *Turbo Patroclus*, d'Orbigny, Prodrome de Paléontologie, vol. i. p. 248.
Syn. 1850. *Purpurina Patroclus*, d'Orb., Pal. Franç. Terr. Jur. vol. ii. Gast. pl. 329, fs. 9–11.
? ,, *Purpurina Philiasus*, d'Orb., Pal. Franç. Terr. Jur. vol. ii. Gast. pl. 329, fs. 12–14, as *Turbo Philiasus* in the Prodrome, vol. i. p. 248.
1856. *Littorina Patroclus*, d'Orb. sp. Piette, Bull. Soc. Géol. France, 2nd ser. vol. xiii. p. 587.
1860. *Eucyclus Patroclus*, d'Orb. sp. Eudes Desl. Bull. Soc. Linn. Norm. vol. v. p. 138. Ibid. Eug. Desl. op. cit. p. 135.
non *Purpurina subangulata*, Mü. sp. Oppel, "Der Jura," p. 386.[1]
nec *Turbo subangulatus*, Münster, Goldfuss, Petref. Germ. vol. iii. p. 98, pl. 124, f. 5.

Description.—Shell thin, elongate, conical, apex acute; whorls 9, angular, screw-like, with a very prominent acute and crenulated keel, situated about two-fifths of the breadth of the whorl from the anterior suture; the whorls slightly concave and gently sloping from the keel to the posterior suture, more deeply excavated and steeply inclined inwards to the anterior suture; the sutures are bounded posteriorly by a raised simple spiral, anteriorly by a finely granulated one; the base is convex and fairly inflated, bearing five equidistant raised granulated spirals, between the middle three of which are two simple ones; the whole surface of the shell is covered with very fine spirals.; the posterior border of the last whorl rises near its termination at the aperture, so as to slightly embrace the penultimate whorl: aperture ovate, a little oblique, the outer lip has its inner border considerably expanded, and its outer edge is thickened by a very narrow rim, and digitated by the keel and basal spirals; columellar border with a thin shelly deposit, columella outwardly twisted anteriorly; a narrow umbilical slit; anterior canal a broad shallow groove directed obliquely outwards, and effuse in front; posterior canal a narrow groove concealed beneath the overlapping portion of the last whorl. Length, 16 mm. Greatest diameter, 9 mm. Spiral angle, 37° Sutural angle, 125°. Proportion of last whorl to whole shell, 7 to 16.[2]

[1] Oppel was evidently mistaken in considering *Turbo Patroclus*, d'Orb., as the equivalent of *Turbo subangulatus*, Mü.

[2] Figs. 1*a*, 1*b*, accurately represent this form, except that in Fig. 1*a* the shelly callus on the inner lip should have been shown to continue as far as the end of the posterior canal.

Affinities.—D'Orbigny, in his Prodrome, gives a short diagnosis of a fossil, which appears to be rather widely distributed in the Upper Lias (étage Toarcien) of the centre and east of France, under the name *Turbo Patroclus*, and the same form appears in the "Paléontologie Française" as *Purpurina Patroclus*. Although no description is given in the latter work of this or indeed of any other *Purpurina*, it is obvious, from the illustrations in the atlas, that we have here our Rutland fossil. Yet the figure in the "Pal. Franç." is remarkable in this, that with the identical form and ornamentation of the English fossil, it presents apertural characters which are very different. Instead of the contracted aperture, thickened outer lip, and anterior and posterior canaliculation, possessed by our shell, we see depicted a large oval aperture with rounded margins and without the trace of a groove or canal. Evidently whilst the body of the shell of *Purpurina Patroclus*, D'Orb., is correctly delineated, the aperture is a beautiful but imaginary restoration; and the same observation will probably apply to *Purpurina Philiasus*, D'Orb., which is probably only a more highly ornate variety of *P. Patroclus*. It is true there are other Jurassic Gasteropods which have a spire and ornamentation extremely like *P. Patroclus*, and which nevertheless belong to different groups, *e.g. Alaria* and *Pseudalaria*; but the points of agreement between the fossil here figured and the illustration in the Pal. Franç. are, I hold, too precise to leave the above identification in doubt. It is to be noted also, that the name *Purpurina* given by D'Orbigny, implies that he considered these shells siphonostomatous, and this is expressed also in the original diagnosis of the genus, by that author in his "Cours élémentaire de paléontolgie,"—"Ouverture pourvue en avant d'un très étroit sillon qui remplace l'echancrure des Purpura." It will not be necessary to give, at this point, the history of *Purpurina*, the more so as this subject was not very long ago treated in some detail by my esteemed friend Mr. W. H. Hudleston, F.R.S., in the pages of the GEOLOGICAL MAGAZINE,[1] and still more recently in the first part of his valuable Monograph on the Inferior Oolite Gasteropoda.[2] It is sufficient for my purpose to point out that, whilst Jurassic palæontologists have rightly followed Deslongchamps and Piette in restricting the genus *Purpurina* to forms possessing the general characters of *Purpurina bellona*, D'Orb., continental authors have been generally misled in their identification of *P. Patroclus*, D'Orb. as one of the Littorinidæ (an *Eucyclus*=*Amberleya*, or a *Littorina*), by the inaccurate figures in the Paléontologie Française. What then are the true affinities of the shell under consideration? In the aggregate of its characters—the rather elongate spire, the aperture with an expanded outer lip, slightly enveloping last whorl, outwardly twisted columella and clearly defined anterior and posterior canaliculation—this peculiar form seems to fall under the Cerithiidæ. It will scarcely, however, come within the genus *Cerithium* or any other established genus of that family. In certain details of form and

[1] GEOL. MAG. Dec. II. Vol. IX. (1882), p. 11.
[2] Pal. Soc. British Jurass. Gast. pt. i. p. 8, and p. 83.

ornamentation *Purpurina Patroclus*, D'Orb., is remarkably like, and is probably related to, the type of Mr. Hudleston's new Jurassic genus *Pseudalaria* (*Alaria*) *Etheridgii*, Tawney, but the characters of the aperture are sufficiently different in these two shells to bring them under distinct generic groups. I believe it will be best to found a new genus for the reception of this remarkable Rutland fossil. I therefore, suggest for it the name *Nortonia*, in reference to the only British locality, East Norton, where it has at present been found. *Nortonia* might be briefly defined as a *Cerithium* with a very shallow anterior canal, and with eucycloid spire and ornamentation.[1] *Nortonia Patroclus* is perhaps one of those "common forms" which serve to link together several very diverse genera, such for example as *Cerithium* and *Pseudalaria* on the one hand, and *Amberleya* and *Purpurina* on the other.

I am indebted to Mr. Beeby Thompson, F.G.S., of Northampton, for the opportunity of examining this extremely interesting fossil.

Geological Horizon and Locality.—Upper Lias Shales, Railway-cutting, East Norton, Rutland.

Cerithium (Cerithinella ?) confusum, Tate, 1875. Plate IX. Figs. 2, 2*a*.

1875. *Cerithium confusum*, Tate, Geol. Mag. Dec. II. Vol. II. p. 205.

I have several specimens of a highly elongate conical shell from East Norton, which answers to the description given by Tate of the above type. The state of preservation of these fossils is not sufficiently good to indicate with certainty their generic position. No figure accompanied the original description. I therefore give illustrations from our Leicestershire specimens.

Marlstone Rock, Tilton (East Norton embankment).

Cerithium ferreum, Tate, 1875. Plate IX. Figs. 3*a*, 3*b*, 3*c*.

1875. *Cerithium ferreum*, Tate, Geol. Mag. Dec. II. Vol. II. p. 205.

A number of shells have been obtained from the Marlstone Transition-bed of Tilton, and from the East Norton embankment, which correspond with Tate's type. No figures of this form having yet been published, I give illustrations from Tilton specimens to supplement the original description in the Geological Magazine.

Marlstone Rock, Tilton (East Norton embankment and Tilton).

Cerithium costulatum? Desl. 1842. Plate IX. Figs. 4, 4*a*.

1842. *Cerithium costulatum*, Desl. Mém. Soc. Linn. Norm. vol. vii. p. 199, pl. xi. figs. 12, 13.

There is a single imperfect specimen from East Norton, of an elongate conical shell, which appears to represent the above type of

[1] As a general principle, no doubt, it is not safe to found a genus or even a species on a single specimen, and this prevents my giving a more precise diagnosis of *Nortonia*. In justification of the above genus-making however, it may be said, that the characters of *N. Patroclus* are exceedingly well defined, that our solitary specimen is apparently an adult shell, and is exceptionally well preserved, and that there is evidence of its maintaining its characters constant over a wide geographical area.

Deslongchamps. The original illustrations are far from satisfactory; but the figured shell has a spire which is identical in its form and proportions, and apparently also in its ornamentation, with the above type, and I therefore make this identification with some confidence in its accuracy.

Marlstone Rock, Tilton (East Norton embankment).

CERITHIUM ILMINSTERENSIS, Moore, 1866. Plate IX. Figs. 5*a*, 5*b*, 5*c*.

1865–6. *C. Ilminsterensis*, Moore, Proc. Somerset Arch. and Nat. Hist. Soc. vol. xiii. p. 200, pl. iv. s. 12, 12*a*.

There are a number of specimens of a shell which agrees in its general characters with Moore's type. These shells are twice the length of the type, with the same number of whorls, and also differ from *C. Ilminsterensis*, Moore, agreeing with *C. Dayii*, Tate, in having four rows of subspinous encircling costulæ instead of three in each whorl. These small points of difference do not, however, seem to me to be characters of specific value.

Marlstone Rock, Tilton (East Norton embankment).

PSEUDOMELANIA (CHEMNITZIA) BRANNOVIENSIS, Dumortier, 1869. Plate IX. Figs. 6, 7.

1869. *Chemnitzia Brannoviensis*, Dumort. Etudes Pal. sur les Dépôts Jurass. du Bassin du Rhone, pt. iii. p. 218, pl. 27, f. 11.

The Marlstone blocks on the East Norton embankment have yielded us a number of shells which, although of much smaller dimensions, seem to agree with this type of Dumortier's. Seeing that this fossil has not hitherto been recorded from the British Lias, the following description and the illustrations here given may be of interest to the students of the English Jura. I adopt the generic designation of Pictet and Campiche as applicable to this form. *Description*:—"Shell conical, short, imperforate; spiral angle regular; whorls eight, flat or very slightly convex, covered with transverse lines of growth, forming thick irregular obscure plicæ, which give origin close to the suture posteriorly, to a series of nodules, slightly scalariform. Aperture high, oval, very oblique, without callosity over the columella. The last whorl occupies nearly half the total height. Length to width 32 : 17. Spiral angle 43°."

East Norton specimens give: Height 22 mm.; Diameter 11 mm.; Spiral angle 42°.

Marlstone Rock, Tilton (East Norton embankment).

PSEUDOMELANIA (PHASIANELLA) TURBINATA, Stoliczka, 1861. Plate IX. Figs. 8, 9.

1861. *Phasianella turbinata*, Stol., Gast. und Aceph. der Hierlatz-Schichten, Jahrbuch der k. k. Reichsanstalt (Wien), vol. xliii. p. 177, pl. iii. fs. 1. 2.

Like *Ps. Brannoviensis*, this is fairly common at Tilton. The genus *Pseudomelania* is suggested as a more fitting generic appellation for this form also.

Marlstone Rock, Tilton (East Norton embankment).

TURBO RUGIFERA, Moore, 1867. Plate IX. Figs. 10*a*, 10*b*, 11.

1867. *Turbo rugifera*, Moore, Middle and Upper Lias, Proc. Somerset Arch. and Nat. Hist. Soc. vol. xiii. p. 209, pl. vi. figs. 23, 24.
Syn. ,, *Turbo coronatus*, Moore, Ibid. p. 209, pl. vi. figs. 21, 22, 22*.
Syn. ,, *Pleurotomaria costulatum*, Moore, Ibid. p. 205, pl. v. figs. 12, 13.

Fresh description.—Shell turbinated, conical, umbilicated, apex acute; whorls 6-7, convex, narrow, with a broad flattened area bounding the sutures anteriorly, ornamented by sharply raised spiral lines, of which there are six or seven on the penultimate whorl, crossed by numerous fine, regular, close-set oblique radial lines, which raise the spirals into neat granulations at their decussations; base very slightly convex, umbilicus deep and generally large, with a squarely angulated and crenulated edge; aperture nearly round and nearly free from the last whorl; outer lip thin, inner lip with a lunate shelly expansion anteriorly. A few fine spirals may mark the circumference of the base, and very faint concentric striæ are sometimes discernible between these and the centre of the base, over which the fine radial lines are continued in flexuous curves. Height 9 mm.; Diameter 8 mm. to 9 mm.; Spiral angle 60° to 92°.

Note.—There is evidently considerable variation within the limits of this species, and different appearances are presented by different individuals according as the spire is more raised or depressed, and according as the varying relative strength of the spirals gives a rounded or an angulated appearance to the whorls. It is not therefore surprising that the late Charles Moore made three species out of the three variable specimens of *Turbo rugifera* which he obtained from the Middle Lias Marlstone of Ilminster. The specimens collected by Mr. Crick at East Norton serve to link these three forms together, and indicate that *Turbo rugifera* is the true type. Having carefully examined the type of *Pleurotomaria costulatum*, Moore, in Bath Museum, I see no reason for considering that shell a *Pleurotomaria*. It shows no trace of a sinus-band, and appears to be only a highly granular and somewhat squarely-keeled example of *Turbo rugifera*, Moore. *Turbo coronatus* also is only a more fully grown shell of the same type, with the difference that the greater prominence and coarseness of one of the spirals gives its whorls a coronated aspect.

Marlstone Rock, Tilton (East Norton embankment).

TROCHUS ROTULUS, Stoliczka, 1861. Plate IX. Figs. 12*a*, 12*b*, 12*c*.

1861. *Trochus rotulus*, Stol., Gast. und Aceph. der Hierlatz-Schichten, Jahrbuch. der k. k. Reichsanstalt (Wien), vol. xliii. p. 173, pl. ii. f. 7.

In the Journal of the Northampton Natural History Society for 1883[1] Mr. E. A. Walford, F.G.S., quotes this fossil from the Marlstone Transition-bed of Aston-le-Wall and Appletree, and gives an illustration (loc. cit. fig. 5), which can however hardly be considered a satisfactory representation of this very elegant little shell. I trust the figures here given may be more successful. *Trochus*

[1] Journ. Northants Nat. Hist. Soc. vol. ii. (1883) p. 296, pl. fig. 5.

rotulus, Stol., must not be confounded with *Trochus Pethertonensis*, Moore, from which it is quite distinct.

Marlstone Rock, Tilton (East Norton embankment).

Pleurotomaria helicinoides, Roemer, 1836. Plate IX. Figs. 13*a*, 13*b*.

1836. *Trochus helicinoides*, Roemer, Die Verstein. des Ool.-Gebirges, p. 150. pl. xi. f. 13.

Syn. 1867. *Trochus carinatus*, Moore, "Middle and Upper Lias of the South-West of England," Proc. Somerset Arch. and Nat. Hist. Soc. vol. xiii. p. 207, pl. 4, fs. 24, 25.

non *Turbo canalis*, Münster, nec *Pleurotomaria helicinoides*, Roemer, of Tate.

Whilst agreeing with Mr. Ralph Tate, F.G.S.,[1] that *Trochus carinatus*, Moore, is a *Pleurotomaria*, and (in all probability) identical with *Trochus* (not *Turbo*) *helicinoides*, Roemer, I cannot go so far as to admit that these are the same as *Turbo canalis*, Münster—a *Pleurotomaria* truly, but a different species I maintain, to the above. The figure entitled *Pleurotomaria helicinoides* in the Yorkshire Lias is, I consider, an illustration of '*Turbo*' *canalis*, Mü., and not of '*Trochus*' *helicinoides*, Roemer.

The following descriptions and the accompanying figures of Tilton specimens will indicate the chief points of difference between these two forms.

Pleurotomaria helicinoides, Roemer (assuming this to be the equivalent of *Trochus carinatus*, Moore), is a smooth and even polished shell, with very clean cut and angular sculpturing; the whorls have an acute keel anterior to the middle line; on this keel is placed the sinus-band, which is bounded by a single rather widely-spaced raised line on each side; from the sinus-band the whorl falls vertically in front to the anterior suture, and slopes gently back in a single concave sweep to a raised line or faint keel close to the posterior suture; the last whorl bears a third angulated keel anteriorly, bounding the broad vertical area below (*i.e.* anteriorly); the shell is covered with very fine curved lines of growth; the base is only slightly convex, smooth, but bearing a few very fine acute concentric lines either limited to the outer part or continuous to the centre; there is a very small umbilicus; the aperture is transversely ovate, with ill-defined columella. Height, 8 mm.; greatest diameter 7 mm.; Spiral angle convex, about 70°.

Marlstone Rock, Tilton (East Norton embankment).

Pleurotomaria (Turbo) canalis, Münster, 1848. Plate IX. Fig. 14.

1848. *Turbo canalis*, Münster, Goldfuss, Petref. Germ. vol. iii. p. 95, pl. 193, figs. 12*a*, *b*.

Syn. 1878. *Pleurotomaria helicinoides*, Roem. sp. Tate, non Roemer, "The Yorkshire Lias," p. 338, pl. x. figs. 7*a*, 7*b*.

Whilst possessing the same general form of *Pl. helicinoides*, as above described, this shell presents rounded instead of angular contours, is far from smooth, and differs in its proportions as well as in its ornamentation. In *Pl. canalis* the keel bearing the sinus-band is situated posteriorly rather than anteriorly to the middle line,

[1] "The Yorkshire Lias," by Tate & Blake, p. 338, pl. x. fs. 7, 7*a*.

and is less angular, and the sinus-band is bounded by two much more closely set lines than in *Pl. helicinoides*. There is indeed a similar broad vertical and nearly smooth area below (anterior to) the sinus-band; but, excepting this, the whole shell from the apex of the spire to the centre of the base is covered with regular and prominent rounded spiral lines; two of these spirals situated in the middle of the sloping posterior portion of the whorls are more raised than the rest, and make the whorls appear more convex; the periphery of the last whorl also is rounded. Very slender curved radial lines may be discerned throughout the shell with the aid of a lens; but these are fainter than in *Pl. helicinoides*, and almost concealed by the spirals. The base is slightly convex; a very small, if any umbilicus; columella indistinct, and the aperture generally very like that of *Pl. helicinoides*. Height 8·5 mm.; width, 7 mm.; Spiral angle convex, about 75°.

Marlstone Rock, Tilton (East Norton embankment).

EXPLANATION OF PLATE IX.

FIG. 1. *Nortonia Patroclus*, d'Orb., Upper Lias, Railway cutting, East Norton, Rutland. *a.* Front view; *b.* back view. Enlarged twice.

,, 2. *Cerithium* (*Cerithinella ?*) *confusum*, Tate, Marlstone Rock, Tilton (East Norton Embankment). Enlarged one and a half times. *a.* Whorl further magnified.

,, 3. *Cerithium ferreum*, Tate, Marlstone Rock, Tilton. *a.* Front view; *b.* back view. Enlarged one and a half times. *c.* Whorl further magnified.

,, 4. *Cerithium costulatum ?* Desl., Marlstone Rock, Tilton (East Norton embankment). Enlarged one and a half times. *a.* Whorl further magnified.

,, 5. *Cerithium Ilminsterensis*, Moore, Marlstone Rock Tilton (East Norton Embankment). *a.* Front view; *b.* back view. Enlarged one a half times; *c.* Whorl further magnified.

,, 6. *Pseudomelania Brannoviensis*, Dumort., Marlstone Rock, Tilton (East Norton embankment). Front view. Enlarged one and a half times.

,, 7. *Ibid.* From another specimen. Back view, similarly enlarged.

,, 8. *Pseudomelania turbinata*, Stol., Marlstone Rock, Tilton (East Norton Embankment). Front view. Enlarged one and a half times.

,, 9. *Ibid.* From another specimen. Back view, similarly enlarged.

,, 10. *Turbo rugifera*, Moore, Marlstone Rock, Tilton (East Norton Embankment. *a.* Front view; *b.* back view. Enlarged twice.

,, 11. *Ibid.* Base, from another specimen, with an exceptionally large umbilicus. Similarly enlarged.

,, 12. *Trochus rotulus*, Stol., Marlstone Rock, Tilton (East Norton Embankment). *a.* Front view; *b.* back view. Enlarged twice. *c.* Whorl further enlarged.

,, 13. *Pleurotomaria helicinoides*, Roemer, Marlstone Rock, Tilton (East Norton Embankment). *a.* Front view; *b.* back view. Enlarged four times.

,, 14. *Pleurotomaria canalis*, Münster, Marlstone Rock, Tilton (East Norton Embankment). Enlarged three times.

(*To be continued.*)

III.—WAS THERE AN ARCTIC OCEAN IN THE MAMMOTH PERIOD?

By H. H. HOWORTH, Esq., M.P., etc., etc.

THE convergence of opinion is now so strong that the climate of Siberia in the Mammoth age was sufficiently temperate to enable trees to grow where only the bare tundra is at present found (if it does not necessitate our extending the forest zone at least as far north as the Liachof Islands), that it becomes at once interesting and important to consider under what conditions such a result would be forthcoming.

The fauna of the polar lands is so uniform in all longitudes that they constitute one of the best-defined zoological provinces; a province to which the name Circumpolar or Panarctic has been given. So far as our evidence goes, the solidarity and identity of forms which now mark the circumpolar lands was shared in the Mammoth age by a considerable zone south of this area, a zone now constituting the greater part of the Palæarctic and Nearctic provinces of Mr. Sclater. If we are to judge by the remains which we can examine of the Mammoth and its contemporaries the Musk Sheep, the Bison, the Horse, the Elk, the Red Deer, the Reindeer, etc., etc., from the Old and the New World, there were not in the Mammoth age the distinctions which now mark off the mammals of North America from those of Northern Asia, and the panarctic and nearctic regions were then condensed into a fairly homogeneous zoological province.

This means of course that there must have existed in the Mammoth age a bridge over which the mammals at least could travel between the Old and the New World and *vice versâ*. Such a bridge would enable the animals to intermingle, and prevent isolation, which is the recognized *causa causans* of divergence of forms. If this be granted, and I cannot see how it can be contested, we have next to discover where this bridge was situated. In my work on the Mammoth I have followed in the footsteps of Mr. A. Murray, and enlarged his reasons for believing that it is quite impossible to suppose that this intermigration took place across *the ice* of Bering's Straits. In addition to the arguments there adduced, I would remark that if Bering's Straits were frozen over, it could only be under climatic conditions, when the Mammoth and its companions would find it impossible to exist on the land on either side of that water-way; and if we postulate (as the facts compel us to do) a comparatively mild winter climate in the Tchukchi peninsula and Alaska when the Mammoth lived, then we cannot also postulate that Bering's Straits were at the same time closed by thick ice such as would alone afford a highway for the animals to travel over. The notion that the intermigration took place over the ice of Bering's Straits is in fact an immature and very superficial one.

Putting aside a highway of ice across Bering's Straits, we are bound to postulate a land communication between Asia and America at this period, and the question is, where this bridge was planted.

It is quite clear that, wherever placed, it must have connected the Mammoth area on the one continent with the Mammoth area on the other, and since, the Mammoth, so far as we know, did not live in Japan, but was there replaced by another species of Elephant, this communication must have been north of Japan. Inasmuch as neither the Tichorhine Rhinoceros, nor the Hyæna, nor the Great Ox (*Bos primigenius*), whose remains are all found along the latitude of Central Siberia (the Rhinoceros occurring as far north as the river Wilui), have ever been found in America, and, so far as we know, they never reached that continent, it is *prima facie* almost certain that the connection required must be found further north than these latitudes; and this is confirmed when we compare the living mammals and birds of Japan with those of America.

This makes it probable that the required bridge was in fact situated at a high latitude, where we must suppose that the conditions, although compatible with forest growth and consistent with the Mammoth, the Elk, the Red Deer, and other forest-frequenting animals finding food, etc., were too severe for the Rhinoceros, the Hyæna, and the Great Ox to find congenial quarters. That it was situated here is further proved by the very close resemblance, if not identity, of the living Rocky Mountain Sheep with that of Kamschatka.

Turning to another class of evidence. I have elsewhere adduced arguments to show that the mammal remains found in the New Siberian Islands and in the Bear Islands (the former 250 miles away from the Siberian mainland) are the remains of animals which actually lived where these remains occur. These islands and the opposite coast are at this moment rising from the sea, and laying bare new sand banks containing heaps of Mammoth and other bones, which are so fresh and sharp and unweathered, that it is clear they have been lying where the animals died. All this makes it exceedingly probable, if not certain, that when the Mammoth lived the Siberian Islands, the Bear Islands, and probably also the small islands discovered in the Jeannette Expedition, on which semi-fossil bones were found, formed part of the mainland, and that the more or less temperate conditions which I have postulated of Northern Siberia then extended at least as far as these islands.

This is very interesting, because, if we postulate so much, we have no difficulty in going further. The deepest soundings found by Nordenskiöld and other explorers between the Siberian Islands and the mainland are about 22 or 23 fathoms. This, again, is the greatest depth which has been sounded in the northern part of Bering's Straits between America and Asia; so that, if the movement of elevation which united the New Siberian Islands to the mainland was as general and widespread as the present elevatory movement in the Arctic regions is, then it follows that the uniting of the Siberian Islands with the mainland was accompanied by the bridging over of the space between North-Eastern Asia and Northern Alaska; thus forming an isthmus between the two continents. We may perhaps go even further, and say that, inasmuch as the present elevatory movement over the whole Arctic basin is general and widespread (as I ventured to show many years ago in a paper read before the Geographical Society, which was reprinted in the Arctic Manual), and inasmuch also as the general evidence goes to show that the portion of the Arctic basin east of Nova Zembla is shallow, it follows as very probable that a large portion of what is now occupied by that sea was in the Mammoth age dry land, and not only dry land, but land upon which trees would grow, and therefore within the climatic zone marked by forests.

This conclusion is largely supported by the fact that Maclure and other Arctic explorers actually found remains of some fossilized trees of species still living in North America in some of the islands of the Arctic Sea east of the River Mackenzie. These trees were rooted in the ground and *in sitû*, and grew therefore very far to the north of the present range of trees in the New World.

The reasoning I have ventured to adduce is based upon empirical evidence. If, as it seems to me, it is well founded, then it follows that the circulation of ocean currents in the Northern Hemisphere must have been entirely different from what it is now, since there was a barrier preventing the outgoing Arctic current from passing through Bering's Straits. Such a change must have materially altered the climate.

Secondly, the climate must have been very largely modified over the whole of Northern Asia in another and more direct way; for the north winds which are now so keen and killing, since they come straight from the great northern reservoir of ice which is never at a higher temperature than 32°, would then come from a land of grass and trees, and be correspondingly softened. This would have a very great effect upon the Siberian climate in the direction of making it consistent with the Mammoth, the Horse, and the Bison finding food and shelter in the area between Alaska and Northern Asia. *Pro tanto* this is a solution of the question of how to account for a mild climate in these high latitudes. It does not, however, exhaust the problem, and other causes remain, which perhaps you will let me discuss on another occasion.

IV.—On some Modes of Formation of Coal-Seams.

By J. G. Goodchild, F.G.S., H.M. Geol. Survey.

(Based upon a paper read before the Royal Physical Society, Edinburgh, on the 17th April, 1889.)

The commonly-received theory that most coal-seams represent vegetable matter that has grown and has been entombed on the spot has never been received by all geologists with quite that measure of satisfaction that has been accorded to other theories of the same general nature. It has been felt again and again that the explanation referred to might be true enough for certain cases; but that in others it failed to account satisfactorily for all the phenomena. It involved too many complications—too nice an adjustment of the rate of growth of the vegetation to the rate of subsidence and of sedimentation—too much straining of the theory in question generally—to be accepted unhesitatingly by those accustomed to judge of such facts for themselves. That certain beds of coal have been formed by the growth of vegetation on the spot no reasonable person can doubt: the only question is whether that is true of every coal-seam. Many competent observers have thought it is not; and the number of those who are dissatisfied with the view set forth in most text-books is certainly on the increase. Mr. W. S. Gresley, and several other geologists, have lately advanced good arguments in favour of other views, which many are disposed to accept as correct.

Perhaps the truth in this case, as in many others, may be that similar results have been attained in a variety of ways, and that, instead of there having been but one mode of formation of coal-seams, there have probably been many.

We might briefly consider some of these at this point. The formation of coal simply requires that a certain quantity of pure vegetable matter should be left at any given spot under conditions that insure its conversion before its chief constituents shall have passed into the inorganic condition. These results may be brought about in a variety of ways. Inland, for example, coal or its representative, lignite, may be formed through the burial of peat beneath the alluvium of lakes or of rivers. In marine areas it may arise through the sedimentation of inland peat whose constituents have been re-sorted and drifted out to sea. The submergence and subsequent burial of maritime beds of peat *in sitû* may, under suitable conditions, give rise in another way to beds of coal. The entombment of masses of drift-timber that have floated seawards must, again, largely contribute to the same result. Marine vegetation must occasionally play an important part in the formation of deposits of carbonaceous matter on the sea-bottom.[1] Then there is the important factor of the growth, decay, and entombment on the spot, of lagoon vegetation, originating in an area where deltas are subsiding intermittently, and with minor oscillations of level. Lastly, coal may be formed, as an ordinary sedimentary deposit, by the slow accumulation, in quiet water, of deciduous, or other, vegetable matter, floated seawards from riparian forests. Each of these modes of formation of coal must have played important parts in the formation of coal-seams, at every period of the earth's history, from the dawn of vegetation down to the present day. The *exclusive* advocacy of any one mode is therefore as illogical as it is unnecessary. It seems to me that the last mode referred to has not received quite as much consideration as its importance deserves, and I propose therefore, while attaching equal importance to the other modes, which are already well understood, to consider this particular one in some little detail. Before proceeding to do so it may be as well to review some of the facts connected with the mode of occurrence of coal-seams in general, with a view of arriving at a clearer idea of their various histories.

It is now admitted on all hands that the principal constituents of nearly every coal-seam represent so much carbon that has at one time existed in the form of carbonic acid in the atmosphere, whence it has been extracted by the vital forces of growing vegetation. Subsequent pressure accompanied by certain chemical changes, well understood, have converted this fixed carbon into coal. The precise nature of the vegetable matter forming the coal varies within wide limits, not only on account of the varied ages, or the geographical position, of the seams themselves; but even within the coal-seams belonging to any one geological period and situated at the same part of the earth's surface. There is, further, much diversity in the

[1] I know of no evidence that *marine* vegetation (i.e. *Algæ*) is capable of conversion into coal.—Edit. G.M.

proportion that the different parts of the plants bear to each other in different seams. As a rule, tree trunks form but a small part of any coal-seam; and in the rare cases where they do so occur, they are not found in the position of growth, or extending upwards through the seam, but are prostrate, and lie parallel to the bounding surface of the coal. The coarser portions of the organic constituents of coals present a mixture, in variable proportions, of the more solid parts of the vegetation in a fragmentary state, together with portions of the cellular and the vascular tissues of the plants. Even such constituents as these are commonly in the minority. Fronds, leaves, and small stems occur rather more plentifully. But the greater part of the recognizable organic constituents of most coal-seams consist of a varied assortment of finely-divided vegetable tissue, together with spores, spore-cases, and bodies of that general nature. Some parts of nearly every coal-seam commonly fail to show any definite structure at all. The relative proportions of these varied constituents differ considerably in different coals; but the peculiar constitution of each coal-seam as a whole remains tolerably uniform over large areas. Not only do the constituents of each coal-seam as a whole differ from those of the seams associated with it, but the component layers of each seam differ amongst themselves. Every coal-seam is seen, on a very cursory examination, to be simply an aggregate of carbonaceous laminæ, which are ordinarily thin, and are occasionally of almost microscopic proportions. A close examination of these laminæ shows that they differ each from the other to a much greater extent than a cursory examination would lead one to suppose. More than that. The structural characters of each of the lamina, whatever its thickness, remain constant to such an extent as to enable one to identify that particular lamina over a large area. Practical coal-miners are well aware of this fact, although they may not always be able to point to the precise nature of the distinction in each case. One lamina may contain nothing but spores and spore-cases; a second next it, above or below, may consist of leafy matter alone; a third may be characterized by the constant presence of mineral charcoal, representing the vascular tissues of the old vegetation; a fourth may be devoid of any evident traces of organic structure; or another lamina of the same coal-seam may contain, along with its organic constituents, a variable amount of impurities of organic origin. And yet, however, the several laminæ may differ among themselves, they are found to retain their own special characteristics throughout the whole of a large coal-field. Even where the coal happens to be changeable, as it often is near old irregularities of the floor upon which it lies, the rate of change is far from being rapid, except, of course, where the coal is splitting up through interlaminations or partings of inorganic matter.

Some coal-seams pass into shales, by a progressive increase in argillaceous impurities; but they rarely, perhaps almost never, graduate into sandstones; although some irregular and lenticular deposits, which clearly represent drifted vegetation, may often do so. Coal not uncommonly graduates into carbonaceous clay ironstone.

In rarer cases still the change can be traced through this last into impure limestone. Of this more presently.

Sedimentary formations of nearly every geological period contain coal-seams in one part of the earth's surface or another; and under every variety of geological or of geographical circumstances they present much the same features; and—allowance being made for the changes the containing rock may have undergone—their composition also is in nearly all cases practically constant. It would seem, therefore, that the formation of coal does not require any very exceptional conditions, such as an excess of carbonic acid in the atmosphere, or other abnormalities.

There is often a curious (and significant) relation between the nature of the rocks associated with coal and that of the vegetable matter entombed therein. In the Carboniferous series proper the sedimentary strata associated with the coals are usually shales; fireclays, and beds of sandstone of various degrees of coarseness also occur. In certain areas limestones and calcareo-siliceous beds ("cherts") are also found. Vegetable remains commonly occur dispersed throughout all of these, though the proportion varies much with the nature of the rock. It is in the coarse, drifted, material forming the sandstones, that tree trunks, if they occur at all, are most commonly found. And it is here that they are so often found embedded stem upward and root downward, reminding one so forcibly of the "snags" that are common in the sandy deposits of tropical rivers. (It should be noted, in passing, that the centre of gravity of most of the trees of the Carboniferous period must have lain close above the roots; so that in floating, they must have travelled root downwards, and as the decay of the soft interior proceeded, they must have tended invariably to sink to the bottom in nearly the position of growth.) The shales associated with coals rarely contain trees (I have not come across any proof that they ever do so); but fronds and leaves occur in plenty, and, more rarely, stems and small boughs may occur as well. The fireclays (which are commonly regarded as old soils that have been exhausted of their alkalies and iron by the growth thereon of vegetation) often, but by no means invariably, contain roots—the well-known *Stigmaria*—in addition to the vegetable constituents found in the shales. Some sandstones show these *Stigmaria* roots as well, whether the rock is directly associated with coal or not. If limestones occur with the coals, these rarely contain traces of coal, except as lenticular masses, which are clearly due to the entombment of vegetable matter that has been drifted. A fine and well-known example of this kind is seen in the Mountain Limestone of Ingleton in North Yorkshire.

A careful consideration of these facts relating to coal will make it clear that, whatever be its precise mode of origin in any given case, coal presents all the characters of a stratified deposit. It resembles most closely, in many of its characters, those strata that have slowly and quietly accumulated in nearly-still water. The resemblance to a stratified deposit is certainly not delusive and to be attributed to the effect of subsequent compression, because, as we have seen, the component laminæ have each structural characters of their own, marking them off from those above and below, and remaining constant over wide areas.

Much stress has been laid upon the intimate association that is said to exist between seams of coal and beds of fireclay. But every practical mining engineer must be well aware of the fact that the two kinds of rock are by no means universally associated. Thick beds of fireclay occur in the Argill Coal-field near Kirkby Stephen, Westmorland,[1] without a trace of coal near. One such bed is thirty feet in thickness. On the other hand, in certain rich coal-fields such a rock as fireclay (or as gannister) is conspicuous by its absence.

Having glanced at an outline of the facts, we may pass on to consider one of the various modes of formation of coal—the others referred to are so obvious that no one can well have any doubt as to their validity in the present connection. As an illustration of what takes place, we may consider the sequence of events that must obtain in the case of any large river that is carrying seawards the spoils of a riparian forest region. Such a river transports vast quantities of inorganic materials; as well as more or less floating animal matter, which is partly terrestrial, partly fluviatile, partly estuarine; there is, in addition, variable quantities of vegetable matter of all kinds—big tree trunks, boughs, stems, leaves, fronds, spores and spore-cases, and all the miscellaneous deciduous vegetable matter that may be derived from every part of the forest region above. The river does not transport its heterogeneous burden at a uniform rate of motion, nor does it drop it all at the same place. Far from that. The coarser mineral sediment drifts seawards along the bottom for a time, but finally comes to rest at no great distance from the land. Some of the tree trunks that have travelled so far as to become water-logged at this point sink here; and, obeying the laws of gravity, they sink with their heavier ends downward and are eventually buried root downward in the coarse sediment. Most of the animal matter, which decomposes quickly, also sinks near, and may be buried along with the trees. The finer inorganic matter drifts in suspension farther out to sea, where it subsides in crescentic zones on the seaward side of the coarser material, and entombs such of the vegetable matter as may have become water-logged at that part. Farther out to sea, or where the submarine currents have lost most of their transporting power, the finest sediment, after rolling about in clouds for a time, gradually subsides to the bottom, and there entombs also such of the vegetable matter whose constitution has enabled it to travel so far. Seaward of the zone where this happens quiet and still water prevails on the sea-bed. Here the littoral forms of marine life do not commonly reach; and here also, it is commonly assumed that little or no organic matter transported from the land ever reaches. Most of the animal remains that may have floated down the river have probably all sunk, and been

[1] "On the Former Extension of Coal Measures over Edenside," Trans. Cumb. and Westmd. Assoc. No. vii. p. 163.

entombed in the zones nearer the land; but with vegetable matter the case is different. Vegetable matter has a low specific gravity, and its ordinary tendency is to float. It is only under certain conditions, and after long maceration, that it sinks at all; and even in that case such of it as is in a fine state of division is especially long in reaching the sea-bed, even where the bottom is quiet and comparatively shallow. In the case we are supposed to be reviewing some of the vegetable matter that enters the river near its source becomes so far water-logged by the time the estuary is reached as to subside to the bottom just outside the zone where the sea-bottom is affected by the stronger submarine currents. Much more of the vegetable matter remains suspended long enough to be transported to a zone on the seaward side of the last referred to. But most of what has been here referred to as the deciduous parts of the vegetation, the leaves, fronds, the resinous spores and the spore-cases, together with the half-decayed parts of the cellular and vascular tissues of the plants themselves, remain in suspension so long, and subside to the bottom so gradually, that by the time they have finally settled, the submarine currents have transported them seawards to a zone well outside that attained by any but the very finest sediment.

There must, therefore, be a constant sorting out of the varied material brought down by the river, and it must be that which remains longest in suspension that is transported farthest from the land. In this way accumulations of vegetable matter, pure, and unmixed with mineral sediment, must be slowly and quietly gathering off the mouths of most of the rivers that traverse regions abounding in vegetation.

It is important to remember that all the while the physical conditions of land and sea remained unchanged, the deeper water deposits, at all events, would continue to be laid down uniformly; so that, if no disturbance of the relative levels of land and sea occurred, there would practically be no limit to the quantity of vegetable matter that might thus accumulate in the course of time.

There is another point to be noticed in more detail. The rate at which any given vegetable organism will sink depends upon several conditions. Its specific gravity is one of the most important; then follows the time it has been exposed to maceration; the velocity of the currents affecting it must affect the results materially; and even the form of the vegetable body itself must be taken into account as a factor. But the most important factor of all is the power of resistance the body presents to the forces that are tending to reduce it to the inorganic condition. If it rots quickly when exposed to maceration, it will become water-logged after only a short journey, and may reach the bottom within the zone of deposition of even the coarser sediment. But if it be of a nature to resist the effects of maceration for long periods (as the resinous spores, etc., most certainly are), then it will be longer in becoming fully saturated with water, and may drift in suspension many miles to the seaward of the point where its original fellow-travellers came to the ground.

One can readily imagine to what different distances the leaf of an oak and one of some tender annual would travel if they started together in the same current. And the difference thus exemplified was probably often as marked in the case of the vegetation forming coal.

In consequence of this relative power of resistance to maceration, a further sorting out of the different vegetable bodies from each other must be in progress. Leaves of one kind subside within one zone, those of another kind within a second; spores, being resinous, must resist maceration longer, and therefore reach the sea-bottom at a zone more distant still; and so on, each kind tending to be sorted out into zones by themselves.

With any disturbance of level the absolute position of any one of these zones must change; but their relative order must, if other conditions remain constant, be the same as before. With a slight upward movement, or with a shallowing of the water of the estuary, due to the seaward advance of banks of sediment, shore conditions advance seaward, and clay, or even coarser material, may be spread over the zone where under former conditions only vegetable matter was left. Such a process might continue until the whole of the depth between the sea-level and that of the old submarine peat had been silted up and converted into dry land. Soils might thus be formed, and lagoon vegetation start into existence, not far above the old submarine deposits of carbonaceous matter. With a slight depression thalassic conditions advance towards the former coast-line, and limestone might be built up where just before coal had been formed. In this case it is important to remember that the formation of the coal would still go on, only that the outer zone where this happens would be situated on the landward side of the limestone zone. The two, however (the coal and the limestone), must be contemporaneous, even though they are not deposited in exactly the same area.

The amorphous parts of coal, and, indeed, much of its present character, owe their peculiarities to the fact that there is a constant reaction going on in sea-water between the sulphate of lime in solution and the bituminous matter carried down in suspension. The bituminous matter is acted upon by the sulphate of lime, and is thereby partly dissolved, and under particular conditions returns to the solid form; while the decomposing vegetable matter, in its turn, reacts upon the sulphate of lime, giving rise eventually to a precipitate of lime in the form of carbonate. Where the proportion of vegetable matter is in excess, beds of impure limestone result; but where, as in the case of inland lakes, an unusually large percentage of sulphate of lime is present, geological facts warrant us in concluding that the whole of the vegetable matter is dissolved. Hence the marked (and otherwise puzzling) absence of vegetable remains in Red Rocks of all kinds. Hence, also, the presence of bitumen in connection with saline lakes. I am inclined to believe that the conversion of vegetable matter into coal is partly affected by the action of the sulphate of lime in sea-water. Where this substance is only present in small quantities, as in fresh-water lakes, the vegetable matter is left simply as lignite.

If we study the details recorded from borings in the deposits forming any great delta, we cannot fail to be struck with the correspondence between these details and those of the case we have been considering. The beds of "peat" so commonly met with generally represent, I consider, the deeper-water accumulation of vegetable matter I have so often referred to. Some, of course, may be true soils; but the majority are far more likely to be due to the causes above noticed. If this view be accepted as true in the main, then it is obvious that we must cease to regard these beds of "peat" as evidence of the former presence of dry land at a platform that owes its present position to submergence at a later date. They should be regarded as simply an integral part of the normal sedimentary deposits that had been formed there; the peat representing, not shallow water nor subaërial conditions, but simply deposits that had been laid down in the ordinary course in water that was comparatively deep.

We have but to imagine such beds of the submarine "peat" exposed to the necessary conditions of pressure and chemical change, and beds of coal would be formed identical in nearly all respects with such as had grown, had died, and had been entombed on the spot.

V.—Note on some Pebbles in the Basal Conglomerate of the Cambrian at St. Davids.

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

More than one kind of rock, as we learn from Dr. H. Hicks and other writers,[1] occurs in the conglomerate which forms a well-marked base to the Cambrian system at St. Davids. Sometimes the pebbles are mainly vein quartz, sometimes felstone predominates, but occasionally, as in the neighbourhood of Nun's Chapel Bay, quartzites (using the term rather generally) are not uncommon. At one place, not far from a quartz-felsite dyke, these are rather large, occasionally about a foot in diameter. From this locality, while spending a few days at St. Davids in 1882, I brought away specimens of three of the most marked varieties of quartzite, of which I had slices prepared, thinking that as examples of rocks which were probably far from modern at the beginning of the Cambrian age, their structures might be instructive. In this I was not disappointed, and now that I have had many opportunities of comparing them with various quartzose rocks, both Palæozoic and Archæan, I think a brief description may have some general interest.

The first, and least remarkable, was broken from a rather angular block about a foot in its longest diameter. The rock is a quartzite, rather compact or even vitreous in aspect, nearly white, or of a very pale pinkish-grey colour. Microscopic examination shows it to be composed almost entirely of quartz. This occurs in grains, from

[1] Q.J.G.S. vol. xl. p. 567, *id.* (Blake) p. 294.

subangular to rather rounded in form, which are often about ·015″ to ·02″ in diameter. It is difficult to be quite certain of the boundaries of the original fragments, but secondary quartz more or less in optical continuity with the original grain has undoubtedly been deposited to some extent. Here and there a tiny flake of light-coloured mica, or a little opacite or ferrite, may be seen, indicating no doubt the residue of the dusty material once present in the original sandstone. One or two of the fragments exhibit a compound structure. Very minute fluid cavities with bubbles are rather numerous in the quartz grains; but on these, and a few tiny accidental microliths, it seems needless to dwell.

The next specimen comes from a block of nearly the same size. It is a fine-grained quartzite, slightly rougher in texture and fracture than the last, and of a purple-grey colour. Examination with a lens shows that, though composed mainly of quartz, a good many tiny flakes of silvery mica are present. Microscopic examination shows that the quartz grains, though rather smaller in size, are very commonly about ·012″ diameter, and somewhat rounded or bluntly polygonal, but slightly wavy in outline. Occasionally they are separated by a flake of mica: more often a few specks of opacite or ferrite indicate the position of the original contact surface. Doubtless the original grains have been augmented by deposit of secondary quartz; but, even more than in the former case, it is difficult to fix the position of the old surface. Still I should infer that the grains had once been fairly regular in outline. Fluid cavities appear to be less numerous than in the former case. The mica is white or a very pale greenish tint; it occurs sometimes in isolated flakes, but is frequently associated and occasionally almost forms "nests," when it is usually mixed up, more or less, with dark granules, which are probably, in part at least, hematite and magnetite. The larger flakes are about ·01″ in length, but the majority are smaller. The sections are fairly rectilinear in outline: the shorter ends not appearing either ragged or "nipped." Even if originally fragmental, these flakes must have been subsequently enlarged, and I suspect that they have been to a great extent, if not wholly, developed *in sitû*. Possibly some tiny crystals of zircon and rutile are present, with perhaps a grain of epidote; but these accessories are so unimportant, that I have not cared to waste time in attempting to determine them with precision.

The next fragment is from a fairly rounded stone about four inches long. This quartzite is whitish in colour, and in structure is fine-grained and rather schistose. Microscopic examination shows that quartz is the principal mineral. The grains commonly present 'ragged' outlines, and are unequal in dimensions, tending to lie with their longer axes parallel. When viewed with crossing Nicols each grain exhibits a border tinted rather differently from the inner parts. This might be produced by the overlapping of the irregular edges of two contiguous grains; but as the tint in some cases continues practically uniform all round the grains, it must result either from a fairly regular thinning of the latter, or from a deposit of secondary quartz which is not in optical continuity with that of the original grain. The mica flakes, practically colourless, vary in length up to about ·006″, and often lie between this and ·004″, they tend to lie parallel one to another, and exhibit bright tints with crossed Nicols. The slide contains two or three grains of brown tourmaline, some microlites of zircon and rutile (probably), some tiny flakes of iron-glance, and some opacite or ferrite.

It seems reasonable to suppose that all these rocks were originally clastic, consisting of moderately worn fragments of quartz, which must have been derived from some more ancient and probably granitoid rock, with a variable amount (in one case extremely little) of mud, which has subsequently been converted into white mica and secondary quartz.

My collection contains a fair number of slides representing quartzites of Palæozoic or presumably Palæozoic age, from various localities in Britain[1] and from a few other quarters. These, however, differ slightly from the first-named specimen, and considerably from the others: the alteration of the constituents, especially in regard to the more earthy, being less complete. But the second specimen bears in some respects a close resemblance to certain quartzites which I obtained from the Huronian Series near Sudbury in Canada.[2] In these we find mica flakes, if not developed, at any rate completed *in sitû*. True, in most of these specimens the mica is brown, but white mica may also be found, especially in one whitish quartzite which much resembles this rock from St. Davids. Again, the third fragment from that locality is different from any specimen of Palæozoic quartzite which I have ever examined, and closely resembles the schistose quartzites or quartz-schists which I have found associated with the more fine-grained mica-schists and chlorite-schists in the Alps and elsewhere. It almost exactly resembles one described by me[3] from above Windisch-Matrei (Tyrol), except that the last-named is slightly coarser in texture and a little more definitely foliated. Both the second and third specimens from St. Davids present some resemblance to a quartzite[4] which, at Pen-y-Parc, near Beaumaris (Anglesey) occurs in association with one of the greenish-grey micaceous schists, which are so abundant in that island.

The quartz grains in the more highly-altered quartzose rocks of clastic origin exhibit under the microscope (as no doubt has often been remarked) a fairly distinct peculiarity of aspect. The edges of the individual grains appear, as it were, fused together. The line of junction is often slightly wavy, irregular, almost inter-

[1] *e.g.* N.W. Scotland, Hartshill, Lickey, Wrekin, Stiper Stones, N. Wales, Cherbourg, the Ardennes, pebbles from Carboniferous and Triassic rocks, etc.

[2] Described in Q.J.G.S. vol. xliv. p. 32.

[3] Q.J.G.S. vol. xlv. pp. 87–105.

[4] See Q.J.G.S. vol. xxxix. p. 47 (note). Prof. Blake (*id.* vol. xliv. 475, 508) calls this a quartz knob, and seeks to show that it has more resemblance to a vein product than to a rock of clastic origin. I cannot, of course, answer for the specimen which he examined, but can only say that if my slide does not represent a quartzite, I have never seen one.

locking, as if the mass had been reduced to a plastic condition and then slightly but rather uniformly compressed in all three dimensions of space, or as if the grains had been growing gradually outwards at the expense of a semi-fluid magma which had filled up all the interstices. A rather similar aspect is presented by quartz grains, which have formed (often mainly by segregation—though no doubt frequently around a clastic nucleus) in a 'silty' rock which has been much affected by 'contact metamorphism.'[1] A similar aspect is presented by the quartzes in certain quartzose schists, which are presumably metamorphosed sediments, and which do not appear to have been subsequently very distinctly modified by pressure. This peculiarity—though distinct to an accustomed eye—is not very easy to describe in words or even to represent diagrammatically; but an idea of it may be obtained by comparing the lower half of figure 3 (omitting some of the small interstitial granules) with figs. 1 and 2 and the upper halves of 3 and 4 of plate xxxi. in the late Prof. R. D. Irving's excellent paper on the Archæan Formation of the North-Western States.[2] A hard and fast line, as indeed these figures show, cannot be drawn between this structure and that of an ordinary quartzite—still, I believe, a very large number of specimens can be classed under one or the other type; and I am quite certain that if these three specimens from St. Davids had been sent to me (as specimens often are sent) without any clue as to their geological horizon, I should have returned them with the remark that they had the appearance of being very ancient rocks.

Here, then, at the base of the British Cambrians, we find, in three specimens selected as fair samples of the materials of a conglomerate, structures, of which one indicates that the rock is not likely to be anything but ancient; the second is more like the structure of the Huronian quartzites than of any indubitable Palæozoic quartzite which I have examined; and the third resembles that of quartz-schists, which are almost certainly Archæan, though they probably do not belong to the oldest part of that series. The structures also of these two are not such as are suggestive of pressure metamorphism, but of slow molecular change, under constraint indeed, in the presence of water, and at a fairly high temperature. Thus the evidence of these pebbles, so far as it goes, is favourable to the opinion that, as a general rule,[3] rocks of Archæan age may be identified by their structures, and that the conditions under which they consolidated have recurred, if at all, only rarely and locally.

[1] See, for instance, Q.J.G.S. vol. xliv. p. 16.

[2] United States Geological Survey, Fifth Annual Report, 1883–4.

[3] I must not be supposed to assert that a hard, fast, and universal line can be drawn between Archæan and Palæozoic (or Cambrian and Pre-Cambrian) any more than between Palæozoic and Mesozoic or between any other geological groups, systems, or classificatory divisions.

VI.—The Present State of the Archæan Controversy in Britain.

By Charles Callaway, D.Sc., F.G.S.

THE Archæan question in this country may be said to be about twelve years old. Rocks older than the Cambrian had indeed been recognized by Murchison and Sedgwick, and brief notices of Pre-Cambrian masses at St. Davids had been published by Salter, Harkness, and Hicks; but the Archæan campaign was formally opened by Dr. Hicks in a paper read before the Geological Society in November, 1876. The attack upon the old views was followed up by Prof. Bonney, the Rev. Edwin Hill, Prof. Hughes, and myself, and, more recently, by Prof. Lapworth and Prof. Blake. The defence has been conducted by Dr. A. Geikie. The controversy has been animated, and not without sensational incidents. Great diversity of opinion has existed even amongst the assailants, and many important divisions of the inquiry must be still regarded as unsettled. The most noteworthy difficulty which has arisen in the progress of our work is the dynamic theory of metamorphism. My chief purpose in writing this paper is to show how far this theory affects our old conclusions; but I shall incorporate any facts necessary to give a true outline of the present state of opinion on the Archæan rocks. I use the word "Archæan" as strictly equivalent to "Pre-Cambrian."

St. Davids.—Dr. Hicks originally described[1] two groups, the Dimetian and the Pebidian. He subsequently[2] introduced an intermediate formation, the Arvonian. According to Dr. A. Geikie,[3] the Pebidian is merely the base of the Cambrian, while the Dimetian and Arvonian are granites and porphyries intrusive in the bedded rocks. Prof. Blake[4] regards all Hicks's groups as Archæan, but he would convert them into one continuous series. I cannot speak from adequate personal examination of the ground; but analogy with other districts would rather suggest to me that the granite and porphyry (the Dimetian and Arvonian) form a group distinct from and older than the Pebidian, and that the Pebidian also is Pre-cambrian.

Shropshire.—Out of the "intrusive greenstones" of Murchison and the Survey, it has been found possible to construct two well-marked Archæan groups.[5] The older of these, consisting of granite and gneissic rocks, I have called Malvernian, from their probable equivalence to rocks of the same character at Malvern. But the new views of metamorphism deprive the term "equivalence" of its ancient meaning. The rocks in question are granites and diorites, which under the influence of earth-pressures have here and there acquired a gneissic structure. These igneous rocks are alike in the two localities, the results of the metamorphism are similar, and there is in both cases a marked unconformity to the Cambrian. We,

[1] Quart. Journ. Geol. Soc. 1877, p. 229.
[2] *Ibid*, 1879, p. 285.
[3] *Ibid*, 1883, p. 261.
[4] Quart. Journ. Geol. Soc. 1884, p. 294.
[5] *Ibid*, 1879, p. 643.

therefore, may infer a general equivalence; but it cannot be proved that the process of schist-making was strictly contemporaneous in the two districts. It may however be safely asserted that the Malvernian rocks are Older Archæan; for the principal types, granites and modified diorites, occur as derived fragments in the conglomerates of the Newer Archæan of Shropshire.

The Newer Archæan, the Uriconian, is a volcanic group resembling the Pebidian of St. Davids, of which it is the probable equivalent. But recent discovery suggests that this well-known formation may have to be thrown back to a period more remote from the Cambrian than has commonly been supposed.

The slates, grits, and conglomerates of the Longmynd have been usually regarded as the stratigraphical equivalent of the Llanberis and Harlech groups. For some years, I have doubted the accuracy of this determination. In 1878,[1] in announcing the discovery of Cambrian rocks at Caer Caradoc, I described a thin band of limestone in the Hollybush Sandstone at the north-eastern extremity of the ridge. This limestone was fossiliferous, yielding, besides *Kutorgina cingulata* and *Serpulites fistula*, several species of indeterminable Brachiopoda and obscure fragments of a trilobitic nature. Subsequent visits brought to light better specimens, which convinced me that the fauna was of a very ancient facies; and I have been in the habit of provisionally referring it to the Menevian epoch. As there appeared to be a considerable break between the Hollybush Sandstone and the Longmynd series, it seemed hardly possible to retain the latter in the Cambrian. In this unsettled state of the question, I proposed [2] in 1887 to call this great group of rocks by the name of "Longmyndian." This term has been adopted [3] by Prof. Lapworth, and he has obtained most important evidence in favour of the Archæan age of the strata. Mr. H. Keeping, of Cambridge, working under his direction, has collected from the limestone at Caer Caradoc material which enables Prof. Lapworth to "recognize a large and well-marked species of *Olenellus*," as well as to make out the generic characters of more of the Brachiopoda, and he concludes that the Pre-Cambrian age of the Longmyndian is "a matter of fair probability." Prof. Blake goes further, and correlates [4] the Longmyndian with his "Upper Monian" of Bray Head. To sum up, we find that the most recent discovery, so far from invalidating my conclusions with reference to the occurrence of Archæan rocks in Shropshire, renders it possible that a third system will be added to the list. We should thus be able to record the existence in the West Midland area of three magnificent rock-systems of Archæan age, viz. 1. *Malvernian* (igneous and igneo-metamorphic), 2. *Uriconian* (volcanic and sedimentary), 3. *Longmyndian* (sedimentary). I have not here discussed the Rushton Schists,[5] because their position is uncertain; but I have little doubt that they are Pre-

[1] Quart. Journ. Geol. Soc. 1878, p. 758.
[2] Trans. Shrop. Arch. Soc. 1887. [3] Geol. Mag. Nov. 1888, p. 484.
[4] Quart. Journ. Geol. Soc. 1888, p. 543.
[5] Described in this Magazine, Aug. 1884, p. 362.

Uriconian, and would therefore have to be thrown in with the Malvernian. They have the appearance of schists which have been derived from igneous rocks by shearing, and the strike (north-westerly) is the same as that of the Malvernian.

The Midlands.—The volcanic rocks of Charnwood, described[1] by the Rev. E. Hill and Prof. Bonney, are now generally regarded as Pebidian. Slight exposures of old masses underlying the Cambrian have been recognized at the Lickey and near Nuneaton by Prof. Lapworth, Mr. W. J. Harrison, and others.

Malvern.—By almost universal[2] consent the crystalline rocks which form the nucleus of the Malvern range have been referred to Archæan times. In 1880[3] I separated the masses forming the eastern spurs of the Herefordshire Beacon from the rest of the crystallines, and placed them in the Uriconian. The older rocks (Malvernian) were regarded by Phillips and Murchison as metamorphosed sediments with extensive intrusions of syenite and granite. Dr. Holl went further than these authors, and contended that many of the massive rocks also were of sedimentary origin. None of these writers attempted to construct a sequence out of the Malvernian. At one time, I cherished the hope that this might be done; and, in 1887, Mr. Rutley[4] submitted to the Geological Society the details of a time-succession which he considered he had established. This scheme assumed that the foliation of the gneisses and schists coincided with an original sedimentation. My own work at Malvern had been leading me to a very different conclusion, and, when Mr. Rutley's paper was read, I gave some of my results,[5] my main contention being that many of the foliated rocks were igneous masses which had acquired a parallel structure under pressure. I have since, in papers to the British Association,[6] and the Geological Society,[7] unreservedly extended this theory to all the schistose rocks of Malvern. If I am right, it is obvious that the order in which the foliated bands occur cannot indicate a time-sequence. The new views on metamorphism, therefore, destroy the hope of constructing a succession amongst the Malvernian rocks; but they do not affect the evidence as to the age of the respective Archæan systems represented in the Malvern Hills.

Caernarvonshire.—Papers on this area have of late years been published by Prof. Hughes, Prof. Bonney, Dr. Hicks, Mr. F. T. S. Houghton, the late Mr. E. B. Tawney, Mr. A. Harker, Prof. A. H. Green, and Prof. J. F. Blake. Dr. Hicks identifies his three rock-groups in the area between Caernarvon and Bangor. Prof. Bonney admits the Archæan age of these granitoid and rhyolitic masses; but would assign them to two periods only. Prof. Hughes is in agreement with these observers on the main question; but he places some of the detrital Archæan of Prof. Bonney in the Cambrian.

[1] Quart. Journ. Geol. Soc. 1877, p. 754; 1878, p. 199; 1880, p. 337.

[2] Murchison's opinion that these rocks are metamorphosed Cambrian has probably no living advocate.

[3] Quart. Journ. Geol. Soc. Nov. 1880, p. 536.

[4] *Ibid.* 1887, p. 481.

[5] Quart. Journ. Geol. Soc. 1887, p. 525.

[6] Reports, 1887, p. 706; and 1888, p. 653.

[7] Read April 17, 1889.

The rhyolites near Llyn Padarn and the felsitic and schistose masses of Lleyn district are also claimed as Archæan by Dr. Hicks, and Prof. Bonney admits the claim so far as Llyn Padarn is concerned. Mr. Tawney and Mr. Harker have, however, maintained that some of the igneous masses in the Lleyn area are intrusive in the Ordovician strata This may well be the case; but I am convinced that the quartz-felsites south of Bangor and on Llyn Padarn are truly Archæan. The massive conglomerate running from Llyn Padarn to the south-west along the crests of Moel Tryfaen and Mynydd y Cilgwym is packed with rounded fragments of the subjacent felsite, while the Cambrian grits further west are largely composed of similar material, which also occurs in smaller proportion in the Cambrians near Harlech.

Anglesey.—Prof. Sedgwick was amongst the first to express the opinion that this island contained rocks older than the Cambrian. In our own times, Dr. Hicks, fresh from his discoveries in South Wales, visited the area, and rapidly concluded that his three systems were represented respectively by the granite (Dimetian), the halleflinta (Arvonian), and the schists (Pebidian). Prof. Bonney and Prof. Hughes, approaching the study of the rocks from different sides, agreed that the island contained extensive tracts of Archæan rock; but they did not venture upon detailed conclusions. My own work in Anglesey extended over several years, and led me to believe that the crystalline and hypo-crystalline rocks were mainly Archæan, but that they could not be grouped into more than two distinct systems, Older Archæan (gneissic) and Newer Archæan (slaty). The latter I did not attempt to subdivide into a definite succession. The former appeared to display a sequence of the following groups, taking them in ascending order:—(1) Halleflinta, (2) Quartz-schist, (3) Limestone, (4) Grey gneiss, (5) Dark schist, (6) Granitoidite. Thus the case stood as the result of work upon the old lines.

My enquiries in Ireland and at Malvern led me in the direction of dynamic metamorphism, and, in the light of the new ideas, I re-examined the most important of my Anglesey sections. I found that some of the green schists were modified diorites, that the grey gneiss and associated schists were modified felsite, and that the limestones of the Older Archæans were probably endogenous segregations. These results I communicated to the British Association [1] in 1887. On the same occasion, Prof. J. F. Blake [2] reported that some of the igneous rocks of the island "put on a foliated character in places." I followed up my clues in the following year, and obtained confirmatory evidence of my previous conclusions. I also ascertained that the halleflinta of Llanfaelog was transitional between felsite and gneiss, and that the granite was a truly igneous and intrusive rock, associated with and apparently passing into quartz-felsites which were quite distinct from the above-named felsite. My original reading of the Newer Archæans did not require modification. They were sedimentaries which had been more or less metamorphosed. These results were made known [3] to the British Association in 1888.

[1] Report, p. 760. [2] *Ibid*, p. 231. [3] Report, p. 654.

It was obvious from these discoveries that the sequence in the Older Archæans would have to be differently interpreted. It ceased to be a succession in time, and was useful merely as a description of the distribution of the respective rock-types. But what we lost in one direction we gained in another and more important one. An empirical sequence was replaced by a revelation of true causation. Thus, the halleflinta, quartz-schist, and grey gneiss are produced from felsite by pressure, the limestone is formed from the same rock by segregation, the dark gneiss is modified diorite, and the granitoidite is a true granite intrusive in the felsite, the diorite, and their modifications.

Prof. Blake in his paper[1] in the Journal of the Geological Society, and in his Report[2] to the British Association in 1888, agrees that the rocks in question are Archæan, that the Newer Archæans are largely sedimentary, that the granitoidite is a true granite, and that the diorite has sometimes been modified into schist; but he does not admit that the grey gneiss and associated schists are of igneous origin, and he contends that the Lower and Upper Archæans form a continuous series.

The Highlands of Scotland.—The history of recent discovery in this remarkable region has been so well told by Prof. Bonney,[3] Prof. Lapworth,[4] and the officers of the Geological Survey,[5] that repetition is unnecessary. It is agreed on all hands that the Hebridean gneiss is Archæan; but there is not the same consensus of opinion as to the age and origin of the Eastern gneiss. In my chief paper[6] on the Highlands, I showed that, by enormous thrusts from the east, the Hebridean had been forced over the Ordovician (or Cambrian) rocks for great horizontal distances, and that the Eastern gneiss overlay the Ordovician in a similar manner. As the younger gneiss was a truly metamorphic rock, quite unlike any of the Ordovicians, I inferred its Archæan age, and called it "Caledonian." In the debate on my paper, Prof. Lapworth, who had visited the Erribol district, said that the sections he had seen there seemed to support my view. Indeed, in the state of our knowledge at that time, no other inference appeared to be possible. However, Prof. Lapworth soon after revisited his old ground, and in 1884 we were startled by the extraordinary theory that the Eastern gneiss was a melange of Hebridean, Ordovician, and igneous, rocks, which, under the influence of the great thrust, had been sheared out and in part recrystallized. In the following year, the Survey admitted the new conclusions, even to the length of adopting Prof. Lapworth's view of the origin of the Eastern gneiss. I have not been to the Highlands since 1882; but, considering the nature of the evidence adduced, and the competence of the witnesses, as well as the confirmatory proofs I have collected in Ireland and at Malvern, I am disposed to concede to the new theory a high degree of probability.

[1] 1888, p. 463. [2] p. 367.
[3] Presidential Address, Quart. Journ. Geol. Soc. May, 1885.
[4] Geol. Mag. 1885, p. 97.
[5] Quart. Journ. Geol. Soc. Aug. 1888, p. 378.
[6] Quart. Journ. Geol. Soc. Aug. 1883, p. 356.

Ireland.—Not much has yet been done amongst the Archæans of Ireland. Leinster has been slightly studied by Prof. Sollas and Prof. Blake, as well as by myself. I have held that there is reasonable evidence of two formations, corresponding to the Gneissic and Slaty groups of Anglesey. Prof. Sollas[1] appears disposed to agree with me in reference to the Gneissic series; but the newer group at Howth and near Wexford he would associate with the Bray Head rocks. Prof. Blake,[2] however, who has given considerable attention to Anglesey, regards the Howth group as the equivalent of his "South Stack series," and therefore as Archæan. Prof. Blake separates—I think rightly—the Howth series from the rocks of Bray Head, and he places the latter in a newer group, very high up in the Archæan.

The metamorphic rocks of Galway and Connemara are probably Archæan. No theory of metamorphism can affect the question of their age. The solution of some difficult problems will probably be found in this remarkable area.

There are indications of the existence of Archæan rocks in Donegal, but the region will require much hard work. The granitoid masses supposed by some to be "Laurentian" prove to be intrusive granites locally modified by pressure into a gneiss.

The Lizard and South Devon.—The banded gneisses and other schists of the Lizard have been studied by Mr. J. H. Collins, Prof. Bonney, and Mr. Teall. By Prof. Bonney,[3] the parallel structure was regarded in 1883 as evidence of an original sedimentation; but Mr. Teall[4] in 1887 contended that the banded gneisses were igneous complexes which had undergone deformation under earth-pressures. Prof. Bonney refers the Lizard schists to the Archæan period, a view which may not be materially affected by theories of origin. The same author describes[5] the micaceous and chloritic schists of the South Devon coast, and considers them a prolongation of the Lizard rocks. Miss C. A. Raisin[6] adds further descriptions of the Devon district.

The Channel Islands.—The Rev. E. Hill has given considerable attention to the crystalline rocks of this group of islands. He describes,[7] *inter alia*, hornblendic schists and felspathic gneisses, and assigns them to the Archæan, contending that their great dissimilarity from the Cambrian and later strata of the adjacent parts of Brittany renders their Palæozoic age highly improbable. This evidence is not likely to be affected by questions of origin.

The length of this bare sketch, in which only the principal contributions are mentioned, will give some idea of the activity of the workers in the Archæan field. Errors have no doubt been made; but, having regard to the extreme obscurity of some of the evidence

[1] Brit. Assoc. Report, 1887, p. 708.
[2] Quart. Journ. Geol. Soc. 1888, p. 542.
[3] Quart. Journ. Geol. Soc. Feb. 1883, p. 1.
[4] Brit. Assoc. Report, p. 707; and Geol. Mag. Nov. p. 484.
[5] Quart. Journ. Geol. Soc. Feb. 1884, p. 1.
[6] *Ibid.* Nov. 1887, p. 715.
[7] *Ibid.* Aug. 1887, p. 322.

and to the misleading influence of old theories of metamorphism, very substantial results have been gained. I believe I am correct in saying that all who have studied the question with any degree of thoroughness, that is to say, in more than one or two localities, have come to substantially the same conclusion. Whether there are one, two, or three Archæan systems—whether, if there are more than one, they are separated by broad or narrow gaps—are questions on which unanimity is not yet attained; but there is little difference of opinion as to the existence and distribution of the Archæan masses as a whole. The dynamic theory of metamorphism affects certain details of the Older Archæans, it renders correlation amongst igneo-metamorphic masses somewhat less precise, and it materially alters all the old views on the Eastern gneiss of Sutherland. On the other hand, it opens up questions of the greatest interest, and renders comparatively intelligible some of the earliest chapters in the earth's history.

VII.—Note on some Points in the Nomenclature of Fossil Reptiles and Amphibians, with Preliminary Notices of Two New Species.

By R. Lydekker, B.A., F.G.S., F.Z.S.

Having occasion in a work now in the press to refer to certain fossil Reptiles and Amphibians of which the commonly accepted nomenclature requires revision, I think it advisable to make the necessary amendments in a Journal specially devoted to Geology and Palæontology. I also take the opportunity of giving two new scientific names to Reptiles from the Wealden.

The name *Diplovertebron*, Fritsch, as being a hybrid word, may be amended to *Diplospondylus*. *Notochelys*, Owen, being preoccupied by Gray, may be changed to *Notochelone*.

Since there is every probability that *Ornithopsis Hulkei*, Seeley, is identical with *Hoplosaurus armatus*, Gervais, while the latter is probably not generically separable from the earlier *Pelorosaurus*, I propose to adopt the name *Pelorosaurus armatus* for the Isle of Wight species, on the assumption that it is distinct from *P. Conybeari* of Sussex. The Kimeridgian and Oxfordian species described as *Ornithopsis* may likewise be referred to *Pelorosaurus*.

The teeth from the Wealden provisionally referred by Mantell and Owen to *Hylæosaurus* are now known to be Sauropodous, and since they appear to be too small to belong to any of the described Wealden forms of that group, I propose to refer them provisionally, on account of their small size, to the genus *Pleurocœlus*, Marsh, with the name *P. valdensis*. I am confirmed in this reference by a small dorsal vertebra in the British Museum (No. R. 1626), from the same deposit, which closely resembles that of the typical American species, and probably belongs to the same form as the teeth.

Finally, I propose the name *Megalosaurus Oweni* for the metatarsus from the Wealden figured by Owen in his 'Wealden and Purbeck Reptilia,' pt. iv. pl. xi. as *Hylæosaurus*, and referred by myself to *Megalosaurus* in the 'Cat. Foss. Rept. Brit. Mus.' p. 167, under the name of *M. Dunkeri.* I am induced to make this new species because metatarsals obtained by Mr. C. Dawson from the Wadhurst Clay of Hastings are clearly specifically distinct from the above-mentioned specimen, and I provisionally refer them, on account of their larger size, to *M. Dunkeri.* The type of *M. Oweni* appears to belong to the right side, instead of to the left, as stated by its describer.

NOTICES OF MEMOIRS.

I.—On a possible Geological Origin of Terrestrial Magnetism.[1] By Professor Edward Hull, M.A., LL.D., F.R.S., Director of the Geological Survey of Ireland.

THE author commenced by pointing out that the origin and cause of terrestrial magnetism were still subjects of controversy amongst physicists, and this paper was intended to show that there is cause for believing the earth itself contains within its crust a source to which magnetic phenomena may be traced, as hinted at by Gilbert, Biot, and others; though, owing to the want of evidence regarding the physical structure of our globe in the time of these observers, they were unable to identify the supposed earth's internal magnet.

The author observed that in the opinion of many geologists there exists beneath the crust an outer and inner envelope or "magma" the former less dense and highly silicated, the latter basic and rich in magnetic iron-ore. This view was in accordance with the views of Durocher, Prestwich, Fisher, and many others. The composition of this inner magma, and the condition in which the magnetic iron-ore exists, were then discussed, and it was shown that it probably occurs under the form of numerous small crystals, with a polar arrangement; each little crystal being itself a magnet, and having crystallized out from the magma while this latter was in a viscous condition, the crystalline grains would necessarily assume a polar arrangement which would be one of equilibrium. Basalt might be taken as the typical rock of this magma.

The thickness and depth of the magnetic magma beneath the surface of the globe were then discussed; and while admitting that it was impossible to come to any close determination on these points owing to our ignorance of the relative effects of increasing temperature and pressure, it was assumed tentatively that the outer surface of the effective magnetic magma might be at an average depth of about 100 miles, and the thickness about 25 or 30 miles. The proportion of magnetic iron-ore in basaltic rocks was then considered, and it was shown that an average of 10 to 15 per cent. would express these proportions; and assuming similar proportions to exist in the earth's magnetic magma, we should then have an effective terrestrial magnet of from $2\frac{1}{2}$ to 3 miles in thickness. The thickness, however, might be very much greater than here suggested.

[1] Read at the Royal Society, May 16, 1889.

Instances of polarity in basaltic masses at various localities were adduced in order to illustrate the possibility of polarity in the internal mass. Magnetic polarity had been found by the author to exist in segments of basaltic columns.

The subject of the polarity of the globe was then discussed, and it was pointed out how the position of the "magnetic poles" leads to the inference that they are in some way dependent upon the position of the terrestrial poles.

The author regarded the so-called "double poles" as merely *foci* of attraction due to protuberances of the magnetic magma into the exterior non-magnetic magma, and maintained that there was really only a single magnetic pole in each hemisphere, embracing the whole region round the terrestrial pole and the *stronger and weaker magnetic foci*, and roughly included within the latitude of 70° within the northern hemisphere.

It was pointed out that the poles of a bar-magnet embrace a comparatively large area of its surface, and hence a natural terrestrial magnet of the size here hypothecated may be inferred to embrace a proportionably large tract for its poles.

In reference to the question why the magnetic poles are situated near those of the earth itself, this phenomenon seemed to be connected with the original consolidation of the crust of the globe, and the formation of its internal magmas.

It was suggested that, owing to the differences of temperature which must have existed in the polar regions, as compared with those of the equatorial, the process of solidification may have been more rapid in the polar regions than elsewhere, and it was inferred that in the case of the magnetic magma the process of crystallization and the polar arrangement of the particles of magnetic iron-ore might have proceeded from the poles towards the equator in radial directions. The manner in which the phenomena of magnetic intensity, and of the dip of the needle at different latitudes, could be explained on the hypothesis of an earth's internal magnet, such as is here described, was then pointed out; and the analogy of such a magnet with a magnetic bar passing through the centre of the earth was illustrated. On the other hand it was conceivable that the process of solidification might have commenced at the Equator—extending towards the poles, and thus the polar arrangement would naturally arise.

The author then proceeded to account on geo-dynamical principles for the secular variation of the magnetic needle, and also endeavoured to show how the objections that might be raised to the views here advanced, on the grounds of the high temperature which must be assumed to exist at the depth beneath the surface of the magnetic magma, could be met by considerations of pressure; and on this subject read a letter which he had received from Sir William Thomson, F.R.S.

II.—Beitrag zur Kenntniss der Mikrofauna aus den oberjurassischen Feuersteinknollen der Umgegend von Krakau. Von Thaddäus Wisniowski. Jahrb. der k. k. geol. Reichsanstalt, 1888, Bd. xxxiv. pp. 657–702, taf. xii. xiii.

Notes on the Microscopic Fauna from the Upper Jurassic Flint-nodules in the Neighbourhood of Cracow. By Thaddeus Wisniowski.

In the limestone strata of the White or Upper Jura formation near Cracow there are layers of flint nodules similar to those in the Upper Chalk of this country. The flints vary from dark to grey in tint, in the latter a great variety of microscopic organisms can be distinguished. These principally consist of detached sponge-spicules, some of which are very perfectly preserved, whilst others have been dissolved and only the infilled casts of their canals remain. The spicules evidently belong to a variety of siliceous sponges, the monactinellid and tetractinellid forms predominating. There are also some minute forms resembling the flesh-spicules of existing hexactinellids. In the flints from one particular locality radiolarians appear instead of sponge-spicules; of these 19 different species have been recognized by the author, and ten are new. Foraminifera are also fairly abundant in the flints mingled with the siliceous organisms; but as only their infilled casts have been preserved, it has not been practicable to distinguish more than 10 species. In contrast to the abundant remains in the grey nodules, there are very few to be found in those of a dark tint; but as there are numerous gradations between these two varieties, it is reasonable to conclude that the silica in both has been derived from the same organisms, and that these have been completely dissolved in the dark nodules. Figures of the different forms are given in the accompanying plates. G. J. H.

III.—Ueber das Devon in Devonshire und im Boulonnais. Von E. Kayser in Marburg. Neues Jahrbuch für Mineralogie, etc. 1889, Bd. I. pp. 179–191.

Prof. Kayser (in company with Prof. Gosselet, of Lille, and some other geologists) visited the classical region of North and South Devon last autumn under the guidance of Mr. W. A. E. Ussher, and in this paper he gives some details of considerable interest regarding the geological structure and fossils of these areas as compared with the corresponding strata in Germany. Prof. Kayser concludes that in South Devon there is the closest resemblance, alike in the Upper, Middle, and Lower divisions, to the Devonian succession in West Germany, and this is further shown by the occurrence of similar eruptive greenstones in both countries. On the other hand, considerable differences are shown in the North Devon Series. There are here no representatives in the Upper Division either of the *Clymenia* Limestone, or of the Adorf *Goniatite*, or the Iberg Coral-limestone; in the Middle Division the *Stringocephalus* and *Calceola*-limestones are wanting, and there is no near resemblance either in the Rhenish or in the Belgian-French Devonian of the prevailing hard quartzitic sandstones and grauwackes of the Lower Division in North Devon. The Pilton beds and the Cucullæa zone or Baggy beds correspond rather to the Belgian than to the Rhenish Upper Devonian, and there is nothing analogous, either in the Rhine district, Belgium, or Northern France, to the Pickwell sandstones and the slates of Morte and Ilfracombe. Not only are the limestones of the South Devon Series almost entirely replaced by the slates and sandstones of the North, but there is further in this area a complete absence of the greenstone and schalstein.

IV.—On the Spinose Rhynchonellæ (Genus *Acanthothyris*, D'Orbigny) found in England. By S. S. Buckman, F.G.S., and John Francis Walker, M.A., F.G.S.—On *Terebratula bisinuata*, Lam., from the London Clay of Hampshire. By J. F. Walker, F.G.S.—On Oolitic Brachiopoda new to Yorkshire. By J. F. Walker, F.G.S. (From the Yorkshire Philosophical Society's Report, 1888, York, 1889.)

THE first of these papers gives a history and bibliography of the genus *Acanthothyris* as distinguished from *Rhynchonella*, and describes the species and varieties (ten in number) occurring in England, with their geological and geographical distribution.

In the second paper Mr. Walker records the occurrence of numbers of the hitherto rare *Terebratula bisinuata*, in beds, apparently of Bracklesham age, near Fareham, in Hampshire. The last paper contains a list and descriptions of sixteen new species and varieties of Brachiopods, some of them new forms, discovered in the Oolitic strata of Yorkshire since 1876.

REVIEWS.

I.—Bulletins of the Geological Society of France.

THE last number of the Bulletin of this Society (ser. 3, vol. xvi. No. 8, 1888) contains several papers of considerable interest.

We have the concluding portion of a paper by M. Œhlert on some Devonian Pelecypoda, and this is illustrated by phototypes of the author's drawings. Species of *Avicula, Pterinea, Cypricardinia, Sanguinolites, Goniophora, Pteronites, Modiomorpha, Ctenodonta, Palæoneilo*, and *Guerangeria* are described.

M. W. Kilian gives an account of a number of Cephalopoda and one Brachiopod, from the Lower Cretaceous strata of Provence. These include Ammonites, which are noted under the perplexing names of *Lytoceras, Silesites, Holcodiscus, Pulchellia*, and *Hoplites*; also species of *Heteroceras*, and a *Rhynchonella*.

M. R. Zeiller notes the presence in the *Grès bigarré* of the Vosges, of the fern *Acrostichites rhombifolius*.

M. H. Douvillé contributes some studies on *Caprina, Caprinula*, and *Plagioptychus*.

M. Hébert gives the second part of his paper on the Cretaceous formation of the Pyrenees, dealing with the Senonian stage.

Of more general interest, perhaps, are the new studies on the chain of St. Beaume, in Provence, by M. Marcel Bertrand.

In a previous communication the author showed that the strata in Provence had been subject to great mechanical disturbance, for remnants of Triassic and Jurassic strata were found reposing on Upper Cretaceous rocks. He now gives additional examples of these "*phénomènes de recouvrement*," and draws attention to evidences of remarkable twisting in the overfolded strata and to sinuosities that were subsequently produced.

Taking a section across the region from St. Zacharie to St. Beaume, he illustrates how the Jurassic, the Neocomian and Cretaceous strata are inverted on the north, being bent over in that area towards the south; while further south the strata are plicated and faulted in places, but the faults are represented as dying out deep down in the folds to whose influence they are due. In the troughs of the synclinals are preserved remnants of Jurassic strata which rest on Upper Cretaceous beds.

The explanation of these structures is given in an accompanying diagram. The Jurassic, Neocomian and Cretaceous strata that were laid down in sequence (interrupted by the local overlap of Neocomian by newer strata) were considerably denuded; great lateral compression followed, and this was attended by the remarkable overfolding of the strata in both the northern and southern portions of the region. The beds were sharply bent over and pushed forward, so that the uppermost strata in the overfolds were disrupted, and the overfolds became over-thrusts or thrust-planes—the disturbance in the north being the more pronounced. Further compression led to undulations in the mass of the strata, so that the comparatively undisturbed beds beneath and the superincumbent overthrust beds were together plicated. Subsequent denudation has left as it were only outlying patches of the older overthrust rocks, and these are portions that occupied the synclinal folds, having by reason of their structure withstood the agents of denudation. Thus the mechanical agents have left their imprint for the most part in relief, and the confused character of the topography finds an explanation. These great earth-movements, it should be added, took place before the Tertiary strata were deposited.

The chief interest in this district is in the evidence afforded of the double folding, and in the overfolds on the north and on the south being inclined the one towards the other. Such a structure reminds the author of the celebrated section in the *Alpes de Glaris* by M. Heim. H. B. W.

II.—The Geological Survey of Bavaria.

Geognostische Jahreshefte. Erster Jahrgung 1888. Herausgegeben von der geognostischen Abtheilung des K. Bayer. Oberbergamtes in München. (Cassel, Fischer.)

In this, the first year-book brought out by the Geological Survey of Bavaria, there are some important papers on the geology of that country. Amongst others, Dr. von Ammon gives a description of the fauna in the brackish Tertiary strata of Lower Bavaria, illustrated by a plate; Dr. Leppla writes on the Bunter Sandstone in the Haardtgebirge, and also, in association with A. Schwager, on the Nephelin-Basalt of Oberleinleiter; Dr. H. Thürach reviews the divisions of the Keuper in Northern Franconia as compared with those of adjoining areas; and Prof. v. Gümbel contributes some very interesting supplementary notes to the geology of the Bavarian Alps. In one of these he calls attention to the succession of Cretaceous beds in the Algäuer Alps, and mentions that an important deposit of green sandstone exposed on the border of the Illerthal, which had been regarded by Murchison in 1849 as a passage-bed between the Cretaceous and Eocene Nummulitic strata, had been proved, by the fossils lately discovered in it by Prof. v. Zittel, to belong to a distinct horizon of the Upper Chalk not hitherto known in the district. Gümbel also confirms the discovery, first made by Professor Penck, of the interglacial age of the beds of brown coal near Sonthofen, which have been deposited between two beds of boulder material with striated erratics. The coal is now extensively worked for fuel. A peculiar feature of some of the erratic boulders is that they are now completely hollow. They appear to have been originally of dolomite, and by the action of carbonated water the inner portions have been dissolved and removed, leaving only a hard surface crust.

Another interesting fact in connection with the Algäuer Alps is that certain crystalline schists exposed in the Rettenschwanger Thal, which have been hitherto regarded as of the age of the Bunter Sandstone, now prove to be Archæan, and indicate the existence of a ridge of these old rocks on the margin of the Alps.

Prof. Gümbel further points out that the springs of petroleum which have long been known on the western slopes of the Tegernsee are probably derived from dark bituminous shales, filled with fish remains, which occur in the Hauptdolomite. The shales are economically worked for asphalt at Seefeld, but the borings for oil at the Tegernsee have been unsuccessful, only small quantities having been met with. G. J. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 8, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "The Rocks of Alderney and the Casquets." By the Rev. Edwin Hill, M.A., F.G.S.

The author in this paper described Alderney, Burhou, with its surrounding reefs, and the remoter cluster of the Casquets, all included within an area about 10 miles long.

Alderney itself consists in most part of crystalline igneous rocks, hornblendic granites of varying constitution which resemble some Guernsey rocks, but seem more nearly connected with those of

Herm and Sark. These are pierced by various dykes, and among them by an intrusion containing olivine, which may be placed with the group of picrites. There is also in the island a dyke of mica-trap.

The eastern part only of Alderney, but the whole of Burhou, the Casquets and their neighbouring reefs, consist of stratified rocks. These contain rare beds of fine mudstone, but are generally false-bedded sandstones, and grits, sometimes with pebbles, often rather coarse and angular, occasionally becoming typical arkoses. At a point on the southern cliffs of Alderney they may be seen to rest on the crystalline igneous mass. A series identical in constitution and aspect occurs at Omonville, on the mainland, a few miles east of Cap La Hague (as had also been noticed a few months earlier by M. Bigot). These have been correlated with others near Cherbourg, and described as underlying the "grès Armoricain." The Alderney grits therefore form part of a series which can be traced over 30 miles, and which belongs to the Upper Cambrian (of Lapworth).

Remarks were made on the Jersey conglomerates (Ansted's conjectural identification of these with the Alderney grits being approved), on the resulting evidence that the Jersey rhyolites are not Permian, but Cambrian at the latest, on the still earlier age of the Guernsey syenites and diorites, and on the antiquity of the Guernsey gneisses.

2. "On the Ashprington Volcanic Series of South Devon." By the late Arthur Champernowne, Esq., M.A., F.G.S. Communicated by Dr. A. Geikie, F.R.S., F.G.S.

The author described the general characters of the volcanic rocks that occupy a considerable area of the country around Ashprington, near Totnes. They comprise tuffs and lavas, the latter being sometimes amygdaloidal and sometimes flaggy and aphanitic. The aphanitic rocks approach in character the porphyritic "schalsteins" of Nassau. Some of the rocks are much altered; the felspars are blurred, as if changing to saussurite, like the felspars in the Lizard gabbros. In other cases greenish aphanitic rocks have, by the decomposition of magnetite or ilmenite, become raddled and earthy in appearance, so as to resemble tuffs. The beds are clearly intercalated in the Devonian group of rocks. and the term Ashprington Series is applied to them by the author. Although this series probably oontains some detrital beds, there are no true grits in it. Stratigraphically the series appears to come between the Great Devon Limestone and the Cockington Beds, the evidence being discussed by the author, however, not so fully as he had intended, as the paper was not completed.

II.—May 22, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "Notes on the Hornblende Schists and Banded Crystalline Rocks of the Lizard." By Major-Gen. C. A. McMahon, F.G.S.

The Lizard district has been visited by the author on three occasions during the years 1887–8–9, and the specimens of the rocks collected were subjected to microscopic examination. After summarizing the work of previous writers, the author proceeded to consider the hornblende schists. He described these rocks and gave a table showing their constituent minerals. He noted the absence of quartz, the presence of pyroxene, and the fact that the minerals present are those commonly met with in volcanic rocks either as original minerals or as secondary products, and he considers that the microscopic study of the schists confirms the opinion of some previous writers that the schists had a volcanic origin and consisted principally of ash-beds. The absence of free quartz militates strongly against the supposition that they were originally sedimentary rocks of an ordinary character, whilst the fact of their being bedded shows that they are not plutonic. The author has found no evidence that the foliation of these rocks is due to dynamic deformation, and gives reasons for supposing that such was not the case. The rock seems to have been originally homogeneous, and its banding produced at a later stage by the segregation of the hornblende in planes parallel to the bedding.

The rocks furnish abundant evidence of the action of water, as shown by the presence of calcite, chlorite, steatite, and other products of aqueous action, as well as by channels fringed with magnetite, ferrite, or limonite. The action of water in converting augite into hornblende may be distinctly traced when the slices still contain pyroxene. The production of periodical currents of water through the water-bearing strata adjoining the roots of a volcano was commented on, and the author suggested that the banding of the hornblende schists was produced by such water leeching out unstable minerals, such as pyroxene, from the spaces between the planes of lamination, and the formation of comparatively stable minerals, such as hornblende, along those planes. The Lizard rocks contain good examples of the formation of hornblende in the wet way, that mineral having been deposited in cracks in such a way as to join together the ends of hornblende crystals severed by these cracks.

The "granulitic" group, of which the author gave a table showing the constituent minerals, was then described. Judged by their mineralogical contents the dark bands consist of diorite and the white bands of granite.

The author considers that portions of this group consist, like the hornblende schists, of converted ash-beds, but that other portions are composed of intrusive diorites of later date, the quasi-bedded appearance of both being due to the injection of granite. He pointed out that the quasi-banding is very irregular in its character, that the bands inosculate, bifurcate, aud entangle themselves in complicated meshes inconsistent with the idea of regular banding, and that they are deflected by the blocks of serpentine imbedded in the dioritic portions of the granulitic rocks as well as by the porphyritic crystals of felspar contained in the latter. In certain places, as on the foreshore at Kennack Cove, the intrusive character of the granitic veins is undoubted, as they cut through the diorite in all directions, but they graduate into bands of normal character. The author considers that the process of injection was aided by the plasticity of the "granulitic" beds induced by the neighbourhood of igneous masses; also in the case of sub-marine ash-beds by the planes of sedimentation; and in the case of intruded sheets of diorite, by the foliation parallel to the bedding, the intrusion of the granite being subsequent to that of the diorite.

At Pen Voose a foliated granite, the author pointed out, occurs in association with a non-foliated gabbro and diorite, a fact indicating in his opinion that the foliation of the granite was produced before its perfect consolidation. The granite was the last to appear in the order of time, and had the foliation of the granite been produced by pressure after cooling, the gabbro and diorite would also have been foliated.

2. "The Upper Jurassic Clays of Lincolnshire." By Thomas Roberts, Esq., M.A., F.G.S.

In Lincolnshire it has generally been considered that the Oxford and Kimeridge Clays come in direct sequence, and that the Corallian group of rocks is not represented. The author, however, endeavoured to show that there is between the Oxford and Kimeridge a zone of clay which is of Corallian age.

Six palæontological zones were recognized in the Oxford Clay. The clays which come between the Oxford and Upper Kimeridge the author divided into the following zones:—

(1) Black selenitiferous clays. (2) Dark clays crowded with *Ostrea deltoidea.* (3) Clays with *Ammonites alternans*; and (4) clays in which this fossil is absent.

The black selenitiferous Clays (1) are regarded as Corallian, because (*a*) They come between the Oxford Clay and the basement bed of the Kimeridge. (*b*) Out of the 23 species of fossils collected from this zone 22 are Corallian. (*c*) *Ostrea deltoidea* and *Gryphæa dilatata* occur together in these clays, and also in the Corallian, but in no other formation.

The zones 2, 3, and 4 are of Lower Kimeridge Clay age. The lowest zone (2) is very persistent in character, and is met with in Yorkshire, Cambridgeshire, Oxfordshire, and the South of England. The remaining zones (3 and 4) are local in their development.

3. "Origin of Movements in the Earth's Crust." By James R. Kilroe, Esq. Communicated by A. B. Wynne, Esq., F.G.S.

The author is convinced that a very important factor has been omitted from the usual explanation offered in accounting for the vast movements which have obtained in the earth's crust. His acknowledgments are due to Mr. Fisher for the extensive use made of his valuable work. He also refers frequently to the views and publications of other writers on terrestrial physics. From a somewhat conflicting mass of figures he concludes that about 20 miles would remain to represent the amount of radial contraction due to cooling during the period from Archæan to Recent times, corresponding to a circumferential contraction of 120 miles. This will have to be distributed over widely separate periods, at each of which there is abundant evidence of lateral compression.

But he considers that this shrinkage alone will not account for all the plication or distortion of strata which constitute so important a factor in mountain-making, and he is disposed to supplement it in the way to which allusion has already been made by Mr. Wynne in a recent Presidential Address, viz. by considering the effects of the attenuation of strata under superincumbent pressure from deposition in subsiding areas, which involves the thickening, puckering, reduplication, and piling up of strata in regions where pressure has been lessened. It should be noted that, until disturbance of "cosmical equilibrium" takes place, mere pressure does not produce metamorphism. The extent of these lateral movements is described, and it is asserted that the theories hitherto adopted to account for plication, etc., are inadequate.

The origin of the horizontal movements is further discussed on the hypothesis that solids can flow after the manner of liquids, when they are subjected to sufficient pressure. He considers that the displacement in N.W. Scotland may have been *initiated* by the force due to contraction and accumulating in the crust throughout the periods marked by the deposition of Torridon Sandstone and Silurian stata, the elements of movement finding an exit at the ancient Silurian surface. In this case the pile of Silurian strata formerly covering the region now occupied by the North Sea and part of the Atlantic forced the lowest strata to move laterally, the protuberances of the underlying pre-Silurian rocks being also involved in the shearing process. Similar results occur in other mountain areas. The strata compressed have been greatly attenuated, and extended in proportion; in this way we may account for the piling up of strata by contortion in certain regions. The connexion of this interpretation with Malet's theory of volcanoes is also indicated, and the author concludes by applying these views to other branches of terrestrial physics.

CORRESPONDENCE.

FOLIATION IN THE MALVERN HILLS.

Sir,—I ask permission to make a brief explanation in reference to the debate on General Macmahon's memoir read before the Geological Society on May 22nd. The published summary of the discussion attributes to Mr. J. J. H. Teall the statement that, in a paper read at a previous meeting, "foliation was actually taken as evidence of deformation." The paper [1] here referred to was one read by me on April 17th. Taken without qualification, Mr. Teall's remark does not accurately express my views. Nothing is more certain than that foliation has been produced in more ways than one, and this I have repeatedly said and printed. In the Malvern Hills, however, I hold that foliation is always the result of deformation. This conclusion is not assumed, but is based upon the fact that, wherever the rock lying between an igneous mass and a schist is exposed, a gradation between the two can be traced, and the pro-

[1] See summary of it in Geol. Mag. for June, p. 285. The discussion of papers, is omitted from the Reports given in the Magazine from want of space.—Edit. G. M.

gressive deformation can be shown under the microscope. I have a right to say "wherever," because I do not think there is a single exposure of any magnitude in the entire chain which I have failed to examine, and the most critical sections I have visited repeatedly.

My paper of April 17th treated, not so much of the origin of the schists in question, as of the production of some of the constituent minerals. The evidence offered under the former head was accordingly very incomplete, and a great part of the debate seemed to me rather premature. I hope my critics will visit the Malvern region, and will favour me with their opinion when I read my paper on the main question. CH. CALLAWAY.

WELLINGTON, *June 11th*, 1889.

OBITUARY

ROBERT DAMON, F.G.S.

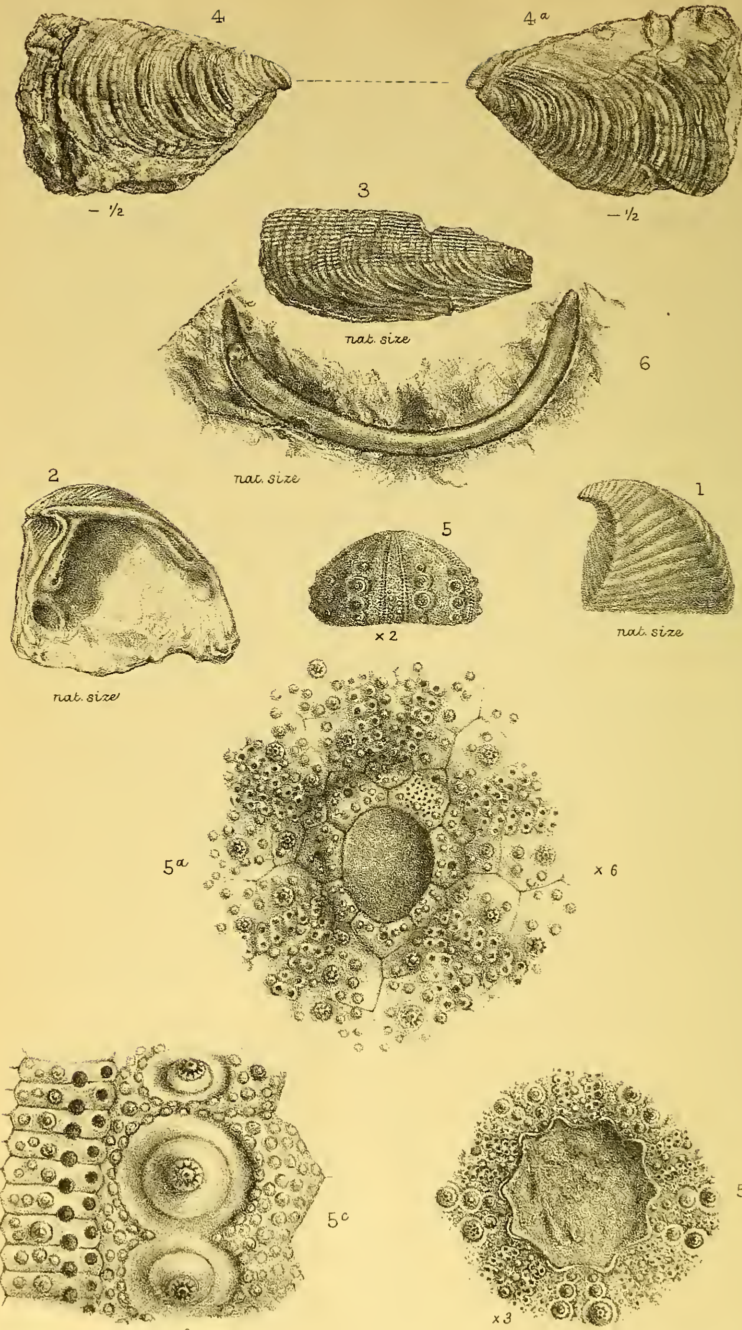
BORN, 1814; DIED, 1889.

WE regret to record the death of MR. ROBERT DAMON, F.G.S., of No. 4, Pulteney, Weymouth, Dorset, the well-known Geologist and Naturalist, which occurred suddenly from heart-disease, on Saturday the 4th May. He was the author of an excellent work on "The Geology of Weymouth, and the Isle of Portland," and was a most extensive traveller and an assiduous collector. He procured a marvellous series of Cretaceous fossil Fishes from the Lebanon, Syria, now in the British Museum (Nat. Hist.), also the most complete example of the skeleton of that rare extinct Sirenian "Steller's Sea-cow," from Behring Island. Although in his 75th year, he contemplated an expedition to Siberia in order to obtain an entire Mammoth's skeleton for the National Museum. Mr. Damon frequently visited Moscow and St. Petersburg, and was a Corresponding Member of the Imperial Society of Natural History, Moscow, and of other learned bodies in various parts of the world. Only a few years since he took passage from Nijni Novgorod down the Volga to Astrakhan, where he made the first collection of the fishes of the Caspian Sea yet brought to this country.

He lately purchased the celebrated collections forming the "Museum Godeffroy" in Hamburg, together with the published catalogues of that museum prepared by various eminent naturalists.

In his native town of Weymouth, Mr. Damon exercised great influence for good amongst his fellow-townsmen, by whom he was greatly honoured and valued for the integrity and uprightness of his character, and his large-hearted sympathy with all cases of distress. His charities were performed without ostentation, and only the recipients ever knew the kind friend who helped them in their time of need. His loss will long be felt by a very wide circle of friends, in all parts of the world, by whom he was warmly esteemed and greatly respected. His son, Mr. R. F. Damon, now carries on his father's extensive Natural History Agency in Weymouth.

HENRY WILLIAM BRISTOW, F.R.S., F.G.S., late Director of the Geological Survey of England.—We have to announce the death on the 14th of June, of this eminent geologist, at the age of 72. Mr. Bristow had for some time past been an invalid. We hope to publish a notice of his scientific labours in the August number.



A. S. Foord del. et lith. West, Newman imp.

Lias Marlstone Rock and Transition Bed Fossils.

Tilton, Leicestershire

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VI.

No. VIII.—AUGUST, 1889.

ORIGINAL ARTICLES.

I.—The Lias Marlstone of Tilton, Leicestershire.

By E. Wilson, F.G.S., and W. D. Crick,
With Palæontological Notes by E. Wilson, F.G.S.

(PLATE X.)

(*Concluded from the July Number, p.* 305.)

Cardinia Slatteri, Walford, 1878. Plate X. Figs. 1, 2.

1878. *Isocardia? Slatteri*, Walford, "On some Middle and Upper Lias Beds in the Neighbourhood of Banbury," Proc. Warwick Nat. and Arch. Field Club, 1878, p. 49. 1879. *Isocardia*, sp. in reprint of same paper, pp. 16, 20, fig. 5 in plate.

Description.—Shell trigonal, thick; umbones large, angulated and terminal, ending in acute points, which curve downwards, forwards, and a little outwards; the sides of the shell, triangular in form, slightly excavated and highly inclined to the areas, are bounded by prominent carinæ, an acute carina separating the side from the slightly concave triangular area in front, and a more rounded carina separating it from the slightly convex triangular area behind. The valves are marked with strongly defined and somewhat sinuous sub-imbricating lines of growth at wide and fairly regular intervals, between which may be discerned numerous fine lines of growth. Lunule small and deep. Cardinal tooth elongated, oblique and prominent in the right valve, small and triangular in the left. Anterior lateral tooth of right valve obtusely conical and very prominent, received into a deep socket in the corresponding valve, immediately above the impression of the anterior adductor muscle; posterior lateral tooth in left valve elongated, longitudinally grooved and attenuated towards the umbo; muscular impressions deeply sunk into the substance of the shell, the anterior triangularly ovate, the posterior oval-oblong; pallial line not discernible in specimens examined; ligament external, groove for its insertion elongated, shallow and curved concentrically with the dorsal margin of the shell. Height of shell, 18 to 25 mm.; breadth, 21 to 29 mm.

Note.—This shell has somewhat the form of an *Opis*, and is very like *Opis Ferryi*, Dumortier (Dépôts Jurassiques, pt. 3, p. 264, pl. xxx. fs. 4–6); but it differs from that shell by its more strongly curved outlines, absence of longitudinal ribs, and larger size. Possibly that form, as well as certain other trigonal bicarinated shells having imbricating growth layers—and the hinge characters of which have not been noticed—may eventually be found to fall under the genus *Cardinia*.

This fossil was first discovered by Mr. E. A. Walford, F.G.S., in the Marlstone and Middle Lias Transition-bed of Aston-le-Wall and Appletree, Northamptonshire, and referred to in this author's paper above cited, and figured but not described in the reprint of same, under the name *Isocardia Slatteri*, Walford. At that time the hinge characters had not been made out, and consequently the generic identification was made with some diffidence. Mr. Crick has since found an almost perfect left valve of this shell on the East Norton embankment, and Mr. Walford has kindly lent me a right valve, in which also, now that the matrix has been cleaned out, the hinge characters are clearly displayed (see Pl. X. Fig. 2). These hinge characters are essentially those of a *Cardinia*, as also is the mode of growth, and to that genus I therefore without hesitation refer this shell, and in this view Mr. Walford concurs.

Marlstone Rock, Tilton (East Norton embankment).

PINNA TILTONENSIS, sp. nov. Plate X. Fig. 3.

Shell elongated, lanceolate, anterior and posterior borders with nearly straight edges, but slightly convex; with concentric longitudinal plicæ, which towards the umbo become broken up and mammillated; the posterior half of each valve is ornamented with slender radial costæ, which are regular and equally spaced except the two lower or median ones, which are more slender and wider apart; about half only of the radial costæ reach the ventral border of the shell; these radial striæ, where they cross the plicæ of growth, form a neat meshwork, and are as a series interrupted at intervals, where they take an oblique direction for a short distance so as to present a distorted appearance. We have two examples of this shell; both are incomplete, and the best-preserved specimen which is figured is very much compressed; hence the materials for founding a species are not the most satisfactory, and the above name must be considered therefore as provisional.

Marlstone Rock, Tilton (East Norton embankment).

INOCERAMUS, sp. Plate X. Figs. 4, 4*a*.

Shell markedly inequivalve, moderately inflated, longer than broad, broadly flattened posteriorly in the left valve, acuminated towards the umbones, which are prominent, pointed, approaching and recurved; the valves are marked with irregular longitudinal ridges and furrows, and finer concentric lines of growth, and by rather ill-defined and irregular radial striæ, which at their intersections give an irregularly mammillated and pitted aspect to portions of the shell. This shell differs in its form and markings from all the Jurassic *Inocerami* with which I am acquainted; but having only a single and incomplete specimen, I hesitate to impose a new name. Should it eventually appear that we have here a new species, the name *Inoceramus Tiltonensis* might be given to it.

Marlstone Rock, Tilton (East Norton embankment).

EODIADEMA GRANULATA.

The beautiful specimens of this Middle Lias Echinoid belong to a new genus, the description of which will be found in "A Revision of the Genera (Fossil and Recent) of the Echinoidea," Journ. Linn. Soc. vol. xxiii. 1889, by Prof. P. Martin Duncan, F.R.S., etc. The following is the diagnosis.

Genus *Eodiadema*, Dunc. 1889.

Test small, thin, circular in tumid marginal outline, sub-conical dorsally, tumid and reentering actinally, broader than high. Apical system moderate in size, ovoid or elliptical in outline at the periproct: five large basal plates, four in contact, but the fifth or posterior separated from the others on either side by radial plates, which thus enter the ring. Ambulacra narrow, straight, wider than the interradia at the peristomial margin, narrower elsewhere; poriferous zones narrow, pairs of pores numerous, in single, simple, vertical series, barely any crowding near the peristome; plates all low broad primaries; interporiferous areas rather broad, crowded with blunt granules dorsally, some larger granules near the poriferous zones, and giving place at the ambitus to some very small crenulate perforated tubercles, which diminish actinally. Interradia broad, plates not numerous, broader than high; two vertical rows of perforate, crenulate and scrobiculate tubercles in each area, a few large at the ambitus, and all becoming rapidly small and almost obsolete dorsally, or replaced there by granulation, diminishing also actinally. Scrobicules of the ambital tubercles large, usually coalescing. A large blunt granulation occurs beyond the scrobicular circles, except on angular median spaces contiguous with the basal plates where there are no granules. Peristome decagonal, sunken, small, with well-marked branchial incisions.

The position of this genus is in the family Diadematidæ and in the sub-family Orthopsinæ.

EODIADEMA GRANULATA, sp. nov. Plate X. Figs. 5, *5a*, *5b*, *5c*.

Test small, sub-conical above the tumid ambitus, circular in ambital outline. Apical system with granulated basal plates, with large perforations; the posterior radial plates large, separating the fifth basal plate and entering the periprocteal ring; the others smaller, triangular and excluded. A raised rim around the periproct. Poriferous zones somewhat sunken; all plates simple primaries; tubercles very small in two vertical rows. Dorsal surface of interradia, except in the median lines down to varying distances towards the ambitus, very boldly granulate; in the triangular spaces, from the basal plates along the median lines there is but slight granulation or it may be absent.[1] About five large primary tubercles in each interradium at the ambitus, perforate, crenulate, and with coalescing scrobicules. Peristome reentering; with branchial incisions limited by raised lines. Height, 6 mm.; breadth, 12 mm.

Marlstone Rock, Tilton (East Norton embankment).

[1] The otherwise faithful drawing, Fig. *5a*, should have fewer granules upon the interradial plates close to the basal plates.

ONYCHITES, sp. Plate X. Fig. 6.

Two of the peculiar bodies known by this name were obtained by Mr. B. Thompson, F.G.S., from the East Norton embankment.

The specimen here figured may be described as follows: Cylindrical curved hollow body tapering to a point at each end, somewhat constricted in the middle (3 mm. in diameter) and expanded towards the ends (4 to 5 mm. in diameter), and flattened and with acute edges towards one end; this body is bow-shaped, the points curving towards the same side, but in planes considerably inclined to each other; the pointed ends are about 4·5 centimetres apart; the shelly covering is thin, smooth and apparently structureless, but under a high-power lens its external surface appears to be finely punctated; the shell is separated from the surrounding matrix by a uniformly narrow hollow space about ·5 mm. broad, indicating apparently the former presence of a soft investing organic layer, which has disappeared in the process of fossilization. At first sight these hollow cylindrical bodies look as if they might have belonged to tubicolar Annelids; but it is to be observed that their tubes are closed at *both* ends, and that, as we have just seen, there are indications of their having been internal and not external structures.

Thirty years ago, Quenstedt described several of these curious bodies in "Der Jura."[1] At one time it appears they were taken for "compressed crabs-claws"! Dr. Fraas considered them to be the acetabular hooks of Cephalopods, referring them to *Onychoteuthis*, and in this view Quenstedt concurred. Messrs. Tate and Blake state in 'The Yorkshire Lias'[2] that they met with these pointed organisms in the 'Jamesoni beds' at Peak, agreeing with the *Onychites numismalis*, of Quenstedt, but they avoided any speculation as to their true nature. I am inclined to accept the explanation suggested by Fraas and Quenstedt.

Marlstone Rock, Tilton (East Norton embankment).

EXPLANATION OF PLATE X.

FIG. 1.	*Cardinia Slatteri*,	Walford. Marlstone Rock, Tilton (East Norton embankment). Left valve, exterior. Nat. size.
,, 2.	*Ibid.*	Marlstone Rock, Transition-bed, Appletree. Right valve, interior. Nat. size.
,, 3.	*Pinna Tiltonensis*,	sp. nov. Marlstone Rock, Tilton (East Norton embankment). Nat. size.
,, 4, 4*a*.	*Inoceramus*, sp.	Marlstone Rock, Tilton (East Norton embankment). Right and left valves. Half nat. size.
,, 5.	*Eodiadema granulata*,	sp. nov. Marlstone Rock, Tilton (East Norton embankment). Side view, enlarged twice.
,, *5a.*	*Ibid.*	Apical system. Same locality. Enlarged six times.
,, *5b.*	*Ibid.*	Mouth opening. From another specimen, enlarged three times.
,, *5c.*	*Ibid.*	Ambulacrum and interambulacrum, enlarged six times.
,, 6.	*Onychites*, sp.	Marlstone Rock, Tilton (East Norton embankment).

[1] "Der Jura," p. 201, pl. 24, fs. 59–62, and pp. 246–7, pl. 34, fs. 2–5.
[2] "The Yorkshire Lias," p. 448.

APPENDIX.

List of Fossils from the Lias Marlstone (including the "Transition Bed") of Tilton, Leicestershire.

Reptilia.

Ichthyosaurus, sp. vertebræ.

Cephalopoda.

Amaltheus margaritatus, De Montf.
,, *spinatus*, Brug.
Harpoceras acutum, Tate.
,, *ovatum*, Young and Bird.
,, *serpentinum*, Rein.
Stephanoceras annulatum, Sow.
,, *commune*, Sow.
,, *semicelatum*, Simpson.
Belemnites apicicurvatus, Blainv.
,, *breviformis*, Voltz.
,, *clavellatus*, Bean.
,, *paxillosus*, Schloth.
Nautilus truncatus, Sow.

Gasteropoda.

Actæonina fragilis, Dunker.
,, *ferrea*, Wilson.
,, *Ilminsterensis*, Moore.
,, *sinemuriensis*, Martin.
Amberleya (*Trochus*) *Gaudryana*, d'Orb.
,, ,, ,, a var.
Cerithium confusum, Tate.
,, *costulatum* ? Desl.
,, *ferreum*, Tate.
,, *Ilminsterensis* ? Moore.
,, *liassicum*, Moore.
,, *reticulatum* ? Desl.
Chemnitzia (?) *Periniana*, d'Orb.
,, (?) (*Turritella*) *undulata*, Benz.
Cryptoenia expansa, Sow.
,, *rotellæformis*, Dunker.
,, *solarioides*, Sow.
Cylindrites æqualis, Wilson.
Monodonta bullata, Moore.
Pseudomelania (*Chemnitzia*) *Brannoviensis*, Dumort.
,, (*Phasianella*) *turbinata*, Stol.
,, sp.
Pleurotomaria (*Turbo*) *canalis*, Mü.
,, (*Trochus*) *helicinoides*, Roemer.
,, *rustica*, Desl.
,, *similis* (= *anglica*), Sow.
Trochus ariel, Dumort.
,, *Fidia*, d'Orb.
,, *lineatus*, Moore.
,, *Pethertonensis*, Moore.
,, *rotulus*, Stol.
Turbo cyclostoma, Benz.
,, *rugifera*, Moore = *T. coronatus*, Moore = *Pl. costulatum*, Moore.
,, *latilabrus*, Stol.

Lamellibranchiata.

Anomia numismalis, Quenst.
Astarte striato-sulcata, Roemer.
Cardinia concinna, Sow.
,, (*Isocardia*) *Slatteri*, Walford.
Ceromya bombax, Quenst.
Goniomya heteropleura, Ag.
Gresslya intermedia, Simpson.
,, *lunulata*, Tate.
Hinnites abjectus, Phillips.
,, *velatus*, Münster.
Inoceramus, sp.
Lima eucharis, d'Orb.
,, *Hermanni*, Voltz.
,, *pectinoides*, Sow.
Limea acuticosta, Münster.
,, *Juliana*, Dumort.
Macrodon Buckmanni, Buckm.
Modiola numismalis, Oppel.
,, *ornata*, Moore.
,, *scalprum*, Sow.
Monotis inæquivalvis, Sow.
Ostrea (*Gryphea*) *cymbium*, var. *depressa*, Lam.
,, *submargaritacea*, Brauns.
Pecten acutiradiatus, Goldfuss.
,, *æquivalvis*, Sow.
,, *calvus*, Goldfuss.
,, *dentatus*, Sow.
,, *lunularis*, Römer.
,, *priscus*, Schloth.
,, *textorius*, Schloth.
Pinna Tiltonensis, n.sp.
Plicatula spinosa, Sow.
Protocardium truncatum, Sow.
Tellina gracilis, Dumort.
Unicardium subglobosum, Tate.

Brachiopoda.

Discina reflexa, Sow.
Rhynchonella acuta, Sow. var. *bidens*, Phill.
,, *Amalthei*, Quenst.
,, *fodinalis*, Tate.
,, *tetrahedra*, Sow.
,, ,, var. *Northamptonensis*, Walker.
Spiriferina rostrata, Schloth.
Terebratula punctata, Sow.
,, ,, var. *Edwardsii*, Dav.
,, ,, var. *Havesfieldensis*, Dav.
,, *punctata*, var. *Radstockensis*, Dav.
,, *Walfordi*, Dav.
Waldheimia indentata, Sow.
,, *numismalis*, Lam.
,, *resupinata*, Sow.
,, *sub-numismalis*, Dav.

BRYOZOA.

Diastopora oolitica, Vine.
,, *stomatoporoides* ? Vine.

ANNELIDA.

Ditrupa capitata, Phil.
,, *etalensis*, Piette.
,, *quinquesulcata*, Münster.
Serpula tetragona, Desl.
,, *tricristata*, Goldfuss.

ECHINODERMATA.

Eodiadema granulata, n.sp.
Pentacrinus lævis, Miller.

ACTINOZOA.

Thecocyathus, sp.

INCERTA SEDIS.

Onychites, sp.

II.—SUBAËRIAL DEPOSITS OF THE ARID REGION OF NORTH AMERICA.

By ISRAEL C. RUSSELL,
of the United States Geological Survey; Washington D.C., U.S.A.

Part II.

(*Concluded from p.* 295.)

A COMPARISON of adobe with the loess of China forms the concluding part of this paper; but as no analyses of the Chinese deposit are known to me, a few analyses of the loess of the Mississippi Valley are inserted, not with the assumption, however, that the deposits bearing the same name in these two regions are identical. A comparison of this table with the one showing the composition of adobe is instructive, as it indicates that these two yellow earths have a very similar composition. There are other respects in which they bear a close resemblance to each other; but as my acquaintance with the loess of the Mississippi Valley is limited, this comparison will not be carried further.

ANALYSES OF THE LOESS OF THE MISSISSIPPI VALLEY.[1]

Constituents.	No. 1.	No. 2.	No. 3.	No. 4.
SiO_2	72·68	64·61	74·46	60·69
Al_2O_3	12·03	10·64	12·26	7·95
Fe_2O_3	3·53	2·61	3·25	2·61
FeO	·96	·51	·12	·67
TiO_2	·72	·40	·14	·52
P_2O_5	·23	·06	·09	·13
MnO	·06	·05	·02	·12
CaO	1·59	5·41	1·69	8·96
MgO	1·11	3·69	1·12	4·56
Na_2O	1·68	1·35	1·43	1·17
K_2O	2·13	2·06	1·83	1·08
H_2O	*a*2·50	*a*2·05	*a*2·70	*a*1·14
CO_2	·39	6·31	·49	9·63
SO_3	·51	·11	·06	·12
C	·09	·13	·12	·19
	100·21	99·99	99·78	99·54

a Contains H of organic matter, dried at 100° C.

Organic Remains.—The fossils occurring in adobe, so far as I have been able to ascertain, are confined almost entirely to two classes, namely, land-shells and the bones of land-animals. Freshwater-

[1] From "The Driftless Area of the Upper Mississippi Valley," by T. C. Chamberlin and R. D. Salisbury, Sixth Ann. Rep. U.S. Geol. Surv. 1884–1885, p. 282.

shells are frequently present, but their number, so far as observed, is always small in comparison with the associated land-shells.

Samples of adobe collected near Fort Wingate, N.M., contained the following fossils, as has been kindly determined for me by William H. Dall, who states that they all belong to living species and occur from Alaska to Mexico.

LAND-SHELLS.

Succinea salleana ?, Pfr.
Hyalina (*Conulus*) *chersina*, Say.
Hyalina conspecta, Bland.
Hyalina arborea, Say.
Pupilla fallax, Say.
Vertigo ovata, Say.
Pupa muscorum, Linn.

FRESHWATER-SHELLS.

Bythinella tenuipes, Couper.
Limnæa desidosa ? Say.
Pisidium virginicum ? Bourg.
Planorbis parvus, Say.
Anodonta ? (in small fragments).

CRUSTACEAN CASES.

Cypris.

Near Cañon City, Col., I saw detached bones, apparently of the Bison, which were obtained at a depth of twenty feet in adobe. Other similar finds are reported in the same region, but the bones obtained have not been preserved. In one instance, near the same locality, a tooth of an Elephant was obtained at a depth of forty feet in the adobe deposit. These bones are always detached, and are true fossils belonging to the deposit in which they occur.

The only marine shells found in the adobe are fossils that have been derived from older rocks. An instance of this came under my notice near Cañon City, where fragments of an *Inoceramus* were found in this deposit, which could be readily traced to Cretaceous outcrops near at hand. These fossils should be considered merely as pebbles so far as they relate to the character and origin of the adobe.

Mode of Formation.—That adobe is a subaërial deposit derived from the waste of surrounding mountain slopes, does not seem open to question. Its accumulation is now in process and may be studied in all its details at thousands of localities; the most instructive being the drainless and lakeless valleys of Utah, Nevada and neighbouring areas. The action of ephemeral streams and of the general surface wash in transporting debris from the uplands to the valleys may be observed in such basins at any time when rain falls. The thousands of little streams and rills, born in the hills of the Arid Region from the waters of passing showers, flow rapidly down the steep slopes, loaded with coarse sediment and turbid with fine yellow silt. On leaving the mouths of the rocky gorges, and entering one or more of the channels that lead from them down the alluvial slopes, the coarse material is deposited, and when the showers are transient, the water disappears by evaporation and by percolation through the material of the alluvial cones. During this process fine silt is deposited in the interspaces of the alluvial cones, and serves to make them more and more impervious. When the rain is copious, the streams may continue to the plain where the waters spread out in sheets among the desert shrubs, and deposit their silt.

The particles of silt deposited by the ephemeral streams absorb the precipitates which are thrown down when the evaporation of the water that transported them takes place. During the long hot summers the water absorbed by the material filling enclosed basins is drawn to the surface by capillary attraction and evaporated. In this manner additional mineral matter is precipitated among the sedimentary deposits. It is evident, therefore, that the fine yellow earths filling enclosed basins owe their accumulation to both mechanical transportation and chemical precipitation.

It may be suggested in this connection that the coherency of adobe, which enables it to stand in vertical escarpments for a long series of years, may be due to the partial cementation of its particles by the precipitation of mineral matter, principally calcium carbonate, among them.

An examination of the fine silt in alluvial cones shows that it is identical with the silt forming the plains in the lower portions of the valleys in which they occur, except that it is not so evenly assorted, and in general is coarser. In both situations it is usually light yellow in colour, seemingly without reference to the character of the rocks from which it was derived. In addition to the material swept into the enclosed basins by ephemeral streams, there is another source of supply through aërial transportation. Dust is blown from the mountains overlooking the areas of accumulation and from neighbouring valleys, but the amount thus contributed is very small in comparison with the vast quantities of both coarse and fine material transported by water in the manner described above. This subject is again referred to on page 349.

The fine dust blown into the air by volcanoes has also contributed to the filling of the valleys of the Arid Region. The total quantity of fine particles thus deposited must be very great, but it has only been observed near recent volcanoes in the neighbourhood of Mono Lake, Cal., and in Southern Utah. Interstratified with lacustrine sediments in the basin of Lake Lahontan[1] there are deposits of white volcanic dust aggregating a thickness of perhaps six or eight feet, which was derived from the Mono craters two hundred miles away. This indicates that very many of the drainless valleys of Nevada and California must have received important contributions from the same source.

Relation of Adobe to Playa Deposits.—When an inclosed basin receives sufficient precipitation to form a lake, a portion of the fine debris swept down from neighbouring hills will be carried into it and deposited. In the Arid Region transient water bodies of this nature termed playa lakes are formed during every storm. These lakes are of all sizes up to hundreds of square miles in area, but are always extremely shallow, a depth of more than a few inches being rare. They usually disappear as quickly as they came, when the storms which supplied them pass away. On evaporating they leave a smooth plain or playa of light yellow mud, which is of almost impalpable fineness, and shows only very obscure, if any, lines of stratification. The last statement is based on a number of excavations which have been made in such deposits to a depth of six or eight

[1] Monograph No. 11, U.S. Geol. Surv., 1885, p. 146.

feet; but, as natural sections are wanting, the thickness of these deposits as well as their internal structure is not well known.

The lack of stratification in playa deposits may perhaps be due to the peculiar conditions under which they accumulate. The material composing them is fine throughout, but the waters continue turbid so long as they remain unevaporated, and the last addition made to the filling of the basin, in part a chemical precipitate, is of exceeding fineness. When the basins are refilled, this mud is quickly saturated, and may be again taken in suspension and in part redissolved. The deposits of various rainy periods may in this way be mingled so intimately that no lines of stratification would appear.

Playa lakes are sometimes alkaline and saline, and on evaporating deposit salts of various kinds. Commonly, however, especially in the smaller basins, no salt appears at the surface, but the playas present a smooth, even expanse of cream-coloured mud, which becomes hard and divided into a net-work of shrinkage cracks when it dries.

The fine sediment carried down the sides of an inclosed basin holding a playa lake is deposited in part before reaching the lake, and in part, as we have seen, in the lake itself. In both instances the accumulation is a yellow, finely divided earth, practically without stratification. In both instances the fine silt may have worn or angular pebbles and stones mingled with it, but in large valleys the accumulations, whether subaërial or subaqueous, are entirely of homogeneous yellow earth. The only marked difference in these deposits is that the playa are much more saline than the subaërial earths. The sediments of playa lakes are sometimes obscurely vesicular, as if small gas bubbles had been formed in them. In subaërial deposits this has not been observed. The subaërial deposits, on the other hand, are traversed, at least in a number of instances, by small vertical tubes that branch downward; in the playa deposits these are not present.

Relation to Stream Deposits.—Wherever the streams of the Arid Region overflow during high water and submerge their flood plains, a fine deposit is thrown down which in many instances is to all appearance identical with the adobe formed in drainless valleys.

The deposit made by a stream in its immediate channel, at least in the vicinity of mountains, is coarse, and is frequently composed of well-worn boulders and gravel. As the stream sways from side to side of its general course during a succession of years, a sheet of gravel is spread out as a flooring over an entire valley. The material deposited on the flood-plain however, and superimposed on the gravelly stream-bed previously laid down, is usually a fine silt, which in many instances does not show lines of stratification.

Along the streams of the Arid Region the flood plain deposits are frequently composed of fine, grey adobe, which breaks in vertical walls when undermined, and is without stratification. In some instances it is penetrated by vertical tubes apparently made by rootlets. In all these characteristics the stream deposit agrees with the subaërial deposit.

That the flood-plain deposits of an arid country should be of the same character as the adobe deposited on gentle slopes and in inclosed valleys by ephemeral streams, is not surprising, since the process in each instance is essentially the same and the material handled is identical. The ephemeral streams spread out their waters on reaching gentle slopes, and deposit their sediment quietly among the scanty desert vegetation. In the case of perennial streams which overflow their banks the process is similar, that is, they form sheets of comparatively still water along their borders, and deposit silt about the vegetation which obstructs their flow. In both instances it is to be expected that casts of the roots of plants would remain in the soil. Evaporation takes place in both instances, thus contributing precipitated mineral matter to the deposits, but occurs most rapidly in the case of the ephemeral streams.

In flood-plain deposits the shells of the freshwater molluscs occur, while land-shells may or may not be present. In the deposits of ephemeral streams the shells of land molluscs predominate, not to the exclusion of freshwater-shells, however, since the deposits are laid down by streams which in their upper course may survive throughout the summer and be inhabited by molluscs. The bones of land-mammals may be buried during either mode of accumulation.

The geological interest of adobe and allied deposits centres not only in the manner in which they are formed, but also in their extent and depth when accumulated under favourable conditions.

It is evident that the subaërial filling of an inclosed basin with fine material might continue in the manner described, until the depression was filled or the source of supply exhausted, so long as the climate conditions remain favourable. A decrease in precipitation would retard the filling or perhaps check it altogether, while an increase would favour the extension of playa lakes, or transform them into permanent water bodies. Should the increase be sufficient, the permanent lakes would overflow and cut down their channels of discharge until their basins were drained to the bottom. It appears, therefore, that the maximum thickness which subaërial deposits may attain in an arid region is very great, especially in the case of fault valleys, which may have their borders raised at the same time that their bottoms are being filled.

The thickness which playa lake deposits may attain is also very great; for, like the subaërial deposits just considered, they depend for their accumulation, the supply continuing, on a combination of climatic and topographic conditions which may remain favourable for a long period of time.

Of the three methods described above, by which fine silt deposits may be accumulated in arid regions, the least important in a geological point of view is the one dependent on the overflow of streams. In the formation of flood-plains the conditions favouring accumulation depend not only on climatic and topographic conditions, but more definitely than in the other instances on the supply of suitable material. The supply of sediment not only determines whether a stream shall deposit or not, but whether the deposits once laid down shall remain. In the formation of adobe and playa deposits, however, there is substantially no waste.

While adobe and playa deposits depend on aridity of climate for their formation, the flood-plain deposits are not so limited, but may go on apparently with the same results in an arid as in a humid climate, provided a periodic variation in the volume of the streams takes place, sufficient to cause them to overflow their banks during the flood stage. There seems to be no reason to suppose that the character of flood-plain deposits in arid and in humid regions should be distinct, unless it be that the fine material washed into streams in dry countries is largely supplied from subaërial deposits which have already been assorted, and perhaps have a different chemical character from the surface debris of humid regions.

It is beyond the scope of the present paper to discuss the processes by which flood-plain deposits are formed, especially as accumulations of this character are comparatively inconspicuous in the Arid Region, and also because the constructive power of streams has been extensively studied elsewhere.

The accumulation of adobe and of eolian and volcanic dust in the central portions of the valleys of the Arid Region, together with the formation of talus slopes and alluvial cones about their borders, promotes the levelling of the hills and the filling of the intervening depressions. The tendency of this twofold process is to reduce the country to a plain, but not to bring it to sea-level. An exception here exists to the nearly universal law of base-level erosion, an exception, however, that is transient when considered in the way that geologists are forced to reckon time. A long continuation of existing climatic conditions, together with an absence of orographic movements, in the Great Basin portion of the Arid Region, would result in the formation of a broad high-level plain with rocky crests projecting here and there to mark the sites of buried mountain-ranges. A change to more humid conditions after this process was far advanced would initiate drainage systems which would make rapid changes in the configuration of the region. One of the first results of an increased rainfall would be the cutting of deep cañons, especially in the unconsolidated adobe and playa deposits, thus exhibiting sections of these peculiar formations and revealing their great thickness.

In connection with a description of the occurrence of adobe it is proper to state that nothing similar to the red soils formed by the residual clays of the South Atlantic States, or the *red earth* of Bermuda and the West Indies, or the *terra rossa* of Southern Europe, or the *laterite* of India, is to be seen anywhere in the Arid Region. Rock disintegration is there active, but rock decomposition is retarded. The absence of residual clays from the comparatively rainless portion of this country is of interest as tending to show that such deposits are formed in humid and not in arid countries.[1]

[1] The subaërial deposits of humid regions have been discussed at some length by the present writer in Bulletin No. 52 of the U.S. Geological Survey (1889), to which this paper may be considered as a supplement.

II.—Comparison of the Adobe with the Loess of China.

It is of interest to compare the adobe of the Arid Region with similar accumulations elsewhere, and especially with the loess of China, which has been very fully described by F. Von Richthofen.[1]

In China there are many basins comparable with those in the more arid portion of the United States, which are deeply filled with a yellow marly-clay of impalpable fineness termed Loess, which is without stratification, breaks most readily in a vertical direction, and stands in perpendicular escarpments for many years. It is traversed by vertical tubes of small dimensions which bifurcate downward; is charged with land-shells, and contains the bones of land-mammals. In all of these particulars the loess of China agrees with the adobe of the Arid Region. The loess is described as being uniformly yellow in colour, and, as we have previously stated, this is the characteristic colour of the vast subaërial deposit of the Arid Region, except when charged with organic matter.

In China certain peculiar concretions occur in the loess, figures of which are given by Richthofen;[2] these, so far as known, are not represented in the adobe.

A portion of the loess of China, termed "lake loess," has been described as being a stratified deposit formed in saline lakes. These beds are practically identical with the playa deposits of the Arid Region, except that a more marked stratification has been observed in them. In each country these deposits are composed of fine, light yellow earth, more or less saline, and sometimes carry salts of various kinds in sufficient quantities to be of commercial value.

The loess of China has been shown by Richthofen to have a thickness of fully 2000–2500 feet. There is a lack of accurate data by which to determine the thickness of the similar deposits in America, but observations based on the contours of valleys and on the records of the few wells that have been bored, indicate, as already stated, that in many instances it is fully as thick as the loess.

In China the peculiar property of the loess, which admits of its standing in vertical escarpments, is utilized by the inhabitants, who excavate houses in the faces of the bluffs. In America the same property in the adobe admits of the formation of sun-dried bricks, which have been used in the construction of thousands of houses, and in many instances of entire towns. In each country the deposits mentioned form exceedingly rich agricultural lands.

The loess is described as being porous, so that rain falling on it is rapidly absorbed. This property is shared in part by the adobe, but is not a characteristic feature of the deposit in general. On the alluvial cones and in the higher portions of the adobe-filled basins of the Arid Region, the rain-water rapidly disappears by percolation, but in other instances, and especially in the playas, the earth is extremely impervious. Only a foot or two beneath the playa lakes

[1] China, Berlin, 1877, vol. i. pp. 56-189. See also abstract in Am. Jour. Sci. 3rd series, 1877, vol. xiv. pp. 487–491.

[2] China, vol. i. p. 58.

the yellow earth is always dry and powdery. These lakes are frequently called "sinks," as the "sink of the Carson River" for example; but a more complete misnomer could scarcely be cited, as the water escapes from them solely by evaporation.

There is one remarkable peculiarity in which the loess region of China differs from the Arid Region, that is, it has been deeply dissected by stream erosion, so that the vast thickness of its superficial deposits is fully exposed. In this country the valleys of the Arid Region are still being filled, and dissection has not commenced. In China a recent climatic change, perhaps very moderate in its character, seems to have occurred, which has allowed of the formation of streams in a previously drainless region, and the streams have sunk their channels in the loess in the wonderful manner described by travellers.

The similarity between the loess of China and the adobe of America is such as to warrant the conclusion that they were deposited under essentially the same conditions. That they are both mainly subaërial deposits, it seems to me, must be acknowledged by every one who is familiar with the geological processes now active in arid regions.

Richthofen[1] refers the origin of the loess of China to three processes: "The first is rain water, which flows down from the upper to the lower parts, and washes away the solids which have become loosened by the decomposition of the rocks of neighbouring mountains. The second is the wind, whose extraordinary aid in accumulating dust-like divided solid material, one has frequent opportunity to notice in the regions occupied by the loess. The third agent lies in the mineral ingredients, which the roots of grasses, by the diffusion of mineral fluids drawn up from below, assimilate, and on their decay leave behind. All these finely divided ingredients are held fast by the vegetable covering, and thence afterwards carried away only in small quantities by the wind."

The second and third of these processes are held by Richthofen to be most important; and of these two by far the greater prominence is given to the second, that is, to the action of the wind in transporting dust. My own studies in the arid portions of this country failed to sustain this explanation, but lead me to refer the accumulation of both the coarse and the fine deposits now accumulating in the drainless valleys of that region to the first hypothesis mentioned above; that is, to the transportation and deposition of fine material by ephemeral streams.

That eolian transportation is an element in the process by which inclosed valleys are filled with fine debris must be acknowledged; but that it is the principal, or even an important element, does not appear to be warranted by a study of the processes by which such deposits are now being formed.

Richthofen has shown so clearly that the loess of China was not accumulated in freshwater lakes or in the ocean, that the hypotheses

[1] China, vol. i. p. 78.

advanced by various writers who have referred its origin to ordinary sedimentation need not be considered farther.

In reference to the accumulation of loess through the vital action of vegetation as advocated by Richthofen, it is perhaps sufficient to suggest, as has been done by T. W. Kingsmill,[1] "that plants could furnish to the mineral accumulations only what they took from it, and hence could add nothing." Apparently no exception can be taken to this argument, unless it be that plants may add carbon derived from the carbonic acid of the atmosphere, to the soils in which they grow.

The similarity between the loess of China and the adobe of the Arid Region is so close that they might properly be designated by the same name; but, as confusion has apparently already arisen from the too general use of the former name, it has been thought best to use a new term instead.

WASHINGTON, D.C., Nov. 27, 1888.

III.—GLACIATION OF HIGH POINTS IN THE SOUTHERN INTERIOR OF BRITISH COLUMBIA.

By GEORGE M. DAWSON, D.Sc., F.G.S.;
Assistant-Director of the Geological Survey of Canada.

IN an article published in the GEOLOGICAL MAGAZINE for August, 1888, an outline was presented of some facts resulting from recent investigations on the glaciation of British Columbia and adjacent regions, bearing more particularly on the flow of ice in a northerly direction brought to light by explorations in the Yukon district, but touching also on the south-eastern extension of the great western glacier-mass of the continent, which I have proposed to name the Cordilleran glacier. Field-work carried out by me during the summer of 1888 has resulted in the accumulation of many new facts relating to the southern part of the area, which was at one time covered by the Cordilleran glacier, from which it would appear that it may ultimately be possible not only to trace the various stages in the recession of the main front of the great confluent glacier beneath which the interior or plateau region of British Columbia was buried, but even to follow the later stages of its decline as it became broken up into numerous local glaciers confined to the valleys of the several mountain ranges which limit the plateau.

As, however, work is to be continued in the same southern part of British Columbia during the present summer, it is not at present intended to discuss these general features, but merely to call attention to the noteworthy heights at which glaciation has now been found to occur on some of the higher parts of the Interior Plateau and its mountains, and to the great mass thereby indicated for the southern part of the Cordilleran glacier.

The highest point on which I had previously noted the marks of

[1] Quart. Journ. Geol. Soc. London, 1878, vol. xxvii. p. 380.

glacier ice in this region was Iron Mountain, at the junction of the Nicola and Coldwater rivers, the summit of which is 3500 feet above the neighbouring river valleys, or 5280 feet above the sea.[1] Evidence of the same kind—all implying the movement of a great glacier-mass entirely independent of the local features of the country—has now been discovered on several still higher points, the most elevated being Tod Mountain, situated 25 miles north-east of Kamloops, and rising 7200 feet above the sea. The actual summit of this mountain is, however, but lightly glaciated, and in this circumstance and the apparent influence which local irregularities of rock-surface have had upon the direction of striation, evidence seems to be afforded that the summit was never deeply covered by the great glacier. This conclusion is further borne out by the fact that a few hundred feet only lower down the same mountain, the glaciation is much stronger, and fluted rock-surfaces and other easily recognized marks of heavy glacier ice are observed. Tod Mountain is the culminating point of a region surrounded on three sides by the wide and important valleys of the North and South Thompson Rivers and Adams Lake, the nearest points comparable in elevation to it being in the Gold Range, at a distance of over 25 miles in a north-easterly direction, or nearly at right angles to the direction of the glaciation. There can be no question as to the fact that the glaciation met with at this place is due to the general or Cordilleran glacier, and it is thus evident that at one period the glacier ice must have attained a thickness of about 6000 feet in the valleys above named, while it covered even the higher portions of the irregular plateau of this part of the interior of British Columbia to a depth of at least 2000 to 3000 feet. When it is taken into consideration that evidence has already been obtained of the south-easterly motion of this part of the Cordilleran glacier for a distance of at least 300 miles to the north-west of Tod Mountain, it is apparent that the mass of *névé-ice* accumulated over the country north of the 55th parallel of latitude from which the southerly- and northerly-flowing extensions of the great glacier were fed must have been enormous.

As previously stated by me, the condition of this part of the Cordilleran region, at the period of its maximum glaciation, must have been clearly analogous to that of Greenland at the present day, save that in the case of British Columbia it has been impossible for any large proportion of the ice to escape to the eastward or to the westward because of the bordering mountain ranges.

Some of the principal new localities at which distinct evidence of the passage of the Cordilleran glacier over the southern part of British Columbia were observed during the summer of 1888, with the approximate position and height of each and the direction of motion indicated, are given below. The variation in direction found in comparing even the highest stations is generally explicable on consideration of the influence of adjacent important orographic features. A number of observations made at points somewhat lower than these here quoted show, as might be anticipated, an increasing

[1] Quart. Journ. Geol. Soc. vol. xxxiv. p. 272.

degree of influence of the same kind dependent on the subordinate relief of the country passed over.

Place.	Approximate Latitude.	Approximate Longitude.	Height in feet.	Direction (true bearings).
High Plateau between N. Thompson and Bonaparte Rivers.	51° 6′	120° 56′	4340	S 20° E
,, ,, ,,	51° 4′	120° 45′	5100	S 34° E
,, ,, ,,	51° 9′	120° 26′	5430	S 37° E
,, ,, ,,	50° 59′	120° 25′	5440	S 35° E
Tod Mountain	50° 56′	119° 55′	7200	S 44° E
High Plateau between Adams and Shuswap Lakes. ...	51° 1′	119° 41′	6100	S 27° E
Cinder Mountain.	50° 34′	121° 8′	5180	S 50° E
Loadstone Peak	49° 25′	120° 50′	6280	S 15° E

IV.—Notes on New and other Dinosaurian Remains.

By R. Lydekker, B.A., F.G.S., F.Z.S., etc.

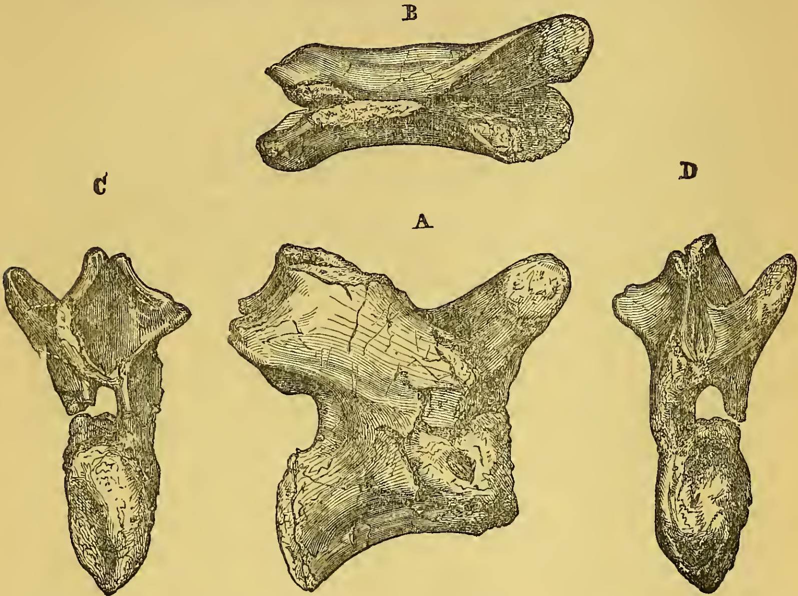
In the present communication I call attention to a Reptilian vertebra which does not appear to have received the notice it deserves, and also give a preliminary diagnosis of certain forms which I hope to describe more fully later on.

1. Arctosaurus Osborni, Adams.

In the year 1875 the late Professor Leith Adams described and figured in the "Proceedings of the Royal Irish Academy" (ser. 2, vol. ii. p. 177) an imperfect Saurian vertebra which had been obtained many years previously from Arctic America during the voyage of Captain Sherrard Osborn, which is now preserved in the Museum of Science and Art, Dublin. The specimen was obtained from beds of unknown but doubtless Mesozoic age at Rendezvous Mountain, which is situated at the north end of Bathurst Island in 70° 36′ north latitude.

By the courtesy of Prof. V. Ball, Director of the Science and Art Museum, Dublin, I have recently had an opportunity of examining this interesting specimen, of which, by permission of the Royal Irish Academy, I am able to reproduce the original figure. In his original description of the specimen, which has suffered by lateral crushing and is otherwise imperfect, Prof. Adams considered that it indicated a cervical vertebra, which had lost the neural spine, the costal articulations, and the right prezygapophysis. And he then proceeds to give his reasons for regarding it as more nearly allied to Lizards than any other reptiles.

My own observations confirm the conclusion that this vertebra belongs to the cervical region; but it appears that its affinities are certainly Dinosaurian. The centrum is compressed and amphicœlous, with a sharp hæmal carina; and it is evident that there were free cervical ribs and a well-developed neural spine. The highly curved ventral profile and the length of the centrum indicate that the owner of this vertebra had an arched and comparatively elongated neck; the whole *facies* of the specimen being essentially Dinosaurian. Moreover, in the deep median incisions between the pre- and post-zygapophyses the specimen resembles the cervicals of many of the Theropoda; while a longitudinal fissure on the right side of the centrum is highly suggestive of the crushing in of an internal cavity. That the specimen does not belong to the *Cœluridæ* is quite clear; and I am inclined to regard it as indicating a Dinosaur more or less closely allied to the *Anchisauridæ*, although, in the absence of figures of the typical American forms, it is at present impossible to institute any exact comparison. The especial interest of this specimen is the evidence which it affords as to the path by which the generic types of Dinosaurs common to the old and new worlds may have passed from the one hemisphere to the other.



Arctosaurus Osborni. Right lateral (*A*), neural (*B*), posterior (*C*), and anterior (*D*) aspects of an imperfect cervical vertebra; from Bathurst Island. Nat. size. (*From the Proc. R. Irish Academy.*)

2. Orinosaurus capensis, n. sp.

In describing certain Dinosaurian remains from the Karoo System of the Cape in 1867, Prof. Huxley (Quart. Journ. Geol Soc. vol. xxiii. p. 5) applied the name *Orosaurus* to a large bone which he regarded as the distal extremity of a femur, and considered to be generically distinct from the other specimens described in the same paper under the name of *Euscelesaurus*. This bone has been recently presented by its describer to the British Museum (No. R. 1626), and after careful examination I am convinced that it is really the proximal extremity of a left tibia. It agrees very closely, both in size and characters, with the tibia of *Iguanodon Mantelli*, but appears to have been solid throughout. The great expansion of the head and cnemial crest distinguishes it from the tibia of *Euscelesaurus*, which appears to have had a bony union with the fibula, as in *Stegosaurus*, and it therefore appears that the generic distinctness of *Orosaurus* is justified. Unfortunately, however, this term is preoccupied by the more correctly formed *Oreosaurus*, Peters,[1] and I accordingly propose to replace it by the name *Orinosaurus*.[2] Since, moreover, no specific name was proposed by Prof. Huxley for this Dinosaur, I would suggest that it should be known as *O. capensis*.

If I am right in regarding this tibia as solid throughout, the specimen is of considerable interest as apparently showing a connection between the *Stegosauridæ* and *Iguanodontidæ*, and thereby serving to confirm Dr. Baur in his conclusion that these two families should be included in a single suborder.

3. Iguanodon Fittoni, n. sp.

Among a series of specimens from the Wadhurst Clay near Hastings, recently collected by Mr. C. Dawson, F.G.S., for the British Museum, are an apparently associated left ilium, part of a pubis, and the imperfect sacrum (B.M. No. R. 1635), which appear to indicate a distinct species. The specimens were obtained at the village of Shornden, and although the sacrum was found at a distance of some fifty yards from the ilium, Mr. Dawson has no doubt that both specimens belonged to the same individual.

The ilium, which I take as the type of this form, indicates a somewhat smaller animal than the ilium from a somewhat lower horizon which forms one of the types of *I. Dawsoni*.[3] Moreover, it differs from that ilium in that the preacetabular process merely forms a thin vertical plate, and entirely wants the horizontal inner extension found on the lower border of the latter. Again, while in *I. Dawsoni* the postacetabular portion forms a deep plate with a rounded termination, the corresponding portion of the present specimen has its lateral surface terminating in a point, while the inferior border is bent inwardly to form a shelf-like projection on that side. The portion of the ilium immediately above the acetabulum is relatively deeper, and the acetabulum itself less well defined than in *I. Dawsoni*. The associated sacrum has laterally-compressed and anchylosed vertebræ like those of *I. Mantelli*, from which species the present form is at once distinguished by the greater height of the ilium and the inflection of the lower border of the postacetabular portion. The only other named form to which this specimen could possibly belong is *Sphenospondylus gracilis* of the Upper Wealden, but the ilium appears to be proportionately much too large for the vertebræ, and the sacrum is different from the one which I have suggested may belong to that genus.

I propose to designate this apparently new form as *I. Fittoni* in

[1] Abh. Ak. Berlin, 1862, p. 201. [2] From the adjectival ὀρεινὸς.

[3] See 'Cat. Foss. Rept. and Amphib. in Brit. Mus.' pt. i. pp. 197-199.

honour of the late Dr. Fitton, so well known for his labours in connection with the Lower Cretaceous of England. The ilium of this species, so far as its posterior portion is concerned, makes a remarkable approach to the type species of the American *Camptosaurus*, from which, however, this form is widely distinguished by the structure of the sacrum.

4. IGUANODON HOLLINGTONIENSIS, n.sp.

Specimens from the Wadhurst Clay of Hollington, near Hastings, appear to indicate a third species from these deposits which I propose to distinguish, at least provisionally, as *I. hollingtoniensis.* Some of these remains I have previously referred in the work cited to *I. Dawsoni*, while others I have suggested might belong either to that species or to immature examples of *I. bernissartensis.*

I take as the type the specimens in the British Museum numbered R. 1148[1] together with others belonging to the same individual numbered R. 1629, and also certain vertebræ numbered R. 1632, which are also believed to have belonged to the same individual.

The femur (R. 1148) agrees approximately in size with that of *I. Mantelli*, but is at once distinguished by its curved shaft and pendant inner trochanter, in which respects it resembles the corresponding bone of *Camptosaurus*. It is smaller and of different contour from another femur, which, from the evidence of the associated ilium, belongs to *I. Dawsoni*. The sacral vertebræ (R. 1632) are of the type of those (B.M. No. R. 811) I have previously referred to the latter species,[2] having flattened hæmal surfaces to the centra, which were not anchylosed together. An ilium (No. R. 811*b*) associated with the sacrum and ischia No. R. 811, although very imperfect, shows that the preacetabular process was of the thin type of *I. Fittoni*, and therefore different from that of *I. Dawsoni*, while this ilium is decidedly different from that of *I. Fittoni*. Finally, the dorsal vertebræ associated with Nos. R. 811 (B. M. No. R. 604) and with R. 1148, are smaller and more compressed than those of *I. Dawsoni.*

That the present form is distinct from *I. Mantelli* is shown by the femur; from *I. Dawsoni* it is distinguished by the size of the femur, and of the dorsal vertebræ, as well as by the size and contour of the ilium which is apparently referable to it. The sacral vertebra, No. R. 1632, which is believed to have been associated with the type specimen, distinguishes this species from *I. Fittoni*; this being confirmed by the sacrum No. R. 811, which is now known to have been associated with vertebræ and an ilium which are clearly not referable to *I. Dawsoni*, and still less to *I. Fittoni.*

Iguanodon hollingtoniensis approximates in the structure of its femur, ischia, and sacrum to *Camptosaurus*, but is distinguished by the peculiar pollex of *Iguanodon*, on which account I include it in the latter genus.

I am at present unable to say definitely whether the unnamed imperfect skeleton in the British Museum from Hollington numbered

[1] 'Cat. Rept. etc.,' *op. cit.* p. 217. [2] *Op. cit.* p. 199.

R. 33[1] belongs to *I. Fittoni* or *I. hollingtoniensis*, although, as I have remarked in the work cited, it is certainly distinct from *I. Mantelli.* I may add that the bone in that skeleton catalogued as a fragment of an ilium proves to be the glenoidal portion of the right coracoid.

V.—The Occurrence of Granite in a Boring at Bletchley.

By A. J. Jukes-Browne, B.A., F.G.S.

In the winter of 1886–7 a boring was made at Bletchley Junction for the London and North-Western Railway Company. and acquired importance from the report that, after passing through the Oxford Clay, it had entered a mass of granitic rock.[2] Probably many readers of this Magazine wondered why no detailed account of the boring was published after this announcement; but the reason was, that when inquiries came to be made, some uncertainty was found to exist as to the position and mode of occurrence of the granitic rock. My attention was recently called to the boring by learning that the water obtained from it was salt. I then obtained all the information I could with regard to the rocks passed through, and think the results are of sufficient importance for publication. The interest naturally centres in the supposed occurrence of granitic rock at a depth of less than 400 feet from the surface, and it seems desirable that the facts with regard to this should be placed on record.

The boring was made by Mr. Ebenezer Timmins, of Runcorn, under the superintendence of Mr. F. W. Webb, the Engineer of the L.N.W.R. Company. The work was personally directed by Mr. Arthur Timmins, to whom I am indebted for the particulars given below; Mr. A. Timmins tells me he had the first handling of all samples which were brought up, and that he took some trouble to ascertain the nature of the rocks through which the boring was carried, making analyses of several of the specimens himself. All this information he has generously placed at my disposal, and the following is his account of the boring.

Old well 148 feet deep. Boring commenced from bottom of well. Level of surface about 260ft. O.D. :—

	Thickness.		Depth.	
	ft.	in.	ft.	in.
1. Depth of old well	—		148	0
2. Blue limestone	8	0	156	0
3. Blue clay	9	0	165	0
4. Black shale	1	0	166	0
5. Yellow clay	2	6	168	6
6. Brown clay	17	6	186	0
7. Blue limestone	1	0	187	0
8. Brown clay	5	0	192	0
9. Blue limestone	12	0	204	0
10. Blue clay	8	0	212	0
11. Blue limestone	5	9	217	9
12. Blue clay	6	3	224	0
13. Blue limestone	1	0	225	0

[1] *Op. cit.* p. 226.
[2] See Prof. Hull's letter, Geol. Mag. Dec. III. Vol. IV. p. 139 (1887).

	ft.	in.	ft.	in.
14. Blue clay with septaria	36	0	261	0
15. Blue limestone	1	0	262	0
16. Blue clay with septaria	40	0	302	0
17. Blue limestone.........................	3	6	305	6
18. Blue clay	4	6	310	0
19. Blue limestone	1	0	311	0
20. Blue clay	45	0	356	0
21. Indurated bluish limestone.........	22	5	378	5
22. Granitic rock	21	7	400	0
23. Clay	1	0	401	0
24. Granitic rock	6	2	407	2
25. Clay	2	10	410	0

The following observations are chiefly by Mr. A. Timmins, with a few remarks of my own on the samples which he sent me, and which are now in the possession of Prof. A. H. Green at Oxford.

No. 3 was a very hard blue clay.

No. 4. A bituminous shale containing iron pyrites.

No. 9. Sample preserved, a dark grey limestone, with well-marked oolitic structure, several Echinoderm spines, and some shell fragments.

No. 11. Samples preserved probably from this bed are of a grey shelly and partially oolitic limestone.

No. 13. Sample preserved from 224 feet, a light grey crystalline limestone, very hard, with glistening surfaces of calcite, possibly parts of Echinoderm tests and spines.

No. 14. A very hard clay full of septaria and pyrites.

No. 16. The same as No. 14. Samples of the septaria preserved and analysis made by Mr. Timmins with following result :—

Insoluble siliceous matter	9·800
FeO (originally $FeCO_3$)	34·418
Fe_2O_3, iron peroxide	33·423
Alumina	3·392
Calcium carbonate	17·050
Magnesium carbonate......................................	2·291
	100·374

Nos. 18, 19, and 20. These beds were full of fossils, but all the larger specimens were broken up by the chisels; those preserved are chiefly fragments of the stems and arms of small Crinoids, with several pieces of small Belemnites and fragments of bivalve shells. They are just such fossils as would occur near the base of the Oxford Clay.

No. 21. No sample preserved, but described by Mr. Timmins as a "very hard limestone." At about 360 feet it contained hard nodules or boulders of stone of a dark buff colour and having cracks filled up with calcite; they were calcareous and ferruginous, with only 15 per cent. of insoluble matter. A sample from 370 feet had the following composition :—

Insoluble matter	53·48
Oxide of iron and alumina	20·40
Calcium carbonate	26·06
	99·94

My colleague, Mr. A. G. Cameron, has sent me a piece of Kellaway rock, from Kempton, near Bedford, which is a very hard, compact, greyish-brown ferruginous and siliceous limestone; the general character of this rock is such as to suggest a chemical composition similar to that of the above analysis of the "indurated limestone" in the boring, and it has cracks filled with calcite.

Mr. Timmins says that from the foreman borer's account it would appear that this bed gradually got harder and harder till they came on to the "granitic rock" at 378′ 5″, and that the depth of colour also increased to a rusty brown.

No. 22. The following are Mr. Timmins' notes on this rock:—"The boring of this bed proved a very tedious operation, averaging about five inches a day, and owing to this incessant grinding of débris, large particles of rock were not to be expected: what samples there are were found after sifting the whole débris through a sieve of 1225 meshes to the square inch. The analysis of a bulked sample between 378′ 5″ and 390 feet is as follows:

Insoluble matter	80·106
Oxide of iron and alumina	11·514
Calcium carbonate	3·838
Magnesium carbonate	·640
Alkalies, etc., not determined	3·902
	100·000

Before analyzing this sample, all particles of steel and iron from the boring tools and casing tubes were extracted as well as possible with a magnet; but it is possible that some of the $11\frac{1}{2}$ per cent. of iron is derived from the mechanical appliances in use."

Samples of this material are preserved in bottles, the larger fragments are undoubtedly pieces of a granitic rock; the finer material which has passed through the sieve is of a brownish colour, and has the appearance of a pounded, fine-grained ferruginous sandstone. More will be said of this in the sequel.

Bed 24 was similar to bed 22, but was not so hard and compact, so that more rapid progress was made through it.

Beds 23 and 25 were clays with a blue colour when first brought into daylight, but after a few days in the air the colour began to fade, and through gradual gradations it arrived at a light brownish tint; this is probably due to the oxidation of the iron. An analysis of one of these clays gave the following results:

Insoluble siliceous matter	79·807
Oxides of iron and alumina	13·778
Calcium carbonate	2·997
Magnesium carbonate	1·718
	98·300

Mr. Timmins remarks that it had somewhat the aspect and composition of a fire-clay. As the sample sent to me had rather a powdery felspathic look about it, I forwarded it to Prof. Bonney, who reported that it appeared to be an ordinary clay, "such as might well occur in the Jurassic series"; and that it was not a decomposed igneous rock or felspar rolled *in situ*, and had certainly not been baked by contact with igneous rock, as it must have been if the beds of "*granitic rock*" were intrusive sheets.

To complete the record of the boring, it may here be mentioned that water was found at the depth of 390 feet 9 inches in the first bed of "*granitic rock,*" and again in the lowest clay at 410 feet, or more probably from a bed immediately underlying this clay, but not pierced. In both cases the water was very salt and unfit for use, so that the boring was abandoned and a coffee-house is now built over the site.

We may now revert to the so-called "granitic rock." It has already been stated that fragments of such a rock do certainly occur among the samples, and there seems no reason to doubt that these fragments were brought up from the depths named. As evidence on this point I quote a letter from Mr. A. Timmins to Mr. Cameron, dated November 19, 1886:—"I enclose a sample of the strata from present depth (390 ft.) . . . I make it out as hornblendic granite, and have had suspicions for some time. A few weeks ago my father brought home a piece of stone similar to the sample, and said that he was told by the foreman that it had come up the boring. Ever since I have sieved the samples sent to me, and Saturday was the first time, since that above mentioned, that I was able to get any larger pieces. My suspicions were at once confirmed, and I make out that we have bored through 10 feet of this granitic rock." With this evidence we may I think take it for granted that pieces of a granitic rock did come up from the depths stated in the account of the boring.

Next as to the nature of the rock: two small fragments were sent to Prof. Bonney, who was kind enough to examine them and reported as follows: "The fragments which you have sent me are of a rock closely allied to granite. As far as I can see with a strong lens they are likely to belong to the microgranulite of Fouqué and Lévy—that is, a rock with felspar quartz and mica or hornblende (probably the latter in this case) in a sort of fine mosaic; the individual grains not being very definite in form unless showing a micrographic structure. It is not a *true* granite, and yet it is rather too crystalline for a normal quartz-felsite . . . I never saw one like it among the Midland Palæozoics, but it has a general resemblance to the rocks of the Narborough district." There is no proof however that the whole of the thickness given to "granitic rock" in Mr. Timmins' account of the boring consisted of the rock above described; there is indeed strong evidence for the belief that it did not. In the first place I am informed by Mr. Cameron that he went over to Bletchley at the time they were boring through this rock, and selected small samples out of the foreman's box from depths of 391 feet and 393 to 396 feet. These he has kindly sent to me, pointing out that they are simply sandstones, without any trace of granitic fragments or minerals. The first is a light-coloured and fine-grained sandstone composed of small quartz grains with ferruginous staining; the second is a dark brown ferruginous sandstone. Both are such rocks as occur in the Kellaways Beds at the base of the Oxford Clay, and the only way of reconciling their existence with the recorded occurrence of granitic rock at about the same depth is to suppose that boulders and blocks of the latter rock are here imbedded in the Kellaways sandstone.

This explanation would necessitate our assigning a thickness of more than fifty feet to the Kellaways Beds, which is more than usual, but Mr. H. B. Woodward tells me that these beds vary considerably in thickness, and that there would be nothing surprising in their having a depth of 50 feet. We might indeed expect them to be thicker than usual at a locality where they included large blocks of a foreign rock. On this supposition, moreover, the occurrence of an ordinary clay at the bottom of the boring is naturally accounted for; whereas if the material above were assumed to be a massive igneous rock, its presence would be anomalous and very difficult to explain.

It has already been mentioned that springs of saline water were found at depths of 390 feet and 410 feet. Mr. A. Timmins has kindly furnished me with analyses of these waters, and they happen to supply further evidence that the beds from which they issue belong to the Kellaways group. The analyses show 340 grs. and 392 grs. of solid matter in the gallon, the following being the principal ingredients:

	Highest Spring.	Lowest Spring.
Combined chlorine	75·00	91·40
Sulphuric anhydride	108·08	123·24
Calcium oxide.............................	20·02	9·98
Magnesium oxide	4·89	4·37
Residue principally soda.		

These proportions are equivalent to about 123 grains of sodium chloride in the highest water, and 150 grs. in the lowest, with 162 grs. of sodium sulphate in the first, and 185 grs. in the second.

My attention has been called to a Report on Bedfordshire well-waters by Dr. C. E. Prior to the Rural Sanitary Authority of the Bedford District (1888), in which mention is made of a band of "saliferous rock" which appears to extend with the Oxford Clay formation from the northern border of the parish of Kempton, across Wootton, and some way into Stanton." He gives partial analyses of some of the well-waters which derive their supply from this rock, and the results show a remarkable correspondence with the Bletchley well-water. The amounts of total solid matter in solution vary from 188 grs. to 250 grs. per gallon. Chlorine is present in all of them, varying in amount from 38 grs. to 92 grs. per gallon. Sulphuric acid is present in several and sulphurous acid in one. Thus at Lower Shelton Marston, which is not many miles north-east of Bletchley, a well-water contained 209·8 grs. of solids per gallon, 72·1 being chlorine and 47·8 grs. being sulphuric anhydride. Dr. Prior comments on the very large quantity of sodium chloride which these waters appear to contain.

There can be little doubt that the saliferous rock of Dr. Prior is one of the beds in the Kellaways group, for all the places he mentions are situate on the lower part of the Oxford Clay.

To sum up, the information available with regard to the boring at

Bletchley points to the conclusion that the Kellaways beds are there thicker than usual, that they include blocks of a peculiar kind of granitic rock, and yield a saline water which contains large quantities of sodium chloride and sodium sulphate.

The occurrence of blocks of microgranulite naturally suggests the possible proximity of some portion of the eastern Palæozoic land. It is generally conceded that the floor of Palæozoic rocks which underlies the eastern counties formed part of a land area during the greater part of the Jurassic period, and indications of the neighbourhood of land are especially abundant in the Great Oolite group which underlies the Oxford Clay. How far the Oxford Clay sea encroached on this land area we do not know, but at the time of the Kellaways Rock the shore is not likely to have receded far from the line which it occupied in Great Oolite times.

The granitic boulders may have been carried to their present position by floating trees borne by currents from the eastern land; or they may have formed part of a small island which had been gradually reduced in size by the encroachments of the sea till a more rapid subsidence enabled the waves to complete its destruction; the last peak of the microgranulite may have been broken up in a storm, and its component blocks scattered over the surrounding sand-banks. Let us hope that other borings in Buckinghamshire may afford further information on this point; and if I were asked to indicate a site for a trial boring in search of the Palæozoic floor with its possible Coal-measures, I should mention the neighbourhood of Aylesbury.

VI.—Palæontology in the Malton Museum.

By A. Smith Woodward, F.G.S., F.Z.S.

Among the local Museums of recent foundation, it would be difficult to find one of more scientific interest and importance than that of the Malton Field Naturalists' and Scientific Society. The commencement of the collection, indeed, was made so lately, that it might naturally be expected to have attained little beyond the nucleus-stage; but as an exponent of local Natural History it already rivals many of the older Museums, and the object of the present notice is briefly to call the attention of palæontologists to the material it affords for all interested in the investigation of Jurassic and Cretaceous fossils.

The oldest portion of the Palæontological collection is a series of Corallian fossils obtained many years ago in the neighbourhood of Malton by Mr. S. King; but the recent discoveries form by far the greater portion of the series, and these have been collected by Mr. Samuel Chadwick, F.G.S. The only difficulty presented to the student is the limited amount of cabinet and exhibition space, which renders it impossible to arrange more than a small typical collection, and it is to be hoped that, ere long, the Society will be in possession of sufficient funds to erect the long-projected new building, and rescue the stowed-away treasures from the dark cellars in which they are still placed.

The Upper Lias of Whitby is represented to a considerable extent; but the later Jurassic formations occurring in the immediate vicinity of Malton naturally claim the largest series of specimens. In addition to the Corallian Mollusca and some Echinodermata and Crustacea, a few Sponges have lately been discovered upon this horizon by Mr. Chadwick, and are now being investigated by Dr. G. J. Hinde; and both Reptiles and Fishes are represented by numerous teeth and spines. The Yorkshire Chalk has also yielded a large number of specimens—the collection of Sponges from Flamborough being, indeed, enormous.

Such a collection necessarily affords much of interest to the specialist, and the present writer's notes, made during a recent visit under the guidance of Mr. Chadwick, relate exclusively to the Fossil Vertebrata.

Among the fossils of the Whitby Lias, in addition to remains of the ordinary Reptiles, there are numerous portions of the gigantic Acipenseroid Fish, *Gyrosteus*, displaying some of its characteristic features, as lately described in the Proceedings of the Geologists' Association. A detached fin, probably of *Gyrosteus*, showing a sparse investment of dermal prickles, seems to be unique; and two portions of the tail exhibit the characters of the caudal scutes, previously only observed in a specimen in the York Museum. Both the fin and the caudal scutes differ in little except size from the corresponding parts of *Chondrosteus* met with in the Lower Lias of Lyme Regis; but the more important structural features of the Whitby fish seem to demonstrate its distinctness from the latter genus.

In the Corallian beds of Malton Reptiles are only represented by detached teeth and imperfectly preserved bones, chiefly Plesiosaurian and Pliosaurian. Fishes, moreover, occur in an equally fragmentary state, but are somewhat more varied and abundant. Among these the fine series of teeth of *Hybodus obtusus* described by Mr. H. M. Platnauer,[1] is conspicuous; and there can be no doubt as to the correctness of the specific identification. A characteristic dorsal fin-spine of *Asteracanthus ornatissimus* has already been noticed by Mr. Chadwick;[2] and it is interesting to find, upon the same horizon as this fossil, portions of the large cephalic spines well known to occur with remains of *Asteracanthus* in the Oxford Clay near Peterborough.[3] No *Strophodus*-shaped teeth, however, have as yet been discovered at Malton. Several slender, pointed Selachian teeth are exactly of the form long ago described by Agassiz, under the preoccupied name of *Sphenodus*,[4] from the Jurassic rocks of the Continent; and no fossils of this character have hitherto been recorded from British strata. There is also an Ichthyodorulite indistinguishable from the dorsal fin-spine of the existing *Cestracion*—a genus believed to occur fossil in the Lithographic Stone of Bavaria, and the possible discovery of the teeth of this Shark in the Yorkshire Corallian will be awaited

[1] Ann. Report Yorksh. Phil. Soc. 1887, p. 35, pl i. figs. 1–16.
[2] Third Annual Report Malton Field Nat. and Sci. Soc. 1885–86, p. 6.
[3] Ann. & Mag. Nat. Hist. [6] vol. ii. p. 340, pl. xii. figs. 7-8.
[4] *Orthacodus*, A. S. Woodward, Catal. Foss. Fishes Brit. Mus. pt. i. (1889), p. 349.

with interest. Several teeth of Chimæroid fishes pertain to *Ischyodus*, among which may be recognized the Middle and Upper Jurassic species *I. Egertoni*; and some very fine examples of tooth-bearing jaws indicate the presence of a Pycnodont Ganoid, probably *Gyrodus*.

A tooth of *Ptychodus* from the Middle Chalk of East Lutton seems to be referable to *P. rugosus*; and the common Cretaceous Shark, *Lamna appendiculata*, is represented by a tooth from the Lower Chalk of Wharram Grange.

Acquisitions of all kinds are continually being made, chiefly through the researches of the Honorary Curator, Mr. Chadwick; and much that is novel and interesting is being met with in nearly all departments.

REVIEWS.

I.—Publications of the Geological Department of the British Museum (Natural History). Catalogue of the Fossil Cephalopoda (Part I.). By Arthur H. Foord, F.G.S. 8vo. pp. xxxii. and 344. Illustrated with Fifty-one Woodcuts. (1889, London, Trübner & Co.)

DURING the past eight years, a very valuable series of Catalogues have been published, under the authority of the Trustees, descriptive of various portions of the fine Collection of fossil organisms preserved in our great National Museum of Natural History. One of the latest of these, by Mr. A. H. Foord, issued in January last, gives us the first instalment of what cannot fail to be a most acceptable contribution to our knowledge of the testaceous remains of that ancient group, the Cephalopoda, which in Scandinavia, Bohemia, and elsewhere, often form entire beds of limestone with their many-chambered shells.

So much having been published of late years both in Europe and America upon the Cephalopoda, it became extremely desirable to have a Catalogue of our own National Collection, in order that we might know how far it could be deemed to be a fairly-complete representation of what must certainly be looked upon as the highest, and also the most interesting class of the Mollusca.

If we may form a criterion of the whole collection from the present Catalogue, which embraces seven families only, namely, the Orthoceratidæ, the Endoceratidæ, the Actinoceratidæ, the Gomphoceratidæ, the Ascoceratidæ, the Poterioceratidæ, and the Cyrtoceratidæ, which are only a part of the suborder Nautiloidea, we have a right to conclude that the Cephalopoda are remarkably well represented in the Geological Department, and that this Catalogue, when completed, will be one of the best of its kind ever produced.

Under each genus, the generic characters are carefully given, and similarly under each species the synonymy and references, the specific characters, with the horizon and locality of each, and remarks upon the specimens described. In fifty-one instances the species are figured as woodcuts in the text carefully drawn with the author's own hand.

The introduction contains a most excellent review of the progress of research by students of the Cephalopoda, amongst the most able of whom are Barrande, Nœtling, Zittel, Mojsisovics, Hyatt, and Blake, besides many others.

To Prof. Hyatt we are indebted for a vast amount of most patient and exhaustive research into the origin, structure and modes of growth of the cephalopod shell; and whether we agree in whole, or only in part, with his views, we cannot but admire the great amount of excellent work which he has achieved. Like other primitive groups, the Cephalopoda have not escaped the efforts of the embryologists, who, basing their classification upon the difference in the structure of the initial chamber in the Ammonoidea and the Nautiloidea, have placed the former in the Dibranchiata, on the ground that the nucleus (protoconch) in the *Ammonites* agrees with that of *Spirula*, rather than with that of *Nautilus*. Hyatt however has found the shrivelled remains of the protoconch in two species of *Orthoceras* (*O. elegans*, and *O. unguis*), which he has figured in "Science" for Feb. 1884, p. 126. But the importance of such a character for purposes of classification is very doubtful. Indeed, Dr. Zittel has well pointed out that no special systematic value has been attached to the presence or absence of the embryonic shell (nucleus) in the Gasteropoda, which corresponds with the initial chamber of the shells of Cephalopoda, and ought to be, and indeed no doubt is, of equal value (Introduction, pp. vii and viii).

Of course, in the absence of all the soft parts of the animal, advantage has to be taken, for purposes of classification, of all the various points of structure of the shells of these Palæozoic Molluscs.

In considering the development of the siphuncle, Professor Hyatt has assumed that the ancestral forms of the Cephalopoda had closed cæca instead of a siphuncle, and that these were the "initial stages" of the necks of the septa; he further imagines that these cæca, "becoming prolonged in descendant forms, were differentiated into the funnels, the remnants of the cæca and the thinner walls of the sheath proper connecting them were formed by the fleshy siphon. This is the condition of the siphon in the typical forms and in the tubular-siphoned *Orthoceras*, but in some aberrant genera [*Endoceras* and *Piloceras*] the fleshy siphon widens near the living chamber, becoming conical and forming a sheath. These sheaths lie in the large tube formed by the true funnels, and may deposit permanent diaphragms as in *Endoceras*."

Since Hyatt wrote the foregoing, new light has been thrown upon this subject by the discovery of the initial chamber of *Endoceras*, by Dr. Gerard Holm, of Upsala. The enormous size of this chamber, which is continuous with the siphuncular cavity, lends countenance to Dr. Zittel's view that the siphuncle was originally a remnant of the visceral sac. A similar opinion was ennunciated by Dr. H. Woodward in his paper "On the Structure of Camerated Shells,"[1] in which, after quoting Owen's statement regarding the connection between the *Nautilus pompilius* and its shell, to the effect that a

[1] "Popular Science Review," 1872, vol. xi. p. 113.

third point of attachment is to the bottom of the shell by the posterior extremity of the mantle, which probably presents a conical form in the embryo Nautilus, he continues, if then, the siphuncle in the young stage forms the main point of attachment between the animal and its shell, we may reasonably argue that the siphuncle in the adult Nautilus is simply the evidence of an aborted embryonal organ whose function is now fulfilled by the shell-muscles, but which in the more ancient and straight-shelled representatives of the group (the Orthoceratites) was not merely an embryonal, but an important organ of attachment between the animal and its shell in the adult.

It has been observed, however, that the shell-muscles in *Nautilus* are incapable of bearing even a slight strain, and that the animal seems readily able to detach itself from its shell when injured (see Introduction, p. xi).

Full justice is done by Mr. Foord in his "Introduction" to all the various writers on the Cephalopoda, and the views of M. Barrande on the appearance in time and the distribution, both in time and space, of the several families of the Nautiloidea, are fully given.

Mr. Foord quotes the opinion of von Jhering, Prof. Hyatt, and S. P. Woodward, that probably *Tentaculites* may have been the prototype of the Cephalopoda, an opinion, however, which Prof. James Hall does not share (p. x).

In the search for connecting links between the Nautiloidea and Ammonoidea, our attention is arrested by the peculiar form *Bactrites*, which, though probably a true Nautiloid, is connected by its ventral sutures with the Ammonoidea through *Mimoceras*, Hyatt. Again, in the Clymenidæ and Goniatitidæ of the Devonian and the Carboniferous and in the Ceratitidæ of the Trias a very decided approach is made towards the complicated sutural line of the Ammonoidea. It is worthy of note also that the Goniatitidæ, which are in many respects Nautiloid in their characters, made their first appearance in the Devonian, and therefore after the Nautiloidea had attained their maximum of development, which took place in the Silurian epoch.

Concerning the first appearance and distribution of the earlier forms of life in the European area, it has been suggested by Dr. Hicks that they originated in the warmer or more equatorial regions, where it is probable that the principal changes in their development took place; and that they gradually migrated northwards as the thermal conditions became more favourable, owing to the subsidence of the land and the consequent spread of the seas in Northern latitudes. Here "the groups as they successively appeared always contained evidence of advance in development over those which had previously reached the areas."

The result of recent discoveries relating to the structure of the shells of *Endoceras*, *Piloceras*, *Actinoceras*, and *Ascoceras* will be found under the descriptions of those genera, with the exception of *Ascoceras*, some new facts having come to light regarding that genus since the description of it was printed: these facts are detailed in the Supplement (p. 334), at the end of the volume, and have been given even more fully with figures in this MAGAZINE for December, 1888, by Dr. Gustav Lindström (p. 532), and subsequently in March last by Mr. A. H. Foord (p. 121).—*Introduction*, pp. xvii and xviii.

Besides giving a "Table of the Nautiloidea," prepared with a view to show the groups into which the species described by the author have been subdivided, Mr. Foord has also provided an excellent quarto table of the classification of the Lower Palæozoic rocks of Europe and North America, giving as nearly as possible the corresponding horizons for Britain, Scandinavia, Russia, Bohemia, France, and North America. This in itself forms a most valuable boon to the scientific worker, and will prove highly acceptable for other groups besides the Cephalopoda.

We are greatly indebted to Mr. Foord for this his first instalment of a Catalogue of the Fossil Cephalopoda in the British Museum, and we trust he will not rest until he has completed this great work, and we, for our part, will continue to pray for its speedy delivery by Messrs. Taylor and Francis, equally well executed in its entire form as is the volume now before us.

II.—CATALOGUE OF THE FOSSIL FISHES IN THE BRITISH MUSEUM (NATURAL HISTORY). PART I. CONTAINING THE ELASMOBRANCHII. By ARTHUR SMITH WOODWARD, F.G.S., F.Z.S. 8vo. pp. xlvii. and 474, with 17 Plates and 15 Woodcuts. (London, Trübner & Co., Printed by order of the Trustees.)

UNDER the above modest title we are presented with an important systematic and descriptive work on the Taxonomical bearing and position of the extinct Elasmobranch Fishes, and their relation to existing members of the group.

The fossil forms are numerous, and range in geological time from the deposition of the Lower Carboniferous rocks—and even earlier, assuming that certain spines, from Devonian and Silurian deposits, really belong to Elasmobranch fishes—and through all subsequent geological periods into the later Tertiaries. The geographical range is also co-extensive with that of the other subclasses of extinct fishes.

The fossil remains, with few exceptions, and these mostly of recent acquisition, consist mainly of unconnected portions of cartilage, vertebræ, bony spines (Ichthyodorulites), and teeth. This dissociation of important parts greatly puzzled the earlier naturalists in their efforts to determine the nature and connection of these fragments with each other; and also in realizing the near affinity of some of the extinct forms to existing genera. But the researches of later investigators, with far greater facilities for comparison and intercommunication, combined with the discovery in some localities of specimens more or less completely preserved, have minimized many of the difficulties encountered by the pioneers of the science. But, notwithstanding these advantages, the modern exponent still has his difficulties, as he must very often base his conclusions with regard to the genus, species, or the affinity of a fossil fish upon a mere fragment of its organism.

In the preparation of the Catalogue, which is much more than a classified compilation of families, genera, and species, the author has studied the best works of the latest writers on the Taxonomy and Morphology of the group, whether palæontological or zoological, and with manifest advantage. He adds a few brief comments on some systems of arrangement hitherto proposed, and on a few of the various opinions regarding the affinities of certain forms. The volume also contains many valuable original descriptions, observations, and revisions of importance. The aim and scope of the work is related in the opening paragraph of the Introduction, which we reproduce. The author states: "The present volume being the first attempt at a systematic treatment of the Palæontology of the Elasmobranch fishes, it seems a fitting occasion for briefly reviewing the bearing of the newly collected evidence upon the various results that have already been attained in the study of the existing members of this great subclass. Notwithstanding its imperfections, Palæontology must necessarily be employed as the test—if it be not adopted as the basis—for all morphological and taxonomic speculations; and though the pages of the Catalogue may indicate extreme imperfection in our knowledge of the past history of most groups, there are still a few well-ascertained facts which may be already profitably discussed with reference to the conclusions of recent Zoology."

"It is therefore proposed:—firstly, to enumerate the principal stages by which the most modern schemes of classification of the group have been elaborated; secondly, to summarize the known and available resources; thirdly, to recapitulate the more important palæontological results; and lastly, to discuss these results in the light of modern theories of taxonomy."

Under the heading "Taxonomic Deductions from the Study of Recent Elasmobranchs," the author gives a brief summary of the diverse classifications, and the varying terminology adopted or proposed by naturalists of repute, to distinguish the existing fishes assigned to the cartilaginous group; the following being the most important, commencing with Willughby and Ray, who "inaugurated the era of modern Ichthyology in 1686." These authors "assigned to the PISCES CARTILAGINEI, the Lampreys, Sharks, Rays and Sturgeons." This arrangement was accepted by Artedi (1738), who made the group an "order" named CHONDROPTERYGII. It was afterwards adopted by Linnæus, who enlarged the group by the addition of other forms, "and proposed the new term of AMPHIBIA NANTES." In 1806 Duméril, following Lacépède, who had returned to Artedi's conception of the Chondropterygii, proposed the name of TRÉMATOPNÉS for the fishes "possessing neither operculum nor opercular membrane," to contain two "families" which he termed Cyclostomes and Plagiostomes. "The latter group comprised the Sharks and Rays," the Chimæroids being "placed far apart." Cuvier later on added the Chimæroids to the Plagiostomes and renamed the group *Selachiens*. Bonaparte (1832-1841) "proposed to elevate this group into a subclass of Elasmobranchii, the two subdivisions to be regarded as orders and known respectively as *Selacha* (Sharks and Rays) and *Holocephala* (Chimæroids) ;" and the Cyclostomes to constitute a distinct subclass. Agassiz about the same time "reunited these two subclasses under an order termed *Placoidei*." "In 1846 J. Müller adopted Bonaparte's subclasses, though using the term *Selachii* as equivalent to Elasmobranchii, and naming the two orders, Plagiostomi and Holocephali." Bonaparte's classification was also adopted in 1870 by Dr. Günther, but he termed "the subclasses Chondropterygii and Cyclostomata respectively, and the orders of the former *Plagiostomata* and *Holocephala*; while the Plagiostomes were further divided into the suborders of Selachoidei and Batoidei." But in 1871 Dr. Günther instituted his subclass PALÆICHTHYES, of which the Chondropterygii became an order, and Plagiostomata and Holocephala were reduced to suborders. In the same year Prof. Cope proposed to unite the Sharks and Rays in one subclass (SELACHI) and the Chimæras to form another (HOLOCEPHALI) ; "this arrangement being based upon the fundamental difference in the structure of the skull already indicated in Bonaparte's second term." This classification was accepted by Prof. Huxley in 1876, but he regarded the two groups as orders, "and preferred the term Plagiostomi to that of Selachi." Our author also adopts Cope's classification, and adds, "Most modern researches have also tended to emphasize the distinction between fishes with autostylic, and those with hyostylic skulls, both among those without membrane-bones and those possessing these skeletal elements ; and such is the arrangement selected for adoption on the present occasion."

"With regard to terminology," the author observes, "the only term originally restricted to the cartilaginous hyostylic fishes is that of 'Plagiostomi,' proposed by C. Duméril; but this is both inappropriate in many instances, and also based upon a misconception of the supposed relationship existing between the Lampreys and the Sharks. We therefore venture to follow Prof. Cope in adopting Bonaparte's name, Elasmobranchii, excluding the Holocephali, and elevating these to the rank of an equivalent subclass."

Prof. Cope, in 1884, established a new order of the Elasmobranch subclass, based upon his studies of some fish remains from the Permian beds of Texas, possessing teeth of the Diplodus type, and also exhibiting "an arrangement of the mandibular and hyoid arches extremely similar to that observed in the living *Notidanus*." There are other supposed distinctive structural characters of the cranial elements ; and upon these fossils Prof. Cope founds his genus *Didymodus*, to be included with Pleuracanthus and the Hybodontidæ in an order he terms ICHTHYOTOMI.

The necessity for forming a new order for the reception of *Pleuracanthus* has also recently (1888) been remarked by M. Charles Brongniart, who has been able to study numerous specimens of the genus, in fair preservation, obtained from the Middle Coal-measures of France. The evidence thus attained enables him to attempt the restoration of the entire skeletal structure of the fish ; and to suggest inclusion in a new order which he proposes to term "Pleuracanthides."

Again, with regard to subordinal divisions. Sir Richard Owen in "Palæontology" (1860), ranks the Plagiostomi as an order, and recognizes four families: the Cestraciontidæ, including the living Port Jackson Shark and the fossil forms supposed by Agassiz to be allied to it; the Hybodontidæ for the extinct Hybodonts; and the Squalidæ and Raiidæ for the Sharks and Rays. Subsequently (1866), he elevated these families into suborders, the Squalidæ becoming Selachii, the Raiidæ, Batides; and the Cestracionts and Hybodonts forming one suborder named Cestraphori, "in allusion to the presence of dorsal fin-spines."

In 1882 Prof. C. Hasse proposed as the result of his studies of the axial skeleton, a classification "based upon the varied conditions of the notochord and the vertebræ," founding thereon four groups which he named respectively: *Palæonotidani*, in which the notochord is persistent; the *Cyclospondyli*, with partial calcification at intervals in the notochordal sheath, represented by the Spinacidæ; the *Tectospondyli*, with numerous calcified rings, comprising the modern Rays, with their near allies the Pristiophoridæ and Squatinidæ; and finally, the *Asterospondyli*, in which the calcification is "so arranged as to appear radiating or star-shaped in vertical transverse section." The author deems this classification one of much significance; for the various modifications of the cranium afford no "satisfactory basis for the definition of subordinal groups," and the types of axial skeleton defined by Hasse correspond nearly with the accepted divisions of the Selachii, namely, the Sharks and Rays. Thus the "Tectospondyli" comprise the Rays and their near allies, the Pristiophoridæ and Squatinidæ, while the "Asterospondyli" include the Cestraciontidæ and other Sharks. Eliminating Hasse's first two groups, the members of which "may be variously distributed" in the other two, the author, in part, accepts this classification and terminology as being in his view the best to define the subordinal divisions of the group, and which is applicable alike to the extinct and recent forms. This arrangement has the merit of being simple as well as natural.

The numerous palæontological authorities consulted in the preparation of the Catalogue are enumerated, and the titles of their respective works annexed, forming a goodly list. The geological formations and localities whence the remains of the principal fossil groups have been derived are also briefly detailed.

The teeth and bony spines of fishes and other fossil remains have long been known, and greatly perplexed the early observers in their attempts to unravel their history. Thus, the teeth of Sharks were described as the petrified tongues of fishes, and named *Glossopetræ*.

An English author early in the seventeenth century [1] thus quaintly describes them:—"Potters, in working their clay which is gotten in some especiall place, doe find in it certaine things which are as hard as stone, and of the very forme and shape of the tongues of some

[1] Richard Verstegan, A Restitution of Decayed Intelligence, 1605.

sorts of fishes, each with the root unto it, to make it the very markable, and right proportion of such a kind of tongue in all respects." Their true nature was first made known by Steno in 1660, and later by Scilla in 1752, who compared them with teeth of recent Sharks. The bony spines were supposed to be jaws, and some even to be plants. That they were the dorsal fin-spines of extinct Elasmobranch fishes was first proved by Buckland and De la Beche about 1830, who proposed the term "Ichthyodorulites." "Agassiz named many of them, and assigned a few to their correct zoological position." Agassiz is also credited as being "the first to place the study of Elasmobranch Palæontology upon a truly scientific basis;" and his great work as still forming "the groundwork of the whole subject." The researches of numerous subsequent authors on the same subject, whether of a general character or limited to a description of the fauna of a geological horizon, of a country, or a district, are respectively noticed.

In a "Synopsis of Palæontological Results," the author states that the general results of these discoveries and investigations add much that is new, and the main points of biological significance are briefly enumerated.

To give an intelligible résumé of the descriptions of the internal and external skeleton and the dentition would exceed the limits of this notice. The respective portions described are first the "*Cartilage*"; and this, even in the Lower Carboniferous, "exhibits a considerable amount of calcification." The "*Head and Visceral Arches*" come next, and all that is known regarding the structure of the extinct Elasmobranch skull in the various genera is fully detailed. The structure of the "*Vertebral Column*," and its importance as an element in the classification of the group, has been already referred to. The structural characters of the "*Pectoral and Pelvic Arches and Fins*," respectively, and of the "*Median Fins*," follow; the "*Shagreen and Dermal Defences*" are the next objects of comment, and finally the "*Dentition*."

With respect to the adoption of a classification for the extinct Sharks and Rays, the author observes, that "the first point to be considered is the validity of Prof. Cope's division of the subclass into the two orders Ichthyotomi and Selachii." The first order was founded upon certain modifications observed in the structure of the skull, the pectoral fins, pelvic arch, and the axial skeleton of the European *Pleuracanthus* and the American *Didymodus*; these modifications being sufficiently pronounced as to justify an ordinal separation from the other groups of the subclass. But the principal character is the structure of the pectoral fin, in which the metapterygium forms a long segmented central axis, and as this structure "differentiates the Crossopterygii from the higher Ganoidei or Actinopterygii," the same character separates the Ichthyotomi—though perhaps less widely—from the Selachii. The order therefore, as here defined, is limited to those fishes that possess this type of fin. The reason for the inclusion of the Sharks and Rays in one order is explained by the difficulty of defining a distinct line of demarcation between the Sharks with lateral gill-clefts and the Rays with ventral gill-clefts, seeing that there are many intermediate gradations of skeletal structure, of habit, and of external form by which one group passes into the other. Some of these gradations are enumerated in the following passage:—"The Squatinidæ and Pristiophoridæ, for example, possess lateral gill-clefts, like Sharks; but the structure of the vertebræ, the partial growth forwards of the pectoral propterygium in *Squatina*, and several striking resemblances existing between *Pristiophorus* and *Pristis* and *Rhinobatus*, all point to the Squatinidæ and Pristiophoridæ as probably survivors of ancestral Rays."

For the grouping of families and genera, "the arrangement formulated by Dr. Günther in his Catalogue of 1870 for the recent forms," is adopted, and where possible the "extinct families and genera will be incorporated among them."

We have referred at some length to this subject of classification, it being an important element in the work. Although Bonaparte's classification and terminology for the whole group is adopted, Hasse's subdivisions founded upon the structure of the axial skeleton, and Cope's new order based upon other structural characters, have been added; but each, as already stated, with modifications and restrictions, the result being an emphatically new classification, which appears to be, approximately, a good natural one, in our present knowledge of the fossil groups. The author modestly observes that "this Catalogue, however, can only be regarded as a provisional attempt to systematize and arrange the ascertained facts of Elasmobranch Palæontology for convenience of reference."

In the Catalogue a diagnosis of the principal distinguishing characters is attached to each order, family, genus and species respectively, with comments. The nature of the type specimen, where preserved, if known, and the formations and localities whence the various specimens have been derived, are also given. The synonyms of the genera and species, if any, also lists, with references, to all the species of each genus described, as far as ascertainable, but of which no specimens are in the Museum, are included. All these details have necessitated much labour and research, the result being a most valuable work of special reference.

The first Order, *Ichthyotomi*, as already mentioned, is limited to those fishes having a long segmented axis in the pectoral fins, analogous to that in the Ganoid Crossopterygians; it comprises the families Pleuracanthidæ and Cladodontidæ. To the former are assigned the genera *Pleuracanthus*, *Diplodus*, and *Chondrenchelys*. We have here, on the very threshold of the Catalogue, interesting evidence of the progress of recent palæontological investigations into the nature and relationships of various imperfect fragments described by previous authors, in the merging of many genera into one. Thus to the genus *Pleuracanthus*, founded by Agassiz for the reception of some barbed spines from the Coal Measures, are referred no less than thirteen genera, namely, *Diplodus, Orthacanthus, Xenacanthus, Triodus, Compsacanthus, Dittodus, Aganodus, Ochlodus, Pter-*

nodus, Thrinacodus, Lophacanthus, Anodontacanthus, and *Didymodus. Diplodus,* however, is provisionally retained for the teeth not correlated with spines.

Pleuracanthus decheni, a small species from the Lower Permian of Rhenish Prussia and elsewhere, has been long and is best known by numerous specimens in fairly complete preservation. With the exception of *P. Gaudryi* and *P.* (*Didymodus*) *texensis,* the other species are only known by teeth and the cephalic spines, the latter being placed on the head in advance of a small fin. Teeth and spines indicate that some species or individuals attained a large size. The remarkable, but imperfectly known *Choudrenchelys,* discovered by Dr. Traquair in the Lower Carboniferous rocks of Eskdale, is provisionally placed in this family on account of the resemblance to *Pleuracanthus* of the axial skeleton, the similarity of the form of the body and the presence of a long dorsal fin, but it has no cephalic spine. The CLADODONTIDÆ are "an indefinable family, apparently closely allied to the Pleuracanthidæ." Dr. Traquair has discovered the pectoral fins of the type genus *Cladodus,* and states that they possess the characteristic structure of the order. But with this exception, all the species of the family are only known by detached teeth, no spines being assigned to the group. Six genera are noticed, three being American, but of these there are no specimens in the collection. *Phœbodus* is a Devonian genus from Iowa. The other genera only occur in rocks of Carboniferous age.

We next come to the order SELACHII, and the suborder *Tectospondyli,* comprising twelve families, the first being the SPINACIDÆ, and the last the TRYGONIDÆ. The first family, Spinacidæ, contains fossil representatives of the existing genera *Centrina, Acanthias, Centrophorus, Spinax,* and *Scymnus,* hitherto classed with the Sharks. The fossil species of *Acanthias* and *Centrophorus* are from the Upper Cretaceous of Mount Lebanon, Syria.[1]

The PETALODONTIDÆ follow next, with nine genera. "The genus *Janassa* affords the most complete insight into the characters of this family;" the dentition of one species (*J. bituminosa*) from the Permian having been found in natural apposition. The other genera being only known by detached teeth and such fragmentary portions. A new genus and species, *Mesolophodus problematicus*; and two species of *Petalodus* (*P. flabellula* and *P. Davisii*) are here first described. With the exception of the Permian *Janassa bituminosa,* all the other species are from Carboniferous rocks. The SQUATINIDÆ have one genus, *Squatina,* and five species, two being Kimmeridgian and three Cretaceous. One new species (*S. crassidens*) from Mount Lebanon is described.

To the PRISTIDÆ a new genus and species (*Sclerorhynchus atavus*) is added, founded on an imperfect rostrum, also from Mount Lebanon.

[1] From this formation and locality the Museum possesses a large series of fish and other remains, remarkable alike for the numbers of genera, species, and of individuals represented, and also the beautiful state of their preservation. The collection contains many of the types of this subclass and also of the Ganoid and Teleostean fishes, described from this locality.

From the same locality the Museum contains four species of *Rhinobatus*, and the type specimens of three; the fourth (*R. maronita*) being in the Geneva Museum. This is the only genus of the Rhinobatidæ in the collection. The Rajidæ is also only represented by the genus *Raja*. The type specimens of three species, also from the Lebanon, are in the collection, one (*R. primarmata*) being here first described and figured. The well-known dermal tubercles from the Norwich Crag, named by Agassiz *Raja antiqua*, are now referred to the common Thornback (*R. clavata*).

The Psammodontidæ, here classed with the Rays, were referred by Agassiz to the Cestraciont group. The family is extinct and only known by the dentition, and this shows "that the two rami of the jaws were evidently placed in the same straight line—a fact indicating a much depressed body, like that of existing Rays." It comprises the genera *Copodus* and *Psammodus*. The former consists of eleven species, of which all the type specimens are in the Museum; the latter of six species and some of the types. One new species (*P. salopiensis*) is described. The species are all Carboniferous, and the best known, *P. porosus*, is now referred to *P. rugosus*.

The Myliobatidæ come next with eight species of *Myliobatis*, all Tertiary. Only those known by the dentition are catalogued, and the published British species are reduced in number. The upper and lower series of connected dental plates are distinguished, the upper series are arched antero-posteriorly, the lower series being flat; and the barbed spines referred to the genus are generically indeterminable. One new species (*M.* (?) *tumidens*) from the Red Crag and also a new species of *Rhinoptera* (*R. Daviesii*) from the London Clay are described. The dental plates named *Zygobatis* by Agassiz were referred to this genus by Dr. Günther in 1880. *Aetobatis* is allied to the last-named genus, but distinguished by the absence of lateral teeth. The long familiar Cretaceous genus *Ptychodus*, and its many species, once prominent members of the Agassizian group of Cestracionts, is placed by the author in this family, he being the first to discover, by the arrangement of the dentition, its natural affinity to the Rays. The teeth were numerous in each mouth, and arranged in many longitudinal and transverse rows. The median antero-posterior row in one jaw is very small, the row on either side being much larger; in the other jaw the teeth of the median row are large, and those on each side smaller. *Ptychodus* is only known by the teeth and vertebræ. The vertebræ are "apparently 'cyclospondylic' in structure," and were found in immediate association with teeth of *P. decurrens* in a block of chalk. Many of Agassiz's types are in the collection; and there is one new species, *P. multistriatus*. The fin-spines and rays referred to this genus by Agassiz do not even belong to the same subclass. Of the Trygonidæ, the only genus in the collection is *Cyclobatis*, with two species and the type specimens of each. This ends the Tectospondylic section.

Only six families are assigned to the suborder *Asterospondyli*, but the genera and species are many. The Notidanidæ is the first family, "its relationships," according to the author, "being obviously closer with the Cestraciontidæ than with any other recognized family." Eight species of *Notidanus*—the only fossil genus known with certainty—are registered, the species ranging from the Jurassic rocks to the Red Crag inclusive.

The Cochliodontidæ come next—"an imperfectly definable family, apparently related to the Cestraciontidæ, but with a more specialized dentition." The group is restricted to the Carboniferous period, and includes many of Agassiz's Cestraciont genera. Of the nine species of *Helodus* originally named by Agassiz, only one (*H. simplex*), from the Coal-measures, remains, the others being variously distributed. We then have an innovation, a new generic name, *Pleuroplax*, as being more appropriate, is substituted for *Pleurodus*. *Psephodus* follows with two new species (*P. salopiensis* and *P. dubius*). A British species, *Sandalodus Morrisii*, from Oreton, appears to be the largest of the genus. In addition to the above named, the following genera are included in the family: *Tomodus*, *Xystrodus*, *Deltodus*, *Pœcilodus*, *Cochliodus*, *Streblodus*, *Deltoptychius*, *Diplacodus*, and *Cyrtonodus*. New species of *Deltodus* (*D. gibbus* and *D. rugosus*), and one of *Cyrtonodus* (*C. Hornei*), are added.

The Cestraciontidæ as here defined form an important group of fifteen genera and about seventy species. Of these only three genera (*Orodus*, *Strophodus*, and *Acrodus*) originally assigned by Agassiz to the family remain. The teeth are described as being "mostly obtuse, never fused into continuous plates; several series simultaneously in function;" and "no distinctive characteristics of value having yet been discovered, the so-called Orodontidæ and Hybodontidæ are included in the family." Its fossil representatives first appear in the Lower Carboniferous, and occur in more or less abundance in all the succeeding periods to the Chalk inclusive, the living Port Jackson Shark being the last survivor of the group. One of the earlier forms, *Sphenacanthus costellatus*, described by Dr. Traquair, is known by a fairly complete fish in the Museum having both dorsal spines in natural position; the other Carboniferous forms being mainly represented by detached teeth and fin spines. *Hybodus* is probably the most completely known genus of the family. Liassic and Wealden specimens in the collection show interesting portions of the cranial structure, the internal skeleton and the external form; also the dermal covering, the hooked cephalic spines (*Sphenonchus*), and the dorsal fin spines, each in their respective positions. Moreover, in its close ally *Acrodus*, the arrangement of the dentition is observed. Portions of nearly complete jaws of each genus with the teeth in natural apposition are figured.

The numerous Oolitic teeth named *Strophodus* are now practically known to belong to the Ichthyodorulites named *Asteracanthus* by Agassiz; *Strophodus*, however, being provisionally retained for the teeth not correlated with spines. The teeth named respectively *S. reticulatus* and *S. subreticulatus* have been found associated with the dorsal fin-spines of *Asteracanthus ornatissimus*, which name they now bear; Owen's *S. medius* is also a synonym. The author has discovered that the species was armed with cephalic spines resembling those of *Hybodus* and *Acrodus*. *Palæospinax* (*Thyellina*), placed by Agassiz among the Squalidæ, now passes to this family; and some interesting specimens of the genus are described, including one new species from the Lias of Ohmden. A closely allied form is the author's Cretaceous genus *Synechodus*, originally referred to the genus *Hybodus*, and known by jaws, teeth, fragments of cartilage, vertebræ and shagreen.

To the genus *Cestracion*, the last of the group, is referred Sir Philip Egerton's genus *Drepanephorus*. Six new species of as many genera are described; and most of the types, either wholly or in part, are in this collection.

The Scylliidæ come next with seven genera. The first, *Palæoscyllium*, is represented by one species (*P. minus*), a new one from the Kimmeridgian of Bavaria. *Scyllium* follows with six species, all Cretaceous, two being new, *S. dubium* from the Lower Chalk, Dover, and *S.* (?) *tumidens* from the Lebanon. *Cantioscyllium decipiens* is a new genus and species, founded upon the character of the dentition, recently exposed by the removal of the matrix on one of Agassiz's figured types (tom. iii. pl. xxxviii. fig. 2) of *Scylliodus antiquus*.

To the Lamnidæ are assigned eight genera, represented by forty-six species; but the teeth of the fossil genera are separated by characters so slight that it is difficult in some instances to distinguish them. Thus *Odontaspis* only seems to differ from *Lamna* in "the greater relative size and more subulate character of its anterior teeth." *Oxyrhina*, again, "only differing from *Lamna* in the prevailing absence of lateral denticles in the teeth." Again, *Lamna*, by *Oxyrhina mantelli*, "appears to be connected with *Oxyrhina*; and by *Lamna obliqua*, with *Carcharodon*." *Orthacodus* is a new generic name proposed for Agassiz's *Lamna* (*Sphenodus*) *longidens*, and *Scapanorhynchus* is another new genus founded upon several more or less perfect specimens from the Lebanon Cretaceous beds, and replaces the genus *Rhinognathus* of J. W. Davis; from the same locality a new species (*S. elongatus*) is described, and a tooth (*S. gigas*) from the Cambridge Greensand. To the same genus are also assigned the Cretaceous teeth respectively known as *Lamna* (*Odontaspis*) *rhaphiodon* and *L. subulata*.

To *Odontaspis* are assigned the teeth universally known as *Lamna elegans*, also the other species of *Lamna* having the same general form of tooth. *Otodus* disappears, the species being absorbed in the genus *Lamna*, which is thus defined: "Dentition only differing from that of *Odontaspis* in the relatively less elevated and less subulate character of the anterior teeth, and the usually larger size of the lateral denticles." One new species is described. Then comes *Carcharodon* with five species, all of Tertiary origin. One species, *C. megalodon*, attained an enormous size, and was very widely distributed. The teeth referred to the genus *Corax* are comparatively small, compressed and serrated.

The last family is the Carchariidæ. Of the type genus *Carcharias*, species of three of its five subgenera are in the collection, and there are two new species. The other genera composing the family, and represented by species, are *Galeocerdo*, *Hemipristis*, *Galeus* (?), and *Sphyrna*.

Having briefly sketched, without criticism, some of the main points of the classification here formulated for the arrangement of the fossil Elasmobranch Fishes, we have only to add that it is based principally on the study of the structural characters, and an intimate knowledge of the numerous remains in the collection whose arrangement forms part of Mr. Woodward's official duties; and also on the study of many specimens in private or public collections. Wherever possible, the fossils have been carefully compared with recent forms, and, as we have seen, other systems of arrangement have been studied with a view to their adoption, wholly or in part. The result is a palæontological classification, apparently the most natural and practical hitherto suggested for this group of extinct fishes. Modifications, sooner or later, will probably have to be made when more is known regarding the structure and affinities of the obscurer forms, but this cannot affect the principle on which it is based. We commend the author for its inception, and also for the industry displayed in the preparation of the Catalogue, and shall look with interest for the publication of the second part, which we understand will contain the Holocephali and Ichthyodorulites.

Six new genera and thirty-one new species are described, and most of them figured.

Of the 17 lithographic plates, seven are double, and the whole contain about 230 figures, while there are 15 woodcuts in the text.

The fossils have been drawn from nature by Miss G. M. Woodward with her usual fidelity to form and structure, and we would specially note the beautiful rendering of the ornamentation on the teeth of *Acrodus* in plates xiii. and xiv. W.D.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—June 5, 1889.—Prof. J. W. Judd, F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "Observations on some undescribed Lacustrine Deposits at Saint Cross, Southelmham, in Suffolk." By Charles Candler, Esq. Commmunicated by Clement Reid, Esq., F.G.S.

These deposits are situated in the basin of the River Waveney, 3¾ miles E. by N. of Harleston, and 9 miles E.N.E. of Hoxne. They occupy a hollow in the Boulder-clay towards the northern edge of the plateau locally known as "High Suffolk." Saint Cross brickyard, which is the only section now visible, shows:—

	ft.
a. Surface-soil and gravel	1–3
b. Red and white loam, variable, fine or coarse, sandy or calcareous. Elephant, Horse, etc., at base of the bed	3–5
c. Fine, tenacious, grey and red clay, with carbonaceous seams towards the base. *Valvata*, *Bythinia*, *Pisidium*.	2–5
d. Black peaty loam and sand, worked to a depth of 5 feet, but no bottom reached. Seeds and freshwater shells	5–
e. Chalky Boulder Clay	

No implements have yet been found in any of the beds; but Pleistocene Mammalia (determined by Mr. E. T. Newton) occur in bed *b*. From bed *d* Mr. Clement Reid obtained seeds of 29 species of flowering plants. These are all marsh or aquatic species, except the hawthorn and dandelion. Unlike those found in Professor Prestwich's bed *d* at Hoxne, there are no Arctic forms among them; but the author pointed out that the Arctic plants of Hoxne were determined from *leaves* found in laminated clays, while the matrix in which the plants are found at St. Cross is only suitable for the preservation of seeds. However, certain of the plants do not range far north, and the occurrence of a large tree in the upper part of bed *d* points to a less rigorous climate than that under which the leaf-bearing beds at Hoxne were deposited.

The lacustrine beds now occupy a ridge between two depressions, the valleys having been deeply eroded, or perhaps formed since the filling-up of the lake. It appears probable that on the final retreat of the last ice-sheet the hollows of the Boulder-clay were occupied by a series of lakes and pools. For the most part the sedimentary deposits formed in these hollows have been entirely swept away; but at Saint Cross the mud and loam of one such lake have been preserved.

2. "On certain Chelonian Remains from the Wealden and Purbeck." By R. Lydekker, Esq., B.A., F.G.S.

In the first part of the paper the author described a portion of the hind lobe of a Chelonian plastron from the Wealden, which was remarkable as showing a median row of epidermal shields. The name of *Archæochelys valdensis* was proposed for the form so represented. The new generic term *Hylæochelys* was also proposed for the Purbeck Chelonian described by Sir R. Owen as *Pleurosternum latiscutatum*, and was also taken to include some other forms from the Wealden.

The second section of the paper treated of the affinities of *Pleurosternum*. It was concluded that *Digerhhum*, Cope (as represented by the so-called *Platemys Bullocki*), is identical with *Pleurosternum*, of which there appears to be only one Purbeck species. Evidence was brought forward to show that in the adult of *Pleurosternum* the pubis had a facet of articulation with the xiphiplastral; and it was proposed to refer this genus, together with *Platychelys* and *Baëna*, to a new section termed "Amphichelydia," which was regarded as allied both to the true Cryptodira and to the Pleurodira.

3. "On the Relation of the Western Beds or Pebbly Sands of Suffolk to those of Norfolk, and on their Extension inland; with some Observations on the Period of the final Elevation and Denudation of the Weald and of the Thames Valley." By Prof. Joseph Prestwich, M.A., D.C.L., F.R.S., F.G.S. Part I.

The author in this, the first part of his paper, described the Westleton beds of the East Anglian coast. He commenced with a review of the work of previous writers, especially Messrs. Wood and Harmer, and the members of H.M. Geological Survey, including Messrs. H. B. Woodward, Whitaker, and Clement Reid. In discussing this work, particular attention was paid to the Bure-valley beds, which were considered as a local fossiliferous condition of the Pebbly Sands; but the term is not so applicable to these sands as that of the "Westleton and Mundesley Beds," which the author proposed in 1881.

The Westleton Beds were carefully described, as seen in coast-sections in East Anglia, proceeding from south to north, and the following classification was adopted :—

The Westleton and Mundesley series (the Mundesley section of it).	1. Laminated clays, sand, and shingle with plant-remains and freshwater shells (the Arctic forest-bed of Reid). 2. Sand and quartzose shingle with marine shells (the *Leda myalis* bed of King and Reid). 3. Carbonaceous clay and sands with flint-gravel and pebbles of clay, drift-wood, land and lacustrine shells and seeds (the Upper freshwater bed of Reid).
The Forest-bed series of Reid (exclusive of No. 3 of above).	4. A greenish clay, sandy and laminated in places, containing abundant mammalian remains, and drift-wood, with stumps of trees standing on its surface (the forest- and elephant-bed of authors; the estuarine division, in part, of Reid). 5. Ferruginous clay, peat, and freshwater remains and gravel (the Lower freshwater bed of Reid).

The Westleton Beds were found to rest with discordance on various underlying beds; in places on the Forest series, elsewhere on the Chillesford Clay, whilst occasionally the latter had been partly or entirely eroded before the deposition of the Westleton Beds. In the north, where the present series dies out, they come in contact with the so-called Weybourn Crag, which the author supposed to be the equivalent of the Norwich Crag. A similar discordance has been noted between the Westleton Beds and the overlying glacial beds, so that the former mark a distinct period, characterized by a definite fauna, and by particular physical conditions. The Westleton Beds being marine, and the Mundesley Beds estuarine and freshwater, the author proposed to use the double term to indicate the two facies, as has been done in the case of other deposits. But these facies were found to be local, and the most persistent feature of the beds is the presence of a shingle of precisely the same character over a very wide area. By means of this the Westleton Beds can be identified far beyond East Anglia, and where there is no fossil evidence, and they throw considerable light on important physiographical changes.

The author described the composition of the shingle, which, unlike the glacial deposits, contained pebbles of southern origin.

The paper concluded with a list of fossils, excluding those of the Forest-bed (the stumps of which, the author considered, were frequently in the position of growth). Should the Forest-bed eventually prove to be newer than the Chillesford beds, it was maintained that the former must be included in the Westleton series, and its flora and fauna added to the list, whilst if, on the contrary, the Forest-bed should be proved synchronous with the Chillesford Beds, it must be relegated to the Crag.

The second part of the paper will treat of the extension of these beds into and beyond the Thames Valley, and on some points connected with the physical history of the Weald.

II.—June 19, 1889.—Prof. J. W. Judd, F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "On Tachylyte from Victoria Park, Whiteinch, near Glasgow." By Frank Rutley, Esq., F.G.S.

This paper dealt with the microscopic characters of certain thin tachylytic selvages occurring on the margins of white-whin (basalt) veins which traverse Carboniferous shales in Victoria Park, and which have already been described in some detail by Messrs. John Young and D. Corse Glen. The white-whin veins, which sometimes are not more than an inch in breadth, are found to become gradually more vitreous in passing from the middle to the sides of the veins. Near the margin they become densely spherulitic, the spherulitic band on either side of the vein being followed by a less spherulitic and more glassy band, the vitreous matter of which appears nearly or quite colourless. A sharp but irregular boundary-line follows, beyond which lies a band of a more or less deep brown or coffee-coloured glass, which the author considers to have resulted from the fusion of the shale, two narrow vitreous bands of different origin being thus developed side by side on each side of the vein, the colourless bands representing the chilled margins of the vein, the brown bands the fused surfaces of the walls of shale. The author only suggested this as a plausible explanation of the microscopic phenomena. An analysis of portion of one of these whin veins with its adherent tachylyte, made by Mr. Philip Holland, was appended to the paper.

2. "The Descent of *Sonninia* and of *Hammatoceras*." By S. S. Buckman, Esq., F.G.S.

The author reviewed the history and literature of the genus *Sonninia*, Bayle, which was founded to receive the Ammonites of the *Sowerbyi*-group, formerly classed, together with those of the *Insignis*-group, in the genus *Hammatoceras*.

The reasons why the genus *Sonninia* is not descended from *Hammatoceras*, or from *Haugia* (*Variabilis*-group), were set forth. Then, proceeding to trace out the life-history of *Pleuroceras*, *Amaltheus*, and *Sonninia*, as shown by their inner whorls, the author arrived at the conclusion that these three genera were descended from a common source, and that they form three branches from one stem.

The development of the genus *Hammatoceras*, *sensu stricto*, was then traced out, and its descent shown to be from the genus *Deroceras*, which is in accordance with the general ideas upon the subject.

The difference in the descent of *Sonninia* and *Hammatoceras* was taken to justify the separation of the former from the latter. The genus *Sonninia* would be correctly placed in the family Amaltheidæ; while the genus *Hammatoceras* would be placed in the same family as *Stephanoceras*.

Of the numerous new species belonging to the genera *Sonninia* and *Hammatoceras*, certain forms, necessary to elaborate the ideas set forth above, were described and definitely separated. The paper also touched upon certain other facts connected with *Hammatoceras*, *Sonninia*, and cognate genera.

3. "Notes on the Bagshot Beds and their Stratigraphy." By H. G. Lyons, Esq., R.E., F.G.S.

The author deplored the necessity of quitting the area which he had studied before completing his observations, and wished to place his results at the disposal of other workers.

In a previous paper he had discussed the beds at their southern outcrop, over a small area, and showed that there the Bagshot and London Clay strata remained of constant thickness, and dipped northwards at an angle of about $2\frac{1}{4}°$. He had since examined the country between Aldershot and Ascot over an area of about fifteen miles square, and attempted by contouring the surface of the Middle Bagshot beds (which showed a nearly constant thickness of 60 feet over the area), to give the form into which the beds had been pushed by the different slight flexures which might occur. After giving details of the heights at which this surface was found, he concluded that an anticlinal of which the axis pointed upon Windsor Castle, appeared to pass through the Swinley and Wellington College area, and probably to Hazeley Heath; and that a synclinal started by Minley and Hawley, and ran by the Royal Albert Asylum, Gordon Boys' Home, upon Ongar and Row Hills, and Woburn Hills; and that another anticline ran to St. George's Hill, Weybridge.

The author had attempted to map the southern and eastern limits of the Upper Bagshot beds, and claimed a much greater extent for these beds in those directions than had been assigned by the members of the Geological Survey. The outcrop of the beds was described in some detail, and the occurrence of outliers on Knaphill Common, by Donkey Town, on Chobham Common, and on Staples Hill, was noted.

4. "Description of some New Species of Carboniferous Gasteropoda." By Miss J. Donald. Communicated by J. G. Goodchild, Esq.

The Gasteropoda described in this paper have, with one exception, been collected by Mr. John Young from the Upper Limestone Series of Scotland. After discussing the characters of the genus *Orthonema*, Meek and Worthen, the following forms were described: *Orthonema pygmæa*, n. sp.; *O.* ?, n. sp.; *Murchisonia turriculata*, de Kon. (Yoredale Shales, Askrigg, Yorkshire); *M. turriculata*, var. *scotica*; and *M. compacta*, n. sp.

5. "*Cystechinus crassus*, a New Species from the Radiolarian Marls of Barbadoes; and the evidence it affords to the Age and Origin of those Deposits." By J. W. Gregory, Esq., F.G.S.

In this paper the discovery of a species of *Cystechinus* from the Radiolarian earth of Barbadoes was recorded. The specimen is now preserved in the National Collection, South Kensington. The form was described and distinguished from the three modern species which were found during the 'Challenger' Expedition. The latter have shown that the bathymetrical range of the genus is from 1050 to 2225 fathoms.

The author gave proofs that the specimen really came from the Radiolarian marl, and not from the overlying Coralline Limestone, and after discussing the age of the marl, as inferred by Prof. E.

Forbes, from an examination of the Mollusca, and by Prof. Haeckel after studying the Radiolaria, gave his reasons for supposing that it is in reality more modern than these authors supposed, and may be referred to the Pliocene or Pleistocene.

Though *Cystechinus crassus* possessed plates of greater thickness than those of the previously described species, the ambulacra were apetaloid, and the author concluded that though an inhabitant of seas of less depth than those in which the modern forms occur, it may be fairly considered to have been a dweller in deep seas, and to indicate that the Radiolarian deposit is a true deep-sea ooze.

CORRESPONDENCE.

A PALÆONTOLOGICAL RECORD.

SIR,—Now that Palæontology has become so complex a science, and new species are from day to day described in various parts of the world, is it not desirable that some International Record of them should be published at stated intervals?

We would suggest that the matter be taken up by the International Geological Congress; and if this be adopted, every one who describes a new species of fossil should send in the name and full references to the work in which it was published and figured, with accounts of the locality, geological horizon and biological order of the species.

In this way we should have an authentic register of new species, that would be of great value to all students of Palæontology; and, in short, "facilitate the preparation of that general list of all described fossils which is at present one of the greatest desiderata in geological science."[1]

RUDOLF SCHÄFER.
HORACE B. WOODWARD.

OBITUARY.

HENRY WILLIAM BRISTOW, F.R.S., F.G.S.,

Late Director of the Geological Survey of England and Wales.

BORN, MAY 17, 1817. DIED, JUNE 14, 1889.

THE name of H. W. BRISTOW will always be associated with the history of the Geological Survey, on which he served for a period of forty-six years. During the first few years of the official existence of the Survey, De la Beche had to depend to a large extent on voluntary or temporary assistance, but gradually he gathered around him a permanent staff of field-geologists and of others occupied in museum-work. Among those attached to the Survey in these early days were John Phillips, Ramsay and Aveline. In 1842 Mr. Bristow, then nearly twenty-five years of age, was appointed an Assistant Geologist, and during the next few years [Sir Warington] Smyth, Baily, Edward Forbes, Jukes, Selwyn and others joined the staff, whose headquarters were then situated in Craig's Court.

[1] See Address to the Geol. Soc. 1889, by W. T. Blanford.

Mr. Bristow was born on May 17th, 1817, and was educated at King's College, London, where, in 1840-41, he obtained certificates of honour in the departments of civil engineering and applied science. His father, Major-General H. Bristow, belonged to an old Wiltshire family, and had served in the Peninsular War.

Commencing Geological Survey work in the neighbourhood of Radnor, on the Old Red Sandstone and Silurian rocks, Mr. Bristow was shortly afterwards transferred to the Jurassic regions of Gloucestershire and Somerset, mapping portions of the Cotteswold Hills near Wotton-under-Edge and Chipping Sodbury, and of the Oolitic district near Bath. In these areas he received guidance from John Phillips and William Lonsdale. Still later he proceeded to the south coast, and working eastwards of Lyme Regis, he personally surveyed the greater portions of Dorsetshire, and eventually much of Wiltshire, Hampshire, and the Isle of Wight, and parts of Berkshire, Sussex, the Wealden area, and eastern Essex.[1]

In the course of this extensive survey all the subdivisions of the Jurassic, Cretaceous, and Lower Tertiary strata came under notice; and students who have subsequently paid attention to the structure of these tracts, whether along the fine cliff-sections of the Dorsetshire coast or inland over the Isle of Purbeck, the Ridgway, or Bridport, have borne testimony to the care and accuracy with which Mr. Bristow has depicted the geology. For it must be remembered that, excepting the small geological maps of Buckland and De la Beche, of Webster, Fitton, and Mantell, the detailed structure of the district had all to be unravelled. Nor was this a simple and easy task, considering the unconformable overlaps (or oversteps), and the effects produced by anticlinal disturbances and faults. In fact, no one, without actual experience of the process of geological mapping, can fully realize the amount of physical toil and mental labour involved in tracing the geological boundaries and faults in a region where so many subdivisions occur, and where they appear often in irregular and unexpected juxtaposition.

It is Mr. Bristow's field-work which will remain as a lasting memorial of his devotion to geological science. If his literary work on the Survey appears small, it must be remembered that in the early days of the Survey, the geologists were moved rapidly on from place to place, so that unfortunately little time was allowed for making detailed notes of the strata, and still less for observing the mode of occurrence of the organic remains. Mr. Bristow's intimate knowledge of the lithology of the stratified rocks is shown in the portions he contributed to the Descriptive Catalogue of the Rock Specimens in the Museum of Practical Geology.

The preparation of the Survey maps, however, was supplemented by numerous sections, longitudinal and vertical, which Mr. Bristow constructed with much skill and neatness to illustrate and explain the geology of the regions he had surveyed. The Purbeck Beds were especially illustrated in this way, and while the palæontology

[1] The Sheets of the Geological Survey Map on which Mr. Bristow was principally engaged, are Nos. 1, 5, 7, 9, 10, 11, 12, 14, 15, 16, 17, 18, 19, 35, 36, and 56.

of these beds was studied by Edward Forbes, the strata themselves were measured in great detail by Mr. Bristow, partly in conjunction with the Rev. Osmond Fisher, and partly with the aid of Mr. Whitaker. In like manner sections of the Tertiary strata in the Isle of Wight were prepared, while the palæontology was worked out by Forbes. The results of this work were published by Forbes, while the geology of the whole island was afterwards described by Mr. Bristow. The task of his later years had been to prepare a new edition of his Geology of the Isle of Wight; and this is now nearly ready for publication, having been revised and considerably augmented by Messrs. C. Reid and A. Strahan, who have lately re-surveyed the island on the scale of six inches to a mile.

In later years other areas surveyed by Mr. Bristow were illustrated by Memoirs. In conjunction with Mr. Whitaker, parts of Berkshire and Hampshire were described, and Mr. Bristow also contributed notes to the Memoirs on the Geology of the London Basin, the Weald, and East Somerset.

Considerable attention was given to the Rhætic Beds by Mr. Bristow, and in company with Mr. Etheridge, he visited the principal sections in the south of England and Wales, measuring the beds in detail, and eventually publishing the records. At the suggestion of Sir Roderick Murchison, in 1864, Mr. Bristow recommended that the name Penarth Beds be applied to the British representatives of the Rhætic Beds. He subsequently was occupied for several years in mapping these strata in parts of Glamorganshire, Gloucestershire, and Somerset, at the same time revising the geological maps over the regions visited.

Notwithstanding his arduous out-door occupation Mr. Bristow utilized his leisure hours in the preparation of a "Glossary of Mineralogy," which was published in 1861. This book was at once well received, proving to be an exceedingly useful work of reference, from its convenient arrangement, and the accurate and concise information given. The author had made considerable progress towards a new edition of the work.

Other works of a more popular nature likewise engaged his attention. In 1869 a translation by him of L. Simonin's "La Vie Souterraine" was published, under the title of "Underground Life; or Mines and Miners," a work which was adapted to the then present state of British mining. Three years later (1872), he produced a translation of Louis Figuier's "World before the Deluge," contributing a fresh chapter on the Rhætic or Penarth Beds. In previous years Mr. Bristow had also written mineralogical articles for Brande's Dictionary of Science, and Ure's Dictionary of Arts, Manufactures, and Mines. He also largely assisted the late Mr. Damon in his Geology of Weymouth, contributing much general information and some sections of the strata.

It only remains to be mentioned that after five years' service on the Geological Survey, Mr. Bristow was in 1847 promoted to the rank of Geologist. Twenty years later (1867) he was appointed District Surveyor, taking charge of the southern counties. In 1872 he was made Director for England and Wales, during the tenure of which office he saw the completion of the Geological Survey of the country on the one-inch scale. Retiring in July, 1888, he enjoyed but for a brief period his well-earned repose. A sudden stroke of paralysis was the immediate cause of his passing away, after a lingering illness, on June 14th, in his seventy-second year.

Mr. Bristow was elected a Fellow of the Geological Society in 1843, and of the Royal Society in 1862. Unfortunately afflicted with partial deafness, he was unable to hold free intercourse with his brother geologists; hence he seldom took part in the meetings of the Geological Society, although he served on the Council for a short time.

He received a Diploma from the Imperial Geological Institute of Vienna, and from the King of Italy the Diploma and Insignia of an officer of the Order of SS. Maurice and Lazarus. For several years, and until the close of his life, he was Examiner in Geology for the Science and Art Department.

LIST OF PAPERS AND GEOLOGICAL WORKS BY H. W. BRISTOW.

1842.—1. A Descriptive Catalogue of the Minerals in the Museum of King's College, London. 8vo. pp. 64. London.

1859.—2. Explanations of Sections (Horizontal and Vertical) of the Strata in the Isle of Wight. Geol. Survey. 8vo. London.

1861.—3. A Glossary of Mineralogy. 8vo. pp. xlvii. 420. London.

1862.—4. The Geology of the Isle of Wight. Geol. Survey Memoir. 8vo. London.

5. Notes on the Auriferous Mines and Deposits of the Spanish and Portuguese Estremaduras. Mining and Smelting Mag. vol. ii. pp. 97–100, 132–135.

1864.—6. On the Rhætic or Penarth Beds of the Neighbourhood of Bristol and the South-west of England. Geol. Mag. Vol. I. pp. 236–239; Rep. Brit. Assoc. for 1864, Sections, p. 50 (1865).

1866.—7. Note on Supposed Remains of the Crag on the North Downs, near Folkestone. Quart. Journ. Geol. Soc. vol. xxii. p. 553.

1867.—8. On the Lower Lias or Lias-Conglomerate of a Part of Glamorganshire. Quart. Journ. Geol. Soc. vol. xxiii. pp. 199–207.

1871.—9. Evidence given in 1869 before the Coal Commission; and Table showing the Thickness of the Secondary Strata in the Southern Counties of England. Rep. Coal Commission, vol. ii. pp. 445–462.

1872.—10. Table of British Sedimentary and Fossiliferous Strata. The Description of Life Groups and Distribution. By R. Etheridge. London.

1873.—11. Table of British Strata showing their Order of Superposition and Relative Thickness. London.

12. Hunstanton "Red Chalk." Geol. Mag. Vol. X. pp. 189, 190.

13. Notes on his Survey of the [Brixham] Cave. Phil. Trans. vol. clxiii. pp. 496–497.

1875.—14. Deep Boring in Prussia. Geol. Mag. Dec. II. Vol. II. pp. 95, 96, 140.

1880.—15. Geological Map of England and Wales (founded on the Map published by the Society for the Diffusion of Useful Knowledge). Part 4 of Letts's Popular Atlas. London.

JOINT WORKS BY H. W. BRISTOW AND OTHERS.

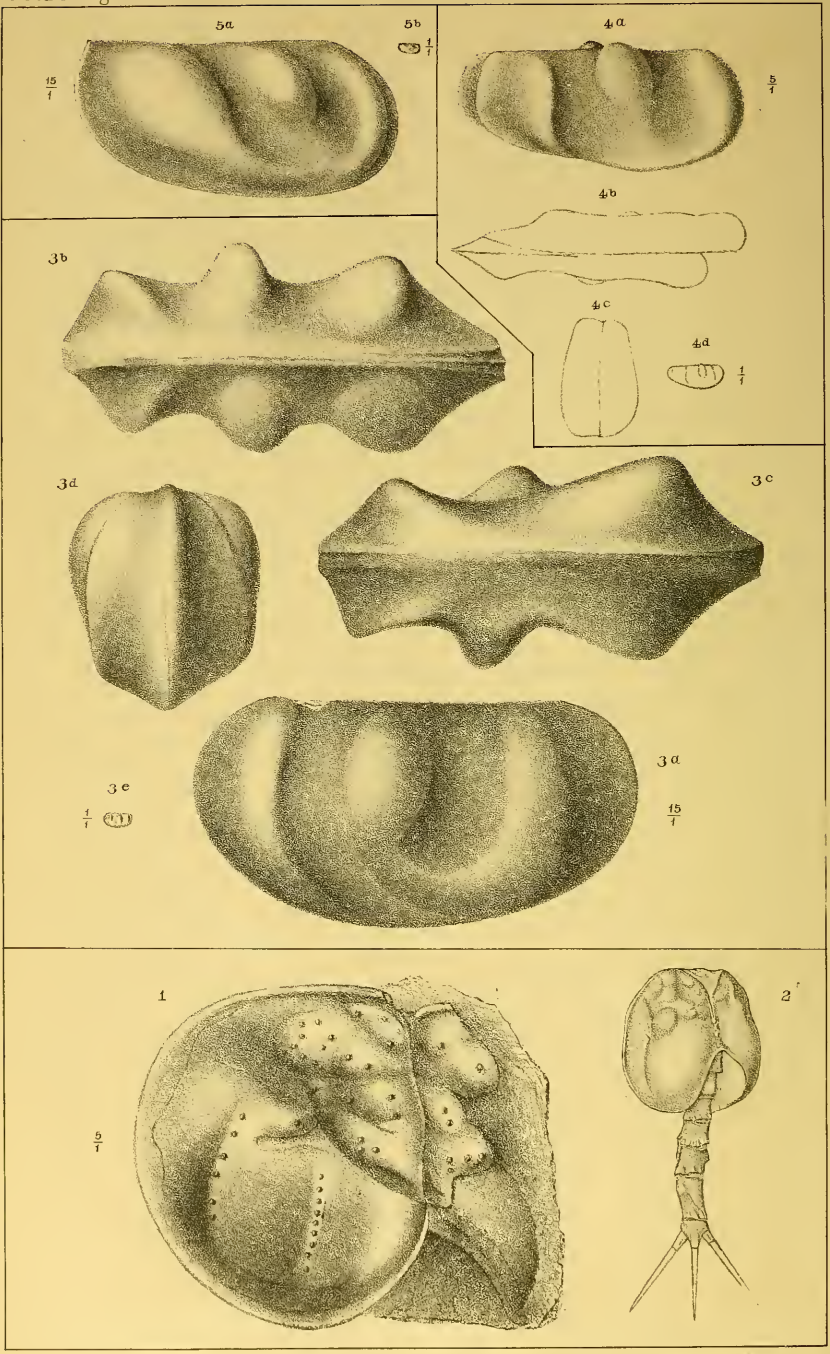
1858.—16. A. C. Ramsay, H. W. Bristow, and H. Bauerman, Descriptive Catalogue of the Rock Specimens in the Museum of Practical Geology. 8vo. London. Edit. 2, 1859, and Edit. 3, 1862 (with part by A. Geikie).

1862.—17. H. W. Bristow and W. Whitaker, The Geology of Parts of Berkshire and Hampshire. Geol. Survey Memoir. 8vo. London.

1869.—18. H. W. Bristow and W. Whitaker, On the Formation of the Chesil Bank. Geol. Mag. Vol. VI. pp. 433–438, 574, 575.

1871.—19. H. W. Bristow and H. B. Woodward, Remarks on the Prospects of Coal to the South of the Mendips. Geol. Mag. Vol. VIII. pp. 500–505.

H. B. W.



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DEVONIAN ENTOMOSTRACA.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VI.

No. IX.—SEPTEMBER, 1889.

ORIGINAL ARTICLES.

I.—On some new Devonian Fossils.

By Prof. T. Rupert Jones, F.R.S., and Dr. H. Woodward, F.R.S.

(PLATE XI.)

I. Echinocaris Whidbornei. Plate XI. Fig. 1.

IN this specimen one valve (the left) and a part of the dorsal region of the other, remain visible; the rest of the right valve being bent down, broken, and imbedded in the matrix. This is a finely micaceous, non-calcareous, grey mudstone, weathering ferruginous towards one edge, which probably abutted on a crack open to water and atmosphere.

The fossil, in the grey portion is darker than the matrix, and fairly represents the test of half of the carapace, with only a very thin lamina wanting, a broken edge of which is traceable (with a lens) near the ventral margin. This left valve measures 9·2 by 7·4 mm. It is subcircular, more boldly curved on the ventral than on the posterior margin, whilst the front margin is somewhat truncate, having a nearly straight edge from above downwards before it bends round into the ventral curve. The dorsal border was probably straight along two-thirds of its length, but has been crushed against the other valve and somewhat distorted. A distinct, narrow, marginal rim is present,—thickened and raised on the front margin, and flatter on the ventral and hinder margins.

The convexity of the surface is interrupted by several elevations and depressions. In the antero-dorsal region are five unequal swellings; one, large and pyriform, is most noticeable, and a small subtriangular swelling in front of it fills the antero-dorsal angle; behind these a triangular space is occupied by three other unequal prominences; and altogether these represent the locality of the important cephalic (buccal or gastric) organs, and their muscular attachments.

Behind the swellings are two ridges on the valve; one along its median line, and the other, parallel, but somewhat curved, on the ventral region. The swellings are each ornamented with a few small tubercles, somewhat wide apart. The ridges also bear such little tubercles; the upper (straight) ridge having about nine, and the lower (curved) ridge has six.

This fossil belongs evidently to *Echinocaris*,[1] Whitfield (1880);

[1] For the latest account of this genus and the several species here mentioned, see Geol. Surv. State of New York, Palæontology, by Prof. James Hall and J. M. Clarke. vol. vii. 1888, pp. 166–181, plates 28–30. See also our Sixth Report (for 1888), Rep. Brit. Assoc. 1889, p. 180.

but it differs from *E. punctata*, Hall (fig. 2, after Beecher, about two-thirds of the natural size), in being rounder behind, and truncate in front,—in the arrangement of the cephalic prominences, —and particularly in having two parallel ridges, instead of one sigmoidal ridge. So also it differs from *E. sublævis*, Whitfield, *E. condylepis*, Clarke, *E. multinodosa*, Whitfield, and *E. Whitfieldi*, Clarke. *E. pustulosa*, Clarke, has only one tuberculate ridge. *E. socialis*, Beecher, has the two parallel ridges, and the valve is slightly pustulose here and there; but it is smaller and more ovate than the specimen under notice; and the cephalic swellings, though analogous, are not identical.

As it is evidently a new species we propose to name this unique fossil from Devonshire Echinocaris Whidbornei, after the Rev. G. F. Whidborne, F.G.S., who drew our attention to the specimen, and first recognized its true affinities.

Mr. J. E. Marr, Sec.G.S., informs us that this rare fossil was found by Mr. Dufton in the leaden-blue shales of the *Lingula-squamiformis* beds in a quarry near Sloly, close to the three-milestone on the Barnstaple and Ilfracombe road. The shales (he adds), which are here interstratified with very micaceous frilled sandstones, belong to the Cucullæa-zone of the Marwood Beds. The specimen is preserved in the Woodwardian Museum, Cambridge, and has been kindly lent to us by Prof. T. McKenny Hughes for examination and description.

II. Beyrichia Devonica, sp. nov. Pl. XI. Figs. 3–5.

Figs. 3, 4, 5 show internal casts of some large *Beyrichiæ* from the Devonian strata near Torquay, in Devonshire, in different states of preservation. Nine or ten other such specimens were sent to us for examination by Thos. Roberts, Esq., F.G.S. They are all preserved in the Woodwardian Museum, Cambridge, and are imbedded in a finely micaceous, purplish-grey, schistose mudstone, weathering red, from the New Cut, above Meadfoot, Torquay. The fossils occur, sometimes on a cleavage-plane, more frequently on the bed-planes, compressed and distorted by pressure; and therefore rarely (as Fig. 3) escape some such modification. The test of the valves has gone, and the casts and moulds are both coated with ruddle, which in some cases seems to represent the test.

Figs. 3*a*—*e*. This is the internal cast of a simple three-lobed *Beyrichia* (4 mm. long, by 2 high), having, in the curved ventral junction of the two hinder lobes, some analogy to both *B. Buchiana*, Jones, and *B. Klœdeni*, var. *antiquata*, Jones,—which are of Upper Silurian age. In the shape and size of the valve, however, and the proportions of the lobes, it differs from both. Another good cast (6 × 2·5 mm.) differs slightly from Fig. 3, appearing sharper in front and blunter behind, if looked at on edge,—that is, the anterior lobe is rather further from the front margin, and the posterior lobe nearer to the hinder margin.

The impression from out of which some of these and other casts have come indicate no other characters of the surface except what the casts show; in some cases, however, the marginal rim is more distinct.

Figs. 4 *a—d*. These show the cast of a very large and much squeezed carapace (7·5 mm. long; the hollow mould is 8 mm., having more marginal rim behind). The valves have been lengthened and compressed (Figs. 4 *b*, *c*), the lobes stretched obliquely, and the curved ventral junction obliterated (Fig. 4*a*). The results of pressure and the lower scale of magnifying give this specimen an appearance very different from that of Fig. 3.

Figs. 5 *a*, *b*, show a neat and smaller cast (3 mm. long) of the same species, but modified by pressure (from above downwards and obliquely), so that the length of the valve has been increased, the height lessened, the lobes thrown into an oblique position (as also seen in Fig. 4*a*), the ventral curve almost obliterated, and by a longitudinal wrinkle or small fold (not well shown in Fig. 5*a*) the large pyriform lobe is puckered all along its postero-ventral region. The result of these changes is that the modified valve looks almost like a variety of *B. Klœdeni*, M'Coy; but the evident effects of pressure are all that separate it from the more typical forms, such as Fig. 3.

As a new species we propose to call this form Beyrichia Devonica.

As is well known, Prof. Dr. Ferdinand Roemer some years ago noticed a large *Beyrichia* (about 4 mm. long) from the Devonian rocks of the Bosphorus.[1] See his "Geognost. Bemerk. auf einer Reise nach Constantinopel," etc. "Neues Jahrb." 1863, p. 521, pl. 5, figs. 8*a*, *b*. At p. 509 F. Roemer referred these fossiliferous rocks to the Middle and Upper Devonian; but M. de Verneuil (Bullet. Soc. Géol. France, 2 sér. vol. xxi. (1864), pp. 147–155) regarded them as of Lower Devonian age. In the Geol. Mag. Vol. VIII. (1870), p. 466, Prof. Dr. Ferd. von Hochstetter is cited as referring[2] them palæontologically to the horizon of the Lower Devonian beds of Western Europe, noting also that they contain some few Upper Silurian fossils.

Roemer's two little figures unfortunately do not allow us to offer an opinion as to the specific characters of his *Beyrichia* from the Bosphorus.[3] It may or may not be related to our species from Torquay.

The new *Beyrichia* from Devonshire has been alluded to in the Ann. Mag. Nat. Hist. ser. 6, vol. ii. 1888, p. 299, by the Rev. G. F. Whidborne, F.G.S., and is there said to have been found by Mr. T. Roberts, Mr. Solly, and other members of Professor T. McKenny Hughes's Cambridge party during their visit to Torquay in the

[1] The Turkish *Beyrichiæ* above mentioned are briefly noticed also by Mr. W. R. Swan, in the Quart. Journ. Geol. Soc. vol. xx. (1864), p. 115.

[2] In his Geological Conditions of the Eastern Part of European Turkey, Jahrb. der K.K. geol. Reichsanstalt, vol. xx. 1870.

[3] This specimen, collected by M. A. Dumont, was sent to Dr. Ferd. Roemer by M. G. Dewalque, who, having the care of the Museum of the Liége University, has allowed us to see the specimen. It is closely allied to, if not the same as our *B. Devonica*.

spring of 1888, in the red beds of the "New Cut" or "Lincombe-Hill Drive," from which the late Mr. Champernowne obtained his *Homalonotus* some years ago.[1] These beds lie high upon the slope of the Ilsham Valley, some hundred yards to the North of Meadfoot Bay. They are considered by Prof. Hughes to be the same as, or, more probably, slightly lower than the *Pleurodictyum*-beds of Kilmorie; and he has obtained *Pleurodictyum* and other fossils from beds in their immediate neighbourhood.

EXPLANATION OF PLATE XI.

FIG. 1. *Echinocaris Whidbornei*, sp. nov.
FIG. 2. *Echinocaris punctata*, Hall; after Beecher, about $\frac{2}{3}$rds.; shown for comparison, and to indicate the form of the whole animal.
FIGS. 3–5. *Beyrichia Devonica.*

II.—ON AN ICHTHYOSAURIAN PADDLE SHOWING THE CONTOUR OF THE INTEGUMENTS.

By R. LYDEKKER, B.A., F.G.S., F.Z.S., etc.

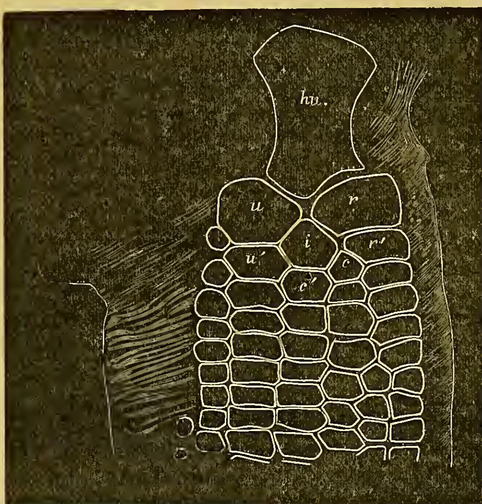
IN the year 1841 Sir R. Owen described and figured[2] a slab ot rock from the Lower Lias of Barrow-on-Soar which showed the impressions of the bones and integuments of a pelvic paddle of an *Ichthyosaurus*, probably referable to the typical *I. communis*. In this specimen[3] it appears that the integuments were produced to a greater extent on the posterior than on the anterior side of the bony framework; and that while the anterior margin of the soft parts showed evidence of squamation, the larger posterior flap was marked by oblique striæ extending from the bones to the periphery which appeared to have been caused by parallel bundles of muscular fibres. The distal extremity of the soft fin terminated in a sharp point far below the distal bones.

This specimen appears to be the only English example hitherto described showing the form of the integuments of the paddles. In 1888, however, Dr. E. Fraas published a paper on the integuments of the paddles of *Ichthyosaurus*,[4] in which he described two specimens belonging to the Longipinnate[5] group of the genus, which may apparently be referred either to *I. acutirostris* or the allied *I. Zetlandicus*. One of these specimens showed both the pectoral and pelvic paddles, while the second only exhibited the pectoral paddle, which is figured in the plate accompanying the memoir. These specimens confirmed the inferences drawn from the English example, but showed that in the Longipinnate group the integumentary portion of the paddles was relatively wider, and terminated in a blunt lower extremity, which extended but a short distance beyond the distal

[1] GEOL. MAG. 1888, pp. 487–491, Pl. XIII.; 1882, pp. 157–8, Pl. IV. Fig. 3.
[2] Trans. Geol. Soc. ser. 2, vol. vi. pt. i. p. 199, pl. xx. See also Liassic Reptilia (Mon. Pal. Soc.) pt. iii. pl. xxviii. fig. 3.
[3] British Museum, No. 29672.
[4] Jahresh. Ver. Nat. Württemberg, 1888, pp. 280–303, pl. vii.
[5] See the writer's Catalogue of Fossil Reptilia and Amphibia in British Museum, pt. ii. p. 69 (1889).

bones. They also showed that the pectoral limb had a broad flap of integument in the axillary region. Oblique striæ, like those of the English specimen, were observed on the posterior flap of integument, and were likewise held to be probably formed by muscular bundles; while the squamation of the anterior border of the fin was shown to be of a very minute and fine structure.

So far as I know, the above is all the original literature which has appeared on this subject, and I proceed to notice the specimen on which the present communication is based. The specimen in question was kindly sent to me by Mr. Montagu Browne, of the Leicester Museum, who obtained it some time ago from the Lower Liassic quarries at Barrow-on-Soar. It consists of a split slab showing the imperfect thoracic region of a small Ichthyosaur clearly



Ventral aspect of the imperfect left pectoral paddle of *Ichthyosaurus intermedius*; from the Lower Lias of Barrow-on-Soar.
Half nat. size. *hu.* humerus; *r.* radius; *u.* ulna; *r′.* radiale; *i.* intermedium; *u′.* ulnare; *c. c′.* centralia.

referable to the Latipinnate group of the genus, and apparently belonging to *I. intermedius*. A large portion of the left pectoral limb is well preserved, the bones having been split in a plane parallel to the dorsal and ventral surfaces; although the distal extremity is unfortunately wanting. The half of the slab which best exhibits the paddle is the one in which, if the specimen were not split, we should look upon its ventral aspect; this view being represented in the accompanying woodcut. An inspection of this figure shows that the lateral flaps of integument are clearly marked on the slab, and that their general arrangement is the same as in the specimens previously described. On the narrow anterior flap a minute squamation can be detected with the aid of the lens; while the wider posterior flap shows the oblique lines described by Messrs. Owen and Fraas. These lines are formed by whitish films lying on the rock, which are distinctly striated, and are at first sight very suggestive of fin-rays, although it is on the whole more probable that they really indicate parallel muscular bundles. The axillary region was evidently produced into a well-marked flap, or prominence. In proportion to the bony framework the posterior flap of integument is much narrower than in the specimen figured by Fraas; and since our specimen agrees in this respect with the pelvic paddle figured by Owen, it may be assumed that the distal extremity of the soft part was produced and pointed as in the latter.

We have, therefore, now good evidence that while the integuments of the paddles of the two primary groups into which the genus *Ichthyosaurus* is divided were of the same general type of structure, yet that they differed so markedly in detail as to afford another important point of distinction between the two groups.

I may add that Mr. Montagu Browne has been good enough to present the figured half of this interesting specimen to the British Museum.

III.—On the Origin of the Stone-Rivers of the Falkland Islands.

By Charles Davison, M.A.,

Mathematical Master at King Edward's High School, Birmingham.

The stone-rivers of the Falkland Islands have been described by Mr. Darwin, Sir Wyville Thomson, Dr. Coppinger, and other naturalists who have visited those regions.[1] The accounts given by the two first-named are well-known and easily accessible, and render a full description here unnecessary. But it may not be out of place to summarise the principal features of the stone-rivers, which must find an explanation in any satisfactory theory of their origin.

They consist of angular blocks of quartzite, "arranged," according to Pernéty, "as if they had been accumulated carelessly to fill the ravines." The blocks are from two to twenty feet long, and rest "irregularly one upon the other, supported in all positions by the angles and edges of those beneath" (Thomson). At the same time, "they are not thrown together into irregular piles, but are spread out into level sheets or great streams" (Darwin), the surface of one visited by Dr. Coppinger being "tolerably flat," and not indicating "a process of accumulation by flow from either side." The streams vary in width from a few hundred feet to a mile or more. Their depth is unknown, but, according to Darwin, is probably great: though "far down below, under the stones," says Sir Wyville Thomson, "one can hear the stream of water gurgling which

[1] A. J. Pernéty, Histoire d'un Voyage aux Isles Malouires, etc. (nouv. éd., 1770, Paris), vol. ii. pp. 1–6; C. Darwin, Journal of Researches, etc. (1879), pp. 196–199; Sir C. Wyv. Thomson, The Movement of the Soilcap; Nature (Feb. 22, 1877), vol. xv. pp. 359–360; also, Voyage of the 'Challenger,' vol. ii. pp. 245–249; and the Enc. Brit., art. on the Falkland Islands; Dr. R. W. Coppinger, Cruise of the 'Alert' (1885), pp. 32 33.

occupies the axis of the valley; and here and there, where a space between the blocks is unusually large and clear, a quivering reflection is sent back from a stray sunbeam." The inclination of the surface of the stone-rivers is very small, and this is their most remarkable feature. "On the hillsides," says Darwin, "I have seen them sloping at an angle of ten degrees with the horizon, but in some of the level, broad-bottomed valleys, the inclination is only just sufficient to be clearly perceived." The actual movement of the blocks does not seem to have been noticed. "As far as I can ascertain," Dr. Coppinger remarks, "no attempt has ever been made to estimate the rate of movement (if any) of these 'runs,' and there is no evidence whatever of their motion during the present century."

The origin of the blocks themselves has been clearly pointed out by Sir Wyville Thomson. "The beds of quartzite are of very different hardness: some are soft, passing into a crumbling sandstone; while others are so hard as to yield but little to ordinary weathering." Being worn away unequally, the harder bands project, and at last the joint-formed blocks fall over. The difficulty, however, is to account for their present position and arrangement, and, for this purpose, the following theories have been proposed:—

1. The action of earthquakes, hurling the blocks down the slopes, and then levelling them out into continuous sheets (C. Darwin, A. J. Pernéty).

2. The movement of the soilcap enclosing the stones, the soil being afterwards washed away by the streamlets in the valleys (Sir C. Wyv. Thomson).

3. The former movement of "earth-glaciers," which, owing to a change of climate, became desiccated, the earth being afterwards washed away by rain and streams (J. Geikie).[1]

4. The action of frost and snow, the alternate freezing and thawing of rain (Sir J. D. Hooker).[2]

5. The action of glaciers. "I believe it will not be difficult to explain their origin in the light of the glacial theory, and I fancy they may turn out to be ground moraines similar to the 'horse-backs' of Maine" (J. R. L. Agassiz).[3]

6. The alternate expansion and contraction of the blocks under changes of temperature taking place mainly down the slopes, being assisted by gravity in that direction (C. Davison).[4]

It is not my purpose to discuss these suggestions here; but I may remark that, according to Thomson, "ice had no hand whatever in the production of these grand 'moraines' of the Falkland Islands." The second theory has been criticised adversely by Prof. J. Geikie

[1] The Movement of the Soilcap: Nature (March 8, 1877), vol. xv. pp. 397-398.

[2] Himalayan Journals (1854), vol. ii. p. 179 (footnote).

[3] Louis Agassiz: His Life and Correspondence, edited by E. C. Agassiz, vol. ii. pp. 694–695. Extract from a letter to Prof. B. Peirce, dated Feb 20, 1871. It should be noted that Agassiz's intention of visiting the Falkland Islands was never carried out.

[4] Note on the Movement of Scree-material: Quart. Journ. Geol. Soc. (1888) vol. xliv. pp. 232–237.

and Dr. Coppinger with, I believe, conclusive force. With regard to the sixth, though slight movements of this nature must undoubtedly be taking place, they must in this case be unusually small, for the climate of the Falkland Islands is dull and the sky almost continually overcast.[1]

Now, in all of the above-mentioned theories, the transport of the quartzite blocks over considerable distances is taken for granted, and the object of the theories is really to account for this transport over a rough and irregular surface, inclined generally at a very small angle to the horizon. But is it not possible that this assumption is unnecessary; that the blocks, though they have doubtless undergone some movement, still remain in the immediate neighbourhood of the places they occupied before the valleys were formed; that the stone-rivers are, in fact, but an extreme case of the inability of a stream to remove the debris in its course?

On the summits of many of our mountains, we have a phenomenon not unlike the stone-rivers in appearance, and perhaps similar to them in origin. The so-called "blocky structure," so conspicuous, for example, on Scawfell Pike, occurs in many, if not in most, cases where alternate bands of hard and soft rock crop out at the summit. The softer layers, being more easily weathered, are gradually removed by wind and rain; and, in course of time, the joint-formed blocks of the harder projecting bands fall over in various directions, giving rise to that confused, tumultuous appearance, which seems at first sight to suggest the action of an overwhelming force. The blocks remain almost as they fall, for the forces in action on the mountain-summits are insufficient to displace them greatly.

Now, in the Falkland Islands, we have, as we have seen, somewhat similar conditions; bands of hard quartzite separated by seams of soft and crumbling sandstone. When streams began to flow over the primitive surface of the country, they bore away, I imagine, the loosened debris of the softer bands, but the resulting blocks of quartzite were too heavy to be moved by them and hard enough to resist atmospheric disintegration. The streams then flowed between and below the blocks, and continued to remove the softer bands beneath, working their way from side to side of the valleys. The quartzite blocks thus gradually subsided vertically all over the valleys, most along the axis and in the lower regions, least at the sides and in the upper parts, forming on the whole a gently sloping surface,[2] but rough and irregular in its details owing to the different

[1] "The temperature is very equable, the average of the two midsummer months being about 47° Fahr., and that of the two winter months 37° Fahr. The sky is almost constantly overcast, and rain falls, mostly in a drizzle and in frequent showers, on about 250 days in the year. The rainfall is not great, only about 20 inches." Enc. Brit., art. on the Falkland Islands.

[2] It should be noted that the quartzite bands are often much crumpled and distorted, but the surface of the stone-rivers would be fairly smooth in any part, if the total thickness of the quartzite bands formerly above that part were approximately the same all over it. Sir Wyville Thomson states, however, that "the general colouring [of the islands] is dark brownish-green, relieved along the strike of the hills by veins of white quartzite denuded by the wearing away of softer rocks on both sides, and left projecting on the mountain-slopes like dilapidated stone dykes" (Enc. Brit.).

sizes of the blocks and the various directions of their fall. The surface of the stone-rivers might thus be continuous with the slopes of the surrounding country; there would not necessarily, although there might, be bounding cliffs.[1] In the "blocky structure" of mountain-summits, a limit in depth must soon be reached, beyond which wind and frost and rain can have but little effect in weathering and removing the softer rock. But, in the stone-rivers of the Falklands, the process may be carried very much further: as long as streams are able to find their way among the blocks and can remove the sand between them.

This theory seems to me to account satisfactorily for the features of the stone-rivers, so far as they are given in the published narratives. It accounts also for another fact which is not referred to in the theories mentioned above, namely, the proportion of the volume of the quartzite blocks to the volume of the rock that must originally have occupied the valleys. From the slight slope of the surface, and the certainly not small depth, of the stone-rivers, we must infer that this proportion is not inconsiderable. If the formation of the stone-rivers, then, began some time after the commencement of denudation in the islands, not only must the quartzite blocks resulting from previous erosion in some way have been removed, but the valleys must also have greatly increased in width in order to provide the material for the stone-rivers: a large amount of the softer rock must have been carried away: and, therefore, in part, at least, a cause like that suggested in this paper must have been in action. But if we suppose that the formation of the stone-rivers has all along taken place concurrently with the excavation of the valleys, we can, I think, account for the origin of the former without having to call in the aid of any non-existing agencies to explain the transport of the blocks.

IV.—Note on *Rhinobatus bugesiacus*—a Selachian Fish from the Lithographic Stone.

By A. Smith Woodward, F.G.S., F.Z.S.

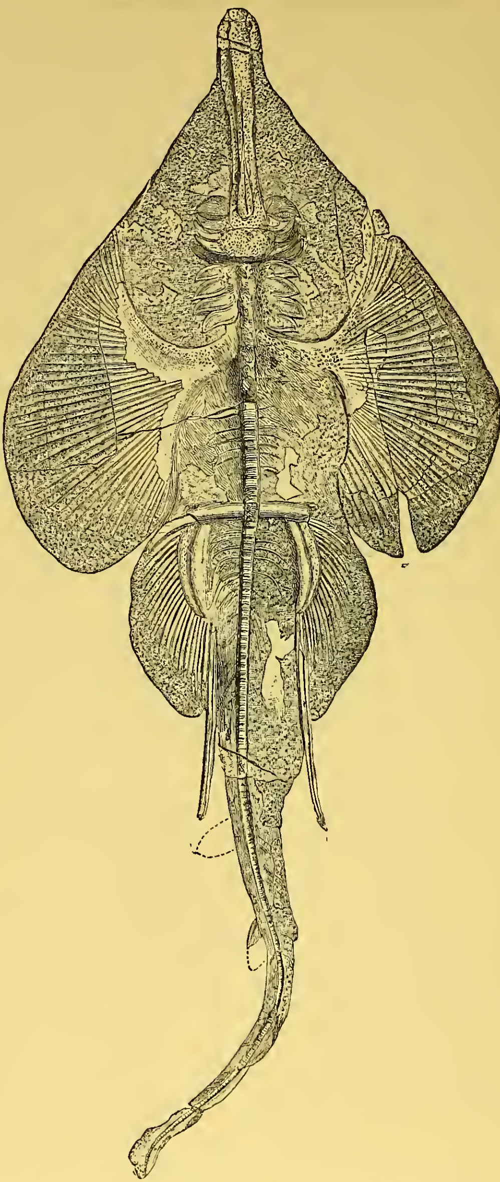
SINCE 1857,[2] the occurrence of a gigantic species of the Selachian family Rhinobatidæ in the Lithographic Stone of Bavaria has been well known, and three fine specimens are exhibited in the Munich Museum. No figure, however, appeared until 1887, when Dr. K. A. von Zittel published[3] the illustration he has kindly allowed to be reproduced here; and the only detailed description is that of Wagner,[4] written about thirty years ago. Quite recently, the British Museum has acquired the counterpart of one of the fossils in the Munich collection—a female individual in a remarkable

[1] "Why," asks Dr. Coppinger, "do they [the stone-rivers] exhibit a margin so sharp and well-defined, yet without the elevated rounded appearance of a river-bank?"

[2] A. Wagner, Gelehrte Anz. bay. Akad. Wiss. vol. xliv. (1857), p. 292.

[3] Handb. Palæont. vol. iii. p. 103, fig. 117.

[4] Abh. k. bay. Akad. Wiss. Math.-phys. Cl. vol. ix. (1861), p. 313.



Rhinobatus Bugesiacus (Thiollière ? sp.).
Lithographic stone, Eichstatt, Bavaria (after Zittel).
(One-twelfth nat. size.)

state of preservation; and this is now exhibited in the form of a slab upon the west wall of the Gallery of Fossil Fishes.

The specimen in question is complete in all important respects, only the proximal portion of the left pectoral fin and non-essential parts of the median fins being wanting; but the vertebral column, except towards the extremity of the tail, is shown as fragments or merely in impression, and the jaws are unfortunately buried in the matrix. The fish is exposed from the dorsal aspect, measuring 1·50 m. (about 5 ft.) in total length; and in general form it agrees with the male individual represented in the accompanying figure. The snout is remarkably produced, and on the outer side of each nasal capsule is a long slender forwardly-directed cartilage, evidently to be regarded as prepalatine. The basal pterygia of the right pectoral fin are more clearly shown than those of the Munich fossil, as here figured, the mesopterygium being large and broad, the propterygium long, slender, and segmented distally, and the metapterygium somewhat stouter than the latter; the large, very broad cartilaginous fin-rays are also all distinct. The dorsal fins are relatively larger than indicated by the outlines in the figure; and the caudal fin has a slightly greater expanse, though this may be due to difference in crushing during fossilization. Coarse rounded shagreen-granules cover the dorsal aspect of the cranium, the pectoral arch, and the longitudinal middle line of the back; but there are no large tubercles or spinous defences.

So long ago as 1836, Count Münster[1] briefly noticed the caudal extremity of a large Selachian from the Lithographic Stone of Kelheim under the name of *Aellopos elongatus*; and in 1843, Agassiz[2] recorded the occurrence of a very large pectoral fin with the provisional name of *Euryarthra Muensterii.* Both these fossils probably pertain to the fish now under discussion, as already suggested by v. Zittel, and, to a certain extent, also by Wagner; but they were not sufficiently described for recognition before 1854, when Thiolliére[3] gave detailed notes and figures of specimens from the Lithographic Stone of Cirin, Ain, France, identical in every respect, except size, with the Bavarian species. The name proposed by Thiolliére—*Spathobatis Bugesiacus*—is thus applicable to this species; and as there is no significant difference between "*Spathobatis*" and the recent *Rhinobatus,* we prefer to regard the former generic name merely as a synonym of the latter.

When studying the Bavarian "*Spathobatis,*" Wagner himself distinctly perceived its identity with the French species described by Thiolliére; but owing to the fact, that the former attained twice the size of the latter, he considered a distinct specific name justifiable, and suggested that of *S. mirabilis.* According to modern ideas of nomenclature, however, this name must become a synonym; and an examination of the type-specimen of *S. morinicus,* Sauvage,[4] from

[1] Neues Jahrb. 1836, p. 581.
[2] Rech. Poiss. Foss. vol. iii. p. 382.
[3] Poiss. Foss. Bugey, pt. i. p. 7, pls. i. ii.
[4] Bull. Soc. Académique Boulogne-sur-Mer, 1873, p. 94.

the Portlandian of the Boulonnais, has convinced the present writer that the last-mentioned name must also share the same fate.

Rhinobatus Bugesiacus thus occurs in the Lower Kimmeridgian of Bavaria and S.E. France and in the Lower Portlandian of N.E. France: in the first and last localities it attains its maximum dimensions, while in the second it is comparatively dwarfed. The same species may also perhaps be met with in the English Kimmeridgian, but as only detached vertebræ have hitherto been discovered,[1] it is at present impossible to arrive at a specific determination.

Woodwardian Museum Notes.

V.—On "Eyes" of Pyrites and other Minerals in Slate.

By Alfred Harker, M.A., F.G.S.

AMONG instances of the bodily deformation of rocks by lateral pressure, the case of the *phyllade aimantifère* of Monthermé is well known. By its strong cleavage this rock gives evidence of considerable lateral compression. Professor Renard[2] has shown that prior to this compression the magnetite crystals already existed in the rock, and were surrounded by a coating of chlorite. The crystals yielded to the pressure much less readily than their matrix, and the latter, having already a firm consistence, became separated from the crystals, carrying the chlorite with it, and was displaced along the planes which are now cleavage-planes, that is, in a direction at right angles to that of the pressure.

My object is to show that similar phenomena are not uncommon among cleaved rocks in our own country. Some years ago I obtained from the Penrhyn quarry a specimen of slate with cubes of pyrites, in which the displacement of the matrix around the imbedded crystals is well exhibited. As in the French *phyllade*, the vacant spaces left have been subsequently filled by infiltered quartz, which grew roughly perpendicular to the faces of the crystals. The arrangement is represented in figure 1 (p. 397). As the "eyes" are from half an inch to an inch in length, the pyrites, quartz, and chloritic mineral can be easily distinguished with the naked eye, while a thin section makes a pretty object under the microscope (No. 501). In the *phyllade aimantifère* the magnetite crystals are only 0·2 to 0·8 mm. in length (No. 502). M. Reusch[3] has noticed a precisely similar disposition of quartz and chlorite around dodecahedra of pyrites in a schistose diabase dyke: here too the crystals appear to be only about one-hundredth of an inch in diameter.

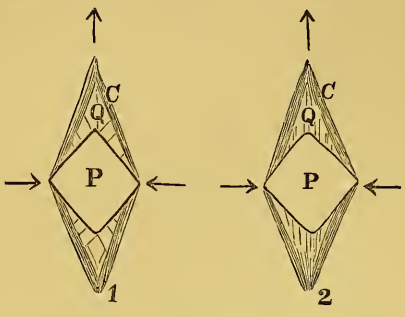
The phenomenon is probably one of wide occurrence. It is seen in sericitic slates at Blaenau Ffestiniog and at other places in North and South Wales; also in the very pyritiferous slates of Ballachulish near Oban. The "eyes" are always flattened parallel to

[1] Catal. Foss. Fishes, Brit. Mus. pt. 1, p. 83.

[2] Bull. Mus. Roy. Hist. Nat. Belg. vol. ii. p. 134, and plate vi. 1883. See also Gosselet's "L'Ardenne," p. 61 and fig. 17, 1888.

[3] Bömmelöen og Karmöen, pp. 69, 70, 1888.

the cleavage-planes and drawn out along the line of cleavage-dip (*longrain* of the French). It indicates that in those cases the pyrites is of very early origin, and that it became coated at an early stage with a chloritic envelope; further, that the rock became thoroughly compacted before it was subjected to the lateral thrust, so that in yielding it was able to leave vacant spaces, which were filled at a later date by crystalline quartz. This last point is proved by the manner in which the quartz has been formed with its crystals perpendicular to the faces of the pyrites. There are, however, other cases in which the quartz has a fibrous structure, the fibres being set parallel to the *longrain*, that is, to the direction of movement, as diagrammatically shown in fig. 2. This is presumably due to the quartz having been deposited concurrently with the process of deformation, so that no vacant space was actually formed. The examples cited by Loretz[1] from the Thuringerwald must be referred to this kind of action. In these the pyrites has been subsequently converted into limonite.



Sections at right-angles to the cleavage-planes. P = pyrites; Q = quartz; C = chloritic mineral.

Another variety of "eye" is found in the Llandeilo slates of Whitesand Bay near St. David's. Here the whole external surface of the "eyes," which are about an inch and a half to two inches long, has a strongly fibrous, slickensided aspect. On making a section, it is seen that the pyrites cubes have their angles and quoins rounded off, and little fragments of pyrites are detached and enveloped in the quartz which occupies the corners of the "eyes."

It should be noted that these lenticular or eye-shaped masses are essentially characteristic of *discontinuous* sliding movement, in which actual disruption has taken place between substances capable of different degrees of yielding, such as the hard pyrites and the less hard rock surrounding it. The same rocks often exhibit the ellipsoidal green spots (distorted spheres) first noticed by Dr. Sorby, which indicate *continuous* deformation without abrupt slipping.

[1] Jahrb. d. königl. preuss. geolog. Landes. for 1881, pp. 283–289.

VI.—On *Phillipsastræa*, d'Orb., with Especial Reference to *Phillipsastræa radiata*, S.-Woodward sp., and *Phillipsastræa tuberosa*, M'Coy, sp.

By Rudolph Schäfer, Ph.D.

(PLATE XII.)

THE genera *Phillipsastræa* and *Smithia* have long been a source of trouble to palæontologists, and since the establishment of the latter genus in 1851, it has been very doubtful in which of the two genera certain species of Corals should be placed. The more extended our acquaintance with the species belonging to both genera became, the more probable it seemed that the distinctions between them were in reality unimportant and insufficient to justify a division into two different genera. It was in fact proposed by Kunth as early as 1870 that both genera should be united under the earlier name *Phillipsastræa.* It has been stated that *Phillipsastræa* possesses a columella, while *Smithia* has none; upon the truth of this statement the retention of the two genera depends. Kunth has denied the existence of such a difference. Nevertheless both genera are still retained. From a careful study of the specimens in the British Museum (Natural History) and in the Woodwardian Museum at Cambridge, I have come to the conclusion that Kunth's opinion is well founded; and in the following remarks I shall further attempt to show that certain species which are still sometimes described as having a true columella do not really possess one.

I am indebted to Dr. Henry Woodward, F.R.S., the Keeper of the Geological Department in the British Museum (Natural History), for granting me facilities for the study of the specimens of *Phillipsastræa* and *Smithia* under his care, and also for the privilege of having sections made from them, without which their characters could not have been determined. I also owe Professor T. McKenny Hughes my best thanks for his kindness in allowing me to examine the specimens in the Woodwardian Museum at Cambridge.

Before giving a description of the specimens in question, a few short notes on the history of both genera might not be without interest.

History of the genera.—In the year 1849 d'Orbigny established the genus *Phillipsastræa*, of which he gave the following diagnosis[1]: "*Phillipsastræa*, d'Orb., 1847.[2] Ce sont des *Siderastrea*, dont la columelle, au lieu d'être styliform saillante, est large et divisée en cloisons rayonnantes, comme chez les *Columnastræa*." He gives two species :—*Phillipsastræa parallela*, d'Orb., 1847 = *Astrea parallela*, F. A. Roemer, Verst. d. Harzgeb. 1843, p. 5, pl. 3, fig. 1.—*Phillipsastræa Hennahii*, d'Orb. 1847 = *Astræa Hennahii*, Phillips, 1841. Pal. foss. pl. 6, fig. 16.

[1] A. d'Orbigny, Prodrome de Paléontologie, etc. vol. i. p. 107, Paris, 1849.

[2] This date is not correct, because though d'Orbigny's manuscript was ready for publication in the year 1847, as he states in the preface, yet the book was not published until 1849.

In the year 1850 Messrs. Edwards and Haime[1] mentioned the genus *Phillipsastræa*; the genus *Smithia* was not established at that date. Their diagnosis of *Phillipsastræa* contains the words: "The centre of the tabulæ presenting a columellarian tubercle." As the type species they mention *Phillipsastræa Hennahii*, Lonsd. (=*Astræa Hennahii*, Lonsd., in Geol. Trans., 2nd ser. vol. v. pl. 58, fig. 3). This is of importance, as in the following year this very species became the type of the genus *Smithia*.

In the year 1851 Messrs. Edwards and Haime established the genus *Smithia*:[2] "*Smithia*. Polypier ayant la même structure que les *Acervularia*, mais manquant de murailles extérieures distinctes et présentant des rayons septo-costaux plus ou moins confluents," and (*loc. cit.* p. 421): "Pas de columelle." Type species: *Smithia Hennahii* (=*Astræa Hennahii*, Lonsd.), the same species which in 1851 was the type of *Phillipsastræa*. The following species of *Smithia* are given: *Smithia Hennahii*, Lonsd., *Smithia Pengellyi*, E. & H., *Smithia Boloniensis*, E. & H., and *Smithia Bowerbankii*, E. & H.

In the diagnosis of the genus *Phillipsastræa* we read (Mon. des Polyp. Foss. p. 173): "*Phillipsastræa*. Polypier présentant la même structure que les *Smithia*, mais ayant une columelle styliforme," and (*loc. cit.* p. 447): "Les Phillipsastrées diffèrent des Smithies par la présence de leur columelle." Type species: *Phillipsastræa radiata*, S. Woodw. The following additional species are mentioned: *Phillipsastræa Verneuili*, E. & H., and *Phillipsastræa tuberosa*, M'Coy.

In the diagnosis of the type species *Phillipsastræa radiata* (*loc. cit.* p. 448) we read: "columelle mince et comprimée, en général peu distincte;" the figure (Brit. Foss. Cor. tab. 37, fig. 2) shows no columella. In the description of *Phillipsastræa tuberosa*, (*loc. cit.* p. 449) Messrs. Edwards and Haime do not mention any columella, neither does M'Coy.[3] Further, the figures given by M'Coy[4] do not present, either in the transverse section or on the surface, any indication of a columella. In the diagnosis of *Phillipsastræa Verneuili* (*loc. cit.* p. 448) Messrs. Edwards and Haime say: "columelle saillante"; the figure (Mon. des Polyp. Foss. tab. x. fig. 5) shows the same clearly, but only on the surface, since a transverse section is not given.

Kunth[5] has already explained all that has been mentioned so far. He has also given (*loc. cit.* p. 30, and tab. i. fig. 4) an exact description of *Phillipsastræa Hennahii*, Lonsd. (= *Smithia*

[1] H. Milne Edwards and J. Haime, A Monograph of the British Fossil Corals, part i. Introduction, p. lxx. Palæontographical Society, vol. iii. London, 1850.

[2] H. Milne Edwards et J. Haime, Monographie des Polypiers Fossils des Terrains Paléozoïques, etc., Archives du Muséum d'Histoire Naturelle, tome v. p. 171, Paris, 1851.

[3] F. M'Coy, On some Genera and Species of Palæozoic Corals and Foraminifera, Ann. Mag. Nat. Hist. 2nd ser. vol. iii. p. 124, London, 1849.

[4] A Synopsis of the Classification of the British Palæozoic Rocks, by A. Sedgwick; with a Systematic Description of the British Palæozoic Fossils in the Geological Museum of the University, Cambridge, by F. M'Coy, pl. 3*b*, fig. 8, 8*a*.

[5] A. Kunth, Beiträge zur Kenntniss fossiler Korallen, Zeitschrift der Deutschen geologischen Gesellschaft, vol. xxii. p. 30, Berlin, 1870.

Hennahii), which contains many valuable remarks, especially in reference to the microscopical structure. In this species the calyx shows a false columella ("columellarian tubercle," as he himself adds in parenthesis), but the sections show no columella. Kunth, therefore, doubts the correctness of making the presence of a columella a distinction between the genera *Phillipsastræa* and *Smithia*; moreover, according to Messrs. Edwards and Haime, *Smithia* also has on the tabulæ a columellarian tubercle, and in *Smithia Hennahii* and *Smithia Bowerbanki* they mention "lobes paliformes," such as might produce a similar structure in the calyx to that shown in the figure of *Phillipsastræa Verneuili*.

Kunth, therefore, arrived at the following conclusion: There is no generic distinction between *Phillipsastræa* and *Smithia* so far as the presence or absence of a columella is concerned; a columella might perhaps be present in *Phillipsastræa Verneuili*, but in this case it would have to be shown in a section. Consequently the four species separated under the name *Smithia* by Messrs. Edwards and Haime must be referred back to *Phillipsastræa* and the name *Smithia* must be abandoned.

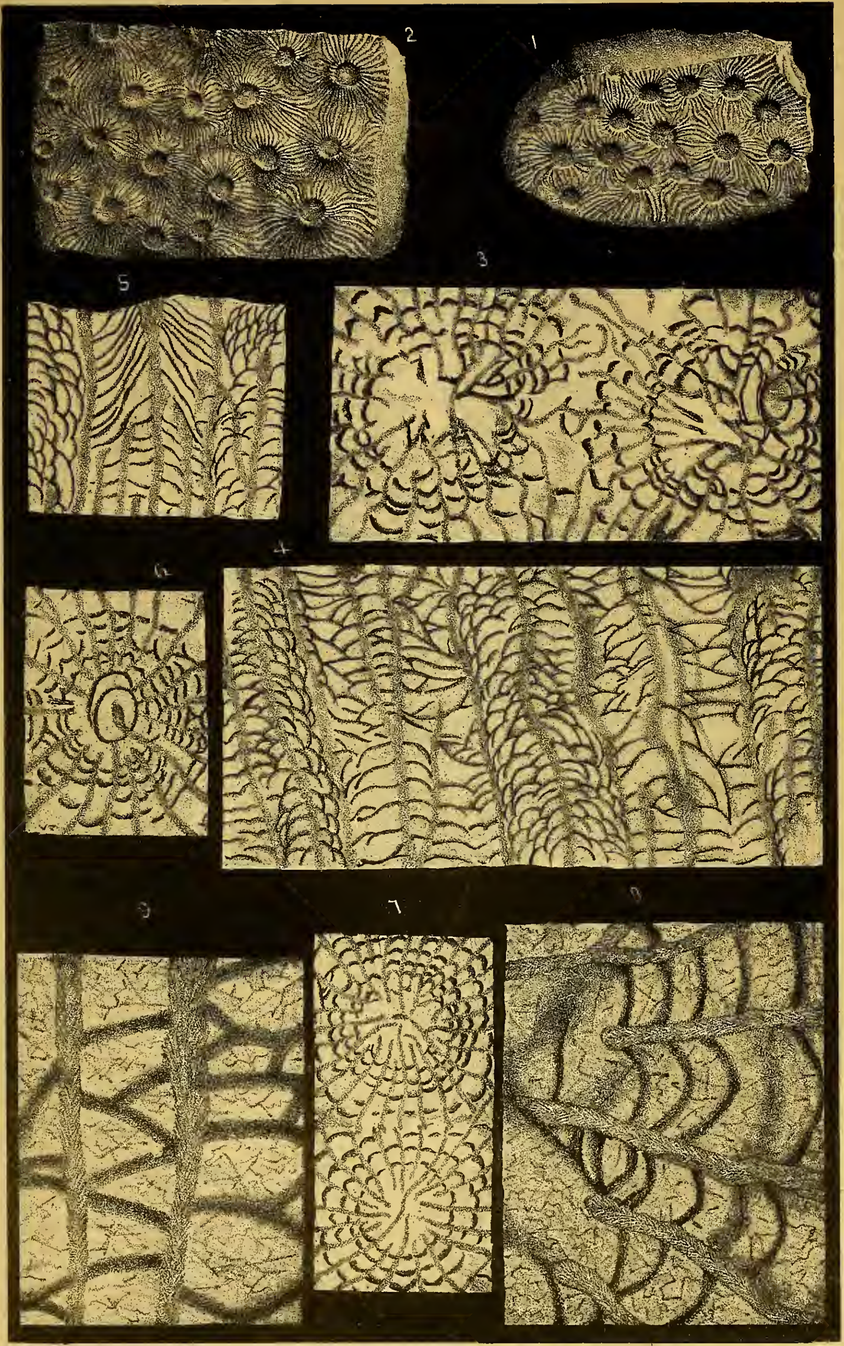
In the year 1876 Rominger[1] gave a description of *Phillipsastræa Verneuili*, in which he says: "The centre of the calyx bottom is raised into a columellar knot, and in vertical sections of calcified specimens a central string of greater density can be observed, but it is not a solid axal column; in some species no indication of a columella is perceptible." Thus it was clearly shown in a section, that the only species about which doubt still existed—*Phillipsastræa Verneuili* — did not possess a columella. Therefore, Rominger also united the genus *Smithia* with *Phillipsastræa*. In the generic diagnosis of *Phillipsastræa* he says (*loc. cit.* p. 128): "The longer lamellæ unite in the centre and form a pseudo-columellar, nodular protuberance, but do not connect into a continuous vertical axis."

Since this time, therefore, Lindström, C. Ferd. Römer, v. Zittel, and others have united the genera.

Mr. James Thomson,[2] however, who in 1883 described certain species of *Phillipsastræa* from the Carboniferous rocks of Scotland, remarks that the species in question possesses a columella. Of *Phillipsastræa radiata* he says (*loc. cit.* p. 395): "there is a central compressed prominent columella in some coralets," and further, "in a longitudinal section the tabula [*sic*] are irregular; some are rectangular, but the great proportion are bent upwards and meet in the centre and form a more or less discontinuous columella." His figures, however (*loc. cit.* pl. iv. fig. 1, 1a, 1b), show no columella, only in one single corallite (pl. iv. fig. 1) four septa are seen to meet. Neither does the longitudinal section show any columella. Of

[1] C. Rominger, Geological Survey of Michigan, Lower Peninsula, vol. iii.; part ii. Palæontology, Corals, p. 128, pl. 23, fig. 2, New York, 1876.

[2] J. Thomson, On the Development and Generic Relations of the Corals of the Carboniferous System of Scotland, Proc. Phil. Soc. Glasgow, vol. xiv. p. 394, Glasgow, 1883.



Berjeau & Highley lith. West, Newman & Co imp.

Phillipsastraea radiata. *S. Woodw. sp.*

Phillipsastræa tuberosa he says (*loc. cit.* p. 396) "the corallum is mammillated, and there is a stout laterally-pressed columella."

It is evident that, if Mr. Thomson were correct in stating that *Phillipsastræa radiata* and *Phillipsastræa tuberosa* really possessed a columella, then the union of *Phillipsastræa* and *Smithia*, as proposed by Kunth and accepted by subsequent writers, would be incorrect; on the contrary, both genera would have to be maintained in the sense in which they were proposed by Messrs. Edwards and Haime.

It therefore appeared to me desirable to re-examine the original specimens of M'Coy and of Messrs. Edwards and Haime, which are contained in the Woodwardian Museum at Cambridge, as also the specimens in the British Museum (Nat. Hist.), to ascertain whether they possessed a columella or no. Below I give a short description of the specimens, together with the results of the observations I was able to make.

PHILLIPSASTRÆA RADIATA, S. Woodw. sp.

(*Tubipora radiata*, S. Woodw., Syn. Table of Brit. Organic Remains, p. 5, 1830).

Spec. Char.—Corallum massive, composite, forming irregular broad astræiform masses. Distance from centre to centre of the calices from 5mm. to 12mm. Diameter of the calicular axial fossa from 2mm. to 3mm. The circumference of the calicular fossa raised in a slightly prominent rim. The inclination of the inner surface of this calicular fossa almost perpendicular. Depth of the calicular fossa about 1mm. Septa thin, 22–30, and confluent with those of the neighbouring calices. Septa alternately longer and shorter; of the longer septa two or more opposite ones meet and thus form in the calicular fossa a transverse ridge, which sometimes is joined by other septa. The shorter septa reach only a very short way into the calicular fossa. Vesicular tissue is plentifully developed between the septa. It consists of hollow, semicylindrical vesicles, the concave side downwards, axis of the semicylinders perpendicular to the septa. In close proximity to the calicular fossa the vesicles are somewhat smaller, more closely set, and the concave side is here turned downwards and outwards. In the inner part of the corallite tabulæ are developed; these are mostly horizontal, still they occasionally bend upwards in the middle and thus assume the form of an obtuse cone with its apex uppermost.

Observations and Remarks.—It is known that this species was proposed by Messrs. Edwards and Haime for certain Corals, described by M'Coy partly as *Sarcinula placenta*, partly as *Sarcinula Phillipsi*. The specimens in the Cambridge Museum were the type specimens of Edwards and Haime, these being also the original specimens of M'Coy. During my visit to Cambridge I had the opportunity of studying them. They agree in so many points that Edwards and Haime appear to have had very good ground for classing them as one species. The specimen described and figured by M'Coy as *Sarcinula placenta* shows somewhat smaller dimensions than that which he describes as *Sarcinula Phillipsi*. Moreover, when M'Coy states that in *Sarcinula placenta* the tabulæ are more horizontal, whilst those in *Sarcinula Phillipsi* are cone-shaped and bent upwards, he is perfectly correct. To this question I shall recur later on, but I would here remark that no distinction of species can be based on this difference of tabulæ, since the two species are connected by individuals showing numerous intermediate gradations.

Arrangement of the septa.—As already mentioned two or more opposite septa in each calyx meet and form a kind of ridge, which other septa join. In this way are produced configurations in the calicular fossa, which, it must be admitted, sometimes closely resemble a columella. This resemblance however is merely superficial; closer observation with the lens shows that the septa only meet. On p. 403, Figs. 1–3 I give enlarged figures of the middle parts of some corallites from one of the type specimens of *Phillipsastræa radiata*, E. & H. (type of *Sarcinula Phillipsi*, M'Coy), which I was able to prepare at the Museum in Cambridge. The type specimen of M'Coy's *Sarcinula placenta* does not show on the surface that septa join inside the calicular fossa; but this I believe is only owing to the imperfect state of preservation. There are however in the British Museum (Nat. Hist.), as also in the Cambridge Museum, other specimens, some of which do actually show configurations which appear to be columellæ. But this is not always the case, as I have already pointed out, and neither the figure given by Phillips,[1] nor that given by M'Coy,[2] to which Edwards and Haime refer in their description of the species, nor that which they themselves give,[3] shows a columella. Thomson's fig. 1, pl. iv. shows only in one single corallite a junction of four septa. The question, however, whether *Phillipsastræa radiata* has or has not a true columella can only be decided by sections. The only three sections, which have hitherto been figured[4] show nothing conclusive. New sections were prepared. It was impossible to make sections of the typical specimens in the Museum at Cambridge without destroying those parts figured by M'Coy. Accordingly, sections of unfigured specimens in the British Museum and in my own collection were prepared. The said specimens exactly corresponded in all essential characteristics with the type specimens. In consequence of this I was able to examine four horizontal and six vertical sections of four different specimens which were found in the Carboniferous Limestone at Haford-y-Calch near Corwen, North Wales, and in the Avon section, near Bristol.

In horizontal section the calices show the same phenomenon as is sometimes observed, although not so clearly, on the surface of the corallum. I was not able to identify in the specimens before me that bilaterally-symmetrical arrangement of the septa, which according to Kunth's researches forms so distinctive a characteristic of

[1] J. Phillips, Palæozoic Fossils of Cornwall, Devon and West Somerset, pl. vii. fig. 15D, London, 1841.

[2] M'Coy, Brit. Pal. Foss. pl. iii.B, figs. 9, 9*a*, 9*b*.

[3] Milne Edwards and J. Haime, Brit. Foss. Cor. pl. 37, fig. 2.

[4] M'Coy, Brit. Pal. Foss. pl. 3B, figs. 9*a*, 9*b*.—M. Edwards and J. Haime, Brit. Foss. Cor. pl. 37, fig. 2*a*.—J. Thomson, *loc. cit.* pl. iv. figs. 1, 1*a*.

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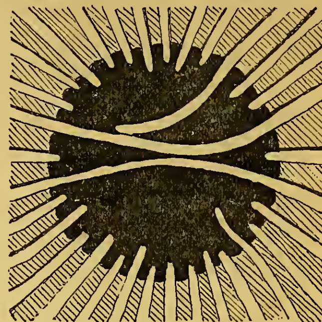

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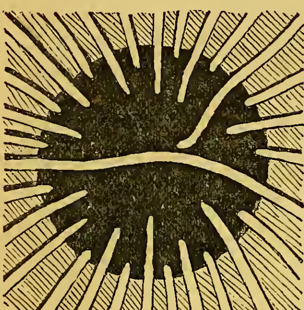

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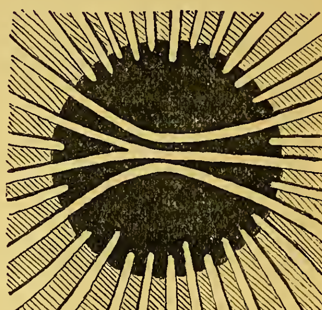

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FIGS. 1, 2, 3. Outline of calices of type-specimen of *Phillipsastræa radiata*, S. Woodw. sp. (= *Sarcinula Phillipsi*, McCoy).

FIGS. 4, 5, 6. Type of *Phillipsastræa tuberosa*, McCoy (= *Sarcinula tuberosa*, McCoy).

the *Tetracorallia*. The reason of this may be that the arrangement above mentioned is shown usually only in young Corals. Kunth[1] himself could not distinguish the bilaterally-symmetrical arrangement of the septa in the genus *Phillipsastræa*, but could distinguish it clearly enough in the closely-related genus *Acervularia*. Under these circumstances I must refrain from indulging in any speculation as to the position of the "*Hauptseptum*," the "*Gegenseptum*" and the "*Nebensepta*," and confine myself solely to giving a description of those relations which I really observed.

All the corallites in the sections show two kinds of septa; when regularly and normally developed, 12 longer septa and 12 shorter alternating seemed to be the number. Such regularity in the development I could not, however, observe in every case; in most cases more than 24 septa were present, and here and there two of the shorter septa came between two of the longer, and often some of the longer septa were shortened and could hardly be distinguished from the shorter. The sections (see Pl. XII. Figs. 3–7) show clearly that in most cases two or more opposite septa unite and form a continuous line, which traverses the whole corallite. In the central part this line is often somewhat thicker; it is in some cases joined by others of the longer septa. No columella is seen in any of the corallites, either in the horizontal or in the vertical sections.

The vertical section of two neighbouring corallites of the best preserved specimen, Pl. XII. Fig. 4, cuts exactly the vertical axis of the latter, only the upper part of the section (owing to an accident of growth) is slightly excentric, that is to say, intersects the imaginary axis of the corallite at a very acute angle. Accordingly the upper part of the figure shows the section of two neighbouring septa, but further down, where the section runs through the central axis, it intersects the point where two neighbouring septa join, and the lower part of the figure shows but one septum line; here these two septa are joined together. The four other vertical sections which I examined agree with this in every particular of importance—a columella is nowhere to be observed.

Wall.—On the upper surface of the coral no wall can be perceived, but the distal ends of the septa of the neighbouring corallites appear to run into one another. Nevertheless some indication of a wall may be perceived here and there in that the septa in some places are not altogether confluent, but the line of apparent junction is broken, and so suggests the place where a wall might be. Neither is any wall perceptible in the horizontal sections of *Phillipsastræa radiata*. When more highly magnified however, one often sees that the septa of neighbouring corallites are not really confluent, but that they overlap each other and are separated by a small space. Sometimes indeed, but very rarely, the septa do run together in a continuous line.

It is worthy of notice that a so-called interior wall unquestionably does not exist. It was formerly generally supposed that in all

[1] A. Kunth, Das Wachsthumsgesetz der Zoantharia rugosa, etc., Zeitschrift der Deutschen geologischen Gesellschaft, vol. xxi. p. 659, Berlin, 1869.

species of *Phillipsastræa* the proper wall was wanting, but that an interior mural investment existed, the presence of which was looked upon as a generic character. This view, however, certainly does not hold good in the case of those species examined by me. Only in very rare cases, in single corallites, could I perceive near the outer part of the central cavity anything that would suggest the rudiments of a wall between the septa. These rudiments show in horizontal sections the same arrangement as the vesicles, but differ from the latter in that they have the same structure as the septa. These rudiments of an interior wall are only of very limited extent, they comprise at the most only one-eighth of the circumference of the calicular fossa, and are besides so seldom met with, that they appear to be unimportant for purposes of classification, and I consider them rather as abnormal structure. Pl. XII. Fig. 7 shows a corallite in which such rudiments occur. In the same way Schlüter and Barrois have disproved the existence of an interior wall in certain species of *Acervularia*.

Endothecal sclerenchyma.—The endothecal sclerenchyma which fills up the interseptal loculi consists of semicylindrical vesicles with their concave side turned downwards, which lie above one another in alternating rows. This arrangement is substantially the same as that of *Phillipsastræa Hennahii*, the internal structure of which has been described by Kunth. To illustrate the structure he has very aptly likened the arrangement of the vesicular tissue to that of "semicircular drain-tiles." The figure which he gives (*loc. cit.* p. 33) will also facilitate the comprehension of the structure of *Phillipsastræa radiata*. In the inner part of the calyx, where the vesicles surround the central cavity, they are closer and more perpendicularly arranged, whilst in the outer parts of the calyx the vesicles are coarser and flatter (Pl. XII. Fig. 4). It is nevertheless difficult to see whether the different forms of vesicles really represent a different structure, or whether it is merely due to the difference of angle at which the section cuts the axis of the semicylinder. A section at right angles to this axis would give the first appearance, while the second appearance would be produced by a section more nearly parallel to the axis.

The vesicles reach as far as the septa, but do not extend through or into them, also their minute structure is quite different from that of the septa.

Tabulæ.—In the middle part of each corallite tabulæ exist. They extend outwards as far as the closer and more perpendicularly arranged vesicles, and continue through the central cavity at equal distances. The distances between the single tabulæ are a little greater than between the vesicles in the endothecal tissue. They are either level, or are slightly bent upwards in the middle, and so take the form of an obtuse hollow cone, with its apex uppermost.

Both kinds of tabulæ are connected by gradations, and occasionally both horizontal and cone-shaped tabulæ may be observed in the same specimen. If a horizontal section is made of a cone-shaped tabula, we see only a circle inside the central cavity as on Pl. XII. Fig. 6.

The space which in the living animal would exist between the tabulæ and the vesicles in the interseptal loculi, becomes filled up by a stony matrix in the process of fossilization. In weathering this stony mass offers less resistance than either septa, tabulæ or endothecal sclerenchyma. Accordingly the appearance which the corallum presents after the surface has been weathered depends largely on the original structures.

Where the tabulæ are conical and bent upwards, the weathered surface appears mammillated, whilst the surface is almost flat where the tabulæ are more horizontal. Since gradations exist between the different kinds of tabulæ, we must expect to find on the surface of weathered specimens all varieties between smooth and mammillated calyces. It seems to me impossible to consider the specimens with a mammillated calyx as of a distinct species from those with a flat calyx. On Pl. XII. Figs. 1 and 2 I give an illustration of two specimens, of which one, Fig. 1, shows a smooth surface, whilst the other, Fig. 2, appears somewhat mammillated; but in other parts of the same specimen the surface of the calyces appears smoother. The bearing of this fact on the specific distinction between *Phillipsastræa tuberosa* and *Phillipsastræa radiata* is obvious.

Minute structure of the septa, the vesicles, and the tabulæ.—The state of preservation of the specimens examined by me was very favourable, and allowed me also to study the minuter details in the sections.

The septa are formed of bundles of calcite fibres, which lie on either side of the median plane of the septum. From this starting point on this plane each fibre passes upwards and outwards in the direction of the proximal end of the septum. Thus a feather-like structure is brought about in the sections, which reminds one of that which Pratz[1] has described and figured for *Thamnastræa.* Pl. XII. Fig. 8, shows this structure in horizontal section, whilst in Pl. XII. Fig. 9, may be seen the same in vertical section. Examined by polarized light, with crossed Nicols, the single calcite fibre shows straight extinction, that is to say, becomes dark when by the turning of the stage the fibre is parallel to the principal section of each Nicol. Hence it arises that each single calcite fibre is a crystallographic individual. The vesicles and tabulæ differ from the septa, but resemble one another in histological structure. This proves that in the living animal the vesicles and tabulæ were produced in the same manner. When viewed with a higher power they do not become transparent, but always remain opaque. Under a still higher power they occasionally appear separated into heaps of fine granules.

The difference of structure between the septa on the one hand, and the vesicles and tabulæ on the other, arises chiefly through their having originated in a different manner in the living animal. If we consider that as the living animal grows upwards it secretes the

[1] E. Pratz, Ueber die verwandtschaftlichen Beziehungen einiger Korallengattungen mit hauptsächlichster Berücksichtigung ihrer Septalstructur. Palæontographica, vol. xxix. p. 81, pl. xiv. fig. 12, Cassel, 1882–1883.

tabulæ and vesicles beneath itself, we shall see that the latter structure must have the same histological origin as the sclerobasis; that is to say, it is the secretion of that part of the ectoderm which invested the deepest parts of the calicular fossa. In the tabulæ and vesicles then the calcification could only take place from below upwards; the septa, on the contrary, were arched over by the ectoderm, and the calcification could continue both upwards and on either side.

Phillipsastræa tuberosa, M'Coy sp.

(*Sarcinula tuberosa*, M'Coy, Ann. Mag. Nat. Hist. 2nd series, vol. iii. p. 124, 1849).

Spec. Char.—Corallum massive, composite, astræiform. The upper surface covered with irregular tuberose projections, separated by flat or concave spaces. Corallites very irregularly arranged. Distance from centre to centre of the calices 5 mm. to 15 mm. Circumference of calicular fossa prominent; consequently the upper surface looks mammillated. Diameter of calicular fossa $2\frac{1}{2}$ mm. to 4 mm. Depth of calicular fossa 1 mm. Septa very thin, about 32, confluent with those of the neighbouring calices. Septa alternately longer and shorter, the shorter ones reaching only a very short way into the calicular fossa. In many corallites some of the longer opposite septa join, and thus occasionally produce the appearance of a stout, laterally compressed columella (false columella). Vesicular tissue, closely resembling that of *Phillipsastræa radiata*, is developed between the septa. The tabulæ are cone-shaped, and bent upwards in the middle part.

Observations and Remarks.—This species was founded by M'Coy,[1] for a specimen from the Carboniferous Limestone of Derbyshire, which is now in the Woodwardian Museum, Cambridge. He called it *Sarcinula tuberosa.* Messrs. Edwards and Haime afterwards accepted the species as *Phillipsastræa tuberosa*,[2] though not without some hesitation. They write thus (*loc. cit.*): "Cette espèce ne diffère peut-être pas de la *Ph. radiata.*" I had an opportunity of studying the original specimen of M'Coy and Edwards and Haime in the Museum at Cambridge. A comparison of this specimen with the type specimen of *Sarcinula placenta*, M'Coy, certainly discloses such striking differences that a separation into two species appears to be well founded. Less noticeable is the difference between the type-specimens of *Sarcinula Phillipsi*, M'Coy, and *Sarcinula tuberosa*, M'Coy. Besides the original specimens of *Ph. radiata*, there are others both in the Woodwardian Museum and in the British Museum, the surface of which is more or less mammillated, so that, although they belong to *Ph. radiata*, they nearly approach to *Ph. tuberosa*. Messrs. Edwards and Haime appear, therefore, to be justified in expressing a doubt as to the validity of *Ph. tuberosa*. Further it is remarkable that amongst all the numerous specimens which I

[1] M'Coy, On some New Genera and Species of Palæozoic Corals and Foraminifera, Ann. Mag. Nat. Hist. 2nd ser. vol. iii. p. 124, London, 1849.

[2] Milne Edwards and J. Haime, Pol. Foss. des Terr. Paléoz. p. 449, Paris, 1851.

examined in the Museum at Cambridge, in the British Museum and in my private collection, there was not a single one which could be classed as *Phillipsastræa tuberosa*, except the single specimen which formed the type of M'Coy's *Sarcinula tuberosa.*

This specimen is not very well preserved. It is much weathered and traversed by several fissures, which have been again closed by infiltration. Since it had been figured in Brit. Palæoz. Fossils, pl. 3*b*, fig. 8 and 8*a*, the preparation of sections was impossible without destroying some of the figured parts. I was therefore obliged to confine myself to the study of those parts which may be seen on the surface. The arrangement of the septa is exactly the same as in *Ph. radiata.* Here also the opposite septa occasionally join and form a continuous line through the calicular fossa. Other of the longer septa join them also. On p. 403, Fig. 4–6, are diagrams of corallites prepared from the type specimen at Cambridge.

M'Coy's figure is not quite exact and does not faithfully represent the course of the tabulæ. The arrangement of the vesicles is essentially the same as in *Ph. radiata*, the tabulæ are cone-shaped, or bent upwards in the middle part of the central cavity. Altogether they present the same appearance which is occasionally presented by *Ph. radiata.* If *Ph. tuberosa* be really a separate species of *Ph. radiata*, the differences are certainly extremely small. But unless a further specimen be found, which may undoubtedly be classed with the type-specimen I think we should be right in referring it to *Ph. radiata* and looking upon it only as a variety, or as the extreme stage in the development of mammillated corallites, the tabulæ of which are cone-shaped and bent upwards.

Concluding Remarks.—I have endeavoured to prove in my investigations that the two species *Phillipsastræa radiata* and *Phillipsastræa tuberosa*, in which a columella was supposed to be present, do not possess one. Consequently there is no important difference between the genera *Smithia* and *Phillipsastræa*, and we must, according to Kunth, unite the genus *Smithia* with the prior genus *Phillipsastræa.*

Lastly, some general remarks on the relationship of the genus *Phillipsastræa.* The genus *Phillipsastræa* is on the one hand closely related to *Acervularia.* Frech[1] declared both genera to be so closely related and the differences so slight that he proposed to unite them under the name *Phillipsastræa* ; this proposition, however, has not been accepted by Steinmann, Neumayr and Barrois in their most recent publications. On the other hand, frequent mention is made of relationship between *Phillipsastræa* and *Heliophyllum.* This relationship is assumed chiefly from the fact that in certain species of *Phillipsastræa* the septa are crossed by conspicuous cross-bars or denticulations, just as in *Heliophyllum.* The same phenomenon has also been observed in different species of *Acervularia.* Our knowledge of the internal structure of the different species of *Phillipsastræa* and *Heliophyllum* is, however, not sufficient to allow

[1] F. Frech, Korallenfauna des Oberdevon in Deutschland, Zeitschrift der deutschen geol. Gesellschaft, vol. xxvii. p. 44, Berlin, 1885.

of a decided and conclusive opinion as to the degree of relationship between the two. Deeper investigations are needed, and for such I have not at present sufficient material, especially of *Heliophyllum*. I must confine myself to stating that I observed the same structure as in *Heliophyllum* in *Phillipsastræa Hennahii*, Lonsd., *Ph. Pengellyi*, E. & H., *Ph. Verneuilii*, E. & H.[1] and *Ph. gigas*, D. Owen, but I did not observe the same structure in *Ph. radiata*, S. Woodw., and *Ph. tuberosa*, M'Coy.

EXPLANATION OF FULL-PAGE WOODCUT (p. 403).

Enlarged figures showing the outline of the calices and the arrangement and the union of the septa. Taken from the type specimens of M'Coy in the Woodwardian Museum of Cambridge.

FIG. 1, 2, 3. *Phillipsastræa radiata*, S. Woodw. sp. (=*Sarcinula Phillipsi*, M'Coy).
FIG. 4, 5, 6. *Phillipsastræa tuberosa*, M'Coy, sp. (=*Sarcinula tuberosa*, M'Coy).

EXPLANATION OF PLATE XII.

Phillipsastræa radiata, S. Woodward sp. Carboniferous Limestone.

FIG. 1. Specimen from Haford-y-Calch, near Corwen, North Wales. Brit. Mus. [R 547]. Natural size.
FIG. 2. Specimen from Avon Section, near Bristol. Brit. Mus. [56740]. Calices more mammillated, approaching *Ph. tuberosa*, M'Coy. On other parts of the same specimen the surface is smoother. Natural size.
FIG. 3. Horizontal section of specimen, Brit. Mus. [R 547], showing the arrangement of septa and vesicles. Enlarged about 6½ times.
FIG. 4. Vertical section of specimen, Brit. Mus. [R 547]. The lower part of the section shows the union of the septa in the central axes of the calices. The arrangement of tabulæ and vesicles is also shown. Enlarged about 8 times.
FIG. 5. Vertical section of specimen, Brit. Mus. [56740], showing the cone-shaped variety of the tabulæ. In other parts of the same specimen the tabulæ are more horizontal. Enlarged about 7 times.
FIG. 6. Specimen from Avon Section, near Bristol. (My collection.) Horizontal section across a corallite with cone-shaped tabulæ, represented as rings in the middle part of the corallite. Enlarged about 5 times.
FIG. 7. Specimen from Haford-y-Calch, near Corwen, North Wales. (My collection.) Horizontal section showing in the upper corallite the rudiments of a wall, which are drawn more faintly than the similarly-shaped vesicles. Enlarged about 4½ times.
FIG. 8. Horizontal section of specimen, Brit. Mus. [R 547], showing the minute structure of the septa and vesicles. Enlarged about 50 times.
FIG. 9. Vertical section of specimen, Brit. Mus. [R 547], showing the minute structure of the septa and tabulæ. Enlarged about 50 times.

VII.—NOTE ON THE MEAN RATE OF SUBAËRIAL DENUDATION.

By CHARLES DAVISON, M.A.,

Mathematical Master at King Edward's High School, Birmingham.

IN his memoir on "Modern Denudation,"[2] Dr. A. Geikie determined approximately the number of years required by the following seven rivers to lower the general surface of their basins by one foot. He found that the Danube would take 6846 years, the Mississippi 6000, the Nith 4723, the Upper Ganges 2358, the Rhone 1528, the

[1] The above-mentioned structure is very well shown in a specimen, lent me by Dr. Hinde, for which kindness I owe him my best thanks.
[2] Glasgow Geol. Soc. Trans., vol. iii. p. 164.

Hoang Ho 1464, and the Po 729, years. The average of these figures is 3378, and "this," says Dr. Croll, in his recent interesting work on "Stellar Evolution" (p. 41), "gives a mean of 3378 years to remove one foot, or a little over one-half the time taken by the Mississippi." As the mean rate of subaërial denudation is an important element in physical geology, it may be worth while to point out a slight mistake in this determination of its value, and also to show how a more correct estimate may, with our present data, be obtained.

In the first place, let us, as in the above method, consider these river-basins of equal area for the purpose of ascertaining the mean rate of denudation. Then, in one year, a layer $\frac{1}{6846}$ of a foot thick is, on an average, worn away from the surface of the Danube basin, a layer $\frac{1}{6000}$ of a foot thick from that of the Mississippi, and so on. The mean thickness of the layers is the average of the seven fractions $\frac{1}{6846}$, $\frac{1}{6000}$, etc., *i.e.* $\frac{1}{1912}$ of a foot. This, and not the average of the denominators of these fractions, gives the mean rate of denudation on the above understanding: so that a layer one foot thick would be worn away from the general surface of the average river-basin in 1912, instead of in 3378, years. Or, if we take the area of the Upper Ganges basin at Dr. Haughton's estimate[1] of 143,000, in place of 432,480, square miles, the mean rate of denudation would be one foot in 1572, instead of in 3159, years.

But, in considering the river-basins as of equal size, undue importance is being given to such comparatively small rivers as the Rhone, the Nith, and the Po. In determining the mean rate of denudation, the *area* of each river-basin must evidently be taken into account, and this may be done as follows. The total volume of sediment brought down by these seven rivers every year is 34,712,610,040 cubic feet. If, as Dr. Geikie estimates, 25 cubic feet of sediment are derived from 19 cubic feet of rock,[2] this is equivalent to the removal of 26,380,817,398 cubic feet of rock; which may be regarded as taken from the surface of one river-basin equal in area to the sum of the areas of the above seven basins, *i.e.* to 2,279,400 square miles, or to 63,546,024,960,000 square feet. From these figures we find that the mean rate of subaërial denudation is equal to one foot every 2409 years, *i.e.* about two-fifths of the rate of denudation in the Mississippi basin.

Dr. Croll points out (p. 43) that the Rhone, the Ganges and the Po are charged with mud from the Alps or Himalayas; and, for this and other reasons, he makes use in his work of the rate of denudation in the Mississippi valley only. But while the rates of denudation in the above cases are among the most rapid, these rivers have at the same time (with the exception of the Nith, which hardly affects the average) the smallest basins; while the Danube, the

[1] A. Geikie, Text Book of Geology, p. 444, footnote. This value is used in the estimate that follows.

[2] Reckoning the specific gravity of the silt at 1·9 and that of rock at 2·5. This tends to diminish the estimate of the mean rate of denudation, for the sediment deposited at the mouth of a river is partly derived from the erosion of earthy beds.

Mississippi and the Hoang Ho, with less rapid rates of denudation, have the largest basins. The following table shows that it is the Mississippi, with its vast length and comparatively slight fall, that weighs excessively in the estimate of the average, rather than the Ganges or the Rhone or the Po.

	Mean rate of denudation, omitting the:	Excess above mean rate of all seven rivers.
Mississippi	$\frac{1}{1524}$ foot per year. ...	+0·000241 foot per year.
Hoang Ho	$\frac{1}{3370}$,, ...	—0·000118 ,,
Upper Ganges ...	$\frac{1}{2765}$,, ...	—0·000053 ,,
Danube	$\frac{1}{2243}$,, ...	+0·000031 ,,
Po	$\frac{1}{2485}$,, ...	—0·000013 ,,
Rhone	$\frac{1}{2424}$,, ...	—0·000002 ,,
Nith	$\frac{1}{2409}$,, .	0·000000 ,,

It thus appears that the rapid rates of denudation by the glacial rivers are to a great extent neutralised by the smallness of their basins. And, as such rivers ought not to be left out of account, it seems possible that the mean rate of subaërial denudation for the whole land-surface of the earth may not differ very greatly from that obtained above, namely, one foot in about 2400 years.

VIII.—Notes on the Lower Palæozoic Rocks of the Fichtelgebirge, Frankenwald, and Thüringerwald.

By J. E. Marr, M.A., Sec. G.S.,
St. John's College, Cambridge.

During the summer I visited Hof with Professor Nicholson, mainly in order to examine the Graptolite-bearing shales of the surrounding region. These we found to be far from rich in fossils, and the principal fossil-bearing localities were remote from one another. Under such circumstances little could have been accomplished, but for the kindness of Herr Glass, of Hof, who allowed us to examine his fine collection of fossils from the district. To him I would tender my best thanks, as also to Prof. Geinitz, who not only permitted me to examine his rich collection of Graptolites from the Thüringerwald preserved in the Dresden Museum, but also devoted some of his valuable time to me.

For a full account of the Lower Palæozoic rocks of the region under consideration, I may refer to Prof. Gümbel's exhaustive "Geognostiche Beschreibung des Fichtelgebirges mit dem Frankenwalde und dem Westlichen Vorlande." In that work the strata are grouped as under:—

Silurian.
Tentaculiten-Knollenkalk.
Upper Graptolite Shales.
Ockerkalk.
Lower Graptolite Shales.
Lower Silurian with Leimitz-shales, etc.

Cambrian.
Upper: Phycodenschichten.
Lower: Green-grey Clay Slates.

As Hof lies at no great distance from the Bohemian Basin, it might be expected that there would be considerable similarity between the beds of the two areas, and in some respects this is the case, though the marked differences induced Barrande to infer the existence of a barrier between the two areas in Lower Palæozoic times. The differences may be accounted for in other ways; firstly, by the absence of some beds in Bohemia owing to unconformable overlap, and in Bavaria owing to faults, and secondly by the greater metamorphism of the Bavarian rocks. The effects of the latter have been described by Prof. Gümbel; the Cambrian beds are frequently converted into schists, the Ordovician into phyllites, and the Silurian into lydites, whilst the associated igneous rocks have also suffered much change, indeed the Fichtelgebirge furnish us with an admirable instance of later rocks having undergone regional metamorphism, and being infolded amongst other rocks which have been universally assigned to the Archæan.

Commencing with the Cambrian Rocks, the only fossils found in them are of very doubtful position, amongst these is *Phycodes circinatum*, which characterises the Phycodenschichten. The rocks are various coloured clay slates, and greywackes, sometimes converted into schists, as at Lamitzmühle, north-west of Hof, where the development of the schistose structure is admirably exhibited. Red beds are seen between Hof and Leimitz, and like similar Bohemian beds are possibly very low in the Cambrian system.

In the typical section at Leimitz the above-described beds are separated from the trilobitic shales of Leimitz by a dolomitic limestone; this is very possibly developed along a fault-plane, and would account for the apparent absence of the representatives of the Menevian and Lingula Flag series. The country here is so extremely faulted that rocks of very different ages are brought into juxtaposition. Not only are all the beds in the Leimitz section reversed, as shown in Murchison's section from the Labyrinthenberg to the Wartthurm (Q. J. G. S. 1863, p. 360); but it can be shown that in several places beds are faulted out, and the failure to discover Menevian and Lingula Flag fossils must not be taken as an indication of the original absence here of beds of these ages.

The next beds to notice, in ascending order, are the Leimitz-schichten, though there is no necessity to linger over these, as not only has Barrande fully described the fauna ("Faune silurienne des Environs de Hof en Bavière," 1868), but Prof. Brögger has shown their close relationship with the Ceratopyge beds of Scandinavia, and the Shineton Shales of Shropshire ("Die silurischen Etagen 2 und 3").

In the Leuchtholz, near Lamitzmühle, is a gritty pisolitic ironstone, containing an *Orthis* compared by Dr. Gümbel with *Orthis Lindstræmi*, Linnrs., whilst the rock containing it is referred to as possibly comparable with the Primordial beds. Concerning this deposit I would say something further. It occurs between the schistose Cambrian rocks of Lamitzmühle, and black phyllites and grey gritty shales near the village of Isaar. The latter are coloured in Dr. Gümbel's map with the Ordovician (Lower Silurian) colour, and though much altered they bear considerable resemblance to the beds of Barrande's étage D. Now, near the base of D, in Bohemia are found the pisolitic ironstones, D d 1 β, containing *Orthis deside-*

rata, Barr., seen at Krus'na Hora and elsewhere, and actually compared by Dr. Gümbel with the Leuchtholz ironstone. The latter I was unable to find *in situ*, but Herr Glass kindly presented me with specimens, and the *Orthis*, though badly preserved, is very near to, if not identical with *Orthis desiderata*, with which I have compared it. The reasons for the identity of the Bavarian and Bohemian deposits are similarity of lithological characters, close resemblance between the Orthides of the two, and the occurrence of both between Cambrian and Ordovician deposits.

In a paper read before the Geological Society (Q. J. G. S. 1880) I correlated the beds D d 1 β with Tremadoc beds, on account of their resemblance to the pisolitic ironstones of North Wales, their occurrence above sandstones full of *Lingula Feistmanteli*, and the existence of *Harpides Grimmi* in them. I believe, notwithstanding the occurrence of the latter fossil, that the reference was erroneous.

The Tremadoc age of the Welsh pisolitic ironstones has not been proved, indeed evidence has been published which indicates that they are much more modern. With regard to the occurrence of *Lingula Feistmanteli* in D d 1 a, this fossil has no relationship with any of the Lingula Flag fossils, but it is very near to the remarkable *Lingula Roualti* of the Armorican grits. Furthermore, the fauna of D d 1 γ is not a Lower but an Upper Arenig one, and the beds of this band immediately and conformably succeed those of D d 1 β. I am inclined therefore to refer the latter, and with it possibly the Leuchtholz deposit to a position high up in the Arenig series, and believe that the beds unconformably overlap the Cambrian rocks, thus accounting for the absence of Lower Arenigs in Bohemia and Bavaria, of Tremadocs and Lingula Flags in the former country, and of Menevians around a great part of the Bohemian basin.

We visited Hof, partly in hopes of detecting Graptolites of Hartfell and Glenkiln types in the Ordovician rocks; in this we were disappointed, nor did we find any trace of such fossils in Herr Glass's collection or in that of the Dresden Museum. I believe however that there are black shales of Ordovician age which have once contained Graptolites (*e.g.* the phyllites near Isaar) but with rocks so greatly altered, it is too much to expect their preservation.

Though rocks of the higher Ordovicians do probably occur in many places, they are elsewhere faulted out, as for instance at Leimitz, where the Lower Graptolite Shales are directly in contact with the Leimitz trilobitic shales. The former are here converted into lydite, but a few obscure graptolites were seen by us. *Clinacograptus normalis* was found here by Herr Glass, and the beds are undoubtedly the equivalents of our Stockdale Shales. In most of the localities near Hof these shales are now covered up, but in the Dresden Museum is preserved a slab from Teufelsberg with *Petalograptus palmeus* and *Monograptus Hisingeri*, indicating the Upper Skelgill beds, and Prof. Nicholson and myself have already recorded the existence of two slabs in the Woodwardian Museum indicating the existence of the *Monograptus fimbriatus* zone at Hof, whilst Herr Glass has *M. turriculatus* and *M. rectus* from Steben.

It is in the Frankenwald and Thüringerwald that the representatives of the Stockdale Shales are most fully developed, and at the risk of becoming monotonous, I give a list of species occurring together on the same slabs in the Dresden Museum, fully bearing out the wide distribution of those zones which we have determined in the Stockdale Shales of the Lake District. In this list the species given under one number occur on the same piece of stone.

OELZNITZ-JUCHHE.

1. *Monograptus fimbriatus*, *M. tenuis*, *Rastrites peregrinus*, *Climacograptus normalis*, *Diplograptus vesiculosus*, *Petalograptus ovatus*. = Zone of *Monograptus fimbriatus*.
2. *Monograptus fimbriatus*, *M. gregarius*, *M. attenuatus*, *Rastrites peregrinus*, *Climacograptus normalis*, *Petalograptus ovato-elongatus*. = Zone of *Monograptus fimbriatus*.
3. *Monograptus cyphus*, *M. tenuis*, *M. attenuatus*, *M. crenularis*? *Diplograptus sinuatus*. = Zone of *Monograptus fimbriatus*?

RAITZHAIN-RONNEBERG.

1. *Monograptus convolutus*, *M. proteus*, *Rastrites urceolus*, *R. hybridus*. = Zone of *Monograptus convolutus*.
2. *Monograptus spinigerus*, *M. jaculum*, *Petalograptus palmeus*. = Zone of *Monograptus spinigerus*.
3. *Rastrites maximus*. = Zone of *Rastrites maximus*.
4. *Monograptus turriculatus*. = Zone of *Monograptus turriculatus*.
5. *Monograptus exiguus*, *M. discus*, *Rastrites capillaris*. = Zone of *Monograptus crispus*.
6. *Monograptus M'Coyi*, *Cyrtograptus*? *spiralis*, *Petalograptus palmeus*. = Zone of *Monograptus crispus*.

LANGENSTRIEGIS.

1. *Monograptus jaculum*, *M. lobiferus*, *Petalograptus palmeus*. = Zone of *Monograptus spinigerus*?

LINDA.

1. *Monograptus pandus*, *M. Hisingeri*, *Retiolites Geinitzianus*. = Zone of *Monograptus crispus*.

HEINRICHSHOHE.

1. *Monograptus revolutus*, *Climacograptus normalis*, *Diplograptus vesiculosus*, *D.*? *longissimus*. = Zone of *Dimorphograptus confertus*.
2. *Monograptus attenuatus*, *M. revolotus*? *Petalograptus ovatus*, *Diplograptus sinuatus*. = Zone of *Monograptus fimbriatus*.
3. *Monograptus gregarius*, *Rastrites urceolus*, *R. hybridus*, *Petalograptus palmeus*. = Zone of *Monograptus convolutus*?
4. *Monograptus gregarius*, *M. Hisingeri*, *M. Becki*, *Rastrites urceolus*, *R. hybridus*. = Zone of *Monograptus convolutus*?
5. *Monograptus crassus*, *M. discretus*, *Rastrites hybridus*. = Zone of *Monograptus spinigerus*.
6. *Monograptus Nicoli*, *M. crassus*? *Diplograptus modestus*. = Zone of *Monograptus spinigerus*.

At Saalfeld a *Dimorphograptus* has been found, though the shales from this locality have been destroyed owing to the decomposition of pyrites.

The following zones which we have made out in the Stockdale shales are represented in Thuringia:—

Zone of *Dimorphograptus confertus*.
,, *Monograptus fimbriatus*.
,, ,, *convolutus*.
,, ,, *spinigerus*.
,, *Rastrites maximus*.
,, *Monograptus turriculatus*.
,, ,, *crispus*.

In short all our graptolitic zones except the insignificant and probably local zone of *Monograptus argenteus* occur here.

Before finally quitting the representatives of the Stockdale Shales, a word concerning the Nereites beds is necessary. These have been referred to the Devonian, and possibly forms like Nereites occur in the Devonian beds, but the specimens which Herr Glass collected at Bad Steben are so exactly like the Gala ones, both with reference to the lithological character of the containing rock, and the nature of the fossils, that I cannot help believing that they are of that age.

The Wenlock shales with *Cyrtograptus Murchisoni* are represented in Herr Glass's collection by specimens from Einzelnhöfen, with *Monograptus vomerinus, Cyrtograptus*, sp., *Cyrto.? spiralis*, and in the Dresden Museum by a specimen from Linda with *Monograptus priodon, M. vomerinus, Cyrtograptus*, sp., *C.? spiralis, Retiolites Geinitzianus.*

Above these shales lies the Ockerkalk with *Cardiola interrupta*, etc., and like the *Cardiola* beds of Sweden and the Lower Coldwell beds of Westmorland separating the *Cyrtograptus* beds from the beds with *Monograptus colonus.*

The latter are found at Gunzenberg near Plauen with *Monograptus Rœmeri*, and at Gräfenwarth near Schleiz with *Monograptus colonus* and *M bohemicus.*

Lastly, the Tentaculiten-knollenkalk with *Pterniea subfalcata, P. retroflexa*, etc., appears to represent the Upper Ludlow beds of Britain, and the limestone of E. 2 in Bohemia.

Beds of higher age, such as the *Styliola* beds and Goniatite limestones are probably comparable with higher stages of the Bohemian basin, which they altogether resemble, thus yielding additional evidence of the accuracy of Prof. Kayser's view as to the age of stages F, G, and H. As I understand that Herr Frech has visited the Hof district in order to examine these Devonian rocks, further discussion is rendered unnecessary.

The result of the cursory examination of the area has been to show that the difference between the Bohemian and Bavarian beds is by no means great, where beds of the same age can be compared, and that even our British deposits are in many cases represented by many similar strata in Bavaria, and the Thüringerwald; that this is specially the case with the graptolite-bearing shales and adds one more instance to those which have been adduced to prove the value of these forms in marking stratigraphical horizons.

IX.—On the Scratched and Facetted Stones of the Salt Range, India.

By Professor George H. Stone.

At the Meeting of the British Association in 1886, a facetted and striated pebble from the Salt Range, Punjab, was exhibited and described, by A. B. Wynne, F.G.S. Another and larger one was presented by Dr. W. T. Blanford, F.R.S.[1]

[1] Geol. Mag. 1886, Dec. III. Vol. III. pp. 492, 494, and p. 574.

During the discussion that ensued, the question was considered whether the stones had received their shapes from the action of wind-blown sand. Having made a special study of sand-carving in a favourable region, the writer became interested in the subject, and with a view to compare the Punjab stones with the sand-facetted rock-fragments so common in various parts of America, wrote to Dr. Blanford in order to obtain specimens of the stones in question. By the kindness of Dr. Blanford and Mr. Wynne, plaster casts of both the specimens described by them have been sent to me. Dr. Blanford also put me into communication with Dr. Henry Warth, who has kindly sent me three of the scratched stones which he had found in the field. It is the object of the present paper not to enter upon the large question of a Glacial period in Palæozoic or Mesozoic time, but briefly to consider the testimony of the specimens about to be described as to their own origin. Most of the conclusions arrived at have been anticipated by those who have discussed the origin of the shapes of these particular specimens.[1]

Yet conclusions drawn from observations made in widely removed regions have a comparative value; therefore, at the risk of repeating what has been observed elsewhere, the facts are here recorded which, observed in Colorado and Maine, throw light on the origin of the markings on the stones in question. The existence of a Glacial period can only be proved by the whole mass of field evidence, and this can only be worked out by the geologists on the ground. In solving the general problem it will be necessary first of all to determine the manner in which the stones and boulders were facetted and scratched. Afterwards comes the question how they were brought to their present positions in the midst of clay or sand. Evidently a study of the markings on the stones can afford little direct evidence except on the first of these questions.

The specimens in my possession are the following.

No. 1. This is a plaster cast of the stone exhibited before the British Association by Mr. Wynne. The form is not that which would be caused by the wind.

No. 2. A plaster cast of the stone described by Dr. Blanford. The cast, Dr. Blanford informs me by letter, does not show the scratches as plainly as the original. Yet the scratches on the facets are so readily distinguished that a friend, a mining engineer, who happened to be present when the cast was received, at once exclaimed: "Why it looks as if it had been in a Mexican arastra." The scratches are not such as could be produced by blowing sand or gravel.

No. 3. Forwarded to me from Stuttgart by direction of Dr. Warth. It is composed of a dark red felsitic ground-mass, containing many crystals and grains of a lighter red felspar, with some free quartz and small quantities of one or more accessory minerals. All fracture surfaces of the stone are quite uneven. On breaking off a portion

[1] Including in addition to the original articles of Dr. Blanford and Mr. Wynne, communications by Mr. R. D. Oldham, Geol. Mag. Jan. 1887, and from Rev. A. Irving, Geol. Mag. April, 1887. Similar specimens are discussed by Dr. H. Warth, Records Geol. Survey of India, vol. xxi. pt. 1, 1888.

of the stone the fresh surface was seen to be of a lighter and more rosy colour than the original surface. The felspar grains and crystals of the surface are perceptibly roughened. The stone is thus proved to be weathered, though the discoloured layer is quite thin. The composition and structure of the porphyry indicate that it is a very enduring rock. The striated surfaces, even at the bottom of the broader scratches, are apparently as much weathered as the rest of the stone. There are four principal planed facets, and their sides are nearly parallel like those of the faces of a prism. One face is nearly plane, the others have a curved or broken-curved cross-section. The facets have been reduced to an even surface and afford a marked contrast to the rough fracture surfaces. The scratches are quite straight and distinct, though their sides are not so sharply defined as is usual on recently facetted stones. The whole outer surface has received a fine polish, such that the apices of the larger projections have been rounded and the smaller ones nearly erased. The stone is three inches and three-quarters in length, and its greatest transverse diameter is two inches and three-quarters. The angles between the facets are not sharp, partly in consequence of the fine polish before described, and partly because the planed surfaces do not in general meet, but are separated by a narrow strip of unplaned surface retaining the uneven form due to fracture, except as it has been modified by the fine polish before mentioned.

No. 4. Sent to me direct from India by courtesy of a returning missionary. Diameters, two inches and an eighth to three inches and a half. It is composed of a light red porphyry. Most of the larger grains and imperfect crystals of felspar which are exposed on the planed facets have weathered so as to be quite rough. There are a number of small irregular depressions on the planed faces caused by the partial weathering of the less resistant grains. The smooth facets are arranged about an axis roughly after the manner of the faces of a prism, and one end of the imperfect prism thus formed is also planed. The remainder of the surface is uneven, and is simply a fracture-surface modified by a fine polish, which has removed the apices of the angles and the smallest of the projecting points. Some of the faces do not show distinct scratches, though planed to a flat and even surface. The surface of this specimen has been more modified by weathering than No. 3. The weathering involves the bottom of the scratches as well as the unscratched surfaces, and there is little, if any, difference in the depth of the weathering in different parts of the stone.

No. 5. Also sent direct from India. It is about three inches long. It is a fragment recently broken off from a water-rounded cobble that was probably about six inches in diameter. It is composed of compact, fine-grained quartzite, which here and there contains microscopic grains of felspar. One portion of the cobble has been distinctly planed and scratched. At least one quarter of an inch has been ground away from the stone, if we estimate its original shape from the curves of the rounded portion of the stone adjacent to the planed facet. The scratched surface presents gentle undulations both parallel to the scratches and transverse to them. Particular scratches or grooves can be traced for two or three inches across the whole facet, though in general the smaller scratches are not so distinct as those on the porphyry, and they often become confluent. On the planed facet some of the felspar grains preserve their polish, except at the edges; others are weathered so as to be uneven, as also are those on the rounded portion of the stone. This specimen shows less weathering than Numbers 3 and 4.

Cause of the Striation and Facetting.

First.—All who have seen the stones agree that they have a genuine and ancient look. They have either been weathered since they were scratched, or the surface has been treated with corrosive acids not found in the field. The number of places where they have been found is inconsistent with such an accident. Most of the scratches are too straight and parallel, also too broad and deep to have been made by the unassisted hand. The scratches on No. 5 might perhaps have been made in such a machine as the arastra. The facets on the others might be produced on a grindstone if the stones were held very firmly. The stones resemble no stone implement, and are not fashioned for use. If ground by man, it must have been for purposes of deception or for grinding something else. In either case it could not have been the act of a Palæolithic man, but of one furnished with modern machinery. The evidence of the stones points to their having been ground and striated a very long time ago. Their testimony thus unites with the field evidence as to the distribution of the stones over wide areas, their situations on the tops of mountains, often remote from places likely to have been inhabited, their being found independently by several different observers, their being associated with the outcrops of certain boulder-beds, etc., to prove that the stones were not the work of man.

Second.—Some, perhaps all, of the specimens have been subjected to a limited amount of polishing since they were facetted. The larger inequalities of the fracture-surfaces remain, yet the surface of both the projections and the shallower hollows has been distinctly smoothed. This is of the same sort as would result from a very limited amount of water-wear, also that resulting from soilcap movement. For instance, in the Rocky Mountains the miners' "float rock" is often found from one-fourth of a mile up to one mile or more from the parent vein. Reference is made not to the stones transported by running water, but to those of the talus or angular gravel which covers the slopes of a large portion of the mountains. This mass of disintegrated rock is a sort of mineral glacier slowly sliding down the mountains, and even the hard vein quartz is usually perceptibly smoothed by the attrition of the earth and stones with which it has come in contact during its journey. The same sort of polish is not seldom found on the harder fragments situated on the talus at the base of a scarp of erosion of sedimentary rock. During the disintegration of the boulder-bed of the Olive group such friction would have helped to smooth the stones in question, as has been suggested by several of the writers on this subject. Here in the Rocky Mountains there are fine facilities for studying soilcap movement, and without exception the instances of it observed by me show only a limited amount of polishing, the apices of the angles being rounded and the surface smoothed without being reduced to a plane like the facets of the Punjab specimens. The soilcap polish is substantially like that which the facetted stones have received since they were facetted. But I have never found, on any piece of float-rock, scratching that in kind or degree resembled the planed and striated facets of the stones under discussion. There is a satisfactory reason for this. The slowness of soilcap movement gives time for the stones to accommodate themselves partially to each other's movements. If the friction were to become great enough to produce such wide and deep scratches as appear on the planed facets of the stones in question, they would partly roll past each other rather than slide. It seems to be certain that the "glaciated" stones have been polished since they were scratched, and this fine polish could be caused by soilcap movement or by a limited amount of water-wear.

Third.—The formation of distinct scratches constitutes a problem distinct from that of the planing to an even surface. Could the scratches have been formed by wind-blown sand or gravel? Scratches may be made, first, by a point rubbing against a surface and being held in the same relative position towards it; second, by a rolling body crushing its way into a softer or more brittle surface; third, both these processes may combine to produce the scratches. It is evident that grinding by the use of loose powders involves the second and third of these processes, while planing and the use of grindstones involve the first, and produce scratches having an even and sharply-defined margin.

Grains of sand and gravel stones when impelled by the wind or by moving water have a rolling as well as a sliding motion. This I know to be the fact from observation, though it is easy to prove that this must be the natural mechanical result of friction applied to one side of a moving solid that is surrounded by a liquid or a gas. As a body of irregular shape, like grains of sand and gravel stones, rolls, or partly rolls, partly slides upon another body, new points of the moving body are continually brought into contact with the stationary body, and since the shape is irregular, the new point of contact will usually be situated to one side of the original point, and the track of the grain will necessarily be crooked. If an irregular grain be impelled in a straight line, it cannot often preserve its direction in the same vertical plane after rebounding, for the friction will be applied to one side of the vertical plane in which is situated the centre of gravity of the body, and the grain will be thrown obliquely sideways. So, too, air and water are constantly being thrown into vortices by the inequalities of the surfaces over which they move. For these reasons it must seldom, if ever, happen that wind or water can impel sand or gravel with the steady motion required in order to produce long straight scratches. The larger stones often produce scratches that can be distinguished by the unassisted eye, but they are seldom more than a small fraction of an inch in length. Here, in the Rocky Mountains, the finer dust broadens these larger scratches more than it deepens them, so that they are soon obliterated or changed to shallow grooves. Stones one-fourth to half an inch in diameter are frequently transported by the winter winds, and the flying gravel is sometimes so painful that horses cannot be made to face it, and I know of a blue eye-shade that was broken by gravel while the wearer was facing a Chinook wind in Colorado.

Now the scratches of these Salt Range stones have sharply-defined borders, and they are two inches or somewhat less in length, and most of them very straight. The graving tools that produced them moved with a very steady motion, and the depth is such, that a considerable force was required. The hypothesis that under any conditions blowing sand or gravel could produce such scratches may once for all be confidently rejected.

Fourth.—Assuming that the scratching could not be caused by wind action, could the facetting be so caused ?

We may classify with sufficient accuracy for our present purpose the conditions under which facetting is done by the wind as follows. First, where the upper surface of a stone only a few inches in diameter lies nearly on the same level as the surface of the soil or of other stones around it. The small stone often has its upper surface ground away to near the level of the adjacent earth, and often has its form determined by the shape of the adjoining bodies. It is surprising how flat many of these small facets are, especially when the stone is homogeneous in composition. Examination of many facets shows a tendency to form a gently undulating surface, the crests of the low undulations more often being transverse to the direction of the wind and an inch or more apart. In the class under consideration the stone is so small, and is so far protected by the adjacent bodies, that a large part of the carving is done by flying grains as they first strike the stone. at which time their motion had been in great measure determined by the adjacent land surface.

If in any way one of these small stones becomes overturned, a new facet may be formed in the same manner.

A somewhat different case is presented when a stone or boulder projects considerably above the ground, or has a large and nearly horizontal surface near the ground. In this case a much larger proportion of the grinding is done after the blowing stones have once rebounded from the fixed stone. The rhythmical friction of the wind against the fixed stone and the repeated reboundings in this case determine the character of the carving more than the direction of original impact. The sand-carved surface under these circumstances is usually covered by shallow grooves parallel with the direction of the prevailing wind. This form of carving appears to be related to the oblique reboundings of the grains sidewise. The grooves are an inch or less in breadth and seldom more than the sixteenth of an inch in depth. The difference between the two forms of sand-carving may be illustrated by sea-waves and true water undulations. In the undulations the crests are convex above, in the wind waves they are bounded by two concave surfaces meeting in a somewhat blunt angle. But the undulations of the sand-carved surfaces are more often transverse to the wind like ripple-marks, while the concave grooves are parallel to it. The two forms are often superposed, so that a large number of the concave grooves can not seldom be traced up and over a long transverse undulation, or they give rise to a large number of conchoidal depressions.

Where the stones project considerably above the ground, several faces are usually being polished simultaneously or as the wind changes. At the base of the Rockies the plains are strewn with multitudes of granite-drift boulders from the mountains. One can hardly go a hundred feet on these plains without finding boulders presenting polished facets in all positions with respect to both vertical and horizontal planes. A single boulder may have a dozen or more facets, just as if one could polish up the Matterhorn, leaving its arrêtes as so many facet-angles extending downward and outward in all directions. The angles between adjacent facets are terminated by rather short convex curves, so that they are somewhat rounded, not true mineralogical angles. The grooves often have different directions on different faces; but in places where the wind can only act when blowing in a certain direction, they are parallel. They can often be traced up to a facet angle and around on to the next facet, especially when the angle is quite obtuse. Grooves can be found at all angles to facet edges, both parallel and transverse to them. The positions of the facets of a given stone are evidently determined partly by the original shape of the stone and partly by the accidents of the grinding process. The facts in Colorado abundantly prove that several facets can be formed contemporaneously, and that it is not necessary in all cases to premise a change of position of the stone when more than one facet is found. These observations, especially those relating to the angles which the conchoidal grooves make with the facet edges, differ from those of Mr. Oldham. This perhaps may be due to the wind being more constant in direction in India than in Colorado. Here the prevailing direction of the grooves is north-west, but sand and gravel are transported by winds from the north, west, and sometimes from the south or south-west.

The conclusion follows that the facetting of the Punjab specimens might be simulated by wind action, but not the flat, almost plane surfaces of the facets.

Fifth.—Were the scratching and facetting done by glacier-ice? This is the opinion of Messrs. Blanford, Oldham, and Wynne; but the Rev. A. Irving objects (*loc. cit.*) that during extensive observations in the Alps, he has not seen stones facetted like these.

The writer has carefully examined the moraines of the local glaciers of the White Mountains in New Hampshire, also those of the Rocky Mountains, and never has found stones facetted in so many planes as the stones in question. In this respect my observations exactly accord with those of Mr. Irving. But in the lower portion of the till of Maine there are literally multitudes of stones glaciated on all sides and often in flat facets like the specimens under discussion. American geologists are now nearly unanimously in accord with the Swedish geologists Torell and Holst that the lower part of the till of New England was a ground moraine beneath an ice-sheet, while much morainal matter was distributed through the lower part of the ice. The stones under this deep sheet of ice were much more intensely glaciated than in the case of the shallower valley glaciers. It is not needful now to go into the discussion of the molecular physics of glaciers. If it be affirmed that glacier ice is too fluid (or plastic) to hold stones long enough and firmly enough to permit them to be facetted and violently scratched, the matter can be decided by an appeal to the ground moraine of the New England ice-sheet. The only way to escape the conclusion that land-ice can scratch and facet stones like the Punjab specimens is by denying that New England was covered with land-ice. But the hypothesis of the glacier origin of the till of New England was never more strongly entrenched than at present. Every year since the days of Agassiz has brought new confirmation. The terminal moraines, the osar marking, the courses of the long glacier rivers, and all the other marks of land-ice, constitute overwhelming proofs of the reality of that ice-sheet.

I conclude that both the facetting and the striation of the specimens under review are of the same kind that in geological time past have been wrought by glacier-ice of considerable thickness.

Sixth.—Could the scratching and facetting have been produced during a landslip? No observations of stones being planed during a landslip have been recorded in America so far as I know. Yet it is extremely improbable that a landslip could occur without attrition of the stones involved. The flames seen at the great slip at Goldau indicate an evolution of molecular heat that could only be caused by great friction resulting in a large amount of crushed rock. During the land-slip the motion is so rapid that the stones would not have much time to roll into new positions; yet where so much work is being done, it is difficult to place a limit to the kind of work we can admit as probable. While, then, no evidence is offered to the effect that direct observation shows that stones such as the Salt Range specimens have been scratched and ground to flat facets during landslips, yet when we consider the forces involved and the great energy of action, it appears highly probable that landslips might produce such a kind of work.

The scratching has plainly not been produced by a modern landslip, unless in the case of specimen No. 5. The weathered condition of the facets proves that the scratching was done before the deposition of the specimens in the boulder-bed, or simultaneously with it.

On the whole I see no cause afforded by the facts now known sufficient to warrant denying that such forms as those under discussion might be produced during landslips of large masses for a considerable distance.

Seventh.—Could the scratchings be produced by fault-movements?

In several cases I have found in the fault-breccia stones that had been scratched, though none of them were facetted in so many planes as these. In the movements of faulted rocks we certainly have an agency capable of a steady motion and powerful enough to plane the hardest rocks. The facets of these specimens are not so smooth as ordinary slickensides on large masses of rock. Most of these scratches were made by graving tools not yet dulled by long friction. No. 5 may have been produced by a recent fault, the others must have been striated before deposition. The hypothesis that these stones were once a part of the fault-breccia would postulate faults occurring before the deposition of the boulder-bed, a portion of the breccia becoming in time exposed on the surface by the decay of the rock on each side of the fault, and the stones subsequently being carried by some means into the boulder-bed. There is much here that is unknown, yet every hypothesis that alleges a cause sufficient for the required work is entitled to a hearing and a fair decision according to the whole evidence.

Eighth.—Were the markings caused by floating-ice? Mr. Oldham (*loc. cit.*) well sets forth the uncertainties regarding the work of ice-floes or bergs upon the stones contained within them. No one seems to have seen shore-ice or any other form of floating-ice facetting stones like the Salt Range specimens. The writer has visited several places on the coast of Maine where ice-floes had been driven ashore with such force as to pile up blocks of ice to the depth of ten to twenty feet. The shore was left strewn with stones and even large boulders four to six feet in diameter. The scratches on the stones were very irregular, in no way resembling those of the stones under discussion. The shore-ice during the rise and fall of the tides produces on the coast of Maine no such markings and planing. Bergs and thick floes would be less easily broken into blocks and might have greater power to facet stones than the shore-ice of Maine. In the present state of the argument floating-ice must be regarded as one of the possible agencies for facetting stones, yet one concerning which little is positively known. River-ice, especially at the time of the breaking of an ice gorge, is here included under the term floating-ice.

The expansion of lake and river-ice produces scratches on the stones of the beach, but no such regular striation and facetting as that under consideration, and large stones driven swiftly along by water can be scratched, but not in a way like these.

The only natural agencies that seem to be adequate to produce such straight scratches and such flat facets as those of the Salt Range stones that have occurred to me are glacier- and floating-ice, land-slips, and fault-movements; and concerning three of these agencies but little is known by direct observation. They must, however, be adequately considered before the theory of glacier-ice can be regarded as fully established, though the glacial hypothesis is not inconsistent with our supposing that part of the stones were formed in some other way than by glacier-ice. In the absence of direct observation of the stones involved in landslips, fault-movements and floating-ice, no test can be named whereby to distinguish stones scratched in these ways from those of the glacier. In other words, in the present state of the argument, the scratching and facetting of the stones do not reveal their origin with certainty. Until proper tests are devised, we must rely on the general field evidence. Some progress can, however, be reported, for the facts certainly prove that the Salt Range specimens are not due to wind or water action. This narrows the field of future research somewhat. It is desirable that observations of the stones involved in the other processes named should be studied as carefully as those of the glacier have been.

It will be noted that the above stated conclusions are based solely on the nature of the markings on the specimens. These specimens are all the material I have for an inductive argument. The general argument in several ways will enable us to distinguish to some extent between the agencies above named as possible causes of the striation, but the matter is for the present left to those who have studied the phenomena in the field.

Four of the specimens described were not much, if in any way, worn by water. They were not, therefore, transported to their position in the midst of clay or sand by running water acting upon them under ordinary conditions. The writer has seen boulders four feet in diameter transported by the rush of water during a cloud-burst in Colorado, and left in the midst of mud and fine sand. If the boulder-bed were formed subaerially, and in a region of severe and sudden storms, the smaller boulders might possibly be accounted for as due to the rush of rapid waters over a soil deposited by rains of ordinary kind. Such a soil if subsequently eroded by the sea or a lake would become stratified and would contain the boulders previously strewn over the region, they being little, if at all, rounded during the erosion of the mud and soil.

Still another method can be named for transporting the scratched stones and boulders to their present positions in the midst of clay or sand. A water-logged stratum of clay or shale is more likely to cause a landslip than any other kind of rock. Suppose such a mass of sedimentary clay to have been deposited over crystalline porphyries previously shattered into boulders of decomposition. If afterwards the region is elevated so as to become part of a mountain range adjacent to the sea or a lake, subaerial erosion would begin to lay bare the underlying rocks, and the waves would form a zone of shingle along the beach. If, subsequently, landslips should occur along the mountain-sides, the clay would carry with it into the sea or lake many of the underlying boulders of decomposition and portions of the beach gravels. Many of the stones might be facetted and striated during the landslip, and we should now find them scattered through the clay or sand involved in the slip. And if this clay or sand were subsequently eroded by the lake or sea-waves, the larger stones would still be left in the midst of the fine material, being but little worn or polished during the process.

The hypothesis of the stones and boulders found in the midst of the fine sediments having been dropped by floating-ice also well accounts for the deposition of the boulders without much water-wear. This was the theory suggested by Dr. Blanford many years ago, and on the whole is the most probable of any of the theories suggested. It may be that these boulders were not all transported in the same manner. The clays and sands that were formed off the shore of the sea in Maine during the "Champlain" elevation of the sea are strewn with erratic boulders up to twenty feet in diameter. The clays are fossiliferous and must have been formed in the open sea. The boulders were dropped from floes of shore-ice or small bergs. Every winter the shore-ice becomes attached to boulders, and in the spring these boulders are carried out to sea and along the coast when the ice becomes detached from the shore. This hypothesis therefore postulates a process that is known by actual observation to be an efficient one.

It is not the writer's purpose, however, to enter on the general question. The character of the specimens imperatively demands some method of transportation that did not involve much water-wear and permitted the preservation of the scratches on the surface. But the specimens afford little evidence as to the exact manner of their transportation.

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X.—On the Greenstone and Associated Rocks of the Manacle Point, Lizard.

By Alexander Somervail.

On De La Beche's Geological Survey Map of Cornwall are three colours representing the associated rocks at, and on each side of the Manacle Point. The Point itself and for a considerable distance south of it is represented as a greenstone. Partially encased in the greenstone and to the south of it is gabbro, which forms the main mass of this rock in the Lizard district. On the north side of the greenstone which forms the extreme south wall of Porthonstock Cove is hornblende-schist, which with some serpentine and other rocks terminates against the killas, or slates near Porthalla.

Several observers with seeming good reason have drawn attention to the fact that the greenstone as represented on the map is made to cover much too large an area to the south, and that any one walking from this direction, or the reverse, finds gabbro where the former rock was expected to occur. That this is the case, there is absolutely no doubt, but, De La Beche may have had his own reasons for this, although perhaps not distinctly stated in the text of his accompanying memoir.

Not only does this seeming discrepancy exist with regard to the relative extent of these rocks, but one also soon seems to get involved in another with regard to their relative ages.

It has been taken for granted somehow or other that the greenstone is the newer rock, as it seems to cut the gabbro; but at Porthonstock this is entirely reversed, the gabbro in several instances traversing the greenstone.

From the commencement of the greenstone on the south side of Porthonstock Cove, as indicated on the map, there is little more than a repetition of alternate greenstone and gabbro for a considerable distance to the south. At first the greenstone is the predominating rock for a short distance, then both almost in equal proportions. The gabbro in its turn, however, soon preponderates, yet still having a number of bands or veins of the greenstone, these becoming fewer as the central mass of the gabbro is reached.

These bands and veins of greenstone differ considerably from each other seemingly in proportion to their width and in their relations from the more central mass of the gabbro. Some of them are like dolerites, others like diorites, and both are frequently porphyritic, and not to be distinguished from similar rocks much further south associated with the granulitic group which cuts the serpentine.

These veins, where I first saw them near the southern limit of the greenstone on the map, firmly impressed me with the conviction that they were due to segregation. During a moderate falling rain I was able to examine them to much advantage, the wet on the rock brings out the very decided way in which the veins shaded into the matrix of the gabbro. Repeated examples bore out the same conclusion, and the broader bands pass in a similar way into the mass of the gabbro, without the slightest sign of intrusion, or of any force having been exerted, or the margins of either having been altered in the very least degree by contact.

The example already referred to of the Porthonstock gabbro traversing the greenstone, so apparently contradictory, is also, I believe, due to segregation from the more extensive mass of the greenstone occurring at this point; so that on the ground of segregation, anomalies and difficulties at once disappear. I have no doubt that it was from the successive bands of both rocks at Porthonstock Point, that De La Beche was induced to colour so much of this area as greenstone, if not from the very reason just given.

There can be no doubt but that the greenstone and gabbro are portions of one and the same magma, the gabbro on its northern margin passing into the former, and as we shall presently see, the hornblende schists immediately north of the greenstone are formed out of this latter rock,[1] so that all three—gabbro, greenstone, and hornblende-schist—are but the modifications chemically and mechanically of one mass, although represented by the three colours alluded to. From south to north, as already stated, there is a gradually growing disposition on the part of the gabbro to become more split up by the segregated greenstone veins and bands, until these become the dominant rock at and north of Porthonstock, resulting in what is now represented by the hornblende-schists north of that locality.

The greenstone of Porthonstock is not by any means a rock that has undergone any very great amount of secondary alteration. Immediately north of it, however, there is evidence of a plane of great disturbance which has much more completely altered its original constituents, especially its augite into hornblende, and pro-

[1] This opinion is expressed in Prof. Sedgwick's paper, Trans. Cambridge Phil. Soc. vol. i. p. 18.

duced a highly schistose structure. Its various mineral constituents are much crushed, flattened and broken up into fine fragments, the long axes of which conform more or less to the planes of cleavage produced by the great mechanical pressure the rock has here undergone. The original porphyritic structure, though much crushed, is yet distinctly traceable, and further north, where the rock is less cleaved or schistose, as towards Porthkerris Cove, and Point, the porphyritic structure much abounds.

There is another point with regard to the Porthonstock greenstone which must not be overlooked, that is, the tendency of the rock in parts to assume the granulitic structure, which, although on a small scale here, is yet the same type of rock as met with in the southern areas. This also is, I contend, but a portion separated from the greenstone by segregation, so that from the parent mass of the gabbro has been evolved the granulitic and the greenstone, which latter by subsequent dynamical movements has been converted into hornblende-schist.

This explanation I am inclined to regard as no mere speculation, but as a fair and just inference based on what we can observe in many localities at the Lizard. In some of these localities all three rocks, gabbro, granulitic, and hornblende, are more or less interchangeable, and a distinct passage can be traced between them all. In certain areas large tracts of the latter rock, which seems to have formed the upper or outer margin of the gabbro, have been cleaved into what now form the schists, while the more granulitic portions, although closely adjoining, have from their coarse and granular nature been much less affected.

It will, I think, be ultimately found that segregation has played a most important part among all the rocks of the Lizard district. The bands of hornblende so frequently occurring in the serpentine in various localities are due, I think, to this cause. The dykes in the outer rocks off the Lizard Head, mapped with such care, and not without danger, by Mr. Howard Fox, F.G.S.,[1] are, I believe, true segregation dykes. The banded structure in the hornblende-schists and associated gneissic rocks is also in my opinion due to this same cause, a subject I hope to deal with very shortly.

If the present suggestion is correct, in reducing the triple division of the rocks at the Manacle Point to mere varieties of one original magma, it seems to go a long way towards simplifying the geology of the rest of this most interesting district.

NOTICES OF MEMOIRS.

1. "On a Head of *Hybodus Delabechei*, associated with Dorsal Fin-spines, from the Lower Lias of Lyme Regis, Dorsetshire." By A. Smith Woodward. Ann. Report Yorksh. Phil. Soc. 1888, pp. 58–61, pl. i.

THROUGH the generosity of Mr. William Reed, F.G.S., the Yorkshire Philosophical Society is enabled to publish, in its recently-issued Report for 1888, a fine quarto plate (drawn by Miss G. M.

[1] On the Gneissic Rocks off the Lizard, Q.J.G.S. May, 1888, p. 309.

Woodward) of the most perfectly preserved head of the Liassic Shark, *Hybodus Delabechei*, hitherto discovered. The specimen is contained in the Reed Collection of the York Museum and exhibits, for the first time, the precise arrangement and relative proportions of the teeth, in addition to some of the characters of the cranial cartilage. The mandibular teeth are disposed upon each ramus of the jaw in ten or eleven transverse series, being thus more numerous than in *Acrodus*; and there is no azygous series of symphysial teeth. The dorsal covering of shagreen is sparse, and the absence of barbed, lateral head-spines is somewhat remarkable.

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2. Fish Remains from the Lower Coal Measures of Lancashire. By Herbert Bolton. Trans. Manchester Geol. Soc. vol. xx. pt. viii. 1889.

THE author records the occurrence of fossil fish remains in shale overlying the Upper Foot, or Bullion Mine Coal, in Rossendale, and publishes brief notes upon the specimens. A large *Elonichthys* appears to be referable to *E. semistriatus*, Traq.; a head of *Cœlacanthus* is shown to differ in some respects from that of the common *C. lepturus*; and other less satisfactory fragments do not permit of any tolerably precise determination.

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3. "Ueber zwei Fische aus den Angulatuskalken des Unter-Elsass." By W. Deecke. Mittheil. Commission geol. Landes-Untersuch. Elsass-Lothringen, vol. i. 1888. 11 pp. 1 pl.

THE author describes a new species of *Heterolepidotus* and another of *Dapedius* from the Angulatus-beds of Alsace, and claims these to be the oldest Liassic fish-remains hitherto discovered. *Heterolepidotus angulati* is founded upon the well-preserved trunk of a typical member of the genus, closely related to *H. serrulatus*, but differing in the smoothness of the scales. Of *Dapedius cycloides*, a complete fish forms the type-specimen, and this seems to differ from the well-known *D. orbis* of Barrow-on-Soar, merely in the prominent sculpturing of the scales upon the foremost half of the trunk. Of the *Heterolepidotus* a description alone is given; but of the *Dapedius* there is a good photograph, with explanatory lettering upon a traced outline of the fossil.

REVIEWS.

I.—The Middle Lias of Northamptonshire. By Beeby Thompson, F.G.S., F.C.S. (London, Simpkin, Marshall, & Co.) 8vo. pp. 150. Price 3*s*. 6*d*.

SINCE the days when Samuel Sharp laboured so successfully among the Oolites of Northamptonshire, no one has studied more assiduously the county geology than the author of the present work. Confining his attention mainly to the country accessible from the town of Northampton, he has added largely to our knowledge of the Upper Lias, in papers published in the Journal of the Northamptonshire Natural History Society; and he now gives us the results of his observations on the Middle Lias. The work itself has appeared in serial form in the "Midland Naturalist," but the author has done well to reprint his papers in a neat and handy volume, and so save them from the oblivion which too often befalls many excellent articles.

Two main subjects are treated of and discussed: 1, the Middle Lias, stratigraphically and palæontologically; and 2, the Strata in their connection with Water-supply, etc.

In the first portion we are given detailed notes of many sections, and, what is of most importance, records of fossils obtained from each minor division of the strata. When we learn that these divisions amount to thirteen in all, we may confidently assert that the position of each assemblage of fossils in the Middle Lias has been worked out much more minutely than in any other area in this country. In saying so much, we do not attach undue importance to these minor or perhaps local divisions; but inasmuch as the author founds his work on the stratigraphical sequence of the beds, his facts and conclusions will be of great value to other workers, who are endeavouring to trace out the biological history of the species.

Some forms are for the first time recorded from the strata in this country; while others altogether new, obtained by the author, and by another zealous worker, Mr. W. D. Crick, have been recently described by Mr. E. Wilson in the pages of this MAGAZINE.

The so-called "Transition-bed" between the Middle and Upper Lias, a bed previously discovered and worked out on the borders of Oxfordshire and Northamptonshire by Mr. T. Beesley and Mr. E. A. Walford, is described as fully as possible. Stratigraphically it is a very insignificant bed, but a few inches in thickness, so that whether it be regarded as Middle or Upper Lias is a question in no ways calculated to disturb the mind of the geological surveyor. It has yielded a fauna of upwards of 90 species—about three-fourths of which belong to the Middle Lias and one-fourth to the Upper Lias. The Ammonites are essentially Upper Lias types, and these include the characteristic *Ammonites acutus.* The Gasteropods are of Middle Lias character and suggest that the bed is approximately on the same horizon as the '*Pleurotomaria*-bed' (of Mr. E. C. H. Day) on the Dorsetshire coast.

Mr. Thompson includes in his Middle Lias only the zones of *Ammonites spinatus* and *A. margaritatus*; thus putting the beds with *A. capricornus, A. Henleyi*, etc., in the Lower Lias—a grouping adopted by the Geological Survey. All the evidence, however, goes to show that the larger as well as the smaller divisions are intimately linked, and the Upper Lias beds in Northamptonshire appear in places to be closely connected with the Northampton Sands, as pointed out elsewhere by the author.

Passing on to the second portion of this work, we find a notice of the Economic products, and then a general account of the Springs in the Gravels and Oolites. The latter portion of this subject is but introductory to a special account of the water-bearing beds of the Middle Lias.

Owing to the increased amount of water needed for the town of Northampton, and partly owing to improved systems of agricultural drainage, the water derived from the deep wells in the Middle Lias was found to be insufficient. Still deeper wells were made in the hopes of reaching water-bearing Triassic rocks; but these were failures.

Mr. Thompson has for some years past advocated that a system of dumb-wells be constructed—about 100 feet in depth on the average. "These dumb-wells would all be situated in the valleys, and would generally require to be cut through a little alluvium and river gravel, and through the Upper and Middle Lias. The wells might be lined with brick, and then filled up with coarse gravel, broken brick, or any good porous material to within 35 ft. or 40 ft. of the top, the material to get finer towards the top, in imitation of the filter beds of the London water companies. The depth of 35 ft. to 40 ft. not filled with gravel is given to enable the water running in from the river gravel, as well as that from the surface, where such water is desirable, to have a good fall, whereby it may be effectually aerated before entering the chief filter bed."

The author would take advantage of the river gravel as a primary reservoir and filter-bed, whence the water would be conveyed into the Marlstone. He mentions that at the present time water obtained from the river gravel is clear, and free from suspended impurities, and would still be so if his plan were adopted, so that, in his opinion, there would be little or no silting up of the dumb-wells. Additional supplies of water might also be obtained from the river by means of pipes when the water was sufficiently high for it to be well spared, and this would tend to prevent the injuries that arise to the banks from overflowing. The author, therefore, contends that his scheme, of which he gives full details, would improve a large district now injured by floods; it would furnish an abundant water supply in a natural reservoir (the Middle Lias); and the water would be very pure, because it would be filtered before entering the well, and filtered again in the well before entering the most effectual filter the Marlstone itself, while it would be well aerated by its fall.

Various objections have been raised against this scheme, and these are fully discussed by Mr. Thompson. Perhaps the most serious objection is that a scheme of this nature has not been tried before in this country, and that it must necessarily be an experiment. Such an objection might have been urged against some of our deep borings! Another question is whether the water would go away through the dumb-wells. Water obtained from old wells was of an artesian nature rising formerly at one place 90 feet above the water-bearing rock. This, however, was before the water-level had been reduced by the large supplies procured, and so long as large supplies are pumped up, there would be no danger of overflow from the dumb-wells. The dip of the beds is considered too slight to offer any obstacles to the scheme. The Upper Lias is 170 to 190 feet thick, and the author calculates that there could be a head of water of 110 feet at Northampton, before the dumb-wells would cease to act or occasion loss.

The scheme, however, was not adopted by the Town Council of Northampton—as it was considered too theoretical by the "practical" men; moreover it was deemed necessary to procure a supply without loss of time, and an artificial reservoir to hold 400 millions of gallons of water has been constructed near Ravensthorpe. Mr. Thompson claims that his plan, if successful, would have saved the town at least £75,000; hence it seems a pity that it was not given a trial by the construction of one or more experimental dumb-wells, for we feel confident that the plan could not have been proposed under geological conditions more likely to prove favourable to its success.

Those occupied in the subject of water-supply will, however, find in this carefully-prepared work much matter of interest and instruction; and the author need not feel that his labour has been unproductive of good, even if he has not been considered as a "prophet" in his own country.

II.—Dr. C. Forsyth-Major's Palæontological Discoveries in the Isle of Samos.

Sur un Gisement d'Ossements Fossiles dans l'Île de Samos, contemporains de l'âge de Pikermi. Par M. Forsyth Major. *Comptes Rendus*, vol. cvii. pp. 1178–1181 (1888).

This paper contains a preliminary notice of a collection of Vertebrate remains of Lower Pliocene age obtained by the author during the year 1887 in the island of Samos in the Turkish Archipelago. Among these are a large number of forms specifically identical with the mammals from the equivalent deposits of Pikermi in Attica, Baltavar in Hungary, and Maragha in Persia; but there are also some new types, which are of interest either from a distributional or a purely zoological point of view.

Among these new forms is a species of Ant-bear (*Orycteropus*), which is the only representative of that genus yet known beyond the Ethiopian region. A large Pangolin, which is estimated to have been nearly three times the size of the West African *Manis gigantea*, is made the type of the new genus *Palæomanis*; and is of interest as showing how the African Pangolins may have been connected with those of India.

Perhaps the most striking new type is a large ruminant referred by the author to the *Giraffidæ*, and stated to connect *Helladotherium* and the Giraffe with some of the aberrant Antelopes of Pikermi. Finally a large Ostrich is especially noteworthy from a distributional point of view, since we now have remains of this genus from Samos, the Thracian Chersonese, and Northern India. R. L.

Note.—We learn that Dr. H. Woodward has just returned (20 August) from Florence, having secured Dr. C. Forsyth-Major's valuable collection from Samos for the British Museum (Natural History), Cromwell Road, to which it will doubtless prove a most important addition.

MISCELLANEOUS.

Coal and Tin Discoveries in Western Australia.

Mr. Harry P. Woodward, F.G.S., Government Geologist for Western Australia, sends some interesting particulars of both coal and tin discoveries in that colony. He writes:—

"From Vasse I made for the Lower Blackwood River Bridge, over the foot of the Darling Range, and so on to the Donelly River. On the south coast, where a small stream flows out, called the Fly Brook, coal has been found of a very good quality, but there is no port nearer than Albany or Vasse, and this latter is not a good one. There seems to be a line of coal-bearing country between the coast-range, which runs north and south from Cape Leeuwin to Cape Naturalist, and the main highlands, the southern continuation of the Darling Range, covered with sand and swamps at the surface, but under these I believe we shall find Coal-measures which may in fact extend west beneath Perth to the Irwin River, but this can only be tested by deep-borings.

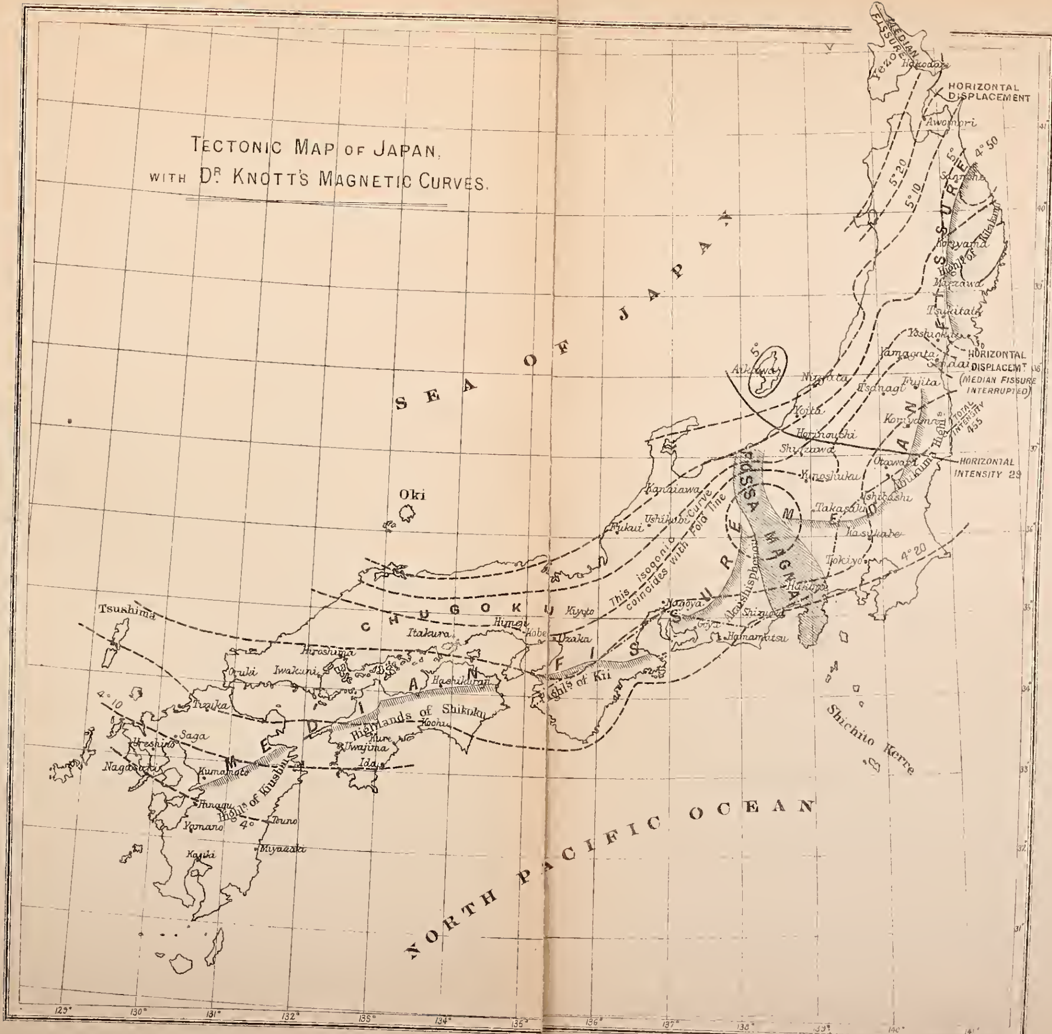
"There was nothing to be seen of the coal or rocks, as they are boring with a 'jumping-drill,' which reduces everything to mud, but there is one 5ft. seam and several smaller, averaging 17ft. of coal in 200 feet of rock. There are two or three outcrops in the bed of the Creek of a much weathered but good coal, some of which is highly bituminous. From Bridgetown I went to Albany, and thence east 200 miles to the Phillips River, and saw the Fitzgerald Coal-field. This is only brown-coal or lignite of no value, but there is some good-looking gold-bearing country near it."

Tin-ore.—In reference to the Tin-discoveries Mr. H. P. Woodward writes:—

"From Bunbury I went towards the Upper Blackwood, to a place called Bridge-town, where tin has been met with: little work has been done yet, but, as far as I am able to judge, it seems to indicate the biggest thing of the kind that has ever been found. One shaft 18ft. deep will 'wash' all the way down at about four or five lbs. to the pan, and they have not got to the bottom of it yet. The richest works in other Colonies are rarely more than two or three feet deep. Tin has been found at the surface, in the sand, over an area of about 100 square miles; but no sinking, except the one shaft, has yet been made; and as the surface is covered, either with sand or clay-ironstone, the formation cannot be seen at all. The late Mr. Edward T. Hardman, F.G.S., suggested that tin would be found here. The shaft shows a few inches of soil or alluvium with gravel containing tin, where it was first found, resting on hard masses of clayey ferruginous sandstone, about one foot thick, then coarse quartz-grit with stream-tin and tourmalines and a few 'colours' of gold. 17ft. not gone through yet, as there was too much water: about $\frac{1}{6}$ in weight being tin-ore."

Erratum.—In the first part of Messrs. Wilson and Crick's paper on the "Lias Marlstone of Tilton," in the July Number, pp. 296–305, East Norton was by mistake stated to be in the county of Rutland instead of Leicester.

To illustrate Dr. Nau



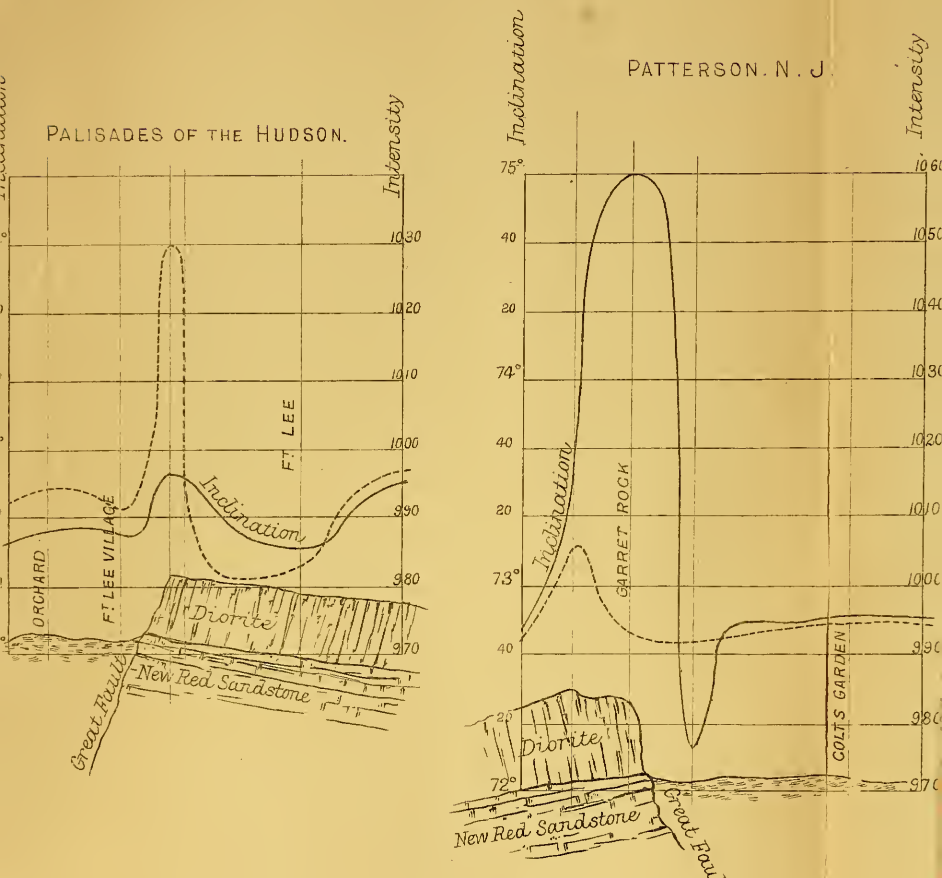
To illustrate Dr. Naumann's Memoir

West, Newman lith.

To illustrate Dr Naumann's Memoir

To illustrate Dr Naumann's Memoir.

LOCKE'S MAGNETIC SECTIONS.



To illustrate Dr Naumann's Memoir on Terrestrial Magnetism.

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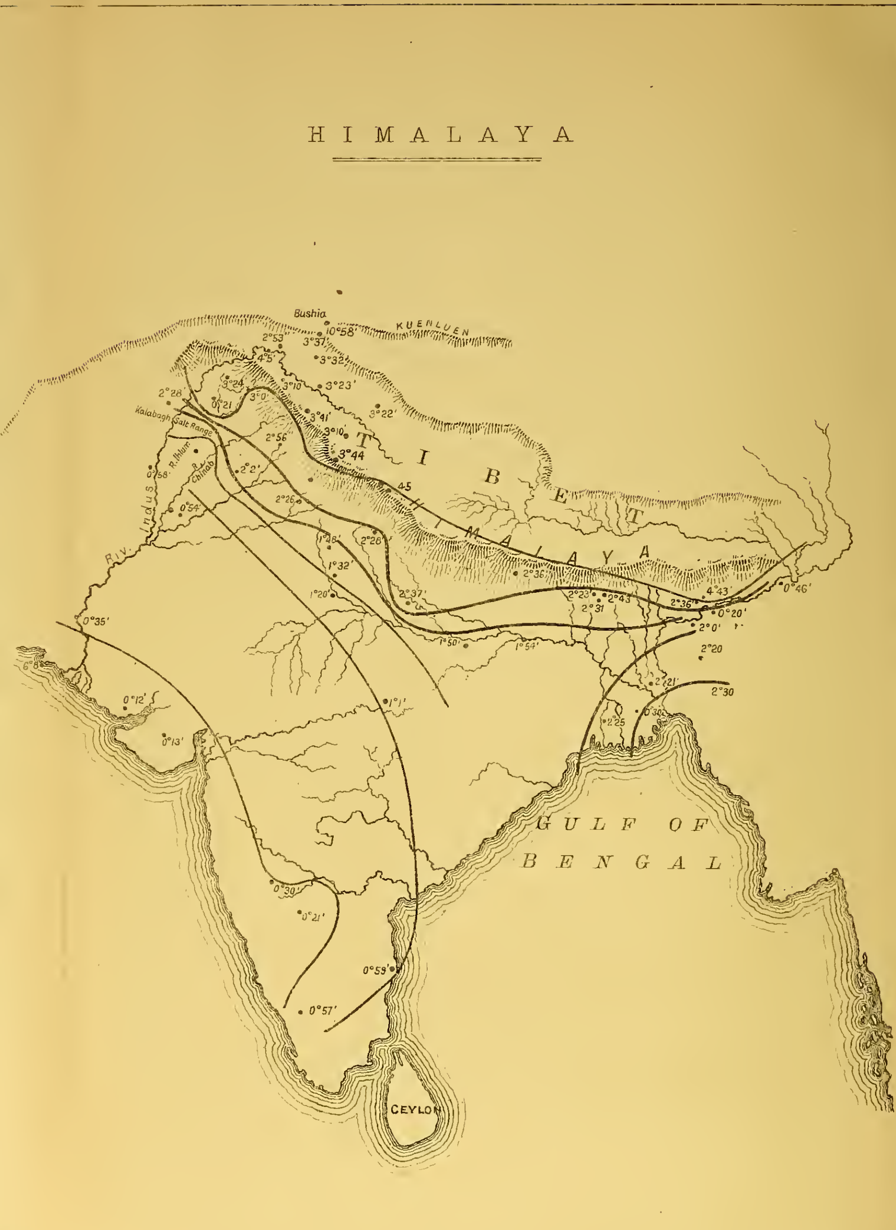

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To illustrate Dr Naumann's Memoir on Terrestrial Magnetism.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VI.

No. X.—OCTOBER, 1889.

ORIGINAL ARTICLES.

I.—On the Relations between the Genera *Syringolites*, Hinde, and *Roemeria*, Edwards and Haime, and on the Genus *Caliapora*, Schlüter.

By H. Alleyne Nicholson, M.D., D.Sc., F.G.S.,

Regius Professor of Natural History in the University of Aberdeen.

In a recent publication ("Anthozoen des rheinischen Mittel-devon," 1889) Professor Schlüter has put forward the conclusion that the genus *Syringolites*, Hinde, is identical with the much older genus *Roemeria*, Edwards & Haime, the former name thus becoming a mere synonym. From this conclusion I feel obliged to dissent, and I propose to show in the following brief communication that *Roemeria* and *Syringolites* are distinguished by important morphological characters, and that the latter is fully entitled to generic rank.

The genus *Syringolites* was founded by Dr. Hinde (Geol. Mag. Dec. II. Vol. VI. p. 244, 1879) for the reception of a beautiful and interesting coral from the Niagara Limestone of Canada, to which the name of *S. Huronensis* was given by its describer. The same species has subsequently been recognized as occurring in the Wenlock Limestone of Gotland. The corallum in *S. Huronensis* (Fig. 1) is composite and has the form of a flattened expansion, furnished with a basal epitheca, and closely similar in general aspect to specimens of the massive forms of *Favosites*, such as *F. Gothlandica*. The corallites resemble those of *Favosites* proper in being prismatic,

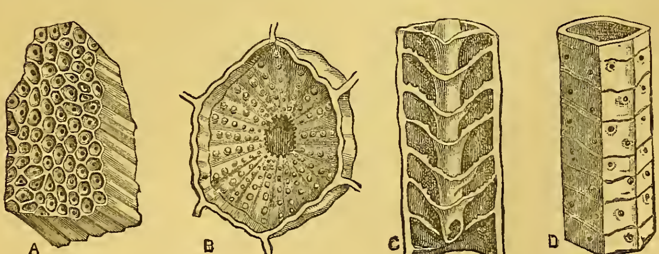


Fig. 1.—a, A fragment of a colony of *Syringolites Huronensis*, Hinde, of the natural size; b, A single calice of the same, enlarged eight times, showing the central tube, and radiating lines of septal tubercles; c, Part of a corallite of the same, split open, and enlarged six times, showing the composition of the central tube out of invaginated tabulæ; d, Part of a corallite of the same, viewed from the exterior and enlarged six times, showing the mural pores. Niagara Limestone, Manitoulin Island, Ontario.

thin-walled, closely contiguous, and furnished with one or more rows of small mural pores on each prismatic face. The corallites are intersected by numerous annular tabulæ, which are invaginated centrally so as to give rise to a median cylindrical tube, which occupies the centre of each visceral chamber, and is furnished with imperforate walls. The upper surfaces of the tabulæ show well-marked septal ridges (primarily twelve in number), which are covered with minute tubercles or spines, two to four rows of such tubercles apparently corresponding with a single septal fold. Increase of the corallum takes place by intercalicinal gemmation.

The essential characters of *Syringolites Huronensis*, as above briefly described, are that the prismatic corallites are *thin-walled*, and are furnished with numerous regularly-distributed mural pores, while the septal system is fairly represented by radiating tuberculated ridges, which are primarily twelve in number in each corallite.

The only corals which have been recognized as belonging to the genus *Roemeria*, E. & H., are the *R.* (*Calamopora*) *infundibulifera* of Goldfuss, and the *R. minor* of Schlüter, both of which occur in the Middle Devonian of Germany. I have had the opportunity of examining the original specimens of the former of these, which are preserved in the University Museum in Bonn; but, so far as I am aware, no complete microscopic examination of these has ever been carried out. There is, however, no doubt that *R. minor*, Schlüter, is congeneric with *R. infundibulifera*, Goldf., and through the kindness of Professor Schlüter, I have been enabled to make a thorough microscopic investigation of the former, which I shall therefore take as the type of the genus *Roemeria*.

The corallum in *Roemeria minor* forms small flattened expansions, composed of erect, polygonal, and contiguous corallites. Thin sections, both transverse and longitudinal (Figs. 2 and 3), show that the corallites are bounded by a thin and well-developed primordial wall, which is enormously thickened by a dense deposit of secondary sclerenchyma ("stereoplasma"), the visceral chamber being thus greatly constricted. The visceral chamber of the corallites, thus restricted, is traversed by a succession of infundibuliform tabulae, which are invaginated one into another, but can hardly be said to give rise to a definite median tube. The septa are practically undeveloped, though one may occasionally observe blunt vertical ridges, which are possibly of a septal nature. The mural pores are of very large size, and comparatively few in number, and are quite irregular in their distribution; while owing to the enormous thickening of the walls of the corallites, they present themselves as elongated canals joining the visceral chambers of contiguous tubes. Increase of the corallum takes place by means of intermural gemmation.

From the above short description of the structure of *Roemeria minor*, as illustrated by the accompanying figures of thin transverse and vertical sections, it will be obvious that *Syringolites*, Hinde, differs in characters of fundamental importance from *Roemeria*, E. & H. This will be sufficiently evident from the following summary:

(1) The corallites in *Roemeria* are enormously thickened by a secondary deposit of stereoplasma; whereas those of *Syringolites* are thin-walled, and resemble those of *Favosites* proper.

(2) The mural pores of *Roemeria* are of large size, are few in number, and are irregularly distributed; whereas those of *Syringolites* resemble the pores of *Favosites* proper in being of small size, numerous, and regularly distributed.

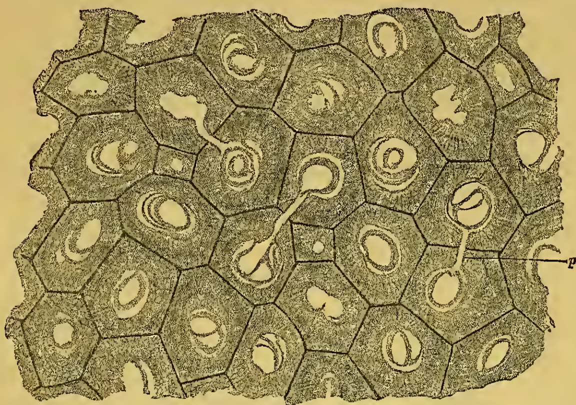


FIG. 2.—Transverse section of *Roemeria minor*, Schlüter, from the Middle Devonian rocks of Dahlem, in the Eifel, enlarged about six times. *p.* Mural pore.

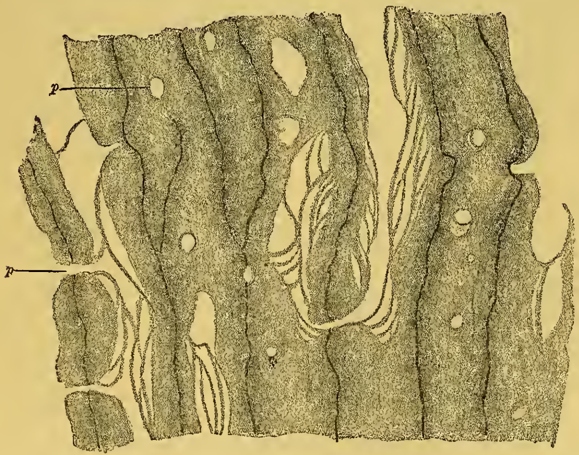


FIG. 3.—Vertical section of *Roemeria minor*, Schlüter, from the same locality, similarly enlarged. *pp.* Mural pores.

(3) The septal system in *Roemeria* is rudimentary or absent; whereas in *Syringolites* each corallite is provided with well developed septal ridges, the number of these structures in each tube appearing

to be primarily twelve, as is the case in *Heliolites*, *Halysites*, *Syringopora*, etc.

Upon the whole, therefore, it cannot be doubted that *Syringolites*, Hinde, is generically distinct from *Roemeria*, E. & H.; and it is not even clear that the two are very nearly related. If the septal system of *Roemeria* had been developed, the genus might be regarded as occupying to *Syringolites* a position analogous to that held by *Pachypora* with regard to *Favosites* proper; and, possibly, this view may be found ultimately to express the real relationships of the two. Both genera afford transitional links between the *Favositidæ* and the *Syringoporidæ*; but their precise relationships must in the meanwhile remain more or less a matter of conjecture.

GENUS CALIAPORA, Schlüter.

The genus *Caliapora* has been proposed by Professor Schlüter for the reception of the well-known *Alveolites Battersbyi*, E. & H., from the Devonian rocks of Britain and Germany. I have long been of opinion that the peculiarities of *A. Battersbyi* are such that it is worthy of separation from *Alveolites* proper, as a distinct genus or

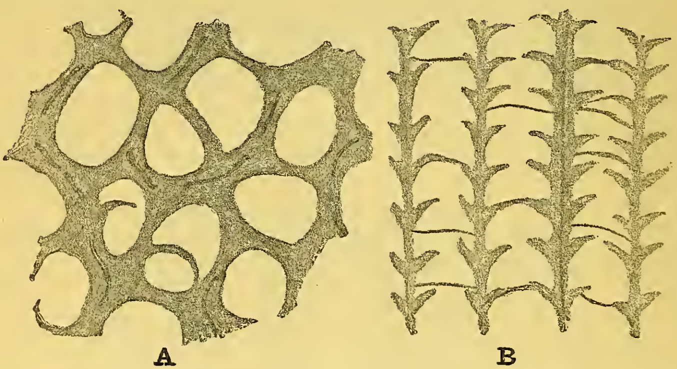
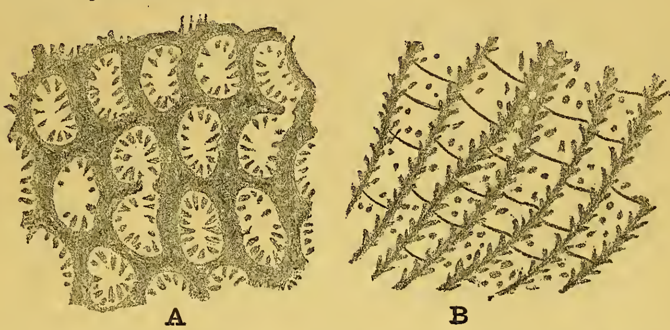


FIG. 4.—A. Tranverse section of *Caliapora Battersbyi*, E. & H., sp. enlarged seven times. B. Vertical section of the same. From the Middle Devonian of Dartington, South Devon.

subgenus; and I am therefore able to cordially concur in the course which Professor Schlüter has taken. At the same time I interpret the structure of *A. Battersbyi* in a somewhat different manner, and I consider that the familiar *Alveolites Labechei* of the Wenlock Limestone must find a place along with *A. Battersbyi*. I cannot, therefore, accept Professor Schlüter's definition of *Caliapora* as altogether sufficient; and I shall endeavour here to indicate what, in my opinion, are the essential characters of the genus.

In both *C. Battersbyi* and *C. Labechei* the corallum has all the general characters of that of *Alveolites* generally, and there is therefore no external feature which distinguishes the genus *Caliapora*. In *C. Battersbyi*, as pointed out by Schlüter, the corallites are subpolygonal and irregular in shape (Fig. 4); but this character is not a vital one, since in *C. Labechei* the tubes have commonly the compressed form and alternating arrangement which is characteristic of the typical forms of *Alveolites.* Again, little importance can be attached to the mode of distribution of the mural pores, since in *C. Labechei* these structures seem to be confined to the short ends of the compressed corallites, whereas in *C. Battersbyi* they are asserted by Schlüter to occur indifferently on all the faces of the corallites. Of still less importance is the supposed absence of tabulæ, since this rests upon a misconception. Not only are tabulæ largely present in *C. Labechei,* but, in all the specimens of *C. Battersbyi* which I have examined, I have found these structures to be fairly well developed, though they are often comparatively few in number (Fig. 4, B). Some of the tabulæ of *C. Battersbyi* have the ordinary form of complete transverse plates; but this species is furnished in addition with numerous imperfect, cup-like tabulæ, which project but a short way into the visceral chamber of the corallites, and which have been compared by Professor Schlüter with swallows'-nests attached to the wall of a house. In *C. Labechei* all the tabulæ seem to be complete, and there are none of the peculiar incomplete or squamous tabulæ which occur in *C. Battersbyi.*



A B

Fig. 5.—A. Transverse section of *Caliapora Labechei,* E. & H., sp. enlarged six times. B. Vertical section of the same, similarly enlarged. From the Wenlock Limestone of Much Wenlock.

The most characteristic feature of the genus *Caliapora,* as compared with *Alveolites,* is to be found in the fact that the corallites are provided with numerous strong ascending tooth-like processes, which must be regarded as of the nature of septa (Figs. 4 and 5). The existence of these strong tooth-like spines in *Caliapora Battersbyi* is recognized by Schlüter, but they are regarded as being due to the intersection of the cup-like squamous tabulæ above spoken of. In this view of their nature I am unable to agree, and I regard them as structures having an independent existence. This is clearly the case in *C. Labechei* (Fig. 5), where their septal nature is quite indisputable. If this view be correct, then the essential feature which distinguishes *Caliapora* from *Alveolites* is the possession by the former of strong tooth-like septal spines, which are developed in a cycle within each corallite in *C. Labechei,* but are fewer in number in *C. Battersbyi.*

Finally, it may be pointed out that in typical examples of *C. Battersbyi* there appears to be the peculiar feature that the walls of certain of the corallites seem to be specially thickened, thus giving rise to strong vertical spines, which constitute a conspicuous feature in vertical sections. I have had no opportunity of observing the termination of these spine-like thickenings on the surface, and I am not clear as to their real nature.

II.—Prof. E. D. Cope, on the Proboscidea.

(PLATE XIII.)

THE following account of the Proboscidea, by Prof. E. D. Cope, appeared in a recent number of the "*American Naturalist,*"[1] and is so interesting, that we venture to give the more important part in full, and some few of the illustrations.—Edit. Geol. Mag.

"The Proboscidea are Ungulata, in which the second row of carpal bones has not moved inwards, so as to alternate with the first, and in which the second row of tarsal bones alternates with the first by the navicular extending over part of the proximal face of the cuboid. The teeth are modifications of the quadri-tubercular type, and canines are absent. To these general characters are added numerous subordinate peculiarities in the known genera and species, which make them among the most remarkable of living beings. These peculiarities are the result of a long period of development. It is one of the most curious facts of palæontology that the order does not make its appearance until the middle of the Miocene system, and the greater number of forms do not appear until the upper Miocene. That it existed earlier cannot be doubted, and that it originated from some Eocene Condylarthran is evident; but the intermediate forms are entirely lost to us as yet; and the phylogeny of the order is absolutely unknown. This is the more extraordinary, since the earliest known genus (*Dinotherium*) embraces only species of colossal size, and its immediate ancestors could not have been insignificant. We may regard *Phenacodus* as the first form we know of earlier than *Dinotherium,* but what a hiatus is expressed in this statement. It is to be anticipated that the gap will be filled by discoveries in Asia, or the Southern Hemisphere. South America may be probably excluded from this prospect, since the extensive researches made there by Burmeister, Ameghino, and Moreno, have not resulted in the discovery of any Proboscidea earlier than the Pliocene. Asiatic investigations have revealed nothing, as the proper formations have not been found, and the same is true of Africa. So we shall have to wait until the palæontology of the present home of the order is exposed to view, before we shall know of the steps which lead from *Phenacodus* to these mighty monarchs of the animal kingdom. The absence of primitive Proboscidea from North and South America and Europe, impels us to believe that the representatives of the order known to us from those regions are the descendants of immigrants from Asia and Africa.

[1] No. 268, April 1889, pp. 191–211, pl. ix.–xvi. and nine woodcuts.

But two families of Proboscidea are known. They are defined as follows:

Adult dentition embracing premolars and molars; no superior incisors—*Dinotheriidæ.*

Adult dentition embracing one or two true molars only; superior incisors—*Elephantidæ.*

The family of the *Dinotheriidæ* embraces one genus and four species, though a fifth species, *D. sindiense*, Lyd., from India, may belong, according to Lydekker, to another genus. The *Dinotherium indicum*, Falc., is known from a few teeth, which exceed in size those of the other species. The *D. giganteum*, Kaup, is found in several

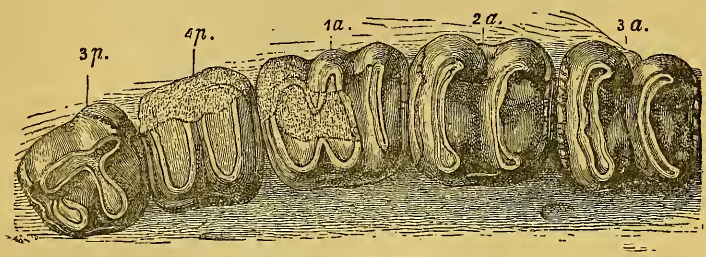


FIG. 1.—*Dinotherium giganteum*, Kaup, from the Middle Miocene of Samaran (Gers), France. (After Gaudry.) The left upper cheek-dentition (¼ nat. size). *a* 1, 2, 3, true molars, *p.* 3, 4, premolars.

Miocene deposits of Europe. It was one of the largest of Mammalia, its femur exceeding in dimensions that of any other land mammal. The inferior incisors were robust, and cylindric in form. With the symphysis of the lower jaw they are decurved so as to form a most effective instrument for the tearing up of trees by the roots, or the pulling down of their branches. The temporal fossa is lateral, and the top of the head flat. The premaxillary region, though toothless, is prominent, and the nasal bones do not project. There is supposed to have been a short trunk. The skull measures three feet eight inches in length. Two smaller species are known, the *D. bavaricum*, from European, and *D. pentapotamiæ*, from Indian, Miocene beds.

In *Dinotherium* all the molars and premolars have two transverse crests, excepting the first (posterior) premolar, and its deciduous predecessor, which have three cross-crests.

The genera of the *Elephantidæ* are the following:

I. Inferior incisors and premolars present. Superior incisors with enamel band—*Tetrabelodon*, Cope.

II. Premolars, but normally no inferior incisors; intermediate molars isomerous; superior incisors with enamel-band—*Dibelodon*, Cope.
Intermediate molars isomerous; superior incisors without enamel band—*Mastodon*, Cuv.
Intermediate molars heteromerous; superior incisors without enamel band—*Emmenodon*, Cope.[1]

III. No premolars, nor inferior incisors.
Intermediate molars heteromerous. Superior incisors without enamel band—*Elephas*, Linn.

[1] Gen. nov. type, *Elephas Cliftii*, Falc. & Cautl. (*Mastodon elephantoides*, Clift).

The characters assigned to the above genera are sufficient to separate them, but they have not come into general use for two reasons. One is the difficulty of verifying some of them, especially the presence of premolars, owing to the difficulty of obtaining specimens of young individuals. The other is the indisposition of naturalists to abandon the system of Falconer. As is well known, this able palæontologist distinguished the genera by the number and depth of the transverse crests of the molar teeth, and the extent to which their interspaces are filled with cementum. This arrangement is insufficient, since it neglects the equally important characters above mentioned; and as observed by Lydekker[1] it fails to furnish clear definitions. He remarks, under the head of the genus *Elephas*:—"There is no character by which the present genus can be distinguished from *Mastodon*; and the division can be therefore only regarded as a matter of convenience." The characters presented in the above table are on the other hand very distinctive, and can be applied in all cases where we have the necessary information. This has not yet been obtained as regards all the species, and I have placed some of them in their respective genera provisionally. Such species are marked with an *i*, when the condition of the incisors is unknown and with a *p*, when the same is true of the premolars. The species of the family described thus far are as follows:[2]—

Mastodon	(*Tetrabelodon*)	*brevidens*,[3] Cope, sp. nov. N. America, *i.p.*
,,	,,	*turicensis*, Schinz. Europe.
,,	,,	*angustidens*, Cuv. Europe.
,,	,,	„ *palæindicus*, Lyd. India.
,,	,,	„ *procævus*, Cope, N. America.
,,	,,	*productus*, Cope. N. America, ? Mexico.
,,	,,	*euhypodon*, Cope. N. America, *p.*
,,	,,	*pandionis*, Falc. Cautl. India.
,,	,,	*pentelici*, Gaudry.[4] Europe, *p.*
,,	,,	*campester*, Cope. N. America, *p.*
,,	,,	*longirostris*, Kaup. Europe.
,,	,,	? *serridens*, Cope. Texas, ? Mexico, ? Florida,[5] *i.p.*
,,	(*Dibelodon*)	*shepardi*, Leidy. California, Mexico, *p.*
,,	,,	*cordillerarum*,[6] Desm. S. America.
,,	,,	*tropicus*, Cope. S. America and Mexico, *p.*
,,	,,	*humboldtii*, Cuv. S. America.
	Mastodon	*americanus*, Cuv.[7] N. America.
	,,	*borsoni*, Hays. Europe, *p.*
	,,	*falconeri*, Lydd. India, *p.*
	,,	*mirificus*, Leidy. N. America, *i.p.*
	,,	*sivalensis*,[8] Cautley. India, *p.*

[1] Catalogue of Fossil Mammalia in the Brit. Mus., pt. iv. p. 72.

[2] In compiling this list I have been greatly aided by the Memoirs of Lydekker in the "Palæontologia Indica" and the Catalogue of the British Museum.

[3] *M. procævus*, Cope, 1884, not 1873.

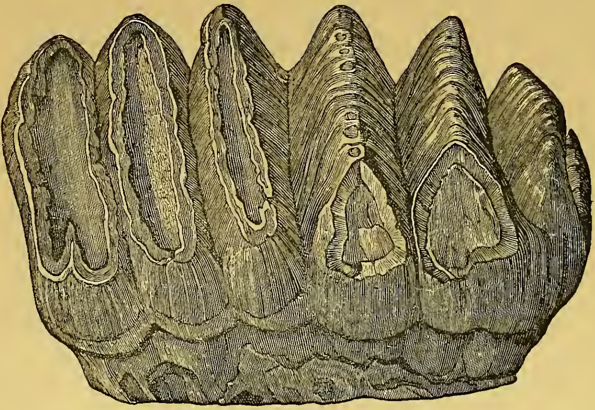
[4] According to Lydekker no premolars have been seen in this species.

[5] *M ? floridanus*, Leidy.

[6] *M. andium*, Cuv. According to the recent researches of Burmeister, this species does not possess mandibular tusks (Sitzungsb. Kön. Preuss. Akad. Wiss., Berlin, 1888, p. 717). Hence the specimen from Mexico with such tusks, reported by Falconer, must be assigned elsewhere.

[7] This species is said by Lydekker not to possess premolars. Leidy, Report U.S. Geol. Surv. Terrs. Pl., figures a tooth as a premolar, and similar specimens are not uncommon.

[8] According to Lydekker, premolars have not been observed.



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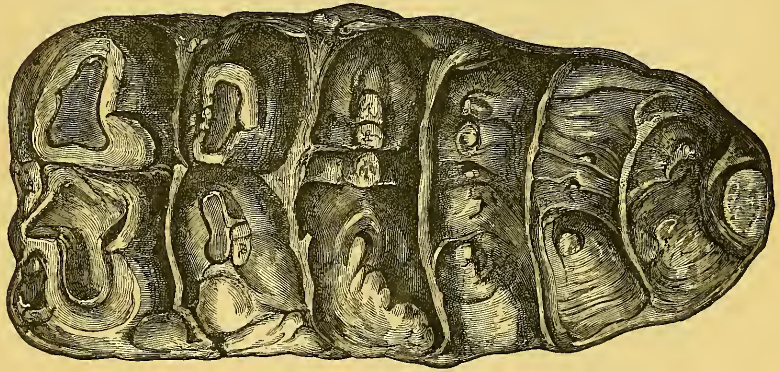


3.

Forms of Proboscidean Molars.

To illustrate Professor E. D. Cope's paper on the Proboscidea.

	Mastodon	*arvernensis*, C. & J. Europe.
	,,	?*punjabiensis*, Lyd. India, *p.*
	,,	*latidens*, Clift. India.
	Emmenodon	*elephantoides*,[1] Clift = *Elephas, Cliftii*. India to Japan.
(*El.*)	,,	*planifrons*, Falc. & Cautl. India.
	Elephas	*bombifrons*, Falc. & Cautl. India, ? China.
	,,	*ganesa*, Falc. & Cautl. India.
	,,	*insignis*, Falc. & Cautl. India to Japan. [N. Africa.
	,,	*meridionalis*, Nesti. Middle and South Europe, aud
	,,	*hysudricus*, Falc. & Cautl. India.
	,,	*antiquus*, Falc. Europe. ? W. Africa.
	,,	*mnaidriensis*, Leith-Adams. Malta.
	,,	*melitensis*, Falc. Malta.
	,,	*namadicus*, Falc. & Cautl. India to Japan.
	,,	*primigenius columbi*, Falc. N.W. America and Mexico.
	,,	,, *primigenius*, Blum. Northern Hemisphere.
	,,	,, *americanus*, De Kay. N.E. America.

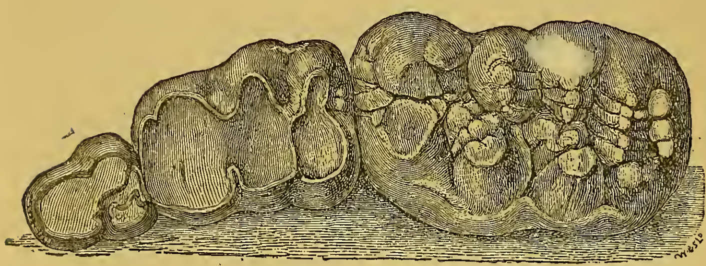


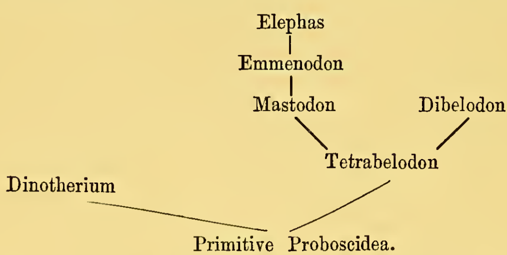
FIG. 2.—*Mastodon longirostris*, Kaup, Upper Miocene, Eppelsheim, Hessen-Darmstadt. (After Gaudry) the left milk-molars (nat. size).

To these we must add the two existing species *Elephas africanus* and *E. indicus*. Several species are not sufficiently known for reference to their proper genus. Such are *Mastodon perimensis*, Falc., Cautl., India; *M. atticus*, Wagn., S. Europe; *M. serridens*, Cope, Texas; *M. cautleyi*, Lyd., India; and *M. obscurus*, Leidy, N. America. In these the characters of both the incisor and the premolar teeth are unknown. In some of the species referred above to Mastodon, mandibular tusks are present in the young, and occasionally one is retained to maturity, as sometimes seen in *M. Americanus*. But such individuals are exceptional among their species. In some other species, while the males possess them, they are wanting in the females. The specific character is in this case derived from the male.

The molar dentition in this family possesses a number of peculiarities which have been worked out mainly by Falconer, Owen, and Lydekker. There are probably deciduous molars in all the species, and they are generally three in number; the posterior of these has the same number of cross-crests as the posterior premolar, which immediately succeeds it. The number of crests diminishes to the first of the series. There are two or three premolars in most

[1] *Mastodon*, Clift.; *Stegodon*, Falc.; *Elephas*, Lyd.

forms of the family, but in the genus *Elephas* they have disappeared. In all the species they are shed early in life in order to make way for the true molars. As the latter teeth are very large, and the fore and aft extent of the jaw is small, there is only space for one or two of them at a time. In most of the species the last molar so much exceeds the others in size, that it occupies the entire jaw, and the other molars are shed in order to accommodate it. In the genera *Tetrabelodon, Dibelodon* and *Mastodon,* the last premolar, and the first and second true molars are isomerous, *i.e.* have the same number of cross-crests. In *Emmenodon* and *Elephas* they are heteromerous; that is, the number of cross-crests successively increases from front to rear. Thus in the three genera named the ridge formula is: P.M. 2–2–3; M, 3–3–4 and P.M. ?–?—4; M. 4–4–5 or 4–5–6. In *Emmenodon* the ridge formula is P.M. ?–?–?–5; M. 6–7—6—7–8; and P.M. ?—6–7; M. 7—8–9—10–12. In *Elephas* the formula extends from M. 6—6–7—8–9, to M. 9–15—14–16—18–27. Each genus then has a certain range of variation in the number of molar crests, extending from a smaller to a larger number. This successive increase in complexity has been regarded by Falconer as the index to the successive evolution of the species, and rightly so. As already remarked, however, other measures of the same succession cannot be overlooked, especially as the ridge formula changes in so gradual a manner as to render it unavailable as a basis of exact divisions, as has been remarked already by Lydekker. It is evident that the primitive Proboscidea had incisor teeth in both jaws, and that these had more or less of the usual enamel investment. The gradual modifications of these features is therefore another indication of the line of descent of these animals. The primitive Proboscidea had likewise four premolars, as is now seen in *Dinotherium.* The successive loss of these teeth is no less an index of the evolution of the modern types of the order, than the other modifications referred to. In general, then, the phylogeny of the order may be represented thus:



Within each genus certain parallel modifications of the composition of the crowns of the molar teeth may be observed. The cross-crests may be single, or they may be divided up into tubercles. The valleys between them may be open, (1) or they may be blocked by (2) a system of single intermediate tubercles; (3) by numerous intermediate tubercles; or (4) by the thickening of the primary tubercles. I arrange the species according to these characters.

	Tetrabelodon.	Dibelodon.	Mastodon.
1.	*T. ? brevidens.*		*M. americanus.*
	T. turicensis.		*M. borsoni.*
			M. latidens.
2.	*T. angustidens.*	*D. shepardi.*	*M. ? cautleyi.*
	T. productus.	*D. cordillerarum.*	*M. falconeri.*
	T. serridens.	*D. tropicus.*	
	T. euhypodon.		*M. arvernensis.*
	T. longirostris.		
3.	*T. campester.*	*D. humboldtii.*	*M. sivalensis.*
	T. pandionis.		*M. punjabiensis.*
4.			*M. mirificus.*
			? M. atticus.

Parallels between the species of *Emmenodon* and *Elephas* also exist. As but two species of the former genus are known, we must look for future discoveries to increase the number of correspondences. The species of both genera which approach nearest to *Mastodon* have a smaller number of cross-crests, which are of lesser elevation,

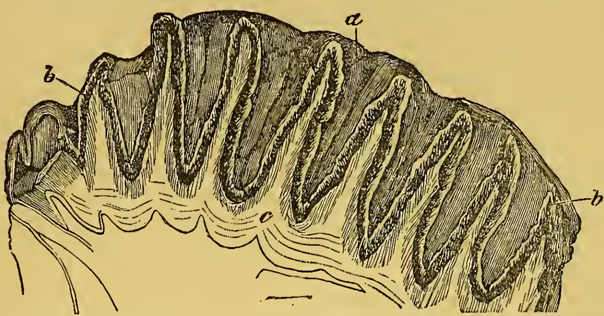


Fig. 3.—*Elephas planifrons*, Falc. & Cautl. Pliocene, Siwalik Hills, India. Vertical longitudinal section of 2nd upper true molar ($\frac{1}{3}$ natural size). *a*, cement; *b*, enamel; *c*, dentine.

and whose intervening valleys are occupied by but a shallow deposit of cementum. These are the *Stegodons* of Falconer; (1). In the other group (2) the crests are numerous and elevated, and their interspaces are filled with cementum.

	Emmenodon.	Elephas.
1.	*E. elephantoides.*	*E. bombifrons.*
		E. ganesa.
		E. insignis.
2.	*E. planifrons* (see Fig. 3).	*E. meridionalis.*
		E. hysudricus.
		E. antiquus, etc.

It is observable that each type of molar teeth of the three genera first compared has representatives in the regions where their species occur: North America, Europe, and India.

The North American species of this family are distinguished by the following characters of the molar teeth[1]."

[1] From the American Naturalist, 1884, p. 524.

I. Intermediate molars with not more than three crests (trilophodont).

α. Crests acute, transverse.

β. Valleys uninterrupted.

Last superior molar with three crests and a heel; crests low, not serrated.—*T. brevidens.*

Last superior molar with four crests and a heel; crests elevated, not serrated.—*M. Americanus.*

ββ. Valleys interrupted.

Edge of crest tuberculate.—*T. serridens.*

αα. Crests transverse, composed of conic lobes.

β. Valleys little interrupted.

Last inferior molar narrow, with four crests; an accessory tubercle in each valley. *D. shepardi.*

β. Valleys interrupted.

Last inferior molar with four crests and a heel; symphysis short, M. 150; smaller size.—*T. euhypodon.*

Last inferior molar with four crests and a cingulum, symphysis longer, M. 280. Size medium.—*T. productus.*

Last inferior molar with five crests and a heel, symphysis very long, M. 450. Size largest.—*T. angustidens.*

'α α α. Crests broken into conic lobes; those of opposite sides alternating.

Last inferior molar narrow, supporting four crests and a heel.—*T. obscurus.*'

II. Intermediate molars with four transverse crests (tetralophodout).

A long symphysis; crests well separated, tubercular, with accessory lobes interruptiug valleys.—*T. campester.*

Symphysis very short; crests thick, closing valleys by contact; no accessory cusps (Leidy).—*M. mirificus.*

III. Intermediate molars with 9–16 crests.

β. Valleys filled with cementum.

Last molar with 18–27 cross-crests.—*Elephas primigenius.*

The stratigraphical position of these species is as follows:—

Pleistocene.
Mastodon americanus.
Elephas primigenius (less abundant).

Pliocene.
Elephas primigenius (more abundant.)
Tetrabelodon serridens (horizon probable).
Dibelodon shepardi

Upper Miocene (Loup Fork).
Tetrabelodon euhypodon.
,, *productus.*
,, *angustidens.*
,, *campester.*
Mastodon mirificus.

Ticholeptus bed.
Tetrabelodon brevidens."

Prof. Cope then proceeds to give an account of the American species, *M.* (*Tetrabelodon*) *obscurus*, Leidy, *M.* (*Dibelodon*) *Shepardi*, Leidy; the latter of which is from the Pliocene of the valley of Mexico. *M.* (*Tetrabelodon*) *brevidens*, Cope, is the oldest North American species, and presents a very simple type of molar: it is from the *Ticholeptus* bed of Montana. *M. Tetrabelodon angustidens*, Cuv., occurs in the Loup Fork beds of Kansas, Nebraska, and Dakota. The molar teeth exceed in size those of the typical European form. "It may become necessary," says Prof. Cope, "to distinguish this form as a species under the name of *Tetrabelodon proavus*." The author adds that, "Probably this species has been recorded by Whitfield from the Phosphate beds of South Carolina, and compared with *M. obscurus*." A figure of the European form is given on p. 447, Fig. 6. *M.* (*Tetrabelodon*) *euhypodon*, Cope, is also from the Loup Fork beds of Kansas, and is known by a nearly perfect left mandibular ramus, with last molar tooth and tusk, and an entire palate with both last molar teeth and tusks. "The superior tusks," says Cope, "are compressed distally, and the inferior tusks are large and have an enamel band; they are cylindric." *M.* (*Tetrabelodon*) *productus*, Cope, is abundant in the Loup Fork beds of New Mexico; it is the only species in which three upper premolars have been demonstrated; other species having generally two. *M. Tetrabelodon campester*, Cope, is a rather large species, with a very long symphysis of the lower jaw and a low ramus. It is in some measure allied to *M.* (*T.*) *longirostris* of Europe, but the symphysis is longer and the teeth more complex. This species is also from the Loup Fork beds of Kansas and Nebraska. *M.* (*Dibelodon*) *Shepardi*, Leidy, was founded on an inferior sixth molar from California. Cope subsequently described other specimens from the Pliocene of Mexico, where it is abundant. *M.* (*Tetrabelodon*) *serridens*, Cope, was founded on a first or second true molar from Texas. It is peculiar among American species in its acute, elevated, entire crests with tuberculo-serrate edges.

Mastodon mirificus, Leidy, is known from a left ramus of a lower jaw which supports the last molar. Its symphysis is short and acute.

"*Mastodon Americanus*, Cuv., is the best known and latest in time of the American elephants. It is one of the largest species, and, after *T. brevidens*, possesses the simplest molar dentition. The symphysis of the lower jaw is short and decurved. The skull is wider and less elevated than that of the Mammoth, and the tusks are shorter and less recurved. It was very abundant during the Pleistocene age throughout North America, from ocean to ocean, and as far south as Mexico; but it has not been found in the latter country. Its remains are usually found in swamps, in company with recent species of Mammalia, and with *Equus fraternus* and *Bos latifrons*, The carbonaceous remains of its vegetable food have been found between its ribs, showing that, like the Mammoth, it lived on the twigs and leaves of trees.

It is at first sight curious that this, the simplest of the family of Elephants in the characters of its molar teeth, appears latest in time on this continent. But it must be regarded as an immigrant from the Old World, where an appropriate genealogy may be traced. Its nearest ally, *Mastodon borsonii*, existed just anterior to it, during the Middle and Upper Pliocene, and this species was preceded in turn in the Middle and Upper Miocene by the *T. turicensis*, which possesses the same simplicity of the molar teeth. In its mandibular tusks the latter possesses another primitive character which was nearly lost by its North American descendant."

"*Elephas primigenius*, Blumenbach, 'the Mammoth,' was at one time distributed throughout North America, as far south as the valley of Mexico inclusive. Its remains are found in the Upper

Pliocene of Oregon, and in the Pliocene of Mexico, unaccompanied by the *Mastodon americanus*, which had not appeared by that time. In the Eastern States its remains occur with those of the *Mastodon*

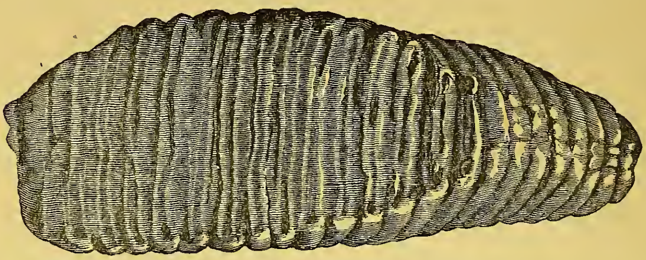


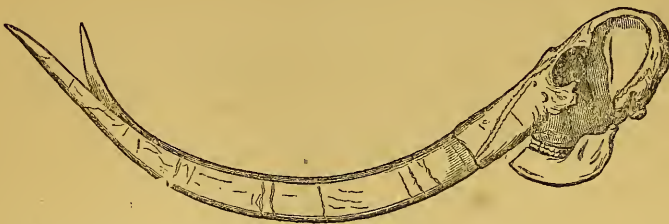
Fig. 4 —*Elephas primigenius*, Blum., the third left upper true molar; dredged off the Dogger Bank, North Sea (one-third nat. size). The lower border of the figure is the inner border of the specimen. Original in British Museum (Nat. Hist.).

americanus at the Big Bone Lick, in Kentucky. It was not found in the Port Kennedy, Pennsylvania, Bone-fissure, although the *Mastodon* was there. This absence may be accidental. Leidy says,[1] The animal (*Elephas primigenius americanus*) was probably of earlier origin, and became earlier extinct than the *Mastodon*, an opinion which my own observations confirm. Since no earlier species of Elephant proper is known from North or South America, we must regard this one as an immigrant from Asia, where, indeed, its remains abound. It remained longer in Siberia than in North America, since whole carcasses have been discovered imprisoned in the ice, near the mouth of the river Lena. These specimens had a covering of long hair, with an under layer of close wool.

Leidy and Falconer have observed that the teeth of the Elephants from eastern North America can be easily distinguished from those of the Mammoth by the greater alternation of the enamel plates. Leidy also observes that the lower jaw is more acuminate in the former. He proposed, therefore, to distinguish it as a species, using Dekay's name *E. americanus*. Teeth from Escholtz Bay, Alaska, he regards as belonging to the true *E. primigenius*.

Falconer regarded the true Elephant of Texas as a distinct species, which he named *E. columbi*. He distinguished it by the coarse plates of the enamel, and by the wide lower jaw, with curved rami, and short symphysis. So far as the dentition goes, I have specimens of this type from Colorado and from Oregon. The Oregon specimen presents the same type of lower jaw as does one from Texas, in my possession. Specimens from the valley of Mexico are abundant in the museums of the city of Mexico, and their characters do not differ from those from Texas. I have in my museum an entire skull, lacking the lower jaw, from the 'orange sand' of the city of Dallas, in north-eastern Texas, which only differs in form from that of the *E. primigenius*, as figured by Blumenbach and Cuvier, in the shorter and wider premaxillary region. This is one-half wider than long (from the molar alveolus), while in the Ilford Mammoth in the

[1] Extinct Mammalia of Dakota and Nebraska, p. 398.



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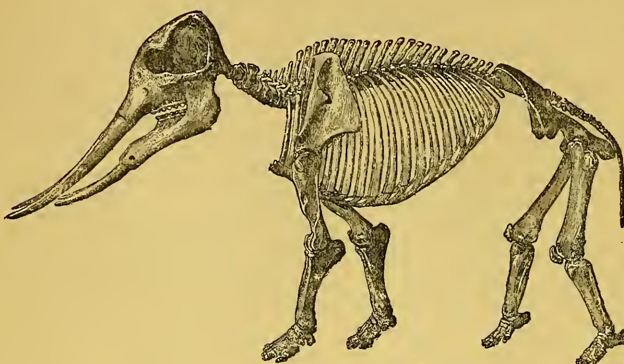

6.

7.

8.

Forms of Skulls and Skeleton of Proboscidea.

British Museum, figured by Leith Adams,[1] the length of this region equals the width. The skull agrees with those of *E. primigenius*, and differs from those of *E. indicus* in the narrow proportions of the posterior part of the cranium. The teeth are of the coarse-plated *E. columbi* type. The individual is not very large, though old. The diameter of the tusks at the alveolus is 110 mm. In a fragment of a huge specimen from south-western Texas, the diameter of the tusk at the base is 210 mm.

As a result it is not clear that the two American forms can be distinguished as yet from the *Elephas primigenius*, or from each other, except as probable sub-species, *E. p. columbi*, and *E. p. americanus*. But more perfect material than we now possess may yet enable us to distinguish one or both of these more satisfactorily. No American species of the family exceeded this one in general dimensions, especially the form *E. p. columbi*."

EXPLANATION OF PLATE XIII. Forms of Proboscidean Molars.

Fig. 1.—*Elephas* (*Emmenodon*) *Cliftii*, Falconer & Cautley. The first (?) left upper true molar in an early stage of wear; from the Siwaliks of Burma ($\frac{1}{2}$ nat. size). The lower border of the figure is the inner border of the specimen. (The original preserved in the Museum of the Geological Society of London.)

Fig. 2.—*Elephas antiquus*, Falconer. The first left upper true molar in a half worn condition; from the Pleistocene of Grays, Essex ($\frac{3}{4}$ nat. size). The lower border of the figure is the inner border of the specimen. (Original preserved in the British Museum, Natural History.)

Fig. 3.—*Mastodon latidens*, Clift. The third left upper true molar of a small individual in a partially-worn condition: from the Pliocene of Borneo ($\frac{2}{3}$ nat. size). The lower border of the figure is the inner border of the specimen.

Explanation of Figures upon Page 447.

Forms of Skulls and Skeleton of Proboscidea.

Fig. 5.—*Elephas ganesa*, Falconer & Cautley. Profile of the skull; from the Siwalik Hills ($\frac{1}{32}$ nat. size). [After Gaudry.] The original preserved in the British Museum (Natural History).

Fig. 6.—*Mastodon* (*Tetrabelodon*) *angustidens*, Cuvier. [After Gaudry.] Middle Miocene, Sansan (Gers), France. The entire skeleton restored and greatly reduced.

Fig. 7.—*Elephas planifrons*, Falc. & Cautl. Profile of skull restored; from the Pliocene of the Siwalik Hills ($\frac{1}{16}$ nat. size). [After Gaudry.]

Fig. 8.—*Mastodon sivalensis*, Cautley. Profile of skull restored; from the Pliocene of the Siwalik Hills ($\frac{1}{16}$ nat. size). [After Gaudry.]

III.—Preliminary Notes on some New and little-known British Jurassic Fishes.[2]

By A. Smith Woodward, F.G.S., F.Z.S.,

Of the British Museum (Natural History).

Since the works of Agassiz and Egerton, few contributions have been made to the knowledge of British Jurassic "Ganoid" and "Teleostean" Fishes, and a considerable amount of undescribed material has thus accumulated in various collections. Much more progress has been made upon the Continent, where the Lithographic

[1] Mon. Pal. Soc. 1879, Brit. Foss. Elephants, p. 69, pl. vi. and vii.

[2] Read before Section C (Geology), British Association, Newcastle, Sept. 1889.

Stones of Bavaria, Würtemberg, and Ain, especially, yield a rich assemblage of forms in a remarkable state of preservation; and it is now an interesting study to compare the British Jurassic fossils with their well-known continental allies. Such an undertaking is facilitated by the recent appearance of Prof. Dr. K. A. von Zittel's admirable critical summary of the extinct Mesozoic fishes;[1] and it is the object of the present notice to offer some preliminary remarks upon a few of the more prominent types observed by the author in English collections.

1. *Eurycormus grandis*, sp. nov.

In 1863, A. Wagner[2] described a genus of fishes from the Lithographic Stone of Eichstädt, Bavaria, under the name of *Eurycormus*, making known a single species, *E. speciosus*; and in 1887, Prof. v. Zittel added some supplementary information to the original diagnosis, while publishing detailed figures of the vertebræ. No precise particulars, however, concerning the cranial osteology and dentition have hitherto been forthcoming; and the recent discovery by Mr. Henry Keeping, in the Kimmeridge Clay of Ely, of a fine head of *Eurycormus*, not only makes known the occurrence of a new species of the genus in England, but reveals structural features of considerable taxonomic significance. The specimen is preserved in the Woodwardian Museum, Cambridge, and the author is indebted to the kindness of Prof. McKenny Hughes, F.R.S., for the opportunity of undertaking a detailed study of its characters. The skull, jaws, and opercular apparatus agree precisely in general form and proportions with the corresponding parts figured in Wagner's typical species, while two anterior vertebræ exhibit the characters assigned to them by v. Zittel. The Ely species, however, is nearly three times as large as the Bavarian form, and differs (according to Wagner's description) in the superficial tuberculation of several of the head-bones; it may therefore receive the distinct specific name of *Eurycormus grandis*. The maxilla is narrow, and its arched margin is provided with a single close series of small slender teeth; the vomerine or palatine bones (or both) bear a cluster of similar teeth of larger size; and the inner side of the mandible seems to be constituted by the splenial element, provided with at least one series of small teeth, while for a short space near the anterior end of each dentary are observed the sockets of about nine large teeth. Each dentary bone is deep and plate-like, and, though much crushed, doubtless inclined inwards in its inferior half; and a very large elongated azygous jugular plate extends between the rami as far back as the suture between the dentary and angular elements. The hyomandibular bone is more lamelliform than in *Pachycormus*, etc., thus more nearly resembling the same bone in *Caturus*, the Leptolepidæ, and modern Teleosteans.

[1] "Handbuch der Palæontologie," vol. iii., pts. i. ii. (1887–88).

[2] A. Wagner, "Monographie der fossilen Fische aus den lithographischen Schiefern Bayerns," Abh. k. bay. Akad. Wiss., cl. ii. vol. ix. (1863), p. 707, pl. iv.

2. *Strobilodus suchoides*, Owen, sp.

An examination of the type-specimen of *Strobilodus giganteus*, Wagner,[1] in the Munich Museum, has convinced the present writer of its generic identity with the so-called *Thlattodus suchoides*, Owen,[2] as already suggested with hesitation by v. Zittel (*loc. cit.* p. 229). One more Bavarian type is thus added to the fish-fauna of the English Kimmeridge Clay; and, as will shortly be pointed out elsewhere, there is evidence of still another British species of the same genus ranging as far upwards as the Purbeck Beds (Brit. Mus. 46,911).

3. *Hypsocormus Leedsi*, sp. nov.

The genus *Hypsocormus* was founded by Wagner in 1863,[3] and, as remarked by v. Zittel, only two species are yet recognized, these being apparently confined to the Bavarian Lithographic Stone. Characteristic portions of the jaws of two other species, however, have been discovered in the Oxford Clay of Peterborough, by Mr. Alfred N. Leeds, of Eyebury, who has kindly entrusted them to the present writer for elucidation; and although the dentition of the genus has not hitherto been described in detail, the recent acquisition by the British Museum of a fine example of *Hypsocormus macrodon* from Solenhofen, renders a direct comparison of actual specimens possible.

The larger species from Peterborough, which may be appropriately named *H. Leedsi*, is represented by the anterior extremity of the snout associated with two fragments of the skull (No. 39, Leeds Coll.), indicating as large a fish as *H. macrodon*. The snout is obviously a compound bone, but the discussion of the homologies of its parts may be deferred. As in the Solenhofen species just mentioned, it is obtusely pointed, the two sides meeting approximately in a right angle at its anterior termination; and the external surface is finely granulated. As in *H. macrodon*, also, there is a pair of large tusk-like teeth, rounded in section, arising from sockets in the middle of the bone; but, whereas in the species just referred to, these "tusks" are directed vertically downwards, in *H. Leedsi* they are much inclined forwards, and, if perfect, would doubtless project beyond the front of the supporting bone. An irregular cluster of small, stout, conical teeth occurs on each side of the central pair, and two of these outer teeth, larger than the others, are placed directly in front.

The abraded anterior extremity of a large right mandibular ramus of *Hypsocormus* in Mr. Leeds' collection (No. 38) also probably pertains to *H. Leedsi*, corresponding to the above-described snout in size; and this fossil is interesting as exhibiting the form and proportions of the splenial element. The dentary constitutes the outer

[1] A. Wagner, "Beitr. Kennt. lith. Schief. Fische," Abh. k. bay. Akad. Wiss., cl. ii. vol. vi. (1851), p. 75, pl. ii.

[2] R. Owen, "On a Genus and Species of Sauroid Fish (*Thlattodus suchoides*, Ow.) from the Kimmeridge Clay of Norfolk," Geol. Mag. Vol. III. (1866), pp. 55–57, Pl. III.

[3] A. Wagner, *loc. cit.* (1863), p. 677.

side of the jaw and exhibits the abraded remains of a series of teeth, of moderate size, firmly implanted in sockets; while the splenial is a short, stout, lenticular bone, perhaps entering somewhat into the symphysis, but having its thickest portion immediately behind, supporting two great rounded tusks, in sockets, accompanied in front and behind by an irregular cluster of relatively minute stout conical teeth.

4. *Hypsocormus tenuirostris*, sp. nov.

The second species of *Hypsocormus* in Mr. Leeds' collection is represented by an imperfect snout, associated with a right maxilla and portions of splenial and dentary bones (No. 40). The original fish must have attained only about half the size of the typical specimen of *H. Leedsi*; and it is readily distinguished by the narrow, somewhat elongated, and acutely pointed form of the snout, which, however, exhibits the characteristic superficial granulations. The pair of tusk-like teeth is placed relatively further backwards than in *H. macrodon* and *H. Leedsi*, and seems to have been directed more nearly vertically than in the latter species; so far as can be ascertained, a single irregular series of teeth of small size also occupies the margin of either side, being accompanied only by few minute teeth. The maxilla is very slender, externally tuberculated, and provided with a single series of teeth of moderate size, well-spaced and nearly uniform, and flanked externally by a few minute teeth; the anterior end of the bone terminates in a stout, smooth projection, slightly directed inwards. The portions of dentary bones are somewhat broken, but this element is stouter and larger than the maxilla, provided with a single spaced series of much larger teeth, irregular in size, the most powerful being situated in the front portion of the posterior half of the bone; a cluster of minute teeth also occupies the whole of the external margin. As in the other species of *Hypsocormus*, all the teeth are oval or round in section, not keeled, though more or less vertically striated; and the enamelled apex often occupies less than half of the exserted portion.

So far as can be ascertained from the foregoing specimens, there is a singular resemblance between the dentition of *Hypsocormus* and that of the long-snouted *Protosphyræna* of the Upper Cretaceous. In the last-named genus there are two great upper teeth at the base of the snout,[1] while two equally large teeth occur on either side of the lower jaw near its anterior extremity; the latter, moreover, are similarly fixed in a short stout, lenticular splenial bone immediately behind the mandibular symphysis.[2]

It may be added that the genus *Hypsocormus* also occurs in the Kimmeridge Clay of Weymouth, portions of jaws being preserved in the British Museum (No. 42,368).

5. *Leedsichthys problematicus*, gen. et sp. nov.

For some years Mr. Alfred N. Leeds, of Eyebury, has obtained

[1] W. Davies, Geol. Mag. Dec. II. Vol. V. (1878), Pl. VIII. Fig. 3.
[2] F. Dixon, "Geol. and Foss. Sussex" (1850), pl. xxxi. fig. 12.

from the Oxford Clay of the neighbourhood of Peterborough a number of large bones of fibrous texture, and often of indefinite form, pertaining to some hitherto unknown extinct vertebrate. The flatter bones were considered by Mr. Hulke, in 1887, as not improbably referable to the dermal armature of a Dinosaur;[1] but, on visiting the collection in 1888, Prof. Marsh expressed the opinion that the remains were piscine, being unlike any of the numerous types of Dinosaurian dermal armour met with in America. At the beginning of the present year,[2] the writer of this note mentioned the possibility of these fossils indicating the presence of a large Acipenseroid fish in the Upper Jurassic rocks; and it is proposed in the following pages briefly to discuss the few facts already available for consideration. One set of bones undoubtedly pertains to a single individual, and is thus of great value; but many of the fragments are scattered, and, if the interpretations now to be suggested prove correct, the axial skeleton of the trunk still remains to be discovered. No known specimens exhibit any traces of superficial ornamentation, and, though often massive, all the elements have the characteristic fibrous texture of fish-bone.

The associated series of bones just mentioned was spread over an area of probably not less than twelve square yards, and the principal specimens may be enumerated and determined as follows:

1. A large, oblong, flattened bone, of the kind already described by Mr. Hulke. It measures 2 ft. (0·61 m.) in length by 1 ft. 3in. (0·38 m.) in maximum breadth, is of a squamous character, thinning at each margin, and consists of two thin hard layers separated by a middle layer of soft diploë. In form and characters the bone is very suggestive of a *frontal* element.

2. An elongated bone, 1 ft. 8in. (0·58 m.) in length, somewhat broader at one extremity than at the other. One long margin is thickened and rounded, while the other is a thin edge; and the broader extremity is thicker than the narrower. This may perhaps be identified as *angular*.

3. An elongated bone, 1 ft. 3in. (0·38 m.) in length, and the broader extremity of the corresponding element of the opposite side. This is probably the *hyomandibular*. The supposed upper extremity is somewhat expanded, and near this end on the posterior outer margin is a small facette, evidently for the operculum. For two-thirds of its width the bone is thick, but the anterior third is thin, as is also the inferior extremity.

4. Portions of four long narrow bones, the largest being 2 ft. 5in. (0·735 m.) in length, and not more than $3\frac{1}{2}$ in. (0·09 m.) in maximum width. Each bone is comparatively hard, irregularly ≺-shaped in transverse section, and seems most nearly paralleled by the ossifications of the *branchial arches* in Teleosteans.

5. A very large number of small, narrow, elongated bones of peculiar shape, probably to be regarded as *gill-rakers*. The largest

[1] J. W. Hulke, "Note on some Dinosaurian Remains in the Collection of A. Leeds, Esq.," Quart. Journ. Geol. Soc., vol. xliii. (1887), p. 702.

[2] Smith Woodward, "On the Palæontology of Sturgeons," Proc. Geol. Assoc., vol. xi. (1889), p. 31.

of these are about 3in. (0·075 m.) in length, and ⅓in. (0·010m.) in width. Each is laterally compressed, slightly expanded at one extremity, and rarely straight, but irregularly bent or contorted. The surface is coarsely rugose, and one long border is rounded, while the other is cleft by a longitudinal median furrow. The rounded border is comparatively smooth, but the furrowed edge is coarsely serrated, a series of short oblique ridges terminating in points on each side.

6. Portion of a large squamous bone, longer (deeper) than broad, with one long margin thickened, rounded, and concavely arched. A nearly complete example of the same element, doubtfully forming part of the series, measures 2ft. 9in. (0·838m.) in length, and suggests that it may be identified either with the *preoperculum* or *clavicle.*

7. Portions of eleven very dense, large, rib-shaped bones, only superficially ossified at the broader extremity, but terminating in a well-formed point at the distal end. These bones are rounded or irregularly quadrangular in section, are more or less arched, and vary considerably in relative width or thickness. The broadest and stoutest specimen is much arched, 1ft. 5in. (0·43 m.) in length; and a nearly perfect detached example of the same bone shows that this wants a length of at least 8in (0·23m.) at the pointed extremity. The largest bone measures 2ft. 4in. (0·712m.) in length, and is straightened; while the smaller examples are more curved and more rounded in section. These bones were evidently arranged in not less than six pairs, and Mr. Leeds' suggestion seems most plausible, that they are the *branchiostegal rays* of the fish.

8. The *fin-rays* are most remarkable, and, judging from the position in which they were discovered, the known specimens may all probably be assigned to the pectoral fin. They consist of fibrous bone, and appear as if composed of numerous long, tapering bony splints, incompletely fused together. The two halves of each ray remain separate, and in some cases they have been proved to attain a length of not less than 5ft. (1·525m.). There are no transverse joints, but all the rays exhibit numerous bifurcations, and Mr. Leeds estimates that the distal extremity of each of the largest becomes divided into at least thirty-two small branches.

Smaller more slender fin-rays, probably of the same type of fish, have also been discovered in the Oxford Clay of the same locality. These are gently rounded and transversely articulated, thus suggesting that the specimens just noticed are characteristic only of a powerful pectoral.

As already mentioned, many other detached bones, undoubtedly of the same genus and species, occur in Mr. Leeds' collection; but, of the elements not described above, the form is so indefinite as to render their determination very uncertain. If, however, the few suggestions here propounded are eventually confirmed, it is obvious that many hard parts of the fish still remain to be discovered. No known fish with ossifications of the branchial arches and branchiostegal membrane of the kind here described is destitute of at least some ossifications in the axial skeleton of the trunk; and it will be strange, indeed, if a monster with such powerful pectoral fins does not prove to have been possessed of a formidable dentition. It is satisfactory to know that there is good reason to hope for the discovery of much more of the skeleton of the individual discussed above, as soon as the bed where it occurs is worked again; and Mr. Leeds is fortunately acquainted with the precise stratum where the specimen occurs.

The characters of the gill-rakers, branchiostegal rays, and pectoral fin-rays, taken together, justify the definite separation of the fish in question from all known generic types; and it is proposed to apply to it the name of *Leedsichthys* in honour of its discoverer. The Peterborough species may be provisionally termed *Leedsichthys problematicus*, and it is probably the most gigantic Jurassic fish hitherto described.

A group of the characteristic gill-rakers, of equally large size, has also been obtained from the Oxford Clay of Vaches Noires (Brit. Mus. No. 32,581), thus indicating the occurrence of the genus in the Upper Jurassic of the North of France.

6. *Mesodon.*

The genus *Pycnodus*, as now defined, is restricted to the Eocene formations, and all the British Mesozoic fossils originally described under that name are to be distributed among the more precisely defined genera determined on the continent. This is a difficult task, so far as the Jurassic species are concerned, for little more than detached examples of jaws and teeth are known, and there is apparently considerable variation in these parts. The so-called *Pycnodus pagoda*, Blake,[1] from the Portlandian, is evidently a vomer of *Microdon*; but nearly all the other described British Jurassic "species" of *Pycnodus* pertain to *Mesodon*. Fricke, v. Zittel, and others, have already pointed out that to this genus may be referred the Agassizian species *P. Bucklandi*, *P. ovalis*, and *P. rugulosus*, and to the synonymy of the first we would add *P. didymus*, Ag., *P. obtusus*, Ag., and *Gyrodus perlatus*, Ag. The latter name is given to some detached scales from the Stonesfield Slate, ornamented by tubercles instead of rugosities or pits, thus being truly referable to *Mesodon*, and agreeing sufficiently in size with the associated jaws of *M. Bucklandi* to be provisionally ascribed to that form. To *M. rugulosus* we would also assign the undescribed *Pycnodus parvus*, Ag., of which a specimen marked as "type" is in the Egerton Collection. Some so-called species of *Gyrodus*, e.g. *G. trigonus*, Ag., are also most probably referable to the same genus; and the Liassic *Pycnodus liassicus*, Egert., was long ago placed in *Mesodon* by Heckel.

7. *Thrissops.*

Since the researches of Agassiz, Münster, Wagner, and Thiollière, so many Jurassic examples of the genus *Thrissops* have been acquired by various Museums, that it would be interesting to study the characters of the specific types already determined in the light of the new material before making any further additions to the

[1] J. F. Blake, "On the Portland Rocks of England," Quart. Journ. Geol. Soc., vol. xxxvi. (1880), p. 228, pl. x. fig. 10.

nomenclature of the group. In recording the occurrence of the genus in the English Jurassic, it must therefore suffice to remark that the British Museum possesses characteristic remains of a species as large as *T. Heckeli*, Thioll.,[1] from the Kimmeridge Clay of Dorsetshire (B.M. Nos. P. 922, P. 3686, P. 6031); while a nearly complete example of a much smaller species has been obtained from the Portland Stone of the Isle of Portland (B.M. No. P. 5538).

8. *Browneichthys ornatus*, gen. et sp. nov.

In the series of vertebrate fossils from the Lower Lias of Barrow-on-Soar, recently obtained for the Leicester Museum by Mr. Montagu Browne, F.Z.S., is an interesting small fish, apparently of a new generic type, which the present writer has been favoured with the privilege of examining. The specimen is only about 0·06 in length, displaying portions of the head and trunk; but, notwithstanding its imperfections, it seems worthy of brief notice as being so different from anything hitherto known. The fish must have been originally elongated in form; and the hinder portion of the head, preserved as far forwards as the front margin of the orbit, suggests the attenuation of the snout. The space occupied by the notochord is vacant, indicating its persistence, but the neural and hæmal arches are well ossified superficially, and there is no evidence of elongated, well-developed ribs. The bones of the head are invested with ganoine, and ornamented with large tuberculations; and at least the front portion of the trunk is covered with thin, deeply-overlapping scales, oval or round in shape, with prominent concentric lines of growth, and externally ornamented with large ganoine tubercles. Three or four relatively large, narrow, pointed ridge-scales, above and below, also indicate a partial or continuous armature of the dorsal and ventral margins. Of the dentition and the fins, nothing can be ascertained from the fossil now described; and although a series of eight slender bones shortly behind the occiput may possibly be the interspinous bones of a dorsal fin, it will be well to await the discovery of other specimens before attempting their interpretation.

So far as can be determined, the new Barrow fossil thus most nearly approaches the early Mesozoic Ganoids, *Belonorhynchus* and *Saurichthys*. From these, however, and from other types with a persistent notochord, it is generically distinguished by the squamation; and employing the discoverer's name, the new form may be termed *Browneichthys*. The type-species may be known as *B. ornatus*.

IV.—An Analysis of The Fullers Earth of Nutfield.

By P. Gerald Sanford, F.I.C., F.C.S.,

Royal School of Mines, London.

During June last I visited the Fullers Earth Pits at Nutfield, near Redhill, Surrey, with the London Geological Field Class, when Professor Seeley suggested to me that I should make an

[1] V. Thiollière, "Poiss. Foss. Bugey," pt. i. (1854), p. 27, pl. x. fig. 1.

analysis of the deposit. This I have been enabled to do through the kindness of the manager (A. Sheridan, Esq.), who was good enough to send me a series of samples of the earth, and the various products prepared from it. The Nutfield Fullers Earth is a heavy blue or yellow clay, with a greasy feel and an earthy fracture. The sample No. 1 contained 27·47 per cent. and No. 2, 29·56 per cent. of water before drying.

No. 1. Blue Earth.

Dried at 100° C				Insoluble Residue.	
Insoluble Residue	= 59·96 per cent. =			SiO_2	= 52·81 per cent.
Iron (Fe_2O_3)	= 2·48			Al_2O_3	= 3·46 ,,
Alumina (Al_2O_3)	= 3·46			Fe_2O_3	= 1·30 ,,
Lime, CaO	= 5·87			CaO	= 1·53 ,,
Magnesia, MgO	= 1·41			MgO	= 0·86 ,,
Phosphoric acid, P_2O_5	= 0·27	Soluble			
Sulphuric acid, $S\ O_3$	= 0·05	in acid.			59·96
Sodic chloride, NaCl	= 0·05				
Alkalies, K_2O	= 0·74				
Combined water	= 14·27				

No. 2. Yellow Earth.

Dried at 100° C				Insoluble Residue.	
Insoluble Residue	= 76·13 per cent. =			Silica	= 59·37 per cent.
Iron, Fe_2O_3	= 2·41			Al_2O_3	= 10·05 ,,
Alumina	= 1·77			Fe_2O_3	= 3·86 ,,
Lime, CaO	= 4·31			CaO	= 1·86 ,,
Magnesia, MgO	= 1·05			MgO	= 1·04 ,,
P_2O_5	= 0·14	Soluble			
SO_3	= 0·07	in acid.			76·18
Salt, NaCl	= 0·14				
Alkalies, K_2O	= 0·84				
Combined water	= 13·19				
	100·05				

V.—Analysis of the Gault and Greensand.

By P. Gerald Sanford, F.I.C., F.C.S.,

Metallurgical Laboratory, Royal School of Mines.

THE sample of Gault, of which the analysis is given below, was obtained from the Clay Pits at Dunton Green, which I visited with the "London Geological Field Class" during June last. At this place the Gault rests upon a bed of reddish yellow sand (Lower Greensand), which is mixed in certain proportions with the Gault clay to form bricks. This sand, of which I also give an analysis, is very moist when first taken from the bed, but very rapidly becomes dry, upon exposure to the air, so that it afterwards loses very little more water at 100°C. The Gault, as taken from the pit, contained 26·68 per cent of moisture, but upon ignition of the dried substance, in a muffle furnace, it becomes so hard that it will scratch glass easily.

ANALYSIS OF GAULT.

	Dried at 100°C.		Insoluble Residue.
Insoluble Residue	= 65·01 per cent =		Silica, SiO_2 = 46·43 per. cent.
Ferric oxide, Fe_2O_3	= 7·92	Soluble in acid.	Fe_2O_3 = 2·05 ,,
Alumina, Al_2O_3	= 3·40		Al_2O_3 = 15·41 ,,
Magauese oxide, MnO.	= trace		CaO = 0·88 ,,
Lime, CaO	= 5·90		MgO = 0·24 ,,
Magnesia, MgO	= 0·75		65·01
Sodium chloride	= 0·05		
Phosphoric acid, P_2O_5	= 0·11		
Sulphuric acid, SO_3	= 0·19		
Carbonic acid, CO_2	= 6·09		
K_2O, and Na_2O	= 0·07		
Combined water	= 10·48		
	99·97		

ANALYSIS OF GREENSAND.

	Dried at 100°C.	
Silica, SiO_2 ...	= 98·80 per cent.	
$Fe_2O_3 + Al_2O_3$	= 0·47	Soluble in acid.
Lime, CaO	= 0·09	
Magnesia, MgO	= 0·05	
Sulphuric acid, SO_3	= trace	
Combined water	= 0·42	
	99·83	

NOTICES OF MEMOIRS.

D. STUR ON BRITISH COAL-PLANTS.

I.—MOMENTANER STANDPUNKT MEINER KENNTNISS ÜBER DIE STEINKOHLENFORMATION ENGLANDS. Von D. STUR. Jahrbuch der k. k. Geolog. Reichsanstalt, 1889, Bd. xxxix. 1 u. 2 Heft. pp. 1–20.

HERR D. STUR, the Director of the Geological Survey of Austria, took advantage of his visit to the International Geological Congress last year, to study in the field and in some of the principal museums, the flora of the British Carboniferous strata, and the present paper contains in a condensed form the results of his observations and his views of the relative age of our different coal-fields, as compared with the beds on the Continent, and more particularly with those of the Moravian-Bohemian-Silesian area. The following are the conclusions arrived at by the author:—

I. In Britain, the first or oldest Culm-flora of the Culm-roofing shales, specially occurs in the great Scotch basin, in the Burdie-House limestones, in the Carboniferous shale of Slateford, and in the Calciferous sandstone. In Devonshire, on the other hand, the Culmdackschiefer is represented by the "Lower Culm-measures" near Bideford, whilst the "Upper Culm-measures" belong to the Lower Carboniferous, and are identical with the Schatzlarer beds.

II. The second Culm-flora, or that of the Ostrauer beds, is probably quite absent in England, and not a single characteristic species was met with. It is probable that the great band of the Millstone-grit, which in the Pennystone and Barnsley district is beneath the horizon of the Schatzlarer beds, may represent the Ostrauer deposits, and in this case the second Culm-flora might be looked for in the thin Coal-seams occasionally occurring in the Millstone-grit. It is further possible that the Coal-measures of the Scotch basin may correspond with the Silesian Ostrauer beds.

III. The greater part of the coals obtained in England are from the horizon of the Schatzlarer beds. To this horizon belong the Coal-areas of Newcastle-on-Tyne, Leeds, Pontefract, Barnsley, Sheffield, Derby, Leicester, Dudley, Coalbrook-Dale, Newcastle-under-Lyme, Manchester, Oldham, Lancaster, and of Whitehaven and Wigton.

IV. The Upper Carboniferous horizon of the Bohemian Rossitzer beds occurs in England in the area of the Bristol Channel, near Bristol and Radstock, and in the vicinity of Merthyr Tydvil, over Swansea to Caermarthen; and more to the north the Coal-fields of the Forest of Dean, the Forest of Wyre and near Wigan, belong to this same Upper Carboniferous horizon.

V. It is remarkable that up to the present no trace of the presence of this Upper Carboniferous horizon has been met with to the east of the great band of Millstone-grit, and in this respect there is a striking correspondence with the Coal-fields of Westphalia, Belgium and Northern France, which belong to the Schatzlarer horizon, and in which the Upper Carboniferous Rossitzer beds are not represented.

VI. The Upper Carboniferous, on the other hand, occurs in Central France, Bohemia and Saxony, also in Banate, and frequently unconformably on much older strata. Thus, also in the line from Swansea, Bristol, Forest of Dean to Shrewsbury the Upper Carboniferous beds are in places unconformably deposited on older strata.

VII. Further, there is in England no trace of the horizon of the Schwadowitzer beds of north-eastern Bohemia, of the Saxon beds of Oberhohndorf near Zwickau, nor of the Radnitzer and Zemech beds. These horizons may probably be looked for where the beds of Schatzlarer approach those of the Upper Carboniferous, as at Wigan and at Coalbrook-Dale.

VIII. It may be concluded from the absence of particular beds in the Carboniferous series of England, France, Belgium and Westphalia, that great changes in the configuration of the land took place during the deposition of the Coal and its associated beds; that they were by no means continuously laid down; and that the changes in the flora of the individual horizons indicate enormously prolonged intervals of time for their production.

The author further adds short critical notices of the more important species of fossil plants in the Hutton Collection, now preserved in the Museum at Newcastle-on-Tyne.

II.—The Geology of London and of Part of the Thames Valley. By William Whitaker, F.R.S.

UNDER the above title there has just been published a Geological Survey Memoir (in two volumes), which gives a very full and detailed account of the geology of the district. Vol. i. Descriptive Geology, pp. xii. 556, folding table, price 6*s.*; and vol. ii. Appendices (well-sections, etc.), pp. iv. 352, price 5*s.* We hope in a future number, after H.M. Government has presented us with a review-copy, to give some account of this important work, which, to say the least of it, offers a large amount of material for study and for reference at an unusually low (official) price.

REVIEWS.

The Ganoids of the German Muschelkalk. "Die Ganoiden des deutschen Muschelkalks." By Prof. Dr. W. Dames. Palæontologische Abhandlungen, Band IV. Heft 2 (1888), pp. 133–180, pls. xi.–xvi*a*.

TO any one accustomed to the writings of Agassiz, Count von Münster, H. von Meyer, and others, upon the fossil fish remains of the Muschelkalk, Prof. Dames' memoir will come as a pleasant surprise. Instead of a series of scattered teeth and scales, the Professor has brought together from various museums a number of valuable specimens affording some real insight into the characters of the Mid-Triassic Ganoids; and the detailed descriptions and discussion of these fossils are illustrated by seven fine plates. The specimens were almost exclusively obtained from the extra-Alpine Muschelkalk, and are referable to the genera *Gyrolepis*, Agassiz; *Colobodus*, Agassiz; *Crenilepis*, Dames; and *Serrolepis*, Quenstedt.

The reference of *Gyrolepis* to the Palæoniscidæ is confirmed by several fine fossils, and a definition of the genus can at last be attempted. The mandibular suspensorium is very oblique, and the operculum extremely elongated vertically; the teeth are long, slender, and conical; the dorsal fin is smaller than the anal, and situated opposite or in advance of this; there are small fulcra upon each of the fins; most of the pectoral fin-rays are not articulated; and the two infraclaviculars are fused together. This genus is the only Palæoniscid yet described from the European Trias, and Prof. Dames recognizes four species, as follows: *G. Agassizii* (Münster), and *G. ornatus* (Giebel), from the Lower Muschelkalk, *G. Albertii*, Agassiz, from the Upper Muschelkalk, and *G. Quenstedti*, Dames, from the Lettenkohle.

Gyrolepis Agassizii has until now been assigned either to *Amblypterus* or *Rhabdolepis*; but a comparison of the well-preserved type-specimen with more recently discovered examples of *Gyrolepis* proper definitely decides its generic position, and the characters of the scale-ornament determine its specific distinctness. *G. ornatus* has also been hitherto referred to *Amblypterus*, and the type-specimen, now figured for the first time, remains unique. *G. Albertii* is no longer known merely from detached scales, but is represented by the anterior portion of a fish and two examples of the head; and Dr. Dames points out that some of the scales have been named *G. maximus*, Ag., and *G. tenuistriatus*, Ag. *G. Quenstedti* is a new species, founded upon the hinder portion of a fish, remarkable for the great length of the anal fin and the comparatively remote situation of the dorsal.

The genus *Colobodus* proves to be a Lepidosteoid Ganoid related to *Lepidotus*, and having no connection with the Pycnodonts, to which it is commonly assigned. It differs from *Lepidotus*, so far as known, in the presence of an apical tubercle upon the rounded teeth, in the prominence of the scale-ornament, and in the depressed form of the head. Considerable variation, however, is exhibited in the five recognized species; and while relegating *Dactylolepis*, *Nephrotus*, and *Asterodon* to the synonymy, Dr. Dames suspects that future discoveries may possibly justify the retention of the two first-mentioned names for the peculiar species to which they were originally applied. The fins and the precise form of the trunk are still unknown in all the species: but tolerably complete specimens of the squamation and dentition are described, and these lead to a considerable reduction in the number of "species" based upon isolated scales and teeth.

A new genus and species, *Crenilepis Sandbergeri*, is founded upon a well-preserved portion of the squamation of a large fish from the Upper Muschelkalk of Krainberg, evidently related to the earlier Lepidosteoids, and distinguished by the form and ornamentation of the scales. In the anterior part of the flank, the scales are very much deeper than broad; and those of all parts are externally sculptured with a number of delicate branching furrows.

The type-species of the genus *Serrolepis*, Quenstedt, from the Lettenkohle, is now named *S. suevicus*; but only scattered scales are known, and Dames doubtfully associates with this fish a fragment of jaw, with stout styliform teeth, discovered upon the same slab of stone. On the whole, the genus seems most probably allied to *Dapedius*.

In conclusion, Dr. Dames discusses an interesting problematical fish from the Upper Muschelkalk of Brunswick, not yet determinable, but in some respects suggestive of close relationship with the Semionotidæ. A summary of results then follows, and it is interesting to note how the distribution of species of Ganoids in the Muschelkalk agrees well with that of the Crinoids and the Cephalopods, the Lower, Middle, and Upper divisions being distinctly separated, and also the overlying Lettenkohle.

A brief appendix records the occurrence of other well-preserved Ganoids in the same formation, including probably a new Palæoniscid genus, a new species of *Gyrolepis*, and a fish allied to *Pholidophorus*. These, and any other materials with which the author may be favoured, will form the subject of a second memoir to which we look forward with considerable interest. A. S. W.

REPORTS AND PROCEEDINGS.

Fifty-ninth Annual Meeting of the British Association for the Advancement of Science.

Newcastle-upon-Tyne, 1889.

Address to the Geological Section of the British Association. By Professor James Geikie, LL.D., F.R.SS. L. & E., F.G.S., President of the Section, September 12th, 1889.

AFTER some introductory remarks, Prof. James Geikie said: Perhaps there is no department of geological inquiry that has given rise to more controversy than that of Glacial Geology, which I have selected for the subject of this address. Hardly a single step in advance has been taken without vehement opposition. But the din of contending sides is not so loud now—the dust of the conflict has to some extent cleared away, and the positions which have been lost or maintained, as the case may be, can be readily discerned. The glacialist who can look back over the last twenty-five years of wordy conflict has every reason to be jubilant and hopeful. Many of those who formerly opposed him have come over to his side. It is true he has not had everything his own way. Some extreme views have been abandoned in the struggle; that of a great polar ice-sheet, for example, as conceived by Agassiz. I am not aware, however, that many serious students of Glacial Geology ever adopted that view. But it was quite an excusable hypothesis, and has been abundantly suggestive. Had Agassiz lived to see the detailed work of these later days, he would doubtless have modified his notion, and come to accept the view of large continental glaciers which has taken its place.

The results obtained by geologists, who have been studying the peripheral areas of the drift-covered regions of our continent, are such as to satisfy us that the drifts of those regions are not iceberg-droppings, as we used to suppose, but true morainic matter and fluvio-glacial detritus. Geologists have not jumped to this conclusion—they have only accepted it after laborious investigation of the evidence, Since Dr. Otto Torell, in 1875, first stated his belief that the "diluvium" of North Germany was of glacial origin a great literature on the subject has sprung up, a perusal of which will show that with our German friends Glacial Geology has passed through much the same succession of phases as with us. At first icebergs are appealed to as explaining everything—next we meet with sundry ingenious attempts at a compromise between floating-ice and a continuous ice-sheet. As observations multiply, however, the element of floating-ice is gradually eliminated, and all the phenomena are explained by means of land-ice and "schmelz-wasser" alone. It is a remarkable fact that the iceberg hypothesis has always been most strenuously upheld by geologists whose labours have been largely confined to the peripheral areas of drift-covered countries. In the upland and mountainous tracts, on the other hand, that hypothesis has never been able to survive a moderate amount of accurate observation. Even in Switzerland—the land of glaciers—geologists at one time were of opinion that the Boulder-clays of the low grounds had a different origin from those which occur in the mountain-valleys. Thus it was supposed that at the close of the Pleistocene period the Alps were surrounded by great lakes or gulfs of some inland sea, into which the glaciers of the high valleys flowed and calved their icebergs—these latter scattering erratics and earthy débris over the drowned areas. Sartorius von Waltershausen[1] set forth this view in an elaborate and well-illustrated paper. Unfortunately for his hypothesis, no trace of the supposed great lakes or inland sea has ever been detected—on the contrary, the character of the morainic accumulations, and the symmetrical grouping and radiation of the erratics and perched blocks over the foot-hills and low grounds, show that these last have been invaded and overflowed by the glaciers themselves. Even the most strenuous upholders of the efficacy of icebergs as originators of some Boulder-clays admit that the Boulder-clay or till, of what we may call the inner or central region of a glaciated tract, is the product of land-ice. Under this category comes the Boulder-clay of Norway, Sweden, and Finland, and of the Alpine lands of Central Europe, not to speak of the hilly parts of our own islands.

When we come to study the drifts of the peripheral areas it is not difficult to see why these should be considered to have had a different origin. They present certain features which, although not absent from the glacial deposits of the inner region, are not nearly so characteristic of such upland tracts. I refer especially to the frequent interstratification of Boulder-clays with well-bedded deposits of clay, sand, and gravel; and to the fact that these Boulder-clays are often less compressed than those of the inner region, and have even occasionally a somewhat silt-like character. Such appearances do seem at first to be readily explained on the assumption that the deposits have been accumulated in water opposite the margin of a continental glacier or ice-sheet—and this was the view which several able investigators in Germany were for some time inclined to adopt.

But when the phenomena came to be studied in greater detail, and over a wider area—this preliminary hypothesis did not prove satisfactory. It was discovered, for example, that "giants' kettles"[2] were more or less commonly distributed under the glacial deposits, and such "kettles" could only have originated at the bottom of a glacier. Again it was found that pre-Glacial accumulations were plentifully developed in certain places below the drift, and were often involved with the latter in a remarkable way. The "brown-coal-formation" in like manner was violently disturbed and displaced, to such a degree that frequently the Boulder-clay is found to underlie

[1] Untersuchungen über die Klimate der Gegenwart und der Vorwelt, etc. Natuurkundige Verhandelingen v. d. Holland. Maatsch. d. Wetensch. te Haarlem, 1865

[2] These appear to have been first detected by Professor Berendt and Professor E. Geinitz.

it. Similar phenomena were encountered in regions where the drift underlies the Chalk—the latter presenting the appearance of having been smashed and shattered—the fragments having often been dragged some distance, so as to form a kind of friction-breccia underlying the drift, while large masses are often included in the clay itself. All the facts pointed to the conclusion that these disturbances were due to tangential thrusting or crushing, and were not the result of vertical displacements, such as are produced by normal faulting, for the disturbances in question die out from above downwards. Evidence of similar thrusting or crushing is seen in the remarkable faults and contortions that so often characterize the clays and sands that occur in the Boulder-clay itself. The only agent that could produce the appearances now briefly referred to is land-ice, and we must therefore agree with German geologists that glacier-ice has overflowed all the drift-covered regions of the peripheral area. No evidence of marine action in the formation of the stony clays is forthcoming—not a trace of any sea-beach has been detected. And yet, if these clays had been laid down in the sea during the retreat of the ice-sheet from Germany, surely such evidence as I have indicated ought to be met with. To the best of my knowledge the only particular facts which have been appealed to, as proofs of marine action, are the appearance of bedded deposits in the Boulder-clays, and the occasional occurrence in the clays themselves of a sea-shell. But other organic remains are also met with now and again in similar positions, such as mammalian bones and fresh-water shells. All these, however, have been shown to be derivative in their origin—they are just as much erratics as the stones and boulders with which they are associated. The only phenomena, therefore, that the glacialist has to account for are the bedded deposits which occur so frequently in the Boulder-clays of the peripheral regions, and the occasional silty and uncompressed character of the clays themselves.

The intercalated beds are, after all, not hard to explain. If we consider for a moment the geographical distribution of the Boulder-clays, and their associated aqueous deposits, we shall find a clue to their origin. Speaking in general terms the stony clays thicken out as they are followed from the mountainous and high-lying tracts to the low ground. Thus they are of inconsiderable thickness in Norway, the higher parts of Sweden, and in Finland, just as we find is the case in Scotland, Northern England, Wales, and the hilly parts of Ireland. Traced south from the uplands of Scandinavia and Finland, they gradually thicken out as the low grounds are approached. Thus in Southern Sweden they reach a thickness of 43 metres or thereabout, and of 80 metres in the northern parts of Prussia, while over the wide low-lying regions to the south they attain a much greater thickness—reaching in Holstein, Mecklenburg, Pomerania, and West Prussia a depth of 120 to 140 metres, and still greater depths in Hanover, Mark Brandenburg, and Saxony. In those regions, however, a considerable portion of the "diluvium" consists, as we shall see presently, of water-formed beds.

The geographical distribution of the aqueous deposits which are associated with the stony clays is somewhat similar. They are very sparingly developed in districts where the Boulder-clays are thin. Thus they are either wanting, or only occur sporadically in thin irregular beds, in the high grounds of Northern Europe generally. Further south, however, they gradually acquire more importance until in the peripheral regions of the drift-covered tracts they come to equal and eventually to surpass the Boulder-clays in prominence. These latter, in fact, at last cease to appear, and the whole bulk of the "diluvium" along the southern margin of the drift area appears to consist of aqueous accumulations alone.

The explanations of these facts advanced by German geologists are quite in accordance with the views which have long been held by glacialists elsewhere, and have been tersely summed up by Dr. Jentzsch.[1] The northern regions, he says, were the feeding-grounds of the inland ice. In those regions melting was at a minimum, while the grinding action of the ice was most effective. Here, therefore, erosion reached its maximum—ground-moraine or Boulder-clay being unable to accumulate to any thickness. Further south melting greatly increased, while ground-moraine at the same time tended to accumulate—the conjoint action of glacier-ice and sub-Glacial water resulting in the complex drifts of the peripheral area. In the disposition and appearance of the aqueous deposits of the "diluvium" we have evidence of an extensive sub-Glacial water-circulation—glacier-mills that gave rise to "giants' kettles"—chains of sub-glacial lakes in which fine clays gathered—streams and rivers that flowed in tunnels under the ice, and whose courses were paved with sand and gravel. Nowhere do German geologists find any evidence of marine action. On the contrary, the dove-tailing and interosculation of Boulder-clay with aqueous deposits are explained by the relation of the ice to the surface over which it flowed. Throughout the peripheral area it did not rest so continuously upon the ground as was the case in the inner region of maximum erosion. In many places it was tunnelled by rapid streams and rivers, and here and there it arched over sub-Glacial lakes, so that accumulation of ground-moraine proceeded side by side with the formation of aqueous sediments. Much of that ground-moraine is of the usual tough and hard-pressed character, but here and there it is somewhat less coherent and even silt-like. Now a study of the ground-moraines of modern glaciers affords us a reasonable explanation of such differences. Dr. Brückner[2] has shown that in many places the ground-moraine of Alpine glaciers is included in the bottom of the ice itself. The ground-moraine, he says, frequently appears as an ice-stratum abundantly impregnated with silt and rock-fragments—it is like a conglomerate or breccia which has ice for its binding material. When this ground-moraine melts out of the ice—no running water being present—it forms a layer of unstratified silt or

[1] Jahrb. d. königl. preuss. geologischen Landesanstalt für 1884, p. 438.

[2] Die Vergletscherung des Salzachgebietes, etc.: Geographische Abhandlungen herausgegeben v. A. Penck, band i. heft 1.

clay, with stones scattered irregularly through it. Such being the case in modern glaciers, we can hardly doubt that over the peripheral areas occupied by the old northern ice-sheet Boulder-clay must frequently have been accumulated in the same way. Nay, when the ground-moraine melted out and dropped here and there into quietly-flowing water, it might even acquire in part a bedded character.

The limits reached by the inland ice during its greatest extensions are becoming more and more clearly defined, although its southern margin will probably never be so accurately determined as that of the latest epoch of general glaciation. The reasons for this are obvious. When the inland ice flowed south to the Harz and the hills of Saxony it formed no great terminal moraines. Doubtless many erratics and much rock-rubbish were showered upon the surface of the ice from the higher mountains of Scandinavia, but owing to fanning-out of the ice on its southward march such superficial débris was necessarily spread over a constantly widening area. It may well be doubted, therefore, whether it ever reached the terminal front of the ice-sheet in sufficient bulk to form conspicuous moraines. It seems most probable that the terminal moraines of the great inland ice would consist of low banks of Boulder-clay and aqueous materials —the latter, perhaps, strongly predominating, and containing here and there larger and smaller angular erratics which had travelled on the surface of the ice. However that may be, it is certain that the whole region in question has been considerably modified by subsequent denudation, and to a large extent is now concealed under deposits belonging to later stages of the Pleistocene period. The extreme limits reached by the ice are determined rather by the occasional presence of rock striæ and *roches moutonnées*, of Boulder-clay and northern erratics, than by recognizable terminal moraines. The southern limits reached by the old inland ice appear in this way to have been tolerably well ascertained over a considerable portion of Central Europe. Some years ago I published a small sketch-map [1] showing the extent of surface formerly covered by ice. On this map I did not venture to draw the southern margin of the ice-sheet in Belgium further south than Antwerp, where northern erratics were known to occur; but the more recent researches of Belgian geologists show that the ice probably flowed south for some little distance beyond Brussels.[2] Here and there in other parts of the Continent the southern limits reached by the northern drift have also been more accurately determined, but so far as I know, none of these later observations involves any serious modifications of the sketch-map referred to.

I have now said enough, however, to show that the notion of a general ice-sheet having covered so large a part of Europe, which a few years ago was looked upon as a wild dream, has been amply justified by the labours of those who are so assiduously investigating the peripheral areas of the "great northern drift." And perhaps I may be allowed to express my own belief that the drifts of Middle and

[1] Prehistoric Europe, 1881.

[2] See a paper by M. E. Delvaux, Ann. de la Soc. géol. de Belg. t. xiii. p. 158.

Southern England, which exhibit the same complexity as the "lower diluvium" of the Continent, will eventually be generally acknowledged to have had a similar origin. I have often thought that whilst politically we are happy in having the sea all round us, geologically we should have gained perhaps by its greater distance. At all events we should have been less ready to invoke its assistance to explain every puzzling appearance presented by our glacial accumulations.

I now pass on to review some of the general results obtained by continental geologists as to the extent of area occupied by inland ice during the last great extension of glacier-ice in Europe. It is well known that this latest ice-sheet did not overflow nearly so wide a region as that underneath which the lowest Boulder-clay was accumulated. This is shown not only by the geographical distribution of the youngest Boulder-clay, but by the direction of rock-striæ, the trend of erratics, and the position of well-marked moraines. Gerard de Geer has given a summary[1] of the general results obtained by himself and his fellow-workers in Sweden and Norway; and these have been supplemented by the labours of Berendt, Geinitz, Hunchecorne, Keilhack, Klockmann, Schröder, Wahnschaffe, and others in Germany, and by Sederholm in Finland.[2] From them we learn that the end-moraines of the ice circle round the southern coasts of Norway, from whence they sweep south-east by east across the province of Gottland in Sweden, passing through the lower ends of Lakes Wener and Wetter, while similar moraines mark out for us the terminal front of the inland ice in Finland—at least two parallel frontal moraines passing inland from Hango Head on the Gulf of Finland through the southern part of that province to the north of Lake Ladoga. Further north-east than this they have not been traced; but, from some observations by Helmersen, Sederholm thinks it probable that the terminal ice-front extended north-east by the north of Lake Onega to the eastern shores of the White Sea. Between Sweden and Finland lies the basin of the Baltic, which at the period in question was filled with ice, forming a great Baltic glacier, which overflowed the Åland Islands, Gottland, and Öland, and which, fanning out as it passed towards the south-west, invaded, on the south side, the Baltic provinces of Germany, while, on the north, it crossed the southern part of Scania in Sweden and the Danish islands to enter upon Jutland.

The Upper Boulder-clay of those regions is now recognized as the ground-moraine of this latest ice-sheet. In many places it is separated from the older Boulder-clay by inter-Glacial deposits, some of which are marine, while others are of fresh-water and terrestrial origin. During inter-Glacial times the sea that overflowed a considerable portion of North Germany was evidently continuous

[1] Zeitschrift d. deutsch. geolog. Ges. Bd. xxvii. p. 177.

[2] For papers by Berendt and his associates see especially the Jahrbuch d. k. preuss. geol. Landesanstalt, and the Zeitschr. d. deutsch. geol. Ges. for the past few years. Geinitz, Forsch. z. d. Landes- u. Volkskunde, i. 5; Leopoldina, xxii. p. 37; I. Beitrag z. Geologie Mecklenburgs, 1880, p. 46, 56; Sederholm, Fennia, i. No. 7.

with the North Sea, as is shown not only by the geographical distribution of the inter-Glacial marine deposits, but by their North Sea fauna. German geologists generally group all the inter-Glacial deposits together, as if they belonged to one and the same inter-Glacial epoch. This perhaps we must look upon as only a provisional arrangement. Certain it is that the fresh-water and terrestrial beds which frequently occur on the same or a lower level and at no great distance from the marine deposits, cannot in all cases be contemporaneous with the latter. Possibly, however, such discordances may be accounted for by oscillations in the level of the inter-Glacial sea—land and water having alternately prevailed over the same area. Two Boulder-clays, as we have seen, have been recognized over a wide region in North Germany. In some places, however, three or more such Boulder-clays have been observed overlying one another throughout considerable areas, and these clays are described as being distinctly separate and distinguishable the one from the other.[1] Whether they with their intercalated aqueous deposits indicate great oscillations of one and the same ice-sheet—now advancing, now retreating—or whether the stony clays may not be the ground-moraines of so many different ice-sheets, separated the one from the other by true inter-Glacial conditions, future investigations must be left to decide.

The general conclusions arrived at by those who are at present investigating the glacial accumulations of Northern Europe may be summarized as follows:

1. Before the invasion of Northern Germany by the inland ice the low grounds bordering on the Baltic were overflowed by a sea which contained a boreal and arctic fauna. These marine conditions are indicated by the presence under the Lower Boulder-clay of more or less well-bedded fossiliferous deposits. On the same horizon occur also beds of sand, containing fresh-water shells, and now and again mammalian remains, some of which imply cold and others temperate climatic conditions. Obviously all these deposits may pertain to one and the same period, or more properly to different stages of the same period—some dating back to a time when the climate was still temperate, while others clearly indicate the prevalence of cold conditions, and are therefore probably somewhat younger.

2. The next geological horizon in ascending order is that which is marked by the "Lower Diluvium"—the Glacial and fluvio-Glacial detritus of the great ice-sheet which flowed south to the foot of the Harz Mountains. The Boulder-clay on this horizon now and again contains marine, fresh-water, and terrestrial organic remains, derived undoubtedly from the so-called pre-Glacial beds already referred to. These latter, it would appear, were ploughed up and largely incorporated with the ground-moraine.

3. The inter-Glacial beds which next succeed contain remains of a well-marked temperate fauna and flora, which point to something more than a mere partial or local retreat of the inland ice. The geographical distribution of the beds and the presence in these of

[1] H. Schröder, Jahrb. d. k. preuss. geol. Landesanstalt für 1887, p. 360.

such forms as *Elephas antiquus, Cervus elephas, C. megaceros*, and a flora comparable to that now existing in Northern Germany, justify geologists in concluding that the inter-Glacial epoch was one of long duration, and characterized in Germany by climatic conditions apparently not less temperate than those that now obtain. One of the phases of that inter-Glacial epoch, as we have seen, was the overflowing of the Baltic provinces by the waters of the North Sea.

4. To this well-marked inter-Glacial epoch succeeded another epoch of arctic conditions, when the Scandinavian inland ice once more invaded Germany, ploughing through the inter-Glacial deposits, and working these up in its ground-moraine. So far as I can learn, the prevalent belief among geologists in North Germany is that there was only one inter-Glacial epoch; but, as already stated, doubt has been expressed whether all the facts can be thus accounted for. There must always be great difficulty in the correlation of widely-separated inter-Glacial deposits, and the time does not seem to me to have yet come when we can definitely assert that all those inter-Glacial beds belong to one and the same geological horizon.

I have dwelt upon the recent work of geologists in the peripheral areas of the drift-covered regions of Northern Europe, because I think the results obtained are of great interest to glacialists in this country. And for the same reason I wish next to call attention to what has been done of late years in elucidating the Glacial Geology of the Alpine lands of Central Europe—and more particularly of the low grounds that stretch out from the foot of the mountains. Any observations that tend to throw light upon the history of the complex drifts of our own peripheral areas cannot but be of service. It is quite impossible to do justice in this brief sketch to the labours of the many enthusiastic geologists who within recent years have increased our knowledge of the glaciation of the Alpine lands. At present, however, I am not so much concerned with the proofs of general glaciation as with the evidence that goes to show how the Alpine ground-moraines have been formed, and with the facts which have led certain observers to conclude that the Alps have endured several distinct glaciations within Pleistocene times. Swiss geologists are agreed that the ground-moraines which clothe the bottoms of the great Alpine valleys, and extend outwards sometimes for many miles upon the low grounds beyond are of true glacial origin. Now these ground-moraines are closely similar to the Boulder-clays of this country and Northern Europe. Like them, they are frequently tough and hard-pressed, but now and again somewhat looser and less firmly coherent. Frequently also they contain lenticular beds, and more or less thick sheets of aqueous deposits—in some places the stony clays even exhibiting a kind of stratification—and ever and anon such water-assorted materials are commingled with stony clay in the most complex manner. These latter appearances are, however, upon the whole best developed upon the low grounds that sweep out from the base of the Alps. The only question concerning the ground-moraines that has recently given rise to much discussion is the origin of the materials themselves. It is obvious that there are only three possible modes in which those materials could have been introduced into the ground-moraine: either they consist of superficial morainic débris which has found its way down to the bottom of the old glaciers by crevasses; or they may be made up of the rock-rubbish, shingle, gravel, etc., which doubtless strewed the valleys before these were occupied by ice; or, lastly, they may have been derived in chief measure from the underlying rocks themselves by the action of the ice that overflowed them. The investigations of Penck, Blaas, Böhm, and Brückner appear to me to have demonstrated that the ground-moraines are composed mostly of materials which have been detached from the underlying rocks by the erosive action of the glaciers themselves. Their observations show that the regions studied by them in great detail were almost completely buried under ice, so that the accumulation of superficial moraines was for the most part impossible; and they advance a number of facts which prove positively that the ground-moraines were formed and accumulated under ice. I cannot here recapitulate the evidence, but must content myself by a reference to the papers in which this is fully discussed.[1] These geologists do not deny that some of the material may occasionally have come from above, nor do they doubt that pre-existing masses of rock-rubbish and alluvial accumulations may have been incorporated with the ground-moraines; but the enormous extent of the latter, and the direction of transport and distribution of the erratics which they contain cannot be thus accounted for, while all the facts are readily explained by the action of the ice itself, which used its sub-Glacial débris as tools with which to carry on the work of erosion.

Professor Heim and others have frequently asserted that glaciers have little or no eroding power, since at the lower ends of existing glaciers we find no evidence of such erosion being in operation. But the chief work of a glacier cannot be carried on at its lower end, where motion is reduced to a minimum, and where the ice is perforated by sub-Glacial tunnels and arches, underneath which no glacial erosion can possibly take place; and yet it is upon observations made in just such places that the principal arguments against the erosive action of glaciers have been based. If all that we could ever know of glacial action were confined to what we can learn from peering into the grottoes at the terminal fronts of existing glaciers we should indeed come to the conclusion that glaciers do not erode their rocky beds to any appreciable extent. But as we do not look for the strongest evidence of fluviatile erosion at the mouth of a river, but in its valley- and mountain-tracks, so if we wish to learn what glacier-ice can accomplish, we must study in detail some wide region from which the ice has completely disappeared. When this plan has been followed, it has happened that some of the strongest opponents of glacial erosion have been compelled by the force of the evidence to go over to the other camp. Dr. Blaas, for

[1] Penck: Die Vergletscherung der deutschen Alpen. Blaas: Zeitsch. d. Ferdinandeums, 1885. Bohm: Jahrb. d. k. k. geol. Reichsanstalt, 1885. bd. xxxv. Heft 3. Brückner: Die Vergletscherung d. Salzachgebietes, etc., 1886.

example, has been led by his observations on the glacial formations of the Inn Valley to recant his former views, and to become a formidable advocate of the very theory which he formerly opposed. To his work and the memoirs by Penck, Brückner, and Böhm already cited, and especially to the admirable chapter on glacier-erosion by the last-named author, I would refer those who may be anxious to know the last word on this much-debated question.

The evidence of inter-Glacial conditions within the Alpine lands continues to increase. These are represented by alluvial deposits of silt, sand, gravel, conglomerate, breccia, and lignites. Penck, Böhm, and Brückner find evidence of two inter-Glacial epochs, and maintain that there have been three distinct and separate epochs of glaciation in the Alps. No mere temporary retreat and re-advance of the glaciers, according to them, will account for the phenomena presented by the inter-Glacial deposits and associated morainic accumulations. During inter-Glacial times the glaciers disappeared from the lower valleys of the Alps—the climate was temperate, and probably the snow-fields and glaciers approximated in extent to those of the present day. All the evidence conspires to show that an inter-Glacial epoch was of prolonged duration. Dr. Brückner has observed that the moraines of the last Glacial epoch rest here and there upon löss, and he confirms Penck's observations in South Bavaria that this remarkable formation never overlies the morainic accumulations of the latest Glacial epoch. According to Penck and Brückner, therefore, the löss is of inter-Glacial age. There can be little doubt, however, that löss does not belong to any one particular horizon. Wahnschaffe[1] and others have shown that throughout wide areas in North Germany it is the equivalent in age of the 'Upper Diluvium,' while Schumacher[2] points out that in the Rhine valley it occurs on two separate and distinct horizons. Prof. Andreæ has likewise shown[3] that there is an upper and lower löss in Alsace, each characterized by its own special fauna.

There is still considerable difference of opinion as to the mode of formation of this remarkable accumulation. By many it is considered to be an aqueous deposit; others, following Richthofen, are of opinion that it is a wind-blown accumulation; while some incline to the belief that it is partly one and partly the other. Nor do the upholders of these various hypotheses agree amongst themselves as to the precise manner in which water or wind has worked to produce the observed results. Thus, amongst the supporters of the aqueous origin of the löss, we find this attributed to the action of heavy rains washing over and rearranging the material of the Boulder-clays.[4] Many, again, have held it probable that löss is simply the finest loam distributed over the low grounds by the flood-waters that escaped

[1] Abhandl. z. geol. Specialkarte v. Preussen, etc., bd. vii. heft 1; Zeitschr. d. deutsch. geol. Gesellsch., 1885, p. 204; 1886, p. 367.

[2] Hygienische Topographie von Strassburg i. E., 1885.

[3] Abhandl. z. geol. Specialkarte v. Elsass-Lothringen, bd. vii., heft 2.

[4] Laspeyres: Erläuterungen z. geol. Specialkarte v. Preussen, etc., Blatt Gröbzig, Zörbig, und Petersberg.

from the northern inland ice and the *mers de glace* of the Alpine lands of Central Europe. Another suggestion is that much of the material of the löss may have been derived from the denudation of the Boulder-clays by flood-water, during the closing stages of the last cold period. It is pointed out that in some regions at least the löss is underlaid by a layer of erratics, which are believed to be the residue of the denuded Boulder-clay. We are reminded by Klockmann[1] and Wahnschaffe[2] that the inland ice must have acted as a great dam, and that wide areas in Germany, etc., would be flooded, partly by water derived from the melting inland ice, and partly by waters flowing north from the hilly tracts of Middle Germany. In the great basins thus formed there would be a commingling of fine silt-material derived from north and south, which would necessarily come to form a deposit having much the same character throughout.

From what I have myself seen of the löss in various parts of Germany, and from all that I have gathered from reading and in conversation with those who have worked over löss-covered regions, I incline to the opinion that löss is for the most part of aqueous origin. In many cases this can be demonstrated, as by the occurrence of bedding and the intercalation of layers of stones, sand, gravel, etc., in the deposit; again, by the not infrequent appearance of fresh-water shells; but, perhaps, chiefly by the remarkable uniformity of character which the löss itself displays. It seems to me reasonable also to believe that the flood-waters of Glacial times must needs have been highly charged with finely-divided sediment, and that such sediment would be spread over wide regions in the low grounds—in the slack-waters of the great rivers and in the innumerable temporary lakes which occupied, or partly occupied, many of the valleys and depressions of the land. There are different kinds of löss or löss-like deposits, however, and all need not have been formed in the same way. Probably some may have been derived, as Wahnschaffe has suggested, from the denudation of Boulder-clay. Possibly, also, some löss may owe its origin to the action of rain upon the stony clays, producing what we in this country would call "rain-wash." There are other accumulations, however, which no aqueous theory will satisfactorily explain. Under this category comes much of the so-called *Berglöss*, with its abundant land-shells, and its generally unstratified character. It seems likely that such löss is simply the result of subaerial action, and owes its origin to rain, frost, and wind acting upon the superficial formations, and rearranging their finer-grained constituents. And it is quite possible that the upper portion of much of the löss of the lower grounds may have been reworked in the same way. But I confess I cannot yet find in the facts adduced by German geologists any evidence of a dry-as-dust epoch having obtained in Europe during any stage of the Pleistocene period. The geographical position of our continent seems to me to forbid the possibility of such climatic conditions,

[1] Klockmann: Jahrb. d. k. preuss. geol. Landesanstalt für 1883, p. 262.
[2] Wahnschaffe: *op. cit.* and Zeitschr. d. deutsch. geol. Ges. 1886, p. 367.

while all the positive evidence we have points rather to humidity than dryness as the prevalent feature of Pleistocene climates. It is obvious, however, that after the flood-waters had disappeared from the low grounds of the Continent, subaerial action would come into play over the wide regions covered by Glacial and fluvio-Glacial deposits. Thus, in the course of time, these deposits would become modified,—just as similar accumulations in these islands have been top-dressed, as it were, and to some extent even rearranged. I am strengthened in these views by the conclusions arrived at by M. Falsan, the eminent French glacialist. Covering the plateaux of the Doubs, and widely spread throughout the valleys of the Rhone, the Ain, the Isère, etc., in France, there is a deposit of löss, he says, which has been derived from the washing of the ancient moraines. At the foot of the Alps, where black schists are largely developed, the löss is dark grey; but west of the secondary chain the same deposit is yellowish, and composed almost entirely of siliceous materials, with only a very little carbonate of lime. This *limon* or löss, however, is very generally modified towards the top by the chemical action of rain, the yellow löss acquiring a red colour. Sometimes it is crowded with calcareous concretions; at other times it has been deprived of its calcareous element and converted into a kind of pulverulent silica or quartz. This, the true löss, is distinguished from another *lehm*, which Falsan recognizes as the product of atmospheric action—formed, in fact, in place from the disintegration and decomposition of the subjacent rocks. Even this lehm has been modified by running water—dispersed or accumulated locally, as the case may be.[1]

All that we know of the löss and its fossils compels us to include this accumulation as a product of the Pleistocene period. It is not of post-Glacial age—even much of what one may call the "remodified löss" being of Late Glacial or Pleistocene age. I cannot attempt to give here a summary of what has been learned within recent years as to the fauna of the löss. The researches of Nehring and Liebe have familiarized us with the fact that at some particular stage in the Pleistocene period a fauna like that of the alpine steppe-lands of Western Asia was indigenous to Middle Europe, and the recent investigations of Woldřich have increased our knowledge of this fauna. At what horizon, then, does this steppe-fauna make its appearance? At Thiede Dr. Nehring discovered in so-called löss three successive horizons, each characterized by a special fauna. The lowest of these faunas was decidedly Arctic in type; above that came a steppe-fauna, which last was succeeded by a fauna comprising such forms as Mammoth, woolly Rhinoceros, *Bos*, *Cervus*, Horse, Hyæna, and Lion. Now, if we compare this last fauna with the forms which have been obtained from true post-Glacial deposits—those deposits, namely, which overlie the younger Boulder-clays and flood-accumulations of the latest Glacial epoch, we find little in common. The Lion, the Mammoth, and the Rhinoceros are conspicuous by their absence from the post-Glacial beds of Europe.

[1] Falsan: La Période glaciaire, p. 81.

In place of them we meet with a more or less Arctic fauna, and a high-Alpine and Arctic flora, which, as we all know, eventually gave place to the flora and fauna with which Neolithic man was contemporaneous. As this is the case throughout North-Western and Central Europe, we seem justified in assigning the Thiede beds to the Pleistocene period, and to that inter-Glacial stage which preceded and gradually merged into the last Glacial epoch. That the steppe-fauna indicates relatively drier conditions of climate than obtained when perennial snow and ice covered wide areas of the low ground goes without saying; but I am unable to agree with those who maintain that it implies a dry-as-dust climate, like that of some of the steppe-regions of our own day. The remarkable commingling of Arctic and steppe-faunas discovered by Woldřich in the Böhmerwald [1] shows, I think, that the Jerboas, Marmots, and Hamster-rats were not incapable of living in the same regions contemporaneously with Lemmings, Arctic Hares, Siberian Social Voles, etc. But when a cold epoch was passing away the steppe-forms probably gradually replaced their Arctic congeners, as these migrated northwards during the continuous amelioration of the climate.

If the student of the Pleistocene faunas has certain advantages in the fact that he has to deal with forms many of which are still living, he labours at the same time under disadvantages which are unknown to his colleagues who are engaged in the study of the life of far older periods. The Pleistocene period was distinguished above all things by its great oscillations of climate—the successive changes being repeated, and producing correlative migrations of floras and faunas. We know that Arctic and temperate faunas and floras flourished during inter-Glacial times, and a like succession of life-forms followed the final disappearance of Glacial conditions. A study of the organic remains met with in any particular deposit will not necessarily, therefore, enable us to assign these to their proper horizon. The geographical position of the deposit, and its relation to Pleistocene accumulations elsewhere, must clearly be taken into account. Already, however, much has been done in this direction, and it is probable that ere long we shall be able to arrive at a fair knowledge of the various modifications which the Pleistocene floras and faunas experienced during that protracted period of climatic changes of which I have been speaking. We shall even possibly learn how often the Arctic, steppe-, prairie-, and forest-faunas, as they have been defined by Woldřich, replaced each other. Even now some approximation to this better knowledge has been made. Dr. Pohlig,[2] for example, has compared the remains of the Pleistocene faunas obtained at many different places in Europe, and has presented us with a classification which, although confessedly incomplete, yet

[1] Woldřich: Sitzungsb. d. kais. Akad. d. W. math. nat. Cl., 1880, p. 7; 1881, p. 177; 1883, p. 978.

[2] Pohlig: Sitzungsb. d. Niederrheinischen Gesellschaft zu Bonn, 1884; Zeitschr. d. deutsch. geolog. Ges., 1887, p. 798. For a very full account of the diluvial European and Northern Asiatic mammalian faunas by Woldřich, see Mém. de l'Acad. des Sciences de St. Pétersbourg, viie. sér. t. xxxv. 1887.

serves to show the direction in which we must look for further advances in this department of inquiry.

During the last twenty years the evidence of inter-Glacial conditions both in Europe and America has so increased that geologists generally no longer doubt that the Pleistocene period was characterized by great changes of climate. The occurrence at many different localities on the Continent of beds of lignite and fresh-water alluvia, containing remains of Pleistocene mammalia, intercalated between separate and distinct Boulder-clays, has left us no alternative. The inter-Glacial beds of the Alpine lands of Central Europe are paralleled by similar deposits in Britain, Scandinavia, Germany, and France. But opinions differ as to the number of Glacial and inter-Glacial epochs —many holding that we have evidence of only two cold stages and one general inter-Glacial stage. This, as I have said, is the view entertained by most geologists who are at work on the Glacial accumulations of Scandinavia and North Germany. On the other hand, Dr. Penck and others, from a study of the drifts of the German Alpine lands, believe that they have met with evidence of three distinct epochs of glaciation, and two epochs of inter-Glacial conditions. In France, while some observers are of opinion that there have been only two epochs of general glaciation, others, as, for example, M. Tardy, find what they consider to be evidence of several such epochs. Others again, as M. Falsan, do not believe in the existence of any inter-Glacial stages, although they readily admit that there were great advances and retreats of the ice during the Glacial period. M. Falsan, in short, believes in oscillations, but is of opinion that these were not so extensive as others have maintained. It is, therefore, simply a question of degree, and whether we speak of oscillations or of epochs, we must needs admit the fact that throughout all the glaciated tracts of Europe, fossiliferous deposits occur intercalated among glacial accumulations. The successive advance and retreat of the ice, therefore, was not a local phenomenon, but characterized all the glaciated areas. And the evidence shows that the oscillations referred to were on a gigantic scale.

The relation borne to the glacial accumulations by the old river alluvia which contains relics of Palæolithic man early attracted attention. From the fact that these alluvia in some places overlie glacial deposits, the general opinion (still held by some) was that Palæolithic man must needs be of post-Glacial age. But since we have learned that all Boulder-clay does not belong to one and the same geological horizon—that, in short, there have been at least two, and probably more, epochs of glaciation—it is obvious that the mere occurrence of glacial deposits under Palæolithic gravels does not prove these latter to be post-Glacial. All that we are entitled in such a case to say is simply that the implement-bearing beds are younger than the glacial accumulations upon which they rest. Their horizon must be determined by first ascertaining the relative position in the Glacial series of the underlying deposits. Now, it is a remarkable fact that the Boulder-clays which underlie such old alluvia belong, without exception, to the earlier stages of the Glacial period. This has been proved again and again, not only for this country but for Europe generally. I am sorry to reflect that some twenty years have now elapsed since I was led to suspect that the Palæolithic gravels and cave-deposits were not of post-Glacial, but of Glacial and inter-Glacial age. In 1871-72 I published a series of papers in the GEOLOGICAL MAGAZINE in which I set forth the views I had come to form upon this interesting question. In these papers it was maintained that the alluvia and cave deposits could not be of post-Glacial age, but must be assigned to pre-Glacial and inter-Glacial times, and in chief measure to the latter. Evidence was led to show that the latest great development of glacier-ice in Europe took place after the southern Pachyderms and Palæolithic man had vacated England—that during this last stage of the Glacial period man lived contemporaneously with a northern and Alpine fauna in such regions as Southern France—and lastly, that Palæolithic man and the Southern Mammalia never revisited North-Western Europe after extreme glacial conditions had disappeared. These conclusions were arrived at after a somewhat detailed examination of all the evidence then available—the remarkable distribution of the Palæolithic and ossiferous alluvia having, as I have said, particularly impressed me. I coloured a map to show at once the areas covered by the glacial and fluvio-Glacial deposits of the last Glacial epoch, and the regions in which the implement-bearing and ossiferous alluvia had been met with, when it became apparent that the latter never occurred at the surface within the regions occupied by the former. If ossiferous alluvia did here and there appear within the recently glaciated areas it was always either in caves, or as infra- or inter-Glacial deposits. Since the date of these researches our knowledge of the geographical distribution of Pleistocene deposits has greatly increased, and implements and other relics of Palæolithic man have been recorded from many new localities throughout Europe. But none of this fresh evidence contradicts the conclusions I had previously arrived at; on the contrary, it has greatly strengthened my general argument.

Professor Penck was, I think, the first on the Continent to adopt the views referred to. He was among the earliest to recognize the evidence of inter-Glacial conditions in the drift-covered regions of Northern Germany, and it was the reflections which those remarkable inter-Glacial beds were so well calculated to suggest that led him into the same path as myself. Dr. Penck has published a map [1] showing the areas covered by the earlier and later glacial deposits in Northern Europe and the Alpine lands, and indicating at the same time the various localities where Palæolithic finds have occurred. And in not a single case do any of the latter appear within the areas covered by the accumulations of the last Glacial epoch.

A glance at the papers which have been published in Germany within the last few years will show how greatly students of the Pleistocene ossiferous beds have been influenced by what is now known of the inter-Glacial deposits and their organic remains.

[1] Archiv für Anthropologie, bd. xv. heft 3, 1884.

Professors Rothpletz[1] and Andreæ,[2] Dr. Pohlig[3] and others, do not now hesitate to correlate with those beds the old ossiferous and implement-bearing alluvia which lie altogether outside of glaciated regions.

The relation of the Pleistocene alluvia of France to the glacial deposits of that and other countries has been especially canvassed. Rothpletz, in the paper cited below, includes these alluvia amongst the inter-Glacial deposits; and in the present year we have an interesting essay on the same subject by the accomplished secretary of the Anthropological and Archæological Congress, which met last month in Paris. M. Boule correlates[4] the Palæolithic cave- and river-deposits of France with those of other countries, and shows that they must be of inter-Glacial age. His classification, I am gratified to find, does not materially differ from that given by myself a number of years ago. He is satisfied that in France there is evidence of three Glacial epochs and two well-marked inter-Glacial horizons. The oldest of the Palæolithic stages of Mortillet (CHELLÉENNE) culminated according to Boule during the last inter-Glacial epoch, while the more recent Palæolithic stages (MOUSTÉRIENNE, SOLUTRÉENNE, and MAGDALÉNIENNE) coincided with the last great development of glacier-ice. The Palæolithic age, so far as Europe is concerned, came to a close during this last cold phase of the Glacial period.

There are many other points relating to Glacial Geology which have of late years been canvassed by continental workers, but these I cannot discuss here. I have purposely, indeed, restricted my remarks to such parts of a wide subject as I thought might have interest for glacialists in this country, some of whom may not have had their attention directed to the results which have recently been attained by their fellow-labourers in other lands. Had time permitted I should gladly have dwelt upon the noteworthy advances made by our American brethren in the same department of inquiry. Especially should I have wished to direct attention to the remarkable evidence adduced in favour of the periodicity of glacial action. Thus Messrs. Chamberlin and Salisbury, after a general review of that evidence, maintain that the Ice Age was interrupted by one chief inter-Glacial epoch, and by three inter-Glacial sub-epochs or episodes of deglaciation. The same authors discuss at some length the origin of the löss, and come to the general conclusion that while deposits of this character may have been formed at different stages of the Glacial period, and under different conditions, yet that upon the whole they are best explained by aqueous action. Indeed a perusal of the recent geological literature of America shows a close accord between the theoretical opinions of many transatlantic and European geologists.

Thus as years advance the picture of Pleistocene times becomes

[1] Rothpletz: Denkschrift d. schweizer. Ges. für d. gesammt. Nat., bd. xxviii. 1881.

[2] Andreæ: Abhandl. z. geolog. Specialkarte v. Elsass-Lothringen, bd. iv. heft 2, 1884.

[3] Pohlig: *op. cit.*

[4] Boule: Revue d'Anthropologie, 1889, t. i.

more and more clearly developed. The conditions under which our old Palæolithic predecessors lived—the climatic and geographical changes of which they were the witnesses—are gradually being revealed with a precision that only a few years ago might well have seemed impossible. This of itself is extremely interesting, but I feel sure that I speak the conviction of many workers in this field of labour when I say that the clearing up of the history of Pleistocene times is not the only end which they have in view. One can hardly doubt that when the conditions of that period and the causes which gave rise to these have been more fully and definitely ascertained, we shall have advanced some way towards the better understanding of the climatic conditions of still earlier periods. For it cannot be denied that our knowledge of Palæozoic, Mesozoic, and even early Cainozoic climates is unsatisfactory. But we may look forward to the time when much of this uncertainty will disappear. Meteorologists are every day acquiring a clearer conception of the distribution of atmospheric pressure and temperature, and the causes by which that distribution is determined, and the day is coming when we shall be better able than we are now to apply this extended meteorological knowledge to the explanation of the climates of former periods in the world's history. One of the chief factors in the present distribution of atmospheric temperature and pressure is doubtless the relative position of the great land and water areas; and if this be true of the present, it must be true also of the past. It would almost seem then as if all one had to do to ascertain the climatic condition of any particular period was to prepare a map, depicting with some approach to accuracy the former relative position of land and sea. With such a map could our meteorologists infer what the climatic conditions must have been? Yes, provided we could assure them that in other respects the physical conditions did not differ from the present. Now there is no period in the past history of our globe the geographical conditions of which are better known than the Pleistocene. And yet, when we have indicated these upon a map, we find that they do not give the results which we might have expected. The climatic conditions which they seem to imply are not such as we know did actually obtain. It is obvious, therefore, that some additional and perhaps exceptional factor was at work to produce the recognized results. What was this disturbing element, and have we any evidence of its interference with the operation of the normal agents of climatic change in earlier periods of the world's history? We all know that various answers have been given to such questions. Whether amongst these the correct solution of the enigma is to be found time will show. Meanwhile, as all hypothesis and theory must starve without facts to feed on, it behoves us as working geologists to do our best to add to the supply. The success with which other problems have been attacked by geologists forbids us to doubt that ere long we shall have done much to dispel some of the mystery which still envelopes the question of geological climates.

British Association for the Advancement of Science.
September 12th to 18th, 1889.

List of Titles of Papers read in Section (C) Geology.

Professor James Geikie, D.C.L., LL.D., F.R.S., F.G.S., President.

The President's Address. (See page 461.)

Prof. J. Milne.—Report on the Earthquake and Volcanic Phenomena of Japan.

Prof. G. Michie Smith.—The Bandaisan Eruption, Japan, July, 1888.

Dr. E. Naumann.—Terrestrial Magnetism as modified by the Structure of the Earth's Crust; and Proposals concerning a Magnetic Survey of the Globe.

T. P. Barkas.—Notes on numerous newly discovered Fossil Footprints on the Lower Carboniferous Sandstone of Northumberland, near Otterburn.

T. Mellard Reade.—The Physiography of the Lower Trias.

Dr. A. Geikie.—Origin and Age of the Crystalline Schists of Norway.

J. E. Marr.—Dynamic Metamorphism of Skiddaw Slates.

Dr. F. H. Hatch.—On the Lower Silurian Felsites of the South-East of Ireland.

A. R. Hunt.—The Age of the Granites of Dartmoor and the English Channel.

R. Swan.—The Island of Paros, in the Cyclades, and its Marble Quarries.

Prof. T. G. Bonney.—Preliminary Note on the alleged Occurrence of Fossils in the Crystalline Schists of the Lepontine Alps.

W. W. Watts.—To exhibit Specimens of Belemnites from Lukmanier.

Prof. T. G. Bonney.—Effects of Pressure on Crystalline Limestone.

J. J. H. Teall.—The Amygdaloids of the Tynemouth Dyke.

Dr. F. Nansen.—Greenland.

Prof. C. Williamson.—Report on Coal Plants; on the Present State of Inquiry into the Microscopic Features of the Coals of the World, and into the Organization of the Fossil Plants of the Coal-Measures.

Prof. T. Rupert Jones.—Report upon the Fossil Phyllopoda of the Palæozoic Rocks.

Dr. H. J. Johnston-Lavis.—Report on the Volcanic Phenomena of Vesuvius.

Prof. E. Hull.—To exhibit Specimens of supposed Coral Structures from Culdaff in Donegal, and to invite opinions thereon.

Prof. E. Hull.—To exhibit a small block of magnetically polar diorite.

A. C. G. Cameron.—Note on the recent exposures of Kellaway's Rock at Bedford.

G. R. Vine.—Polyzoa of the Red Chalk.

W. A. E. Ussher.—The Devonian Rocks of Great Britain.

John Marley and Professor G. A. Lebour.—Sketch of the Rise and Progress of the Cleveland and South Durham Salt Industry, and on the Extension of the Durham Coal-field.

C. E. De Rance.—Report of the Committee on the Circulation of Underground Waters.

Dr. D Embleton.—On the Spinal Column of *Loxomma Allmanni* from the Northumberland Coal-field.

Dr. R. Laing.—The Bone Caves of Cresswell, with the recent discovery of an Extinct Feline (*Felis brevirostris*) new to Great Britain.

Dr. R. H. Traquair—On the Devonian Fishes of Canada.

A. Smith Woodward.—On the Occurrence of the Devonian Ganoid *Onychodus* in Spitzbergen.

A. Smith Woodward.—Notes on some new and little-known British Jurassic Fishes. (See page 448.)

Prof. A. W. Rücker and *Prof. T. E. Thorpe.*—On the Relation between the Geological Constitution and the Magnetic State of the United Kingdom.

Prof. A. C. Haddon.—Notes on the Geology of Torres Straits.

G. W. Lamplugh.—Report on an Ancient Sea Beach near Bridlington.

Dr. H. W. Crosskey.—Report on Erratic Blocks.

W. Whitaker.—On a Deep Channel filled with Drift in the Valley of the Cam, Essex.

H. H. Howorth.—Are the extreme Glacial Views developed by Agassiz and his scholars consistent with our Present Geological Knowledge ?

G. W. Lamplugh.—Note on a New Locality for the Arctic Shell-beds of the Basement Boulder-clay on the Yorkshire Coast.

H. H. Howorth.—Did the great Rivers of Siberia flow Southwards and not Northwards in the Mammoth Age ?

E. B. Dorsey.—On the Witwatersrand Gold Fields.

A. Bell.—Report on the Manure Gravels of Wexford.

Prof. F. Clowes.—On Waterbox Deposits and their Bearing on the Cementing Material of Rocks.

J. Starkie Gardner.—Report on the Eocene Plants of the Isle of Wight.

Prof. A. H. Green.—A word or two about the so-called Concretions in the Magnesian Limestone of Durham.

W. Topley.—The Work of the Geological Survey in Northumberland and Durham.

R. Tiddeman.—On Concurrent Faulting and Deposit (Craven, Yorkshire), with a note on Carboniferous Reefs.

List of Papers bearing on Geology read before other Sections.

Section A. (Mathematical and Physical Science.)

Report of the Committee on Underground Temperature.

Section B. (Chemical Science.)

J. Pattinson and Dr. H. S. Pattinson.—On Chilian Manganese Ore.

Prof. Frank Clowes.—On Barium Sulphate Deposits from the Waters of Durham Coal-mines and in Nottingham Sandstone.

Report of the Committee on the Formation of a Uniform System of Recording the Results of Water Analysis.

Section D. (Biology.)

Prof. H. F. Osborn.—The Palæontological Evidence for the transmission of acquired characters.

R. Irvine and G. Sims Woodhead.—On the Secretion of Carbonate of Lime by Animals.

W. S. Anderson.—The Solubility of Carbonate of Lime in Fresh and Sea Water.

Dr. Traquair.—Restoration of *Asterolepis maximus* (Agassiz), with remarks on the Zoological affinities of the Pterichthyidæ.

Section E. (Geography.)

Joseph Thomson.—Report to the Committee appointed to investigate the Geography and Geology of the Atlas Ranges in the Empire of Morocco.

W. J. Flinders Petrie.—Wind Action in Egypt.

Section F. (Economic Science and Statistics.)

Prof. Edward Hull.—The State of our Coal Resources.

Prof. Edward Hull.—Diagram showing the rate of Production of Coal during the present Century.

Section G. (Mechanical Science.)

C. E. De Rance.—Records of River Volumes and Flood Levels.

CORRESPONDENCE.

SIR,—So many of your readers must go Alp-wards that I appeal, though late, to any who may visit the Chamounix district, to help me in a little investigation by looking out for diorites about the junction of the gneiss with the protogine—the inner portions of de Saussure's "Artichoke." I am prevented from doing so myself this year.

Last summer I picked up a worn pebble in the gorge below Pierre a l'Echelle, and above Pierre Pointue, both mere cockney points of interest on the way up Mont Blanc.

I do not remember any mass of diorite thereabouts. But it appears at intervals from the Mottets[1] to the upper Grands Mulets. I did not climb in search, not having sufficient time left.

My specimen proved to be an epidiorite, under the microscope, with slightly banded structure. Hornblende, not orientated, probably of augitic origin, showed two periods, one, the older, giving the usual pleochroic green and yellow, the other nearly colourless, with a cement, so to speak, of the secondary hornblende. The cleavage continued through this portion. There is apatite, plagioclase and a ground mass which I have not properly investigated.

I feel sure that careful study would give interesting results if this contact-region were investigated. Something like what my section gives is shown in Teall's grand book, at plate 17.

The problem of at least two periods of formation of the hornblende points to an interesting history of the Mont Blanc "Artichoke" formation period. MARSHALL HALL.

GROSVENOR CLUB, *September*, 1889.

[1] The rocks exposed close to the Glacier des Bois and Mer de Glace.

1.

2.

3.

To Illustrate Mr. Teall's paper on the Amygdaloids of the Tynemouth Dyke.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VI.

No. XI.—NOVEMBER, 1889.

ORIGINAL ARTICLES.

I.—On the Amygdaloids of the Tynemouth Dyke.[1]

By J. J. H. Teall, M.A., F.G.S.

(PLATE XIV.)

IN a paper published in the Quarterly Journal of the Geological Society for 1884,[2] I gave some account of the Tynemouth Dyke. In that paper, however, I omitted to describe one feature, connected with the microscopic structure of the dyke, because at the time of writing I did not understand it. A short time ago I had occasion to re-examine my preparations, when my attention was again directed to the feature in question; and this time an explanation suggested itself which appears to be in every respect satisfactory. The main object of this communication is to supplement my already published description by giving an account of the feature to which I have referred, and which may be briefly described as the occurrence of spherical patches of interstitial matter. (See Pl. XIV. Fig. 1.)

At the time of my residence at Tynemouth (1882) the dyke was exposed in the angle formed by the breakwater and the cliff on which the Priory stands, and also in the cutting close to the railway station. The rock of which the dyke is composed varies somewhat in character owing to the presence or absence of porphyritic felspars and small spherical amygdaloids. A typical specimen may be said to consist essentially of porphyritic crystals, or rather crystalline aggregates of a felspar closely allied to anorthite, embedded in a dark, finely-crystalline ground-mass, composed of augite, lath-shaped felspars, and interstitial matter. Olivine has been detected in one or two slides; but it is not usually present.

The porphyritic constituents undoubtedly belong to the earliest phase in the consolidation of the original mass of molten matter. They consist, as a rule, not of single crystals, but of two or more individuals. Where the individuals of one and the same group are in contact with each other, they exhibit no trace of crystalline form;[3] but where they are in contact with the ground-mass, they are bounded by definite faces. In other words, the internal relations of the individuals forming a group are those of plutonic rocks (*e.g.* gabbro), whereas the external relations of the same individuals are those of volcanic rocks. This, of course, is in strict accord with the general view that the porphyritic constituents have been developed under plutonic conditions. An examination of the porphyritic aggregates

[1] Read at the Brit. Assoc., Newcastle-on-Tyne, in Section C. (Geology), Sept. 1889.
[2] Petrological Notes on some North of England Dykes, vol. xl. p. 233.
[3] See fig. 1, plate xiii. accompanying the paper already referred to.

under crossed Nicols reveals the fact that the felspar-substance to which the external idiomorphism is due differs from that forming the central portions. This, taken in connection with the fact that the augite-grains of the ground-mass are occasionally included in the peripheral zone of the porphyritic groups, justifies the conclusion that such external form as the individuals possess was given to them at a later stage in the history of the consolidation of the rock than that at which the groups themselves were formed, and also under different physical conditions.

The augite is pale in colour, and occurs in grains or granular aggregates. It is occasionally penetrated by the lath-shaped felspars, and must, on the whole, have been formed after them.

The lath-shaped felspars call for no special description. They frequently show multiple twinning of the usual type.

The interstitial matter contains extremely minute microlites and skeleton crystals of felspar, grains and skeletons of magnetite, and an indistinct brownish granular substance. It is not possible to recognize any true glass, even with the highest powers. This interstitial matter occurs in more or less angular patches wedged in between the other constituents. and gives to the rock the structure for which Professor Rosenbusch has proposed the term *intersertal.* The rock itself would be termed by this author a tholeite.

Now the peculiar feature to which I wish to call special attention is the occasional occurrence of spherical patches of interstitial matter. These appear in the thin sections—and they have only been recognized in the sections—as circles. How are these spherical patches to be accounted for? An answer to this question is found by studying the amygdaloids, which have been already referred to as occurring in certain portions of the dyke. (See Pl. XIV. Fig. 2.)

Microscopic examination enables us to determine the precise stage in the history of consolidation at which the vesicular cavities, now for the most part filled with carbonates with or without a narrow border of chalcedony, were formed. Their development evidently displaced the lath-shaped felspars, for these are often arranged tangentially with reference to the bubbles; but it produced no effect on the disposition of the constituents of the interstitial matter. It appears, then, that the gas bubbles were produced after the formation of the porphyritic constituents, the augite and the lath-shaped felspars, but before the consolidation of the interstitial matter. It is possible that their development was due to the relief of pressure consequent on the rise of the semi-liquid mass in the crack. If so, then they are analogous, so far as their mode of formation is concerned, to the bubbles which arise in the contents of a soda-water bottle as the cork is partially removed.

Now, the spherical patches of interstitial matter agree in form and size with the amygdaloids, and to account for them we have only to suppose that the portion of the mass which was liquid at the time of their formation, oozed into some of the vesicles owing to the absorption, escape, or condensation of the gas. That this is the true explanation is proved by the occurrence of cavities which have been only partially filled up. (See Pl. XIV. Fig. 3.) The last act to which we have to call attention was the filling up of the cavities remaining empty after final consolidation with chalcedony and carbonates.

We may summarize the history of the rock so far as it is recorded in microscopic structure as follows:—

1. Development of granular aggregates of a felspar allied to anorthite under plutonic conditions.
2. Addition of felspar substance to the external portions of the granular aggregates, and the consequent production of crystalline form.
3. Development of lath-shaped felspars.
4. Separation of augite.
5. Formation of vesicles owing to the separation of gas from the magma.
6. Partial or complete filling up of some of these vesicles with interstitial matter.
7. Consolidation of the interstitial matter.
8. Filling up of the vesicles remaining empty after final consolidation with carbonates.

EXPLANATION OF PLATE XIV.

Augite is indicated by dots, interstitial matter by lines. The felspar is left clear. Magnetite is black.

Fig. 1. Vesicle filled with interstitial matter.
,, 2. ,, filled with carbonates.
,, 3. ,, partly filled with interstitial matter and partly with carbonates.

II.—The Effects of Pressure on Crystalline Limestones.[1]

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

THOSE who have carefully studied the crystalline schists cannot fail to have noticed that a community of structure—a sort of family likeness—prevails throughout any one group of rocks, while those which occur apparently at different horizons exhibit dissimilar structures. Thus the marbles associated with any group of crystalline schists are coarse or fine in grain, according to the structure of the latter. But to this rule exceptions appear, at first sight, not infrequent. For instance, in the Alps, we find not uncommonly, in that group of schists which seems to occupy the highest position, marbles which present an abnormally compact aspect. On closer examination they prove indeed to be crystalline in structure, but the crystals seem so small, the general structure so compact, that until we find them graduating into typical mica or other schists, we can hardly feel satisfied we are not being duped by infolded limestones of Mesozoic or Palæozoic age. When, however, we study the microscopic structure of such crystalline limestones, the abnormality proves to be more apparent than real. This compact structure is due, not to the absence of crystallization, but to the destruction by pressure of an original crystalline structure: for we find on examination that the rock, once perhaps coarsely crystalline, has been crushed and again consolidated, so that it has now assumed a comparatively compact appearance.

A proof of the above statement may be afforded by a brief description of the structures which are exhibited by a series of limestones[2] which I have from time to time collected and examined.

[1] Read before Section C, Brit. Assoc. Newcastle-upon-Tyne Meeting, Sept. 1889.

[2] Many of the Alpine limestones, both in the Mesozoic and in the Crystalline series, are more or less dolomitic, but I have not thought it necessary to distinguish these. The statements apply to both, except that, among the ordinary sedimentaries, the

In the Alps, as is well known, large masses of limestone occur which are indubitably of Mesozoic age. Sometimes these have been exposed to great pressure; sometimes they appear to have been uplifted with comparatively little disturbance. In either case there does not appear to be a very marked difference in their crystalline condition. A Mesozoic Alpine limestone may be described in general terms by saying that it resembles, often closely, in texture and sometimes even in colour, one of the Carboniferous limestones of Britain—that is to say, it varies from black to grey—though the peculiar light grey of the English Carbonifeous limestone is, so far as I know, most unusual. Not seldom the rock is yellowish in colour, like some of our Mesozoic limestones, but with a different texture; occasionally it is reddish. Even where the calcareous constituent exhibits a crystalline character, it is obvious that, if this were removed by the action of an acid, the residue would be, roughly speaking, mud, silt, or sand which, as a rule, has not undergone more alteration than would be observed in the above-named British rocks. If, however, we examine a limestone which both is indubitably associated with a series of crystalline schists and has been selected from a comparatively undisturbed region, we find that whether coarse or fine (in the latter case of course the statement may be less precise) the constituents throughout are in a crystalline condition. If quartz-grains are present, they bear no resemblance to those in a sandstone, but have evidently assumed their present outline *in sitû*.[1] If mica, it is in like way evidently authigenous. So also with the malacolite, sahlite, or other mineral constituents. In short, it is evident that, whether the rock were originally an organic aggregate, a chemical precipitate, or a detrital accumulation, the constituents have undergone a molecular rearrangement, which is in all cases considerable and is often complete.

If now we turn from the examination of such specimens to one of the abnormal-looking limestones, collected from a crystalline group which has been exposed to severe pressure, we find that its constituents, as before, are in a crystalline condition, but that the structure of the rock is different. Instead of finding a considerable uniformity in the size of the calcite grains, we observe a marked diversity. In a ground-mass of granules are scattered grains variable in size and number, subangular or slightly irregular in outline, and sometimes exhibiting a slightly linear arrangement. If an outline sketch were made of the slide, it might be supposed to represent a subangular breccia or conglomerate—except that the outline of the larger grains is slightly irregular or 'ragged.'

Further, many of these grains exhibit the twin lamellæ, which, as is well known, can be artificially produced in a calcite crystal by pressure, and which, if they occur in rocks, are now commonly

'dolomites' generally have a more crystalline aspect, and, among the crystalline schists, do not usually show mineral cleavage so readily as those which only contain calcite; they also exhibit the usual differences to which I called attention in 1879 (Q.J.G.S. vol. xxxv. p. 167).

[1] Of course they may have had a clastic nucleus, but of this their present outline shows no trace.

regarded as indicative of the same disturbing cause.[1] Not seldom there seems to be a tendency to orientation in these lamellæ, since they either lie in or make angles of about 20° with the rude planes of incipient cleavage in the rock; these, of course, being roughly perpendicular to the direction of pressure.

The well-known crystalline limestone of Tiree is an interesting example of the same process. This rock was for some time a puzzle to me, for the large size of the sahlite grains, which were such as might be expected from the geological position of the rock, seemed to be incongruous with the apparently compact calcareous matrix. One would have expected the latter to resemble the crystalline calcite in one of the malacolite limestones in the "Granville series" of Canada. But an examination of a set of slides prepared from specimens of the Tiree rock has removed the difficulty. The brecciated or conglomeratic structure above described is at once revealed by the microscope. Grains of calcite, of various sizes, in some cases almost as large as those of the sahlite, are scattered about in a finely granular matrix of calcite, which gives the usual indications of having suffered from pressure, although subsequently it has been completely reconsolidated. On closer examination, we find here and there a grain of calcite, either occupying an inlet in one of the sahlite grains or sheltered between two adjacent grains of the same, which has evidently formed part of a larger grain, and which indicates that the calcite matrix was once in a coarsely crystalline condition and that its grains corresponded in magnitude with that of the sahlite. In one case that I have examined the accidental proximity of some sahlite grains has so protected the calcite that two or three crystals of it remain unbroken, and we can, as it were, study a fragment of the original rock. In one instance, adjacent to an unbroken grain of calcite, are some of much smaller size, which, in their relation to the matrix and their disposition, suggest that an original grain, thus imperfectly protected, has been broken up but not crushed. The matrix of the slide consists of calcite granules, in which a faint streaking is seen, suggesting the action of pressure. It is remarkable that the sahlite grains do not appear in my specimens to be broken or even distorted. Probably they have been saved by the easy cleavage and brittleness of the calcite, which was reduced to a powder by the pressure, and again consolidated as the latter diminished.

Miss C. A. Raisin has recently shown me a specimen, collected by herself, in which the effect of pressure on calcite is well illustrated. It is a brecciated volcanic rock (? andesite) from Porth Oer, north of Aberdaron, the fissures in which have been filled up by calcite with a little quartz. In consequence of subsequent pressure the quartz is displaced and shows strain-shadows, but the calcite exhibits various stages of crushing, as described above, most of it being reduced to granules, and these sometimes are slightly 'streaky' in their arrangement. Here then the history of the rock is complete and there can be no doubt as to the cause of the structure.

Hence the observations—and they have been rather extensive—

[1] Rutley, Rock-forming Minerals, s.v. *Calcite.*

which have been briefly summarized above, lead me to the following conclusions :

1. While I would not venture to affirm that pressure has no effect in producing crystallization in a limestone, this is only small and subordinate, quite insufficient as a rule to obliterate the ordinary character of a limestone, such as occurs in strata of later Palæozoic or of Mesozoic age. Certainly, as is shown by the study of limestones into which igneous masses have been intruded, the effects of pressure are far less marked than those of heat, under circumstances which appear to be otherwise similar.

2. When limestone already crystalline has undergone severe pressure, its structure, macroscopically and to a considerable extent microscopically, is rendered less coarsely crystalline, *i.e.* instead of becoming more distinctly crystalline, it is made to resemble more nearly an ordinary limestone (non-oolitic and unfossiliferous) such as might be obtained in Derbyshire, in South Devon, or in many parts of the Alps.

Perhaps I should add that I am fully aware that some geologists, whose opinion is entitled to respect, have recently asserted that certain crystalline limestones in the last-named district are Jurassic rocks which have been altered by pressure. The typical instance of this, as it may be called, has long been known to me, and has been recently examined anew. It will take some time to complete the study of the specimens which have been added to my collection, and until that is done, I will say no more than that this identification appears to me an hypothesis, in support of which only a little and against which very much evidence can be adduced.

Indeed, as I hope to show in a paper now nearly completed, which will include the results of this and other work in a like field, the direct effects of pressure are rather destructive than constructive—a matter which I think has sometimes been overlooked in speculations on 'pressure-metamorphism.' It is but a part of a chain of sequences, though here also it may be true that (to speak figuratively) "mille animas una necata dedit."

III.—Terrestrial Magnetism as Modified by the Structure of the Earth's Crust, and Proposals Concerning a Magnetic Survey of the Globe.[1]

By Dr. Edmund Naumann.

"THE study of any new science," says Alexander v. Humboldt, "may be compared to a journey to distant lands. Before starting in company with others, the question as to the practicability of the journey is raised; while examining one's own powers, the qualities of fellow-travellers are looked upon with distrust. It is feared—perhaps without just reason—that they might cause unpleasant detention. In our time the difficulties of an undertaking of this kind are much diminished. Any confidence is founded on the bright blossoming state to which natural sciences have grown, their wealth being no more the abundant quantity, but the concatenation of what has been observed."

[1] Read at the Brit. Assoc. Newcastle, before Section C (Geology), Sept. 1889.

These remarkable words were spoken nearly half a century ago. Since then natural sciences have undergone enormous development, many methods of investigation have been completely changed, and the aim of concatenating facts has greatly influenced the methods of observation. Systems which were then descriptive have been replaced by others in which the various facts are arranged, so as to exhibit their relation to causes, and by reducing the number of isolated facts, different fields of investigation have been brought into closer relationship.

The change which has taken place is particularly striking in the case of Mineralogy. Modern mineralogists devote considerable attention to Physical Crystallography, a study which borrows its methods from a sister science, and the results attained by the combination are very satisfactory.

By the aid of light we are enabled to discern the structure of crystallized bodies, and to trace the marvellous connection between composition, structure, and form. The motions of light, although the best, are not the only means of investigating internal structure, for those of heat, electricity, and magnetism, also depend on the shape, size, and arrangement of the smallest particles and their interstices. Any interposition, any fissure, causes changes of wave motion, for this motion can only be propagated regularly in homogeneous media, and its character, velocity, and direction of propagation are altered wherever any variation from homogeneity exists.

Changes of this kind occur even at the planes of composition of twin crystals, where no alteration of substance, but a mere change of structure, takes place. In the same way, the electric currents passing through the earth's crust must be diverted, or accelerated, retarded, or modified, wherever the uniformity of composition is interrupted. Such interruptions will be caused by deep fissures, once open at the surface and leading towards the earth's interior. These clefts cannot generally be found by direct observation, but require the aid of geological research.

At the present day, probably the majority of physicists consider the globe to be a body of very uniform composition or structure, and though it is generally admitted that there is a change of structure radially, the irregularities which divide one and the same of the presumed concentric layers into unequal parts, are generally neglected, although geology has proved the predominance of such irregularities in the earth's crust.

Modern geology no longer accounts for the differences between observed and calculated polar altitudes by assuming constant errors, the compensation of which is effected on the method of Least Squares. We know that the earth is irregular in form, and that its shape cannot be expressed by any mathematical equation. The so-called geoid is not geometric in form, and there is in fact an infinite number of geoids. These discoveries have greatly limited the application of the method of Least Squares. Irregularities exist not only in the form of the earth, but also in the distribution of matter, and precautions are just as necessary in physiographical researches as in geodetic investigations, if a mathematical compensation of errors is to be attempted. Though errors of observation cannot be avoided, there is no doubt that in many cases deviations from a certain expected result are not due to errors, but to actual irregularities presented by nature. These deviations were formerly referred to accidental causes or to local influences, and the unexpected results were considered anomalous and disappointing; and even up to the present day it has been customary to arbitrarily modify results which do not agree with mathematical formulas, and to constrain curves that would not otherwise have exhibited the expected regularity.

The earth's crust is considerably broken and fissured, and its superficial layers folded; these disturbances must have some influence on the phenomena resulting from the motions which we call heat, electricity, and magnetism. Of these forces, magnetism is the one most useful in the study of the earth's structure, and just as optical phenomena are employed in researches on the internal structure of crystals, those of magnetism may be used to investigate the internal structure of the globe. Magnetic phenomena may be regarded as telegraphic messages from distant depths, but, unfortunately, in the present state of science, it is impossible to decipher them.

In a memoir entitled "The Phenomena of Terrestrial Magnetism in their Dependence upon the Structure of the Earth's Crust,"[1] I have given a large number of instances in which the distortion of magnetic curves are caused by clefts in the crust, and have pointed out that the isogonic lines afford the clearest indications of a connection between magnetic and structural conditions. The 'isogones' are much more important than the magnetic meridians; this will be easily understood as soon as electricity and magnetism are considered to be different manifestations of one and the same force. From recent investigations made in Germany it is highly probable that an intimate connection exists between Earth Currents and Terrestrial Magnetism, and if this be true, deviations in the direction of the currents ought to be accompanied by changes of declination. For such reasons I consider the Isogones to be the best indicators of the course of the earth-current.

The systems of magnetic curves show very distinctly a relation to mountain ranges, faults, eruptions, and tectonic disturbances, wherever a detailed magnetic survey has been made. Irregularities in the curves are so frequent that their existence could not be denied even at the very beginning of magnetic surveying; however, they were not attributed to want of internal uniformity of the globe, but to the influence of magnetic masses at or near the surface, to denote which, the special name "Rock Magnetism" was introduced. There *are* magnetic rocks *at the surface*, and almost any kind of rock, such as Serpentines, Granites, Syenites, Porphyries, Diorites, Trachytes, Andesites, Basalts, etc., may act on the needle, but there are no magnetic rocks *below the surface!* Even magnetic iron ore does not show a trace of magnetism directly after it is taken from the mine,

[1] Die Erscheinungen des Erdmagnetismus in ihrer Abhängigheit von Bau dei Erdinde. Stuttgart, 1887

but the magnetic property is developed after being exposed to the atmosphere for some time.

In the above-mentioned memoir I have endeavoured to prove that the so-called "rock magnetism" does not produce the distortion of magnetic curves, and I here quote one example to show how insignificant these local disturbances are. The long chain of mountains, Katschanar-Blagodat-Wissakaja Gora of the Ural, consist chiefly of magnetic iron ore, and although the compass is strongly affected in the immediate neighbourhood of the ore in the quarries, yet the chain produces no remarkable distortion in the system of magnetic curves. Other examples might be given to show that "rock magnetism" is a secondary phenomenon confined to the *very surface* of masses, and not a property of the masses themselves. Moreover, the surfaces of rocks which exhibit magnetic properties, generally present a considerable number of irregularly distributed poles.

The connexion between magnetic and structural phenomena was foreseen by several distinguished observers. It was on the 26th of May, 1849, that Kreil read his paper "On the Influence of the Alps on the Reactions of the Magnetic Force of the Earth."[1] He was not clear about the tectonic relations, but knew with certainty that some connexion existed between magnetic phenomena and the internal condition of the earth's crust, and that the cause of mountain ranges had considerable influence on the direction of the magnetic curves.

At a still earlier date Locke communicated his paper to the American Philos. Soc. of Philadelphia.[2] In it, many interesting observations were made which might have been followed with advantage, but unfortunately his work, like that of many others, was forgotten. He surveyed magnetic profiles, and plotted inclination curves having distances as abscissæ and "magnetic dips" as ordinates. The curve for the line passing over the horizontally stratified rocks of the West, through Kentucky and Ohio, and along the Mississippi, shows generally a very gradual rise until it crosses eruptive rocks between Baltimore and New York, where it exhibits a rise and fall "like the contour of primitive or igneous mountains." (See Plate XV. Fig. 1.)[3]

Many extensive surveys have been made since Humboldt and Gauss brought the subject into prominence, but there have been few observers who were not somewhat embarrassed by the mathematical theory of Gauss, and nearly all have considered the irregularities in magnetic charts as something accidental, anomalous and vexatious. The recent activity in magnetic surveying is very gratifying, but many observers still use the old methods, although they are capable of considerable improvement.

The rate of progress could be further accelerated by establishing

[1] Denkschriften der Kaiserlichen Akademie der Wissenschaften. Mathem. naturwissench. Klasse. Bd. I. Wien, 1850.

[2] Locke, Observations of the Magnetical Force in several parts of the United States. Trans. Am. Phil. Soc., Philadelphia, vol. ix. 1846, p. 283.

[3] The Plates illustrating Dr. E. Naumann's paper will accompany Part II. in December Number Geol. Mag.—Edit.

and following a general scheme for a Magnetic Survey of the whole globe, and united efforts might considerably reduce the labour involved in so great an undertaking. It is very desirable that such a systematic and complete survey should be taken in hand, instead of giving particular attention to limited districts, and I solicit the help of those interested in the subject, in starting an undertaking in which we may be sure that all nations will gladly join.

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

IV.—On the Systematic Position of the "Dendrodont" Fishes.

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

In a short paper on the nomenclature of the Old Red Sandstone Fishes published in this Magazine for November, 1888, I expressed the opinion "that the scattered teeth and fragments of jaws known as *Dendrodus* and *Lamnodus* belong to fishes at present known to us by their scales as species of *Holoptychius* and *Glyptolepis*." The family terms "Holoptychiidæ" and "Dendrodontidæ" I consider absolutely synonymous. On the other hand, the Rhizodontidæ (*Gyroptychius*, *Tristichopterus*, *Rhizodus*, etc.) present a somewhat different form of tooth-structure, and one which is, in the main, identical with that which, in so many Stegocephalous Amphibia, is called "labyrinthodont."

The reasons in support of this opinion are something considerably beyond the region of conjecture,—they amount to positive proof.

As far back as 1849, Hugh Miller[1] figured portions of jaws with teeth, as well as microscopic sections of teeth from Thurso, which are undoubtedly referable to Owen's genus *Dendrodus*, both as regards external configuration and internal structure. Of this Miller was aware, though he refers them to *Asterolepis*, Eichwald, along with the large cranial shields and other remains of a great coccostean fish, *Homosteus* of Asmuss. Now nothing can be more certain than that these dendrodont teeth from Thurso belong to a large species of *Glyptolepis*, in more than one head of which, belonging to the Edinburgh Museum, they may be seen in *situ*. This *Glyptolepis* is also identical with Agassiz's "*Platygnathus*" *paucidens*.

As regards the *very* closely allied Upper Old Red genus *Holoptychius*, I have not obtained any microscopic sections of teeth found in *situ*; but, to judge from the external characters of these teeth, as seen through a good hand-lens, it is impossible to doubt their dendrodont nature. And finally the portions of jaws which occur displaying teeth of "Dendrodus" are undoubtedly Holoptychian in their configuration.

Now, the occurrence in the Holoptychiidæ of pectoral fins displaying the "archipterygeal" configuration clearly enough shows that there must be *some* genetic connection between this family and the Dipnoi. I was therefore interested to read in the introduction to a recent paper on this subject[2] by Dr. J. V. Rohon that the

[1] Footprints of the Creator, first edition, 1849, figs. 30, 31, 32 and 33.

[2] Die Dendrodonts des devonischen Systems in Russland, Mem. Acad. Imp. Sc. St. Petersbourg (vii.) vol. xxxvi. No. 14, 1889.

"Dendrodonts" do not belong to the Ganoidei, but to the Dipnoi, as he had been able to prove the autostylic condition of the skull—"d.h. das mit dem Schädel unbeweglich verschmolzene Palatoquadratum und das verkümmerte Hyomandibulare." On reading the paper, however, and examining the two very pretty plates by which it is illustrated, one is rather disappointed as to the evidence which Dr. Rohon has adduced to prove his position.

It is of course not always easy to identify every part of a fossil fish skull from drawings only, but there are a few points concerning the fossil figured by Dr. Rohon as the "skull" of *Dendrodus biporcatus* which are self-evident.

This "skull" (pl. i. fig. 1) is not the entire skull, with several body-vertebræ fused with it, as Dr. Rohon seems to imagine, but only the anterior part or snout broken off near the interorbital region. His "pterygo-palatine" bones are the two elements of the duplex vomer, each of which, as in the Rhizodonts and Saurodipterines, bears one or more large tusks. The skull being broken off quite anterior to the brain-cavity, it will hardly be appropriate to designate anything here displayed as "quadrate" or "hyomandibular," the parts so lettered being in reality ante-orbital in position! What Dr. Rohon interprets as orbit (though indeed with a query) is a crevice apparently at the postero-external part of the premaxilla.

Dr. Rohon seems to put great weight on the "einheitlichen Hautknochen" by which the "Schädeldecke" is represented. The fusion of the dermal plates of the snout with the premaxillæ into one piece is not, however, a very rare phenomenon in Devonian Crossopterygii, and is indeed well seen in a large skull of *Glyptolepis paucidens* in the Edinburgh Museum.

In fig. 3 Dr. Rohon represents a broken-off snout which he refers to a new species of *Cricodus* (*C. Wenjuckowi*). Here the supposed "orbits" have a most suspicious resemblance to nasal openings. The orbits in many old fossil fishes are anterior enough, it is true, but not quite situated upon the very front of the snout itself.

In fig. 10 Dr. Rohon has given a view of a dentigerous fragment from Thurso which he supposes to be a part of a skull of *Dendrodus* showing the cranial cavity. As the diameter of the supposed cranial cavity is not greater than that of the base of the large tooth attached to the specimen, this interpretation can hardly be correct.

Nor can I admit that the dentigerous fragment depicted in his fig. 11 represents the entire mandible either of *Dendrodus* or any other fish. I think also that Dr. Rohon is hardly entitled to explain the discrepancies between this fragment and the mandibles, figured by Pander, Trautschold and Agassiz, on the supposition that they belonged to fishes which, though "allied to the Dendrodonts in the structure of their teeth, were tolerably far removed from them as regards the constitution of the lower jaw, and probably also of the skull."

At the end of the paper he gives an "attempt at a restoration" of *Dendrodus biporcatus*, Owen. Here the body and fins are formed as in *Gyroptychius*, and, if the author considers *Dendrodus* to be a

Dipnoan, it is certainly strange that he should represent it with the obtusely lobate pectorals of the Rhizodonts and Osteolepids instead of with the acutely lobate or unabbreviate archipterygeal members of *Ceratodus* or *Dipterus*. Except the mandible, no bones are marked off on the head, in accordance with the idea that the cranial roof is represented by a single dermal bone, while near the end of the snout are placed two minute orbits. It is to be hoped that no future compilers of geological or palæontological text-books will copy this extraordinary figure and insert it as a "restoration of *Dendrodus*."

As the result of his researches Dr. Rohon announces that the genera *Dendrodus*, Owen, and *Cricodus*, Agassiz, are not Ganoids, and considers that they should be reckoned as forming a peculiar order of Dipnoi. Of this supposed "order" he gives the following definition:—"Fishes with depressed head, whose surface-ornament consists of ridges and tubercles. The free margin of the snout is set with numerous small teeth, whose folded dentine encloses a spacious pulp-cavity. Two powerfully developed palatal teeth, which are intimately united with the pterygo-palatine, and within the folded dentine contain a spacious pulp-cavity; they are placed asymmetrically. The bony quadrate is fused with the skull. A styliform parasphenoid displays on its surface a tract of little tubercle-like teeth, and is the bearer of several fused vertebræ, drawn into the skull. Very small orbits (?) and two internal nasal openings are present. The skull-roof represents a simple dermal bone, whose histological structure corresponds to that of true osseous tissue."

Now as this definition is founded upon an entire misinterpretation of the specimens figured in the paper, I fear it can only be looked upon as a curiosity of scientific literature. Whatever relationship "*Dendrodus*" may have with the Dipnoi, it is certainly not in the manner indicated by Dr. Rohon, and I for one do not as yet see any reason for separating the Holoptychiidæ, of which I consider "Dendrodontidæ" to be a simple synonym, from the Crossopterygian Ganoids.

Again, I must refer to my paper on the nomenclature of the Old Red Sandstone fishes with regard to *Cricodus*, which Dr. Rohon also includes in his Dendrodont Dipnoi. If Pander's *Polyplocodus* be synonymous with Agassiz's *Cricodus*, then the latter is certainly not a Dendrodont or Holyptychian, but a Rhizodont.

V.—On Zonal Structure in Olivine.

By J. Shearson Hyland, Ph.D., M.A.,
Of Her Majesty's Geological Survey.

In a recent paper on the volcanic rocks of Kilimandjaro I referred to the presence in the basaltic lavas of olivine crystals, which appeared to possess zonal structure. Although actual proof was wanting, still the symmetrical arrangement of the inclusions, as also the mode of alteration of the crystals, rendered the occurrence of such a structure highly probable. The olivines, being rich in iron, were altered into ferric oxide or ferric hydrate; and the line of division between the fresh and decomposed portions was mostly parallel to the crystallographic outlines.[1] There was, however, no break in the optical continuity, such as the presence of zonal structure would demand.

A microscopical examination of some similar rocks from the same locality has led to the gratifying discovery of true evidence of zonal structure in this mineral. Fig. 1 shows a corroded olivine exhibiting this phenomenon. The inner zone is shaded in order to graphically represent its outline with reference to the contours of the crystal.[2] The zones are dissimilar in their optical behaviour, the difference between their extinction-angles being as much as 6°. In transmitted light there is a trace of the structure apparent; the upper line of division being a plane of fracture, the lower being marked by glass inclusions.

Fig. 1.

The literature on the subject is not extensive. Van Werveke, in 1879, seems to have been the first to suggest the possible occurrence of zonal structure in this mineral. In his paper on the Palma basalts he mentioned the presence in this constituent of glass inclusions, which were arranged parallel to the crystallographic outlines. This induced him to expect zonal structure.[3] In the same year Hofmann formed a similar opinion as the result of his observations of the presence of "zones which were different in their optical characters and in their manner of alteration."[4] Bruno Doss, in his paper on Syrian basalts, described and figured olivines composed of concentric layers, but was able only in one instance to note a variation in the polarisation tints.[5] Stock has also mentioned a similar experience.[6] I fail, however, to find any instance recorded where the difference in the extinction-angles was so great as to allow of its accurate determination.

Crystals grow by accretion, that is, by the addition of matter to their external surfaces. If this addition be regular and constant, the crystal formed will be a correct type of the species. But, if the growth be intermittent, complications will arise. In this respect a crystal is like a living organism: it is affected by its environment. The crystal modifies its surroundings, and is in turn modified by them: there is action and reaction between it and its environment. Intermittent growth must, accordingly, tend to produce zoned structure. In the case of isomorphous mixtures like augite and felspar this

[1] "Ueber die Gesteine des Kilimandscharo und dessen Umgebung." Tschermak's Mittheilungen, 1888, vol. x. pp. 224 and 226; also plate vii. fig. 2.

[2] The mineral gives reactions characteristic for olivine.

[3] "Beitrag zur Kenntniss der Gest. d. Insel Palma." Neues Jahrbuch für Mineralogie, etc., 1879, p. 820.

[4] "Die Basaltgest. des südlichen Bakony," Budapest, 1879, pp. 27 and 193.

[5] "Die basaltischen Laven und Tuffe der Provinz Hauran, etc.," Tschermak's Mitt. 1886, vii. p. 488; plate ix. fig. 32.

[6] "Die Basaltgest. des Löbauer Berges," Tschermak's Mitt. 1888, ix. p. 437; and plate ix. fig. 2.

tendency is particularly strong, and usually leads to the construction of crystals built up of innumerable layers, different in chemical constitution and often so fine as to require the microscope for their detection. Since olivine represents an isomorphous mixture of $Mg^2 SiO^4$ and $Fe^2 SiO^4$, it should be equally liable to this structure, and the poverty of observations on the point seems all the more remarkable.

If the outline of the inner zone be studied, decided evidence of its corrosion through the fluid magma, previous to the deposition of the outer shell, will be observed. This alone is proof of the two zones representing different periods of growth. The corroded form of this inner zone reminds us of the analogy existing between a crystal and an organism in manner of growth. The influence of the environment has already been referred to; but the regeneration of lost or injured parts[1] is also common to both. M. L. Pasteur has particularly studied this property in crystals. He refers to the process as follows: "Quand un cristal a été brisé sur l'une quelconque de ses parties et qu'on le replace dans son eau mère, en même temps qu'il s'agrandit dans tous les sens par un depôt de particules cristallines, un travail très-actif a lieu sur la partie brisée ou deformée, et en quelques heures il a satisfait non-seulement à la régularité du travail général mais au rétablissement de la régularité dans la partie mutilée. . . . . La partie endommagée reprend peu à peu sa forme primitive, mais la travail de reformation des tissus est en cet endroit bien plus actif que dans les conditions normales ordinaires."[2]

Applying these observations to the case under consideration, we conclude that, corrosion having ceased and the constructive process having recommenced, growth was more rapid at the corroded than at the uninjured part of the crystal. Consequent upon this special activity, regularity of form was re-established, and, "regeneration" having thus occurred, constant accretion completed the crystal.

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VI.—On the Muscular Impressions of *Cœlonautilus*[3] *cariniferus*, J. de C. Sowerby, sp., compared with those of the Recent Nautilus.

By Arthur H. Foord, F.G.S., and G. C. Crick, F.G.S.

In examining the remarkably fine series of examples of *Cœlonautilus cariniferus*, mostly from the Carboniferous Limestone of Ireland, contained in the Geological Collections of the British

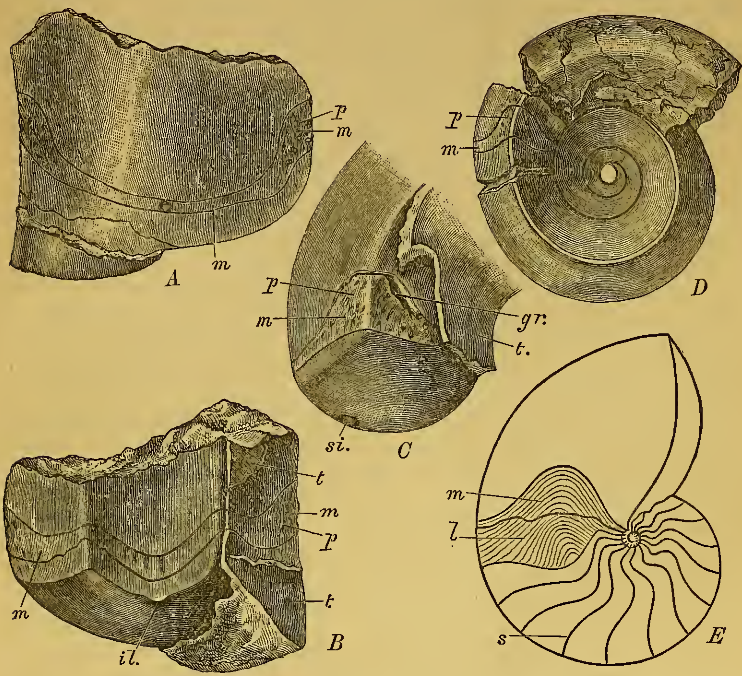
[1] Ger. Reproduktion verletzter Theile.

[2] "Etudes sur les modes d'accroisement des cristaux, etc." Compt. rend. tome 43, 1856, p. 795; see also, F. Scharff, "Ueber die ausheilung verstümmelter oder im Wachsen verhindert gewesener Krystalle, etc.," Pogg. Ann. vol. 109, 1860, p. 529; W. Ostwald, Lehrbuch d. allg. Chemie, Leipzig, 1885, Bd. i. p. 738; according to Scharff (l.c.) Jordan made an observation similar to Pasteur's as far back as 1842 (in Müller's Archiv.).

[3] This name from κοῖλον hollow (referring to the umbilicus), and *Nautilus*, is proposed by one of us in substitution for *Trematodiscus*, Meek and Worthen, which

Museum (Nat. Hist.), some were found to exhibit upon the cast of the body-chamber distinct marks of the shell-muscles. In one specimen (No. 50190) these are so perfect as to give a very clear outline of their form, and some of the test having been removed, their entire course can be made out.

The accompanying Figures (*A*, *B*, *D*) show the appearance of these muscular impressions, carefully drawn of the natural size, from this specimen.



Cœlonautilus cariniferus, J. de C. Sowerby, sp., from the Carboniferous Limestone, Cork, Ireland.—*A*, ventral or peripheral aspect of the base of the body-chamber (nat. size), showing at *m*, *m*, marks of the shell-muscles (*m* in all the other figures has the same meaning) ; *p*, in all the figures (exclusive of *e*) refers to the pitted and rugose surface of the muscular impressions : *B*, dorsal (internal) aspect of the same fragment, *t*, test, *il*, dorsal lobe of a septum : *C*, base of the body-chamber of a larger (? adult) specimen, *t*, test, *gr*, groove : *D*, reduced figure of a nearly perfect example of this species, from which the fragment lettered *A* and *B* was removed, as explained elsewhere in the text : *E*, outline, much reduced in size, drawn from a cast of the interior of *Nautilus pompilius* ; *l*, finely impressed lines left by the shell-muscle, *s*, sutures of the septa.

was used by Häckel for a genus of Radiolarians. The name *Trematoceras* proposed by Hyatt (Proc. Boston Soc. Nat. Hist. 1883, vol. xxii. footnote, p. 291) in lieu of *Trematodiscus* is equally ineligible, because preoccupied, for although the species described by Eichwald (Leth. Rossica, 1860, vol. i. p. 1259)—*Trematoceras discors*—was a *Bactrites*, a generic name once published cannot be again employed, even for a different group, without risk of confusion.

A drawing has also been made (Fig. *E*), much reduced in size, from a cast of the interior of the shell of *Nautilus pompilius*, in order that the muscular impressions of *C. cariniferus* might be compared with those of existing species.

Fig. *D* represents the specimen selected for illustration, it is reduced in size from the original about one-half. The portion marked with the letters *p*, *m*, was removed from the rest of the shell in order that the muscular impressions might be drawn as seen in Figs. *A* and *B*, which are of the actual size.

Fig. *C* is taken from a larger (probably adult) specimen of *C. cariniferus* ("Sowerby Collection," No. 43861), and shows the marks of the shell-muscle on one of the angles of the whorl more distinctly than they can be seen on the smaller one.

We will now describe these figures more in detail. Figure *A* represents the ventral or peripheral side of the base of the body-chamber. The impressions of part of the shell-muscles are seen at *m*, *m*, while *p* indicates their rugose and pitted surface, and proves how strongly they were attached at the angles of the whorls; this is further evidenced by the deep groove *gr.* in Figure *C.*

Connecting the broader portions of the muscular impressions is a narrow band, near the centre of which there is a little shallow pit (see Figure *A*), which undoubtedly formed part of the muscular system, as the narrow band is slightly enlarged at this point to embrace it.[1]

Figure *B* is the under side of *A*. On this side it will be seen that the narrow band at its central part is strongly deflected backwards, in a similar manner to that of the annulus of the recent *Nautilus* (*N. pompilius*), so well figured (pl. xxxix. fig. 4) by Dr. W. Waagen in his well-known memoir entitled "Ueber die Ansatzstelle der Haftmuskeln beim Nautilus und den Ammoniden."[2]

The deflected portion bears several shallow, more or less elongated pits (see Figure *B*), which seem to indicate a rather strong attachment of the muscles at this point, though not so strong as at the angles of the whorls, where the muscular impressions are broadest.

Figure *C* represents the base of the body-chamber of a larger specimen than that from which *A* and *B* were drawn, and is designed to show more distinctly the pitted and rugose surface of the cast, proving, as already remarked, the strong attachment of the muscles at the angles of the whorl. Part of the test (*t*) has been removed in order to expose this part of the muscular impression more completely.

On examining the interior of the body-chamber of the shell of the recent *Nautilus* (either *N. pompilius* or *N. umbilicatus*) two somewhat inconspicuous lines (Fig. *E*, *m*) are observed, enclosing a space which on the dorsal and ventral sides of the shell forms a narrow band,—the impression of the annulus,—but expands at each side into an irregularly oval space,—the impression of the shell-muscle,—of which the outer boundary is strongly arched forwards. Corresponding in direction

[1] This enlargement is not indicated in the Figure, as it should have been.

[2] Palæontographica, bd. xvii. 1870, p. 185, plates xxxix. xl.

with the line forming the outer boundary, and covering the whole of the space between this and the last-formed septum, are a series of very fine impressed lines (marked *l* in Fig. *E*). These lines indicate successive points of attachment of the upper edge of the shell-muscle, representing a gradual forward movement, little by little, of the animal in its shell during growth. It should be observed that the line constituting the lower boundary of the muscular impression is only seen where the muscle was last attached.

That the organic attachment of the shell-muscles of the recent Nautilus to the shell was very slight (thus contrasting strongly with *Cœlonautilus*) has been pointed out by J. D. Macdonald[1] and subsequent writers.[2] Macdonald's description is so important and interesting in this connection that we quote it *in extenso*:—

"With reference to the action of the great lateral muscles of *Nautilus*, the following ideas have suggested themselves to my mind.

"As though preparatory to the complete separation of the body of the Cephalopod from the shell, which is usually present in the lower genera, the fasciculi composing the lateral muscles in *Nautilus* do not perforate the mantle, and therefore cannot be directly fixed into the shell; they are, however, connected with it through the medium of thin filmy layers of a corneous texture, which frequently remain attached to the shell after the animal has been removed. The feeble hold of those muscles, even in a very recent state, is thus readily accounted for. Indeed, it is highly probable that the fixity of the body of *Nautilus* during the inhalation and forcible ejection of the respiratory currents is effected by the shell-muscles reacting upon one another, on the principle of a spring purchase, rather than by simple traction, as illustrated by the withdrawal of a Gasteropod within its retreat, or the closure of a conchifer by the adductor muscles.

"This view, which is supported by the foregoing facts, has its principal basis in the line of direction of the shell-muscles, and the angle at which they meet one another, at the root of the funnel-lobe; for, the outer extremity of each being fixed, it follows that the first effect of the contraction of the muscular fibres would be to increase the angle just noticed; and this cannot possibly be accomplished, according to the recognized laws of muscular action, without tending to throw apart the points of origin, or, in other words, exerting outward pressure against the internal wall of the shell, and thus, as it were, jamming the occupant tightly in its cell."

In order that the above description may be more readily comprehended we here append a reduced copy of the figure given by Sir Richard Owen in his "Memoir on the Pearly Nautilus," 1832, plate 3, fig. 2.

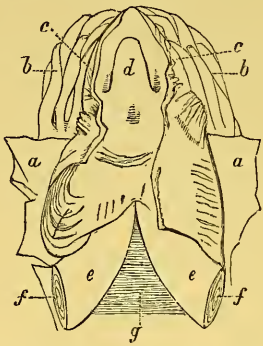
A comparison of the muscular impressions of *Cœlonautilus* with those of the recent *Nautilus* points to the conclusion that the animal

[1] Proc. Roy. Soc. 1856–7, vol. viii. p. 381.

[2] Prof. Blake, "Brit. Foss. Ceph." pt. i. p. 10; see also "Note on the Pearly Nautilus," by E. A. Smith, F.Z.S., in "Journ. of Conchology" for Oct. 1887; also 'Catalogue Fossil Cephalopoda,' British Museum (Nat. Hist.), pt. i. 1888, p. xi.

must in the former have been fixed more firmly in its shell than in the latter, and that in all probability the shell-muscles were not limited to the sides of the animal, as in the recent *Nautilus*, but completely encircled it.

The difference between the shell-muscles of *Cœlonautilus* and those of the recent *Nautilus* strongly supports the view that the two forms are *generically* distinct, a conclusion already arrived at from the great dissimilarity in the form of their shells by such an eminent authority as Prof. Hyatt. The subdivision of *Nautilus* was, in fact, begun long ago by M'Coy[1] and continued by Meek,[2] the latter of whom expressed his decided opinion that such divisions should at least rank as distinct subgenera.



Under surface of the head of *Nautilus pompilius*, with the mantle divided and the funnel turned back to expose its cavity and the shell-muscles.

a. a. The divided portions of the mantle; *b. b.* Sheaths of the tentacles; *c. c.* The funnel; *d.* Its valve; *e. e.* Shell-muscles; *f. f.* Their terminations or surfaces of attachment; *g.* The transverse fibres connecting them.

VII.—Foraminifera from the London Clay of Sheppey.

By Frederick Chapman and C. Davies Sherborn.

In the Proceedings of the Geologists' Association for 1878,[3] Mr. W. H. Shrubsole, F.G.S., published a list of Foraminifera obtained from the London Clay of Sheppey. The following list, the result of an examination of some material courteously lent to us by Professor J. W. Judd, F.R.S., adds considerably to the fauna of Sheppey and includes two species not previously recorded from the London Clay. Forty-one forms have been determined, of which twenty-six[4] are new to Sheppey, thus bringing up the number of forms recorded from that locality to eighty-six. The geographical distribution of the Foraminifera of the London Clay was fully tabulated in 1886,[5]

[1] Synopsis of the Carboniferous Limestone Fossils of Ireland, 1844.
[2] United States Geol. Survey of the Territories, 1876, vol. ix. p. 490.
[3] Proc. Geol. Assoc. vol. v. no. 7, p. 355, 1878.
[4] Numbers 4–9, 11, 13–15, 19–23, 26–30, 33, 36–41, of the list appended.
[5] Sherborn and Chapman, Journ. R. Microsc. Soc. [2], vi. 1886, p. 759; and *ibid.* 1889, p. 483.

and it is interesting to find so many of the forms there figured and recorded for the first time from the London area common to both localities. The figure following the specific name in the list appended shows the relative abundance of the varieties found.

The two forms deserving mention as new to the London Clay are: *Pleurostomella alternans*, Schwager, Novara Reise, 1866, p. 238, pl. vi. figs. 79 and 80; H. B. Brady, Rep. "Challenger," 1884, p. 412, pl. li. figs. 22 and 23; *Pleurostomella eocæna*, Gümbel, Abh. k.-bay. Ak. Wiss. vol. x. 1868, p. 630, pl. i. fig. 53. A single small specimen, slightly broken on one side, but preserving all the characteristics of the genus.

Lagena desmophora, Rymer Jones. *L. vulgaris*, var. *desmophora*, Rymer Jones, Trans. Linn. Soc. vol. xxx. 1872, p. 54, pl. xix. figs. 23, 24; *L. desmophora*, H. B. Brady, Rep. "Challenger," 1884, p. 468, pl. lviii. figs. 42 and 43. Characterized by prominent decorated costæ, the intercostal areas being occupied by one or more costæ, less prominent and unornamented. One specimen precisely corresponding to figure 42 in Brady's report cited above. Four species of Ostracoda were found, of which two are apparently new.

The following is a list of the Foraminifera:—

1. *Miliolina trigonula*, Lam. sp. 6.
2. *Ammodiscus incertus*, d'Orb. sp. 3.
3. *Textularia agglutinans*, d'Orb. 13.
4. *Bigenerina capreolus*, d'Orb. sp. 14.
5. *Gaudryina pupoides*, d'Orb. 10.
6. *Clavulina communis*, d'Orb. 7.
7. —— *parisiensis*, d'Orb. 2.
8. *Bulimina affinis*, d'Orb. 2.
9. *Pleurostomella alternans*, Schw. 1.
10. *Lagena globosa*, Mont. sp. 1.
11. —— *desmophora*, Ry. Jones, 1.
12. —— *marginata*, Walk. & Boys, 1.
13. *Nodosaria radicula*, Linn. sp. 3.
14. —— *humilis*, Roem. 9.
15. —— *longiscata*, d'Orb. 16.
16. —— *soluta*, Reuss, 4.
17. —— *raphanus*, Linn. sp. 1.
18. —— *badenensis*, d'Orb. 2.
19. —— *polygona*, Reuss, 5.
20. *Dentalina communis*, d'Orb. 5.
21. —— *consobrina*, d'Orb. 12.
22. —— *spinulosa*, Mont. sp. 10.
23. *Dentalina acicula*, Lam. sp. 2.
24. *Marginulina Wetherellii*, Jones, 27.
25. *Cristellaria italica*, Defr. sp. 1.
26. —— —v. *spinulosa*, Sherb & Chap. 1.
27. —— *cultrata*, Montf. sp. 18.
28. *Polymorphina gibba*, d'Orb. 1.
29. —— *gutta*, d'Orb. 1.
30. *Uvigerina asperula*, Cziz. 6.
31. *Globigerina bulloides*, d'Orb. 4.
32. *Orbulina universa*, d'Orb. 1.
33. *Pullenia quinqueloba*, Reuss, 3.
34. *Discorbina rosacea*, d'Orb. sp. 1.
35. *Planorbulina ammonoides*, Reuss, sp. 1
36. —— *complanata*, Reuss, sp. 6.
37. *Anomalina grosserugosa*, Gümb. sp. 4.
38. *Pulvinulina repanda*, Ficht. & Moll, sp. 2.
39. —— —— var. *concamerata*, Will. 3.
40. —— *Karsteni*, Reuss. 1.
41. —— *punctatula*, d'Orb, sp. 17.
42. —— *striato-punctata*, Ficht. & Moll, sp. 1.

VIII.—On the Occurrence of the Devonian Ganoid *Onychodus* in Spitzbergen.[1]

By A. Smith Woodward, F.G.S., F.Z.S.

During a visit to Stockholm last spring, Prof. Gustav Lindström kindly permitted the writer to examine the series of remains of Palæozoic fishes obtained from the Devonian of Spitzbergen by Dr. A. G. Nathorst, during the Swedish Geological Expedition in 1882. Some of the more prominent specimens have already been briefly noticed, with figures, by Prof. Ray Lankester;[2] but the

[1] Read before Section C (Geology), British Association, Newcastle, 1889.

[2] E. Ray Lankester, "Report on Fragments of Fossil Fishes from the Palæozoic Strata of Spitzbergen," Kongl. Svenska Vetensk.-Akad. Handl., vol. xx. (1884), No. 9, pp. 1-6, pls. i.-iv.

collection is worthy of a more detailed comparative study than that to which it has hitherto been subjected, and among the undescribed specimens most readily identified is a small fossil indistinguishable from the so-called "intermandibular arch" or "presymphysial bone" of *Onychodus*.[1] Through the kindness of Prof. Lindström, this specimen has been forwarded to the British Museum for examination, and it forms the subject of the following remarks.

Four fractured teeth are exhibited, attached in close series to a narrow arched base, and the fossil is firmly imbedded in a hard matrix. It is evidently imperfect, but the base preserved is 0·005 in length, and the uppermost and longest tooth has a nearly similar measurement. This tooth is slender, tapering, and gently curved, without any sigmoidal twist; and both it and the more imperfect teeth below are characterized by the relatively enormous size of the internal cavity.

In its small dimensions the presymphysial dentition from Spitzbergen most nearly approaches that of *Onychodus anglicus*,[2] from the Lower Old Red Sandstone Passage Beds of Ledbury, Herefordshire; but it is distinguished by the more uniformly tapering character of the teeth, and the relatively larger size of the pulp-cavities. In the latter feature it seems to be more nearly paralleled by the much larger, typical species from the Devonian of the United States; but all described forms differ from the new fossil in the larger size of the teeth in proportion to their base of attachment. The Spitzbergen species, thus imperfectly indicated, may therefore be regarded as hitherto unknown, and, in reference to its interest from a distributional point of view, may be named *Onychodus arcticus*.

NOTICES OF MEMOIRS.

The Geology of Devon, Facts and Inferences, from the Presidential Address to the Devonshire Association. By W. H. Hudleston, Esq., F.R.S., Sec.G.S., etc. August, 1889.

We can have little doubt that this South-western part of England had the honour of leading off the Geological Surveys of the world because of its great metallic wealth, and because of the interesting and complicated phenomena associated therewith. But it must not be supposed that the early Surveyors settled every question fifty years ago, especially when we bear in mind the varied nature of the region, the obscurity of many of the problems, and the comparative novelty of the task. Devonshire especially has been the theatre of many a geological battle since then, nor can we aver that the temple of Janus is at present closed. It is twenty-one years ago, I believe, since a President of the Devonshire Association dealt with any of these topics from the chair. Mr. Pengelly, in the year 1868, after giving an admirable summary of

[1] J. S. Newberry, Geol. Survey of Ohio, vol. i. pt. ii. (Palæontology), pp. 296–302, pts. xxvi. xxvii.

[2] Smith Woodward, "Note on the Occurrence of a Species of *Onychodus* in the Passage Beds of Ledbury," Geol. Mag. Dec. III. Vol. V. (1888), p. 500.

the progress of geology in Devonshire up to that date, propounded nine questions for special consideration in the future. These I venture to recall to your memory—

1. The age of the crystalline schists of the Bolt.
2. The precise chronology of our Limestones and associated rocks.
3. Is there east of Exmouth a break in the Red rocks?
4. Whence come the Budleigh Salterton pebbles?
5. Whence also the porphyritic trap nodules so abundant in the Trias?
6. Are our Greensands really of the age of the Gault?
7. Whence the flints so numerous in our existing beaches?
8. What is the history of our superficial gravels, and are there any indications of glaciation in Devonshire?
9. To what race did the Cave-men belong?

During the interval of over twenty years most of these questions have been discussed, often by Mr. Pengelly himself, and the records are to be found in the volumes of your *Transactions*. Confining any remarks I may have to make on the present occasion to points bearing on the physical history of the county, I would say that these questions may be grouped under five heads — (1.) Recent and Pleistocene geology; (2.) The extent and nature of the Cretaceous rocks; (3.) The New Red question; (4.) The Old Red question; and lastly (5.) The age of the crystalline schists, to which may be appended any necessary remarks on petrological questions.

Recent and Pleistocene Geology.

The recent geology of the county is famous, as all the world knows, for the occurrence of raised beaches, submerged forests, and bone caves. On these I scarcely venture to touch, the cave-question especially verging on the confines of archæology. If the caverns at Oreston were first made the subject of scientific enquiry, those of Kent's Hole and Brixham have yielded results of surpassing interest. Going a step further back in time, there are few problems more obscure than the history of the plateaux gravels of the southern counties: these consist largely of flint. Mr. Parfitt, speaking of the drift gravels towards Dawlish, has expressed his opinion that the agents producing these were ice and water. To this we can scarcely demur, but it was hardly necessary to have included Devonshire in the ice-sheet. The indications of glaciation in this county are matters of inference rather than self-assertion, and observers, like Mr. Somervail, accustomed to the marked features of a thoroughly glaciated country, are slow at finding any evidence of it here. Still it must be obvious to all who reflect upon the subject that the cold which has left such enduring evidences of its intensity in areas so near, for instance, as Caernarvonshire, must have affected the Devonshire climate to a considerable extent. The absence of true Boulder-clay should reconcile the Devonian to the fact that his country is destitute of cowslips, which are very partial to the Boulder-clay soils of the North of England, and are far from scarce in the heavily-bouldered regions of East Anglia. It is true that the

Swedish botanist Nathorst, speaking of the peculiar mixture of clay and stones known as the "'Head' of Bovey Tracey," called it Boulder-clay; and Mr. Pengelly likewise mentioned lately that another Scandinavian authority, Dr. Torell, when in company with Mr. Ormerod as long ago as 1868, professed to have detected three moraines on Dartmoor in the neighbourhood of Chagford. That these were the results of an ice-cap, as that term is generally understood, I do not regard as probable; but bearing in mind the recorded facts, and also the frequency of such features as "terminal curvature," we may well believe with Mr. Worth in the existence of something like a local snow-cap on the higher grounds. The peculiar nature of the cave-breccia, and the Arctic character of some of the cave-animals, also point in the direction of a colder climate. Not that this evidence is really required, except as a matter of corroboration. We may believe, then, in a glaciation so modified that its results require close search before they can be appreciated.

The Extent and Nature of the Cretaceous Rocks.

There are few problems in the physical history of the South-west of more interest than this. Speaking of the geology of the neighbourhood of Dawlish, Mr. Ussher says there can be little doubt that the Cretaceous highlands of Devon, such as the Haldons, are portions of a great plain of marine denudation, and he speaks of a time when that Cretaceous tableland abutted on the flanks of Dartmoor. He also refers to the presence of flints in the old and more modern gravels as evidence of the extension of Chalk *débris*. It is interesting to know that abundant fossil evidence of the former existence of Middle Chalk (the Upper Chalk of some writers) is found in the chert and flint beds which form the capping of Little Haldon; the Echinodermata are especially characteristic. Mr. Ogilvie Evans has called attention to this fact.

As regards the former extension of the Chalk, I see no reason to doubt that the western part of what is now the Channel and the greater portion of Devonshire and Cornwall were submerged beneath the Chalk Sea. It seems to me that in no other way can you account for the quantity of flints on the western beaches and in the bottom of the Channel. But, irrespective of this corroborative evidence, one would expect the Chalk Sea to have extended in this direction. Then comes the question, Was there any western limit to the Chalk Sea, or did its waters mingle freely with the Atlantic Ocean during the period of extreme depression? At the epoch when the Upper Greensand, or basal sediment of the Chalk, was being laid down, Mr. Jukes-Browne, in his "Building of the British Isles," represents the extreme western shore-line, plotted on the existing map of Devon as passing from the Ermemouth towards the Haldons; *i.e.* roughly parallel to the E.S.E. flank of Dartmoor. Now the distance from the Ermemouth to the present edge of the deep Atlantic basin is about two hundred miles, and that two hundred miles would represent the width of the land which intervened between the Upper Greensand Sea and the Atlantic Ocean at the particular period indicated in the hypothetical map to which I have referred. It is a question for separate consideration whether that intervening space of land was wholly or only partially submerged at a later epoch during the period of extreme depression. For our purpose it will be sufficient to have carried the western margin of the Chalk Sea beyond the limits of the Cornish peninsula during the period of lowest depression, and this I think we may fairly claim. I ought to observe that it is not assumed that the English Channel had any existence at that time. Mr. Jukes-Browne regards the Channel as a very modern feature in physical geography, but the existence or non-existence of the Channel as a mere excavation will hardly affect the question of the westward boundary-line of the Chalk Sea.

One more question of Mr. Pengelly with reference to Cretaceous geology remains, viz. the age of the Devonshire Greensand. It was Fitton, and after him Meÿer, who maintained that the Blackdown Beds were of Lower Cretaceous age, although before their time De la Beche had classified them as Upper Greensand, whilst Godwin-Austen described them as possibly a sandy condition of the Gault. The littoral facies and abundance of *Trigoniæ*, having considerable resemblance to Lower Greensand species, led Mr. Meÿer astray. Dr. Barrois and other authors entered the lists, and when Mr. Downes read his excellent paper before the Geological Society in 1881, the balance of opinion tended to the view that the Gault, or most of it, is represented in the Blackdown Beds, and that seemed also to have been Mr. Downes' opinion. If the Ammonites in that gentleman's collection have been correctly determined, there would seem to be a mixture of Lower-Gault with Upper-Gault forms; but as the Upper-Gault of the East of England is represented to a considerable extent in the West by the Upper Greensand, it follows that, if we allow most of the Gault to be represented in the Blackdown Beds, such a determination carries the Upper Greensand with it, so that both De la Beche and Godwin-Austen were right.

There is not a trace of Lower Greensand, and when we bear in mind that the Lower Greensand has already disappeared to the eastward, its revival at Blackdown would be an anomaly. But a further argument in this direction, which Mr. Downes, aided by Mr. Vicary, was the first to indicate, is derived from the fact that the nine lowest horizons indentified at Blackdown are missing at Haldon. This proves conclusively that the basal rocks of the Upper Cretaceous ever occupy a higher horizon as we proceed westwards, and, as we have already seen, this has an important bearing on the question of the final westward limit of the Chalk Sea. It is quite possible also that the missing beds of Chalk were more siliceous than their equivalents further eastwardly, and this would still further help to account for the flints so numerous in the Channel and adjacent shores.

There are two points in connection with Blackdown which might be mentioned: 1st, Mr. Downes read a paper before the Geological Society in November, 1884, "On the Cretaceous Beds of Black

Venn, with some supplementary remarks on the Blackdown Beds." There he appeared to arrive at the conclusion that the *Lima-parallela*-bed of Black Venn is lower than the lowest of the Blackdown Beds, for it thins out before reaching Sidmouth. He again notices the general thinning out westwards. These latter conclusions are somewhat at variance with his previous ideas that the Blackdown Beds represent the whole of the Gault, and he finally inclined to the opinion that the Blackdown Beds were Upper Greensand rather than Gault. I have before pointed out that the Upper Greensand partly represents the Upper Gault of the south-east of England, and this interpretation will help to explain the apparent contradiction.

2nd. The mode in which the clumps of *Turritella* and *Pectunculus* occur in the Blackdown Beds reminds me of the similar way in which their modern representatives occur in the English Channel. Not far from Hope's Nose is a muddy bed full of *Turritella*, showing how the shell is apt to accumulate from some cause or other in one or two particular spots, and throughout the Channel it is by no means uncommon to come across *Pectunculus* in great numbers at particular spots.

New-Red Beds.

The New-Red question next demands our attention, since the Jurassic rocks of Devonshire are limited to a very narrow strip of Lias in one corner of the county. The phenomena in connection with the New-Red beds are of great interest in spite of their poverty in organic remains. We are as much interested in the composition of these beds as in ascertaining their precise chronological value. Thus two of Mr. Pengelly's questions relate to the composition of Triassic pebble-beds. It would certainly appear from Mr. Davidson's determination of the Brachiopoda that a considerable portion of the Budleigh-Salterton pebbles were of Devonian origin or aspect, although there are a sufficient number of admitted or possible Silurian species. Thus Salter's original proposition that they are Normandy types of the May-Hill Sandstone may in part be correct, the fossils being characteristic of beds on both sides of the Channel. The rocks from which such pebbles were derived are certain to be no longer in existence; the pebbles themselves are mere survivals of an ancient denudation, just as is the case with the flint pebbles whose origin we have lately been considering. It is not difficult to believe that both Silurian and Devonian beds were largely developed in portions of what is now the Channel area. Indeed the form of the present peninsula of Normandy clearly points in that direction, whilst projections of Palæozoic rock from what is now the Devon-Cornwall peninsula may likewise have contributed their share. Hence an extension of the Gorran Haven beds, or of La Manche, points almost equidistant, may have been amongst the missing rocks from whose hardest parts some of these pebbles were long ago torn. There is no evidence, so far as I am aware, that the English Channel, in anything like its present form, had any existence in Mesozoic times, and we may well believe this without going so far as Mr.

Jukes-Browne, who represents the English Channel as merely a feature of Pleistocene geography. Doubtless the origin of the English Channel is a problem well worthy the attention of Devonshire geologists, but at present we are considering the composition of Triassic pebble-beds, and must not, therefore, allow ourselves to be led off on a false scent.

Mr. Pengelly's other question, as to the origin of the porphyritic trap nodules, is one which embraces a far wider scope; for along with it must be considered the subject of igneous fragments in the New-Red generally. One would be disposed to say that most of them were derived from the felspathic traps, so many of which make their appearance at the junction of the Carboniferous and New-Red. This peculiarity of position Mr. Vicary was disposed to attribute to the circumstance that these traps have served to arrest denudation in the Trias. It is said that none are to be seen in the coast section. Mr. Vicary regarded the earliest eruptions of this class of rock as having taken place between the close of the Carboniferous and the commencement of the Triassic, whilst the latest outbursts were of Triassic age. Mr. Downes also, whilst endeavouring to account for the presence of some Upper Devonian fossils in the Trias near Tiverton, has expressed his opinion that the hypothesis of an active volcano upon the coast of the early Triassic sea best meets the requirements of the case. Mr. Somervail likewise has expressed his views on the probable volcanic origin of the breccias at the base of the Trias in South Devon, and as to the conditions prevailing during their accumulation.

It cannot be doubted that a careful and unprejudiced study of the igneous rocks in the Devonshire Trias will help to throw much light on an important stage in the physical history of the area. But in undertaking such an investigation due allowance must be made for the changes which the fragments have themselves undergone in a highly permeable formation. If lumps of hard limestone, under the influence of siliceous infiltration, have been converted into that peculiar form of orbicular silica known as "Beekite," we need not be surprised at felspars, derived originally from Dartmoor, having been converted into Murchisonite, which chemically differs from orthoclase mainly in containing somewhat more alumina.

And thus it came to pass that pieces of Dartmoor granite were unrecognizable, whilst a generation of geologists, following De la Beche and Godwin-Austen, were disposed to believe that during the New-Red epoch, the granite of Dartmoor had not as yet reached the surface. Lately, speculation has taken quite a different turn. Mr. Worth is disposed to think that the granite of Dartmoor passed upwards into felsitic and volcanic rocks, remnants of which, he says, are to be found in the Triassic conglomerates of the county. Geologists, therefore, having started with the belief that the Dartmoor granite was covered up by sedimentaries in Triassic and pre-Triassic times, are now presented with a picture of a pre-Triassic volcano towering into the skies. It is also intimated that andesites and specimens of volcanic grit such as arise from the denudation of volcanic cones have been found in much more recent deposits.

Confining our attention for the present to the New-Red rocks, one would suppose that if the above speculations have a good foundation, the evidences of volcanic rocks derived from the disintegration of the old Dartmoor volcano ought to have been much more abundant in the Triassic conglomerates than they have hitherto seemed to be. But the further investigation of this matter must be deferred until we have considered the chronology of the New-Red beds.

We now perceive the import of the question put by our propounder of riddles, "Is there east of Exmouth a break in the 'red rocks'?" So recently as 1881 Mr. Pengelly wrote: "I incline to the opinion that our Red Rocks, taken as a whole, belong to the Keuper; or, if not, that all three sub-systems of the Trias are represented in Devon." Of course, when Mr. Pengelly thus infers the existence of the middle member of the Trias, he can only mean that the Muschelkalk is represented in time.

Mr. Ussher, four years previously, had given in the Transactions of the Association the results of his experience in the classification of the Triassic rocks. His view was that whilst in the Midlands there is complete unconformity between the Bunter and Keuper, in Devonshire the Triassic beds present a conformable series. He also showed that the beds cut out at Straight Point and Exmouth, in the south-coast section, are visible in the inland districts, thus practically answering Mr. Pengelly's question in the negative. The once prevalent notion, therefore, that the whole of the Devonshire Trias is of Keuper age, a notion which seemed to have the support of high authority, must be abandoned. A series of marls and sandstones, called by Mr. Ussher "Middle Trias," he thought might roughly represent the Muschelkalk in time, whilst his "Lower Trias," consisting of sandstones and breccias with igneous fragments, so well developed between Dawlish and Watcombe, is mainly of Bunter age. The older beds would presumably occur to the westward, but there does not seem at this time to have been a suspicion of Permian on the part either of Mr. Ussher or Mr. Pengelly. Mr. Ormerod, in his notes on the deep borings in the Trias at Teignmouth, also describes the beds between the Exe and the neighbourhood of Torquay as belonging to the Bunter.

In a communication to the Geological Society Mr. Ussher speaks of the lowermost beds of the south-coast Trias as far exceeding their more northerly equivalents in thickness, and as affording a strong probability that a reconstruction of the English Channel valley would exhibit a still greater development of beds, dating as far back perhaps as late Permian times. It is thus evident that Mr. Ussher considers that a large extent of New-Red rock has been destroyed in the formation of the English Channel, and possibly portions may yet be proved in the bed of the Channel itself. Mr. Worth, as you know, considers that he has evidence of the existence of Triassic rocks *in sitû* fifty miles to the south-west of the Triassic outlier at Cawsand, in Plymouth Sound, but it is rather a peculiar feature in this case, that the supposed submarine Trias resembles the Keuperian or eastern variety of the Devonshire Red Rocks. Mr.

Irving, who has paid some attention to these questions, differs from Mr. Ussher, and still more from Mr. Pengelly, in the belief that the breccia series is of Permian age. He regards it, in fact, as the result of terrestrial and littoral deposits on the flanks and on the shore-line of the old mountain region of which the Devon-Cornwall peninsula is one of the remnants, the high inclination of the dip being in favour of its being mainly composed of mountain detritus.

It would be difficult indeed to assign any other origin to the wonderful group of beds which constitute the sea-cliff between Teignmouth and Dawlish. The only matter in dispute is the precise chronology of these beds. Shall we say with Mr. Pengelly that they are of Keuper age? or with Mr. Ussher and Mr. Ormerod, that they are of Bunter age? or shall we agree with Mr. Irving that they are of Permian age? In the absence of marine mollusca the precise age of any series of beds is difficult to determine; all that we can affirm with absolute certainty is that they belong to the Permio-Triassic interval, and that in this country such beds are more usually Permian than Triassic. The brecciated beds of the Leicestershire Permians, for instance, have been recently shown to be composed of the re-arranged talus of the harder portions of the Palæozoic rocks surrounding that part of the old Permian lake.

The Post-Carboniferous Interval.

Leaving the question of the actual chronology of the Dawlish beds as almost hopeless in our present state of knowledge, we must be content to bear in mind the main facts of the case, viz. that towards the close of the Carboniferous period one of those great shifts in the earth's crust occurred, of which there have been three or four during geological time. Roughly speaking the Palæozoic epoch terminated with this great movement, whose flexing action has, in the main, governed the axes of the series of synclinals and anticlinals existing between the Bristol and English Channels, with an extension towards the south so as to include the peninsula of Brittany. The principal of these earth-throes occurred during the unrepresented period of time which intervened between the Coal-measures, as usually developed, and the Permian; and though there are evidences of subsequent oscillation in our district to a moderate extent, no instances of folding and contortion occur in the beds deposited afterwards. Then it was that the building of the British Isles commenced in earnest, and that the first rude sculpturings of the future Devonshire were made. Some of these points we shall have to consider again in reference to the general structure of the county.

The Carboniferous.

Before proceeding to answer the remainder of Mr. Pengelly's questions, a few words may be devoted to a formation which in Devonshire is both extensive and disappointing. No attempt will be made to correlate any portions of these beds wih their presumed equivalents on the Welsh side. All we can say is, that the Old-Red of the Welsh border does not differ from the Devonian of Devonshire more than does the Carboniferous of Wales from beds of the same system in this county. The Culm-measures are something *sui generis*, and it seems difficult to account for their origin.

It may be worth mentioning in this connection that Dr. Barrois, speaking of the physical history of Brittany, which presents certain analogies with that of our south-western peninsula, observes that the Carboniferous period in that region was one of oscillation between terrestrial and marine conditions—a period of extensive eruptions and great earth movements. Hence he says that a considerable portion of the sediments, especially towards the base, are of volcanic origin. This is not at all the case with the Carboniferous in North Devon, where the sequence is undisturbed. According to the views generally accepted, the main horizon for contemporaneous igneous rocks in the Palæozoic of Devonshire lies in the Lower Devonian, though there seems to be some difference of opinion upon this point.

The Old-red or Devonian Question.

This may with justice be termed the home question; but in order to attempt a solution, it will be found necessary, in the first instance, to take into consideration the Old-Red Sandstone of other areas. The claim of the Devonian to recognition as one of the great geological systems has been challenged more than once; and even when this has not been disputed, there have been divers contradictory efforts to fit in the marine Devonians with the several members of the Old-Red Sandstone. In North Devon the matter was further complicated by the great Jukesian heresy, based on the alternative supposition of a concealed anticlinal with an inversion towards the north, or more probably an east and west fault. These ideas, as you know, were successfully combated by Mr. Etheridge and Mr. Townshend Hall in the earliest days of the Association; and about ten years ago the latter gentleman reviewed the history and classification of the North-Devon Rocks in an able paper which appeared in the "Transactions." His own classification of the North-Devon beds differs in details from that adopted by Ussher and Woodward; but this is a matter of minor importance, since all agree in regarding the Ilfracombe limestones and associated slates as a definite central datum line, from whence to proceed either above or below. Mr. Hall observes that the North-Devon beds from Lynton to Pilton, though preserving a general dip to the south, are folded into many anticlinals, reducing their apparent thickness very considerably.

Having got the North-Devon beds, which are really the key to the whole Devonian system, into something like order, it now becomes necessary to quit the county for a while in order to study the Old-Red Sandstone on the other side of the Bristol Channel. And here we realize the fact that there are two Old-Red Sandstones, the Lower of which is perfectly conformable with and passes down into the underlying Silurian, whilst the Upper passes conformably into the Carboniferous, of which system, in a certain sense, it may be regarded as the base. It is only in recent years that this unconformity between the Lower and Upper Old-Red Sandstone has been fully recognized. Moreover, this is by no means a local phenomenon confined to the Welsh districts, since in the South of Ireland there is a great hiatus between the presumed equivalents of the Pickwell Down beds above and those of the Lynton beds below. Thus both in the South of Ireland and in South Wales the time representatives of the Ilfracombe and associated beds are absent. These three districts are more or less involved in the great post-Carboniferous east-and-west folding, and may be said to belong to the same system of physical disturbance. But even in Scotland Hugh Miller's Old-Red Sandstone is found to consist of two portions, the lower part shading off into Silurian, the upper into the Carboniferous. Thus, throughout the British Isles, what was formerly known as the Old-Red Sandstone is found to consist of two very distinct members, widely separated from each other in point of time, each having affinities with the neighbouring system. If, then, the case rested on the Old-Red Sandstone alone, its fate would only differ from that of Poland in being partitioned between two instead of three ambitious neighbours.

Having learnt thus much with regard to the Old-Red Sandstone, it is now time to return to North Devon, where we have a fossiliferous series interposed between beds which are held to be the equivalents, *mutatis mutandis*, of the Lower and Upper Old-Red Sandstone respectively. It is these fossiliferous beds which forge the link that was missing, whilst the intermediate yet independent character of their fauna justify, on palæontological grounds, their being regarded as the head-quarters of a distinct and separate system. The more copious development of the remains of marine organisms in the corresponding beds of South Devon further justify the original determinations of Lonsdale. It is these central beds, therefore, which constitute the backbone of the Devonian system; and if the correlations to which I have alluded be substantiated, they must carry with them the Upper and Lower Old-Red Sandstone as integral parts of that system.

It seems to be generally admitted that the Pickwell-Down beds are really the equivalents of the Upper Old-Red Sandstone. Perhaps it was Professor Hull who first suggested this, but nearly ten years ago Mr. Champernowne, whilst agreeing that the Pilton and Marwood beds should be referred to the Carboniferous, considered the Pickwell-Down Sandstone to be true Old-Red Sandstone, and also Upper Devonian. The fact of the Pickwell-Down beds being unfossiliferous lends additional probability to this view. The correlation of the lowest Devonian beds with the Lower Old-Red Sandstone seems more open to discussion. In the first place the subject is complicated by the suggestion that the Foreland and Hangman Grits are repetitions of the same beds by means of faulting, and secondly the arenaceous beds of the Lower Devonian in North Devon yield some marine mollusca. The resemblance of the Foreland Sandstones to the Glengariff Grits was regarded by

Professor Hull as most striking. On the whole there still seems a little obscurity as to the details of the lowest Devonian beds on the Bristol Channel.

There would be no use in considering the Devonian sequence in South Devon until that in North Devon had been fairly settled. It is not always that opportunities are afforded for studying a set of beds in duplicate within a limited distance, but I have had occasion to notice, more than once, the very great differences of development that present themselves under such circumstances within areas not so very far apart. Doubtless the original differences were very considerable, since South Devon must be regarded to a certain extent as a reef region, and the beds moreover were largely reinforced by contemporaneous volcanic matter of a basic nature, from which the equivalent beds in the North Devon area were almost entirely free. But in addition to these congenital elements of difference are others belonging to a subsequent period, such as a further extravasation of igneous rocks, and above all the extraordinary folding and compression to which the beds have been subjected. The confusion is something terrible, and we may regard the district as practically unmapped, although, thanks to Mr. Champernowne and others, a certain amount of correlation with the North Devon beds bas been established.

The backbone of the system is constituted by the Great Devon and Plymouth limestones with their associated upper and lower slates, the upper or Dartmouth slates more especially corresponding with the Morte slates of North Devon. Underlying these central beds, or Middle Devonians, are the Torquay Grits, containing the *Homalonotus*-beds, some of which struck Mr. Champernowne as being suspiciously like certain Ludlow rocks. These of course are naturally correlated with the Hangman Grits and Lynton Slates. Whether beds as low, or even lower than these, occur in any other part of South Devon, I am not in a position to state; but the beds of Yealmpton Creek have been placed on this horizon, and some geologists have even spoken of Silurian beds in the country north of Tavistock. On the other hand, the Upper Devonian, according to Mr. Champernowne, is represented by the Cockington Grits, originally described by De la Beche as Old-Red Sandstone, and these are the equivalents of the Pickwell-Down beds of North Devon. For Mr. Champernowne the Upper Devonian would appear to terminate with these beds, which he correlates with the *Psammites du Condroz.* Mr. Ussher, in describing the relations of the Devonian and Culm rocks on the east side of Dartmoor, observes that, as a rule, the Upper Devonian rocks occur in faulted association with the basement-beds of the Culm-measures. But in the area between Bovey Tracey and Bickington the uppermost Devonian beds are irregular slates, similar to the Pilton beds, and in one or two unfaulted junctions they pass up into Culm-measures, which are overlain by indurated shales of the Coddon Hill type. These recent observations of Mr. Ussher would seem to complete the analogy between the Devonian rocks in North and South Devon.

It would be beyond the limits of a Presidential Address if I were to follow this very interesting subject much further on the present occasion. I hope to have demonstrated that considerable progress has been made with the Devonian question during the last twenty years, although, as stated by Mr. Whidborne, in his preface to the "Devonian Fauna of the South of England," the correlation of the different parts of the system with the major divisions in America and the Continent is still a matter of discussion. Crumpled up and reversed as the beds are in South Devon, their stratigraphy will always be complex; but it is probable that in their original condition there was considerable resemblance to the Rhenish and Belgian Devonians, pointing to the prevalence of fairly similar conditions during the period of deposition.

Referring to the subject of correlation with Continental beds, there is an article in the "Neues Jahrbuch" for the present year "On the Devonian of Devonshire and the Boulonnais," writted by Herr Kayser, which, he says, is the outcome of a trip to the South-west after the Geological Congress of last autumn.

Herr Kayser finds in South Devon a development which intimately approaches the West-German. In the Upper Devonian of that region he recognizes nodular limestones with *Clymenia* (more typically developed at South Petherwin), "*Cypridinen*-schiefer," Adorf Goniatite-limestone, Büdesheim-shales, and Iberg Coral- and Brachiopod-limestones. In the Middle Devonian he recognizes *Stringocephalus*-limestone, *Calceola*-limestone, *Calceola*-shales, and possibly also Goslar-beds. In the Lower Devonian he finds the Upper and Lower Coblenz stages and "Siegen-Grauwacke" especially represented by a small but typical fauna at Looe. This general agreement is further increased by the appearance of numerous "greenstones," which, just as in Nassau and the Harz, are accompanied by schalsteins.

He notes the difference of development in North Devon. In the Upper Devonian the *Clymenia*-limestone, the Adorf Goniatite-limestone, and the Iberg coral-limestone are missing. In the Middle Devonian he notes the absence of the great *Stringocephalus*- and *Calceola*-limestones of South Devon. The Lower Devonian of this area, with its preponderance of hard quartzitic sandstones and grauwackes, does not for the present permit of any close comparison with the Rhenish or Belgian-French Devonian. He recognizes the horizons of the Pilton beds and of the *Cucullæa*-zone, or Baggy beds, which seem to have their Continental analogues rather in Belgium than on the Rhine, but there is nothing in those countries to represent the Pickwell-Down Sandstone. So likewise the phyllitic shales of Morte and Ilfracombe, which alone represent the whole Middle Devonian of North Devon, are equally without analogues.

From the above we may fairly conclude that the North-Devon beds have very little in common with the Devonians on the Continent. But it is mainly through the North-Devon Beds, as we have already seen, that the Devonians generally can be made to fit in with the two members of the Old-Red Sandstone. Both geographically and in character the North-Devon beds occupy an intermediate position between the calcareous-volcanic Devonians of the South and the coarse quartzose sediments of the Welsh border, altogether devoid of mollusca. If we regard the "Old-Red" of South Wales as an inshore deposit over an area which was deluged with fresh water from off the land, we can believe that further out to sea, in the times of the Lower Old-Red, conditions were favourable for a moderate amount of marine mollusca. This does away with the necessity for a barrier, and also, in a general sense, it suggests a kind of gradation between the Old-Red, the North Devon, and the South Devon deposits.

Bolt Rocks, etc.

The age of the crystalline schists of the Bolt.—Besides the mere chronology of the subject, there are questions of considerable interest in connection with these schists, the consideration of which more or less involves the physical history of the bed of this part of the Channel, as well as of the adjacent lands. In this connection also we may endeavour more especially to review the physical structure of the entire South-west, to which allusion has already been made in reference to the effects of the great post-Carboniferous disturbance so obvious throughout Devonshire.

The subject generally is by no means ripe for final decision, and even if we limit our observations, in the first instance, to the Bolt Rocks and their submarine connections, real or supposed, we must allow that, if metamorphism has usually proved an obscure question, the study of metamorphism under water is hampered with additional difficulties. There are no rocks in the county whose age and origin, even to this day, are so much debated as those which, speaking generally, we may term the Bolt Rocks.

Of the numerous theories which have been advanced, the most doubtful, it seems to me, is that which regards the mass as the result of progressive metamorphism from the action of underlying or contiguous submarine granite. Allowing, for the sake of the argument, that there is progressive metamorphism, although Prof. Bonney and Miss Raisin distinctly deny it, there is very little in the chlorite- and mica-schists of the Bolt district which resembles the peculiar fringe of partially metamorphic rock due to contact with a granitic mass. Such fringes are usually marked by abundance of andalusite, amongst their other characteristics, especially when slates are invaded. Yet we do not hear of this mineral in connection with the Bolt Rocks, though it must be admitted that the microscope has revealed the existence of kyanite, hitherto unsuspected.

Let us now for a moment examine the case for progressive metamorphism, which has found a recent advocate in Mr. Somervail. Many of us perhaps, in common with that gentleman, fail to understand why all metamorphic rocks, not absolutely the result of contact action, should be claimed as Archæan. But this unwillingness to accept their Archæan age does not compel us to believe that there has been progressive metamorphism, whereby an extension of the Dartmouth Slates, even with the addition of interbedded igneous rocks, has yielded, under peculiar circumstances, the mica-schists and chlorite-rocks of the Bolt. Mr. Somervail's argument, that the chlorite rocks are the metamorphic equivalents of interbedded sheets of igneous rock on the north side of the syncline, though ingenious, is scarcely convincing. A series of chemical analyses at this stage of the argument would be useful. On striking the balance of evidence it seems probable that the slaty beds are wholly distinct from the true metamorphic rocks in the south. If reliance is to be placed on the microscope, this must be regarded as proved. I would remark also, that few things are more deceptive than an apparent sequence in a highly compressed region; so that the presence of a fault is more often a matter of inference than of direct observation in such districts.

It is not absolutely necessary for us to believe that the crystalline schists of the Bolt are of Archæan age, if indeed we know exactly what is meant by Archæan. But I think that there are fair reasons for considering them to be older than the Devonian against which they abut; and that, in point of fact, they owe their present position to having been involved in the anticlinal uplift of which there are traces here and there along the channel shores of the Devon-Cornwall peninsula.

And this brings me to the consideration of the general structure of Devonshire from a stratigraphical point of view. Regarded as a whole, every one knows that Devonshire is a broad synclinal. The Lower Devonian beds of Torquay on the one side and of Linton on the other are practically on the same horizon, and, omitting minor curves and breaks, the extensive region between these two points is one great trough of Palæozoic rocks. But if we start again from the neighbourhood of Torquay in the direction of Dartmoor, it is still found that, on the whole, newer beds come to the surface as the south-east flank of the granite mass is approached. No matter how the beds in the immediate vicinity of the granite may be affected, the south-east flank of Dartmoor must be regarded as lying in a depression, relative to the coast rocks at the points already mentioned. Again, shifting our position considerably with regard to the central mass of granite, we find a suspicion of Lower Devonian rocks at Yealmpton, and a certainty of them at Looe, all pointing to the conclusion that there are traces of the northern wing of an anticlinal on the Channel coast. An inner and more deeply-seated portion of this anticlinal, in places resulting in a dislocation and possibly an inversion, has brought up the crystalline schists of the Bolt. With these perhaps may be associated inferentially the gneissic rocks in the neighbourhood of the Eddystone, mixed with other crystalline rocks, such as those mentioned by Mr. Arthur Hunt. But if the submarine granite or granites have had no more effect than that of Dartmoor in uplifting the country, they must be regarded as factors of minor importance in the structure of the Channel anticlinal.

Of course, the probability of an anticlinal axis in the English Channel has long been recognized, and indeed the space between the Devon-Cornwall peninsula and Brittany is wide enough for many a flexure, the mean result being an east-and-west axis of principal uplift, the exact position of which it is impossible to determine. Taking a wide geographical view of the subject, we cannot fail to see that there is, first of all on the north, the synclinal of the Glamorganshire coal-field; next the anticlinal of the Bristol Channel, both being rather limited in extent. The second and central synclinal is that of Devonshire, somewhat bulged by the mass of Dartmoor. The succeeding anticlinal of the English Channel was, in all probability, of a very complex nature, bringing up to-day many old and curious rocks, more or less injected by granites, of which we now have the evidence in the Channel Islands, to say nothing of the traces in the bed of the Channel itself, such as Mr. Hunt has so often brought to the notice of the Association.

Beyond this mysterious region of the Channel lies the rocky country of Brittany, which, according to Dr. Barrois, is essentially constituted by a vast geosynclinal depression, running from east to west. The flanks of this great basin consist of very ancient rocks, not quite parallel to each other, but converging somewhat towards the west, and opening out towards the east. The area enclosed has numerous secondary folds, and includes a large series of beds from the Silurian to the Carboniferous. In this region also there are granites, but of more than one age, and Dr. Barrois thinks that they have rather a tendency to follow the anticlinal axes.

Brittany, therefore, constitutes our third great synclinal; but in that country a far lower sequence of beds is brought to-day than in Devonshire, proportionate in fact to the much greater area of the country itself. The principal folding movements there also date from Carboniferous times, and thus the entire region, from South Wales to Brittany inclusive, belongs to what we may call the Hercynian system of mountain-making. It is interesting to note that, in the vicissitudes of time, the three synclinal areas still keep their heads above water, whilst the two areas occupied by the anticlinals are submerged—by no means an uncommon geognostic feature. I am not quite prepared to believe that, on this meridian, the so-called Hercynian system ever attained to any great degree of elevation, though undoubtedly of great width. Its degradation has contributed enormously to the Mesozoic deposits, and in a lesser degree perhaps to the Tertiaries of the country to the eastward.

(*To be concluded in the December Number.*)

REVIEWS.

I.—Marine Deposits in the Indian Ocean.

"On Marine Deposits in the Indian, Southern, and Antarctic Oceans." By John Murray, LL.D., F.R.S.E. Scottish Geographical Magazine, vol. v. (1889), pp. 405–436, woodcuts 1–12.

In November, 1887, Dr. John Murray communicated to the Scottish Geographical Magazine an account of the marine deposits in the deeper regions of the Indian Ocean, mainly based upon materials obtained by Captain J. P. Maclear, of H.M.S. *Flying Fish*. Subsequent investigations by Captain Pelham Aldrich in H.M.S. *Egeria*, and Captain A. Carpenter in H.M.S. *Investigator*, in addition to recent dredgings off the east coast of Africa for the purpose of laying cables, have furnished the author with ample means for extending the results formerly attained; and, on the present occasion, Dr. Murray ventures to map the area described, carefully marking all the points from which sediment has actually been examined, and those from which sufficient material has been obtained for a chemical and microscopical analysis. The map "represents the Indian Ocean and those portions of the Southern and Antarctic Oceans between the meridians of 20° and 150° E., and is estimated to contain 27,600,000 square miles." In this area, 415 reliable soundings in depths of 1000 fathoms and upwards are available for study and comparison; and the descriptions and conclusions detailed in the memoir before us form an important addition to the quota of information concerning marine sediments already placed by Dr. Murray at the disposal of geologists.

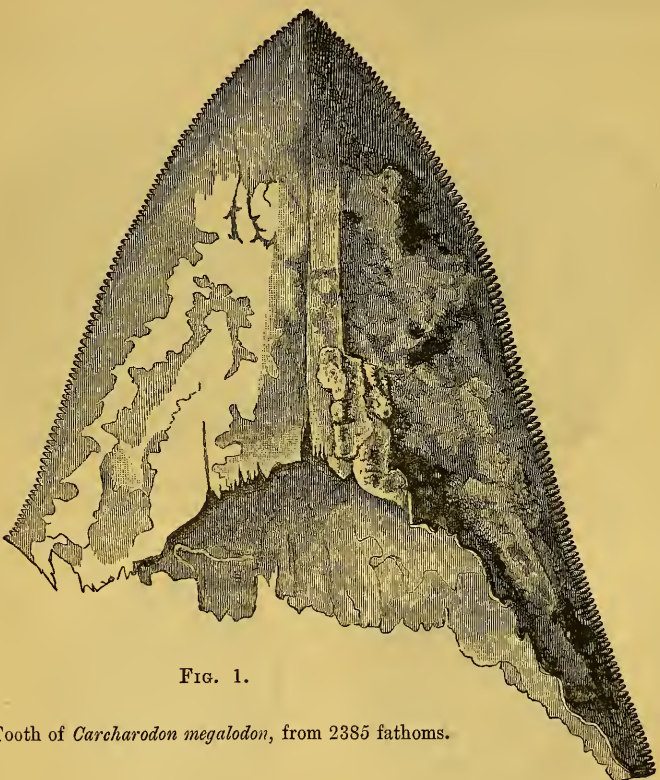


Fig. 1.

Tooth of *Carcharodon megalodon*, from 2385 fathoms.

"Beyond the 1000-fathom line there is a gradual deepening from the shore, extending southwards and eastwards, the deeper soundings being found in the eastern portion of the region under consideration. The deepest part is, indeed, situated between the equator and the

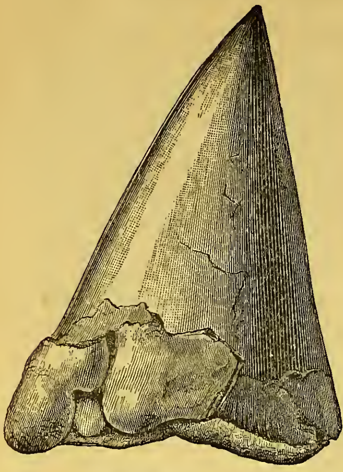


Fig. 2.—Tooth of *Oxyrhina hastalis.* From 2350 fathoms.

Fig. 3.—Ear-bone of *Ziphius cavirostris.* From 2335 fathoms.

Fig. 4.—Section of a Manganese Nodule, showing ear-bone of *Mesoplodon* in the centre. From 2600 fathoms.

Fig. 6.—Spherule of Bronzite. From 3500 fathoms. (× 25.)

Fig. 5.—Black Cosmic Spherules, with a metallic nucleus. From 2375 and 3150 fathoms, respectively. (× 60.)

Organic Remains and Mineral Bodies obtained from Deep-sea Deposits.

40th parallel of south latitude. South of this the ocean gradually shallows towards the Antarctic Continent. . . . The zone between 2000 and 3000 fathoms occupies a much larger portion of the whole area than any of the others, and it is estimated that the mean depth of the whole region is about 2300 fathoms."

The deposits are classified, as usual, into Oceanic and Terrigenous; and under the former are included the Globigerina, Diatom, and Radiolarian Oozes, besides Red Clay, while the latter comprise Blue Mud, Coral Mud and Sands, and Green Sands. A brief section of the memoir is devoted to each of these sediments, and a series of detailed descriptions of typical specimens, with lists of organisms, is appended.

Among the more striking features, perhaps, is the discovery by Capt. Aldrich in the Red Clay area of semi-fossil teeth of Sharks and ear-bones of Whales, more or less encrusted with oxide of manganese, as already observed by the *Challenger* expedition in certain similar regions of the Pacific and Atlantic Oceans. Through the kindness of Dr. Murray we are enabled to reproduce the figures of four such specimens (Figs. 1–4) obtained by the *Challenger*; and it will be noted that two, at least, pertain to species characteristic of the Middle Tertiary and, so far as known, no longer existing.

The hollow shell of a dental crown shown in Fig. 1, is indistinguishable from the well-known fossil tooth discovered in the Miocene or Pliocene of nearly all parts of the world, and ascribed to *Carcharodon megalodon*. Fig. 2 represents a tooth of *Oxyrhina hastalis*, which seems to have an equally wide distribution in Tertiary formations; and another tooth, not figured, is very suggestive of the so-called *Otodus obliquus* of the London Clay. The Cetacean ear-bone shown in Fig. 3 is identified with the existing *Ziphius cavirostris*; and Fig. 4 gives a view, in section, of a manganese concretion formed round an ear-bone of *Mesoplodon*. Small spherules, with metallic iron as a nucleus (Fig. 5), regarded as of cosmic origin, are also found in the Red Clay; and numerous small mineralogical curiosities, including granules of bronzite (Fig. 6), are mingled with the same sediment. "There are indications that volcanic disturbances have taken place at the bottom in these regions, but at a remote period rather than recently." A. S. W.

II.—Geological and Natural History Survey of Canada. Contributions to Canadian Palæontology. By J. F. Whiteaves, F.G.S., etc., Palæontologist and Zoologist to the Survey. Vol. I. Part II. 8vo. pp. 90–196, plates xii.–xxvi. (Montreal, W. F. Brown & Co., 1889.)

PART I. of this series[1] contained only one memoir; the present consists of three, viz.—(1) On some Fossils from the Hamilton Formation of Ontario, with a list of the species at present known from that Formation and Province; (2) The Fossils of the Triassic Rocks of British Columbia; (3) On some Cretaceous Fossils from British Columbia, the North-West Territory and Manitoba.

[1] Reviewed in the Geol. Mag. March, 1886.

Advance copies of the letter-press of these memoirs have already been distributed, pages 91–122[1] having been issued in September, 1887; pages 123–150 in December, 1888; pages 151–184 in June, 1889; while the remainder, or pages 185–196, are dated August 1, 1889.

It may fairly be questioned whether palæontological science is in any way benefited by the practice of issuing advance copies of descriptions of fossils, without any figures to assist in their interpretation. The object of so doing, viz. to secure priority to the author of the species, is, of course, a perfectly legitimate one, but who that has attempted to picture to himself, from a description alone, the form, say of an Ammonite, with all its intricacies of sculpture and suture-line, will not admit that the task has been in too many cases a hopeless one? Good figures have now become indispensable for the accurate identification of species, and not only do new species require them, but many old ones should be refigured from the original types. Such work would greatly lighten the labours of the palæontologist.

However, the volume now under review is amply supplied with figures of all the new species described, in a series of excellent lithographic plates, whose execution reflects much credit alike upon the artist and the lithographer.

The first paper of the series enumerated above contains descriptions of Corals, 1 species, of Crinoids 11, of Blastoids 5, of Brachiopods 11, of Lamellibranchs 2, of Gasteropods 6, of Trilobites 1, and of Fishes 1. Of these the following are considered to be new to science, viz. *Taxocrinus lobatus*, Hall, var., (unnamed), *Homocrinus crassus, Dolatocrinus Canadensis, Pentremitidea filosa* (doubtfully new), *Lingula Thedfordensis, Spirifera subdecussata, Platyostoma plicatum.* These are followed by a useful list of fossils from the Hamilton Formation (Middle Devonian) of Ontario.

The author acknowledges his indebtedness to Mr. Charles Wachsmuth for the identification of three species of Crinoids, "as well as for valuable critical suggestions in reference to the Crinoids and Blastoids generally."

It is a pity that so competent a conchologist as Mr. Whiteaves should not have taken upon himself to decide the point as to the affinities of the fossil named by de Verneuil, and later by Professor James Hall, *Turbo Shumardi*, figured on plate xvi. (fig. 3) of the present memoir. Mr. Whiteaves goes no further than to observe that "the reference of this shell to the Linnæan genus *Turbo* does not seem entirely satisfactory, and it is not easy to define in what particular it differs from *Platyostoma*."

The second memoir "On some Fossils from the Triassic Rocks of British Columbia" is prefaced by a brief account of the geographical range of some of the typical species collected, one of which, a species of *Halobia*, is of interest as coming from the most northerly locality on the continent of North America (the Stikine River), from which Triassic fossils have yet been obtained.

[1] Pages 1–90 are contained in Part I. of these Memoirs.

The collection of the Triassic fossils of British Columbia now contained in the Museum of the Survey consists of 3 species of Brachiopoda, 5 of Lamellibranchiata, 1 of Gasteropoda, and 8 of Cephalopoda, besides some undeterminable fragments of *Pentacrinites*. Of these the four following are identified with previously described species, viz. *Terebratula Humboltensis*, *Monotis subcircularis*, *Halobia* (*Daonella*) *Lommeli*, and *Arcestes Gabbi*; the remainder are regarded as new, or of uncertain affinities, viz. *Spiriferina borealis*, *Terebratula Liardensis*, *Monotis ovalis*, *Halobia occidentalis*, *Trigonodus* (?) *productus*, *Margarita Triassica*, *Nautilus Liardensis*, *Popanoceras McConnelli*, and variety *lenticulare*, *Acrochordiceras* (?) *Carlottense*, *Trachyceras Canadense*, *Arniotites* (species uncertain), *Arniotites* or *Celtites* (species uncertain), *Badiotites Carlottensis*. Most of the species of Cephalopoda described as new were examined by Professor A. Hyatt, of Boston, whose observations regarding them are appended to Mr. Whiteaves' descriptions. The new genus *Arniotites*, Hyatt, is here jointly described by Mr. Whiteaves and Professor Hyatt, the latter regarding it as the equivalent of the *Balatonites arietiformes* of Mojsisovics. The type-species is the *Celtites* (?) *Vancouverensis* of Whiteaves, described in Dr. G. M. Dawson's "Report of a Geological Examination of the Northern Part of Vancouver Island and Adjacent Coasts" (Ann. Rep. Geol. Surv. Canada for 1886, p. 110 B.)

The third memoir—On some Cretaceous Fossils from British Columbia, the North-West Territory and Manitoba—is divided into the following sections, viz. (A.) "From the Earlier Cretaceous of British Columbia," in which the following species occur:—*Aucella Mosquensis*, var. *concentrica*, *Yoldia arata*, Whiteaves, *Astarte Carlottensis*, n.sp., *Opis Vancouverensis*, Whiteaves, *Placenticeras occidentale*, Whiteaves, *P. Perezianum*, Whiteaves, *P.* (*Perezianum*? var.) *Liardense*, and *Scaphites Quatsinoensis*, Whiteaves.

(B.) "From the North-West Territory."

(1.) From Rink Rapids, on the Lewis River, a tributary of the Yukon, in Latitude 60° 20′ and Longitude 136° 30′; collected by Dr. G. M. Dawson in 1887.

The following species are recorded from this locality:—*Discina pileolus*, n.sp., *Cyprina Yukonensis*, n.sp., *Schlœnbachia borealis*, n.sp.?, *Estheria bellula*, n.sp.

(2.) From the Rocky Mountains, three miles north of the east end of Devil's Lake; collected by R. G. McConnell in 1887.

The fossils here obtained are said to be "probably from the same geological horizon as the Lower Shales and Sandstones of the Queen Charlotte Island Cretaceous," and consist of the following, viz. *Terebratula robusta*, n.sp., *Ostrea Skidegatensis*, Whiteaves, *Exogyra* (species undeterminable), *Lima perobliqua*, n.sp., *Pteria* (*Oxytoma*) *Corneuiliana*, d'Orbigny, *Inoceramus*, *Trigonoarca tumida*, Whiteaves, *Trigonia Dawsoni*, Whiteaves, *Astarte Carlottensis*, Whiteaves, *Protocardium Hillanum* (?) var., *Cyprina occidentalis*, Whiteaves, *Pleuromya Carlottensis*, Whiteaves, *Schlœnbachia borealis*, Whiteaves, *S. gracilis*, n.sp., *Belemnites* (species undeterminable).

(3.) From the Peace River, a few miles below Fort Vermilion; collected by Mr. W. Ogilvie, D.L.S., in 1885.

Only one species was collected in this locality, viz. *Placenticeras glabrum*, n.sp.

(4.) From the Fort Pierre Group of the Later Cretaceous Rocks of the Saskatchewan and its tributaries; collected by J. B. Tyrrell in 1885 and 1886.

From this locality the following species were obtained, some of which were described in Mr. Tyrrell's Report in the Annual Report of the Survey for 1886 (vol. ii. new series, pp. 153–163 E), but without figures, a want which is here supplied:—*Pteria linguiformis*, var. *subgibbosa*, Meek, *Inoceramus Sagensis*, var. *Nebrascensis*, Owen, *I. Vanuxemi*, Meek & Hayden, *Gervillia recta*, var. *borealis*, Whiteaves, *Tancredia Americana*, Meek & Hayden, *Cyprina ovata*, M. & H., *Cyprina subtrapeziformis*, Whiteaves, *Protocardia subquadrata*, Evans & Shumard, *Protocardia borealis*, Whiteaves, *Linearia formosa*? Meek & Hayden, *Pholadomya subventricosa*, M. & H., *Liopistha undata*, M. & H., *Solecurtis* (*Tagelus*) *occidentalis*, Whiteaves, *Martesia tumidifrons*, Whiteaves, *Hydatina parvula*, Whiteaves, *Lunatia concinna*, Hall & Meek, sp., *Baculites ovatus*, Say, *B. grandis*, Hall & Meek, *B. compressus*, Say, *Scaphites nodosus*, Owen, *Placenticeras placenta*, Dekay, sp., *Palæastacus* (?), *ornatus*, Whiteaves, Tooth of a Selachian.

(C.) "From Manitoba."

From the Niobrara-Benton Formation of the Later Cretaceous in the Duck and Riding Mountain District. Here the following species have been collected:—*Serpula semicoalita*, n.sp., *Lingula subspatulata* (?), Hall & Meek, *Ostrea congesta*, Conrad, *Anomia obliqua*, Meek & Hayden, *Inoceramus problematicus*, Schlotheim, *Modiola tenuisculpta*, n.sp. (?), *Belemnitella Manitobensis*, n.sp., *Loricula Canadensis*, n.sp., *Ptychodus parvulus*, n.sp., *Lamna Manitobensis*, n.sp., *Enchodus Shumardi*, Leidy, *Cladocyclus occidentalis*, Leidy.

A. H. F.

III.—Notes on the Jurassic and Cretaceous Strata of Russia and England. By Prof. A. Pavlow.

Etudes sur les Couches Jurassiques et Crétacées de la Russie. I. Jurassique Supérieur et Crétacé Inférieur de la Russie et de l'Angleterre. Par le Prof. A. Pavlow. Bulletin de la Soc. Imp. de Moscow, 1889, No. 1, pp. 61-127, 176-179, Pls. II., III., IV.

CONFLICTING opinions touching the relative age and position of a series of strata in the higher portion of the Jurassic and the lower portion of the Cretaceous in the East of Russia, have for a long time existed among Russian palæontologists, and curiously enough the question as to the proper correlation of the strata on the same horizons in this country is still a debated point, as shown in the excellent paper "On the Subdivisions of the Speeton Clay," brought recently before the Geological Society by Mr. G. W. Lamplugh. Prof. Pavlow has studied for many years the Russian beds, developed more particularly near Simbirsk on the Lower Volga, and in the neighbourhood of Moscow, and last year he made a personal examination of the section at Speeton, and of the fossils therefrom in the Woodwardian and other museums of this country, with the result of discovering a very close resemblance in the fossils and petrographic character of these beds in the two countries, so that there can be no doubt that they should be considered as synchronic or homotaxial. The points of similarity and difference in the deposits and the fossils are discussed in considerable detail in the present paper, and the following are the conclusions arrived at by the author: (1) The beds with *Perisphinctes virgatus* of the East of Russia immediately overlie the strata with *Hoplites eudoxus* and *Exogyra virgula* (Middle Kimmeridge), and are intimately related to these latter. (2) The Russian strata with *Perisphinctes virgatus*, correspond to the Upper Kimmeridge of English geologists (Blake), to the Lower Portlandian, and, in part, to the Middle Portlandian of the French geologists (Loriol). (3) The zone of *Olcostephanus triplicatus*, or the Lower Portland of Blake, exists in the Russian Jura, and serves as base to the beds with *Oxynoticeras catenulatum* (the first étage of Rouillier). (4) Judging by its stratigraphical relations, this first étage with *O. catenulatum*, cannot be more recent than the Upper Portland. (5) The bituminous schists of the Province of Simbirsk and those of Speeton are on the same geological horizon. (6) The zone of *Belemnites lateralis*, Phill. (*corpulentus*, Nik.), of Simbirsk, and the first étage of Rouillier, correspond to the zone at Speeton of this same fossil, and, consequently (7) the *Bel. lateralis* zone at Speeton corresponds to the Upper Portland of the South of England. (8) The gravels of Spilsby, Lincolnshire, are nearly equivalent to the *Bel. lateralis* zone of Speeton, and to the corresponding beds in Russia. (9) Between the zone of *Bel. lateralis* (*corpulentus*) and the Neocomian beds of Simbirsk there is a well-marked unconformity, which (10) nearly coincides with the epoch of *Hoplites noricus* and *Bel. jaculum* (type). (11) The zone at Speeton with *Amm. speetonensis* corresponds to the lower part of the Neocomian clays of Simbirsk (clays with *Olcost. versicolor* and *Inoceramus aucella*). (12) The fauna of the higher stages of the Russian Jura (first and second étages of Rouillier, Volgien inférieur et supérieur) is so intimately allied to that of the corresponding stages in England, that it is possible and desirable to adopt a common stratigraphical classification for the two countries.

The author further shows in tabular form the corresponding zones in the two countries, and describes and figures some of the principal fossils, including new species of *Olcostephanus* from Swindon, and Spilsby, as well as from Simbirsk.

IV.—Prof. F. Fouqué on Earthquakes.

Les Tremblements de Terre. By F. Fouqué, Membre de l'Institut (Académie des Sciences), Professeur au Collège de France. 328 pp. (Paris, J. B. Baillière et Fils, 1888.)

As the whole of Prof. Fouqué's book will repay a careful study, this notice may be confined to one or two passages that seem to me to admit of improvement, and a few others as being worthy of especial attention from geologists.

In a recent work on Earthquakes, we should expect to find a fair discussion of some of the excellent seismographs which have lately been invented in Japan and other places. M. Fouqué excuses himself from the task of writing such a chapter (pp. 7–8), partly on the ground that the subject deserves to be treated in a separate work; partly because improvements are continually being made in these instruments, and their description will gain by being deferred for some years. If this latter principle were consistently carried out, how many works on natural science would ever see the light? But the influence of these reasons is not very apparent. For the average length of one of M. Fouqué's chapters is a little less than 18 pages; and the scattered references to seismographs and other instruments amount to rather more than 20 pages, excluding the description of those used in the experiments on the velocity of earth-waves. Now, of these twenty pages, seven are devoted to Cavalleri's seismoscope and some of the results that have been obtained with it. But, owing to the fact that the period of vibration changes during an earthquake, and to the natural defects of the instrument itself, these pages are of little value. Of other instruments alluded to, the accounts are too short and incomplete to be of much use, and in only one case is the description accompanied by a figure. It is to be hoped therefore that, in a new edition, M. Fouqué will see his way to replacing these twenty pages by a chapter in which a few of the more trustworthy seismographs are exactly figured and described.

In the chapter on the "centre of disturbance," the approximate and imperfect nature of our methods for determining its superficial position and depth is carefully pointed out. The method employed by Messrs. Dutton and Hayden, in the case of the Charleston earthquake, is however quoted with some approval. But this method makes the depth of the centre independent of the intensity of the initial disturbance. For instance, in every earthquake originating at a depth of $3\frac{1}{2}$ miles, the intensity would, if the method were correct, decrease most rapidly at a distance of about two miles from the epicentrum. But we can imagine the intensity of the earthquake to be so feeble initially that it cannot, by the most delicate instrument yet constructed, be felt at so great a distance from the epicentrum, or perhaps even be felt at the surface at all. The method is thus unreliable, however carefully applied. Perhaps a more accurate statement of it would be that it gives an inferior limit to the depth of the seismic focus.

Microseismology, one of the latest and most fascinating developments of the science, is dismissed in a short chapter of a dozen pages. Half of the chapter is allotted to the perturbations of magnetic instruments during earthquakes. But, whilst these interesting pages could ill be spared, might we not have expected a fuller account of the other advances that have recently been made? Such a chapter must surely be incomplete when the names of Bertelli, the founder of microseismology, of d'Abbadie, and the Darwins are not so much as mentioned.

The rotation of columns during earthquakes is an interesting historical problem, and M. Fouqué adheres to the original explanation of Mallet. He seems (p. 55) to doubt the real existence of vorticose shocks, whereas it is evident, as was shown some years ago in this MAGAZINE (Vol. IX. 1882, pp. 257–265), that such shocks in the neighbourhood of the epicentrum are a necessary consequence of a large seismic focus, and may be one of the causes of the rotatory movement so frequently observed. The cause suggested by Mr. Gray is probably, however, that which acts most widely in producing this effect.

It would be difficult, within reasonable limits, to point out the many excellences of Prof. Fouqué's book. But as, in this country, it will probably be read chiefly as a supplement to that written by our leader in seismology, Prof. Milne, it may be well to note the passages that, in this view, will best repay perusal. First and foremost is the admirable treatment of the relations between earthquakes and geological structure, the evolutionary aspect of the science (pp. 9–30, 189–201). Here we have discussed and summarized the work of Suess, Höfer, von Lasaulx, Hoernes and others, as well as some of the earlier results obtained by the Swiss Seismological Commission. The subject of seismic periodicity is considered with great fullness in Chapter x. The useful list of questions drawn up by Prof. Heim for aid in the study of earthquakes is reprinted in Chapter viii. The velocity of earth-waves occupies a long and interesting chapter, and includes an account of the valuable experiments made by the author in conjunction with M. Lévy. Lastly, the second part of the book (pp. 249–326) contains a description of a few of the more important earthquakes that have happened between 1854 and 1887.

The illustrations, with one or two exceptions, are good; and among them may specially be noticed the maps of the Swiss earthquakes of Nov. 1879—Dec. 1880, and of July 22, 1881, the Charleston earthquake of August 31, 1886, and the Andalusian earthquake of Dec. 25, 1884.

C. DAVISON.

V.—REYNOLDS'S GEOLOGICAL ATLAS OF GREAT BRITAIN. Comprising a series of County Maps geologically coloured from the best authorities.[1] Second Edition, 1889.

ANY book which calls for a new edition, by reason of its intrinsic value, is worthy of notice. A new edition of the well-known Geological Atlas of Great Britain, published by Messrs. Reynolds & Sons, 174 Strand, has just been issued. This atlas comprises 32 county maps geologically coloured and arranged alphabetically, the colours depicting the varied geological features of each county are mainly those used on the published maps of the Geological Survey.

Every county is carefully coloured, and the colours numbered

[1] Published by James Reynolds & Sons, 174 Strand, 1889.

according to the legend for geological reference separately given at the commencement of the atlas, of which there are 30 divisions. The execution of the maps geologically and topographically leaves little to be desired; this atlas, in fact, forms a most perfect pocket travelling companion, combining both convenience and portability, with clearness and accuracy; we commend this work to all travellers in Great Britain.

Advantage has been taken of the advanced state of the Geological Survey maps, to correct and re-draw the geological lines, and depict the solid geology as accurately as possible. The want of a new edition of this atlas has long been felt by those who have used the first one, its completeness and portability for ready reference either for the library or as a companion in the field, render it indispensable.

Each map is accompanied by a small skeleton index to the numbered and published sheets ($\frac{1}{4}$ or whole) of the 1-inch geological maps of the Survey, and the divisional lines upon each of the maps of the atlas also correspond to the area occupied by them. This enables any one to order the special maps of the Survey from which the 32 counties in the atlas have been constructed.

Marginal notes are appended to each map, denoting the places of occurrence of the more important organic remains, as well as of the economic minerals met with in the county. Examination of maps 8, 10 and 11, or, indeed, any others, will readily show the usefulness and value of these notes to those seeking mineralogical, geological, or palæontological information.

Twenty-three pages of letterpress (p. 1–23), containing short geological descriptions of the 32 maps, will be found of value and interest, as affording a short description of the structure of each county. Pages 24–32 are devoted to the mineral products of Great Britain, their distribution and value. Agricultural geology and water supply receive attention. A most admirable tourists' guide of 10 pages, giving the chief places of interest, finest views and scenery, fishing stations and streams, etc.; indeed, in relation to each of the 32 counties, matters of much general interest and use are given.

Probably no other work of the kind will so readily commend itself to, or meet the requirements of, the traveller by rail or road, and the construction of the maps will satisfy the most critical, as fulfilling the purpose for which they are published as an atlas of England geologically illustrated. A geological map of Scotland accompanies the atlas; it is to be regretted that Messrs. Reynolds & Sons did not prepare an equally good geological map of Ireland to accompany it.

We recommend this extremely good and well-got-up book to all who desire to know something of the geological structure of Great Britain.

VI.—New Map of the Environs of London geologically coloured. Scale ½-inch to the Mile.[1]

THIS will prove to be a very useful Geological Map of the London area. The high price of the two 1-inch maps of the Geological Survey illustrating the same district deters many from possessing a reliable map of the complicated geological structure of the London Basin. This map issued by Messrs. Reynolds & Sons quite supplies the want. The geological lines are correctly laid down, being taken and reduced from the larger one-inch Ordnance Geological Map.

London in both cases is placed in the centre of the sheet [this was expressly arranged in the Survey map for the convenience of its many inhabitants]. The two maps issued by the Geological Survey exhibit two important features over the London area, one showing the solid geology and the other the superficial or more modern Post-Pliocene accumulations; this is partly done on the map before us, but to have placed all the Quaternary sands, gravels, and clays (as depicted on the Survey map) on this map (on half the scale) would have been at the expense of clearness of definition. The superficial area of the map is 2280 square miles or 60 miles by 38. London being in the centre, gives a radius of 30 miles east and west, and 19 miles north and south; concentric lines four miles apart denote distance in miles from the centre of London. The east and west of the country illustrated extends from Long Reach east of Chatham to Laurence Waltham west of Maidenhead. Latitudinally the area extends from Godalming, Guildford, and Tunbridge on the south, to St. Albans and Chelmsford on the north. The area covered by the one-inch Survey map is 1144 square miles or 44 by 26 miles; thus Messrs. Reynolds' map contains geological information over 1136 more square miles than the Government sheet. The structural or physical lines are carefully laid down over the entire map, the geological epochs shown on the map, ranging from the Weald Clay to the Post-Tertiary, or Post-Pliocene beds of the Thames Valley, etc., all the railways are well defined, a desideratum for scientific as well as ordinary travellers, and the stations are prominently marked.

The colours illustrating the geological formations are numbered to correspond with the legend, thus leaving little to be desired as a thoroughly convenient map of the Environs of London both topographically and geologically constructed.

Thirty-three pages of letterpress accompany the map, naming and describing no less than 152 places of interest within the radius of 30 by 19 miles, being a clear and general history of the more remarkable places in the counties of Middlesex, Surrey, and Essex. On p. 15 a short account is given of the geology of the London area, tersely explanatory of the varied geological formations that occur within the area depicted. We commend this map, published by Messrs. Reynolds & Son, to all residents in London and its environs, also to travellers and geological students.

[1] Published by James Reynolds & Sons, 174, Strand, 1889.

CORRESPONDENCE.

RATE OF SUBAËRIAL DENUDATION.

Sir,—Referring to Mr. Davison's paper in the September Number of the Geological Magazine, it will not do, as I have endeavoured to show in "Stellar Evolution," to take the average rate of denudation of the seven river basins which he names, as in any way representing the mean denudation of the whole earth. The majority of these rivers are exceptionally muddy, indicating a very high rate of denudation: much above that of the whole earth.

Perth. James Croll.

THE FULLERS EARTH OF NUTFIELD.

Erratum.—Mr. P. Gerald Sanford regrets that some mistakes occurred in the setting up of the figures of his analysis of the "Fullers' Earth." Geol. Mag. October, 1889, p. 456, which he desires now to correct.

No. 1. Blue Earth.

Dried at 100° C				Insoluble Residue.		
Insoluble Residue	=	69·96 per cent. =		SiO_2	=	62·81 per cent.
Oxide of iron, Fe_2O_3	=	2·48	Soluble in acid.	Al_2O_3	=	3·46 ,,
Alumina, Al_2O_3	=	3·46		Fe_2O_3	=	1·30 ,,
Lime CaO	=	5·87		CaO	=	1·53 ,,
Magnesia, MgO	=	1·41		MgO	=	0·86 ,,
Phosphoric acid, P_2O_5	=	0·27				
Sulphuric acid, SO_3	=	0·05				69·96
Sodio Chloride, NaCl	=	0·05				
Alkalies, K_2O	=	0·74				
Combined Water	=	15·57				
		99·86				

P. G. Sanford.

OBITUARY.

CHARLES SPENCE BATE, L.D.S.R.C.S. Engl., F.R.S., etc.

Born 16 March, 1818; Died 29 July, 1889.

Charles Spence Bate was born at Trennick, Truro, on the 16th March, 1818. He was the eldest son of Mr. Charles Bate, who for many years practised as a dentist in Plymouth. He was educated at the Truro Grammar School under the late Dr. Ryall. On leaving school he entered the surgery of Mr. Blewett, where he remained about two years; he then devoted himself to the study and practice of dentistry with his father. After becoming duly qualified, he removed, in 1841, to Swansea, where he soon acquired a considerable practice. While at Swansea he developed an ardent love for Natural History, by his knowledge of which he afterwards became distinguished. He was speedily associated with all the scientific men of the place; and on the occasion of the visit of the British Association to the town in 1848, he took an active part in arranging for the reception of that body, and became one of its members. On more than one occasion subsequently he was President of one of the Sections. He was mainly instrumental in securing the visit of the British Association to Plymouth in 1877; and as one of the Vice-Presidents at that meeting, he contributed largely by his liberal exercise of hospitality to make the gathering a success.

In 1851 Mr. Spence Bate left Swansea and returned to Plymouth, taking up his residence at 8, Mulgrave Place, where he succeeded to the practice of his father as a dentist, in which profession he was almost unrivalled. He was the author of many works on dentistry, which appeared separately, or in the "Lancet," the "British Journal of Dental Science," and the "Medical Gazette," and in the "Transactions of the Odontological Society," to the Presidency of which he was elected in 1855. Two years previously he had been President of the British Dental Association. In 1881 Mr. Spence Bate was a Vice-President of a section of the Medical Congress. He was Honorary Surgeon-Dentist to the Plymouth Dental Dispensary and other local Institutions.

Nor was it only in dentistry that Mr. Spence Bate became celebrated. He devoted a large amount of time to the investigation of the habits of marine animals, and, in conjunction with Mr. I. O. Westwood, was the author of a most important work on the "British Sessile-eyed Crustacea." The value of this work was fully recognized by the scientific world, and for this and other Memoirs on the Crustacea, Mr. Bate was elected a Fellow of the Royal Society in 1861. Other works by him on the same subject were a British Museum "Catalogue of Amphipodous Crustacea," and a "Report on the Crustacea Macrura, collected by H.M.S. 'Challenger,'" during the cruise of that Vessel round the world. This last-named work was only completed a year ago, and forms a most valuable contribution to carcinological science.

He was keenly interested in all scientific matters connected with the town of Plymouth and county of Devon, and earnestly exerted himself to promote their progress and success. The restoration of the Plymouth Institution to its present healthy activity, after a period of comparative inertness, must be mainly ascribed to him.

Elected a member of the Institution in 1852, he became Secretary 1854–60, President in 1861–62 and 1869–70, and Member of Council 1853–83. He served as Museum Curator at different times, and as Editor of the Transactions in their present form 1869–83. He delivered no fewer than thirty lectures and Presidential Addresses between 1853 and 1882 to this Institution.

Mr. Bate was one of the founders of the Devonshire Association, and during the first year of its existence (1862) was Senior General Secretary. In the following year he vacated this post, having been elected to the office of President of the Association. He delivered his Presidential Address at the Annual Meeting at Plymouth in 1863, and qualified as a permanent member of the Council. He was seldom absent from the annual meetings, and never ceased to take the liveliest interest in the progress of the Association. Between 1862 and 1873 he contributed eleven papers to its Proceedings.

He was an Honorary Member of the Torquay Natural History Society, Honorary Member of the Teign Naturalists' Field Club, and likewise Honorary Member of the Royal Institution, Truro.

Mr. Spence Bate took great interest in Art, and was not only a promoter, but also a working member of the Plymouth Fine Art Society. He also took a warm part in the Plymouth School of Art, and in the carrying out of the new Art, Science and Technical Schools about to be erected as a Jubilee memorial in Plymouth.

Mr. Bate naturally felt a keen interest in the Marine Biological Association, and was very active and energetic in promoting the establishment of their Marine Biological Laboratory recently erected at the Plymouth Citadel.

Some years since he purchased a country residence, called the Rock, at South Brent. There he died, after a brief but painful illness, on Monday, the 29th July, 1889, aged 71 years.

Mr. Bate was twice married. His first wife was Miss Hele, of Ashburton. She died in 1884. His second wife, to whom he was married about two years ago, survives him. He also leaves two sons, one of them, Captain McGuire Bate, of the Royal Engineers; the other, Dr. Hele Bate, of London, who was with his father throughout his last illness; and one daughter, Miss Bate, who has inherited much of her father's artistic taste. The titles of 52 papers by Mr. Spence Bate are given in the Catalogue of Scientific Papers published by the Royal Society, vols. i. and vii. 1867 and 1877.

One of his most valuable researches was published in the Phil. Trans. Roy. Soc. 1858, p. 589–606, on the development of *Carcinus mœnas,* but his "Challenger" volume was his last and greatest labour.

The loss of one possessed of such varied and brilliant talents cannot fail to be both widely and severely felt amongst men of science generally and by a large circle of friends by whom he was greatly and justly esteemed.

MISCELLANEOUS.

The Island of Paros, in the Cyclades, and its Marble Quarries.[1]

The Island of Paros is eleven miles long and eight miles broad at its widest part. There is a broad belt of nearly level land round the coast; but the interior is mountainous, rising to a height of 2530 feet at Mount St. Elias (probably the ancient Mount Marpessus).

The northern and western parts consist of schist and gneiss, granite appearing also in the environs of Parekhia. The southern part of the island consists chiefly of crystalline limestone. There is no evidence here of the age of this limestone; but that of Attica is now known to be Cretaceous, and probably that of the Cyclades is of the same age. The finest statuary marble, or *lychnitis,* varies from five to fifteen feet in thickness at the quarries of St. Minas; it occurs in a bed of coarse-grained white marble, with bluish black veins. The coarse marble becomes dark in colour near the lychnitis, both above and below it, and thus the layer of statuary marble is distinctly marked off. The dark colour is due to traces of binoxide of manganese and magnetic oxide of iron. It seems probable that the impurities have been withdrawn from the lychnitis and have become concentrated near the edges of the adjacent seams of limestone.

The rocks are much disturbed and folded, and often dip at right angles. The ancients avoided the marble lying near the axis of elevation, that being of less good quality than in other parts. A Greek company formed a few years back to work the marble attacked it here, where it could be got at least expense; this discredited the marble in the market, and the company failed, having spent over £160,000 in a railway, landing-pier, and elaborate installation of various kinds.

There is a good deal of excellent coloured marble in the island; but, not having been used by the ancient Greeks, this is little known. Robert Swan, F.C.S.

[1] From British Association Reports, Section C. (Geology), Newcastle Meeting, Sept. 1889.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VI.

No. XII.—DECEMBER, 1889.

ORIGINAL ARTICLES.

I.—Notes on the Ponza Islands.

By H. J. Johnston-Lavis, M.D., B.-ès-Sc., F.G.S., etc.

In 1884 I spent about a fortnight investigating the geological structure of these islands, and intended to have to a certain extent completed my studies at that time. Cholera was then raging at Campobasso on the mainland, and the islanders, not comprehending the curious habits of a travelling geologist, supposed I had been sent by the Government to spread the "Cholera Powder," and requested me to leave the islands by the next steamer. This I naturally for safety's sake did, and opportunities for returning to the locality not having again presented themselves to me, and lest I should forget some of the interesting observations I then made, I think it desirable without further delay to record what I then saw. This is all the more important since my own observations differ considerably from those of the few other observers of the geology of these islands, or include facts which they do not mention in their writings.

Santo Stefano is of exceeding interest from the very clear sections which its steep cliffs near the Cemetery present. The following are the details of the section:

		M.
(*a*)	Breccia with vegetable soil and modern pottery together with made earth	1·50
(*b*)	Compact brown tufa with weathered pumice, probably an old vegetable soil	1·30
(*c*)	Ditto, but not compact and containing concretions, especially at bottom, where it is a little more sandy	1·10
(*d*)	Two or three pumice-beds with intermediate ash-beds irregularly interbedded and concretionary along fissures	2·20
(*e*)	Dust-bed somewhat irregularly reposing on pumice-bed	0·50
(*f*)	Pumice-bed, the lower part is about m. 0·10	0·65
(*g*)	Black sand or lapillo bed finely stratified; coarser as it graduates down to next	0·55
(*h*)	Pumice and pumiceous scoria	0·55
(*i*)	Earth buff fine-bedded pumice, with lapilli?	0·30
(*j*)	Loose pumice and lapilli	0·90
(*k*)	Very fine buff dust, finely stratified, containing bits of pumice and is also concretionary	1·00
(*l*)	Slightly concretionary dust-bed, yellow at top, purple-brown at bottom and graduating thence into fine stratified dust; the yellow bed is an old vegetable soil with concretions that have formed around roots and fills in the eroded surface of the purple-brown bed, showing weathering had occurred at the surface	1·78
(*m*)	Fine lapilli with concretionary bands	0·30
(*n*)	Pumice-bed	0·30
(*o*)	Fine black scoria	0·14
(*p*)	Fine greenish-grey dust with band of lapilli at bottom	0·28

(*q*)	Irregular finely (occasionally) brecciated yellow earth; probably an old concretionary soil	1·00
(*r*)	Ochre-stained pumice; the upper ten centimetres are less stained, have larger fragments with pyroxene crystals and ejected blocks	0·90
(*s*)	Brown earth with concretions, finer at the top and passing down into	2·60
(*t*)	Same as last, lighter in colour with intermixed pumice which at some spots forms a band	1·20
(*u*)	White dust not concretionary	0·80
(*v*)	Brown pumice	0·25
(*w*)	Pumice bed with lapilli and few ejected blocks	2·00
(*x*)	White pumiceous dust-bed	0·15
(*y*)	Pumice-bed with light buff concretionary dust-bed in middle	1·85
(*z*)	White pumiceous dust-bed	? 1·50
(*zz*)	Trachyte forming main mass of the island.	

The main body of the island is composed of a mass of trachyte which seems to have oozed forth as a compound dome. The flow arrangement resulting from this is well shown as the rock exhibits a distinct pipernoid structure. Doelter has fully described[1] this rock both from a chemical and microscopical point of view, but says little of the overlying strata of pumices, lapilli, dust and earth. These all point to a considerable number of explosive eruptions in the vicinity, as there are no signs of a crater of explosion visible on the island itself. That during the deposition of these tuffs the island was above the water is proved by the numerous vegetable soils, roots preserved by concretions, surface erosion, etc. That the explosive eruptions extended down to the metamorphosed limestones beneath the volcanic platform from which occurred the explosive eruptions is proved by the few ejected blocks met with in the tuffs. The ejected blocks also include lava fragments like the underlying trachyte and the dolerite of Ventotene, but most interesting is a leucitophyre, no massive remains of which have been discovered in the islands. The latter, nevertheless, is another addition to the widely-distributed localities of Italy in which leucite forms an important rock constituent. Loose blocks have been found in tuff at Procida, but so far leucite rocks have not been recognized in Ischia or the Ponza group of islands.

Ventotene is also exceedingly interesting. as the continuous cliff section stretching round it clearly reveals its structure. The following is a compound section of the island, beginning from the most superficial deposits:—

		M.
(1)	Vegetable soil, rich in snail shells	—
(2)	Blown sand of powdered sea shells with many snails, chiefly *H. Cantiana.* It is very full of concretions	4·00
(3)	Brown earth with concretions especially at bottom, often with bands of blown sand	7·00
(4)	Compact yellow tuff, used for carving into portable furnaces, passes down to	4 to 7·00
(5)	Compact grey dust and pumiceous scoria with bands of loose pumiceous scoria in the middle	0·90
(6)	Scoriaceous pumice with pieces of lignite	0·05
(7)	Lapilli consolidated in patches	0·20

[1] See Doelter, "Carta geologica delle Isole Ponza Palmarola e Zannone," Roma, 1876.—Memorie per servire alla descrizione della Carta Geologica d'Italia, vol. iii. Parte Ia, 1876.

(8)	Brownish red dust bed	0·25
(9)	Pumice bed decomposed at bottom	1·00
(10)	Red ash bed	0·40
(11)	Pumice bed. The pumice often compact from calcareous infiltration ...	1·10
(12)	Stratified pumiceous dust, red at top	0·65
(13)	Slightly decomposed pumice bed	0·90
(14)	Finely stratified black dust graduating down into	0·60
(15)	Pumice and lapillo	1·80
(16)	Same, but with many fine ash bands and more compact	0·60
(17)	Grey pumice and lapillo	1·60
(18)	Fine and coarse buff-grey stratified dust, with pumice at bottom. It is compact, pisolitic, and concretionary	4·80
(19)	Brownish earth, with scoria and pumice, a very irregular bed	1·20
(20)	Finely stratified greenish dust	1·60
(21)	Pumice and lapilli, mostly fine	1·00
(22)	Finely stratified buff dust	1·50
(23)	Pumice and lapillo bed, fine, but more so above	1·00
(24)	Stratified buff-grey dust, coarser in stripes with bits of pumice	1·60
(25)	Pumice-bed, with thin ash bands and finer in upper half	1·13
(26)	Concretionary bed of ash	1·10
(27)	Lava and scoria intercalated in tufas at south-east angle of the island. Maximum height	20·00
(28)	Red earth with pumice and small lava fragments...	0·55
(29)	Band of decomposed pumice, finely bedded	0·15
(30)	Fine red earth with concretions	2·00
(31)	Pumice-bed with ash bands...	1·80
(32)	Breccia, ash dust, with pumice, banded, probably part of last	0·35
(33)	Pumice-bed passing up into red dust at top	0·95
(34)	Red earthy breccia, stratified with scoria fragments	2·30
(35)	Doleritic lavas.	
(36)	Stratified lapilli and dust, red at top, possibly marine	3·00
(37)	Brown and yellow scoria ... ... over	5·00
	Sea-level	

It would be out of place here to go into all the details of each separate deposit. I shall therefore simply point out the general conclusions to which I have been led from their examination.

The earliest deposits visible are brown, yellow, and red scoria, lapilli, and dust, presenting characters which indicate that they were basic essential ejectamenta from a cone in a state of activity, not unlike some of the more active phases of Vesuvius. This cone seems to have been situated somewhere west of the south end or perhaps west-north-west of the island, as this point shows the oldest deposits at the highest level, and represents parts of the slope of that cone. Also the valleys, if such they may be called, radiate from such a theoretical point.

These deposits were followed by a great and continuous outflow of doleritic lavas forming the base of the southern prominence of the island. They have been studied microscopically and chemically by Doelter. A field study shows them to have been poured out almost continually without the intermission of extrusive action, as practically no fragmentary materials separate the different streams. In many places they show beautifully corded surfaces which would indicate their poverty in dissolved water at the time of their issue, the phenomena of which must have much resembled the eruption of 1858 at Vesuvius. The existence of the island depends upon the presence of these lavas extending below the surface of the sea, and resisting the powerful scirocco breakers. It seems to me that these lavas issued by some lateral fissure in the old cone, and piled themselves up at this point, just as many of the eruptions of lava of Vesuvius may have been observed to do during the last ten years, just resembling in fact the guttering of a candle.

The volcano then seems to have remained inactive for some time during the deposition of (34), but during that inactivity at the surface, the magma immediately below was gradually assimilating water, or in other words rising in elastic tension. This eventually overcame the overlying obstructions, and a series of explosive eruptions followed, interrupted by periods of repose (34–28). Whether these explosions drilled out a great crater or craters in the old cone, or were at some distance, is not possible of determination; but it is not improbable that the ruin of the dolerite cone had been in part brought about.

Bed (28) seems to show that repose did not follow the last of the explosions, but that the eruptive action continued, and as a consequence dwindled into a state of chronic activity, probably repairing in part or wholly, the old cone, during which time fine ash and lapilli, now red clay and lapilli, covered the surface (26). At any rate, a dyke forced its way to the surface, and gave rise to a small scoria cone, from which one or more lava streams poured forth. This scoria cone is seen on both sides of the island, and I give in Figs. 1 and 2 its relative position to the pumice-beds and the old lavas. Fig. 3 is a diagram showing how it is probably cut by the present cliff.

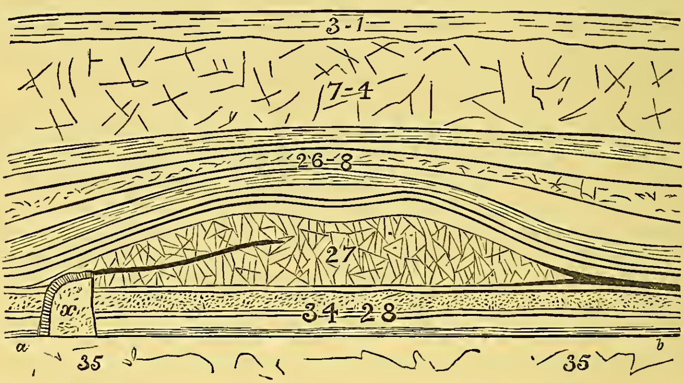


Fig. 1.—Section of a Volcanic Cone and Tuffs N.E. of the Piano degli Olive at Island of Ventotene.

35. Submarine reefs of amygdaloid lava.
34–28. Pumice and other explosive eruptive products.
27. Doleritic scoria and lavas forming a small volcanic cone.
x. Dyke which probably supplied same.
26–8. Upper pumice and other explosive eruptive products.
7–4. Compact tufa.
3–1. Vegetable soil, blown sand, etc.
a, *b*. Sea-level.

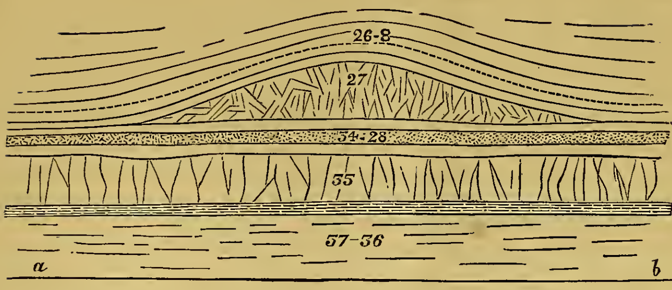


Fig. 2.—Section of Lavas, Tuffs, Pumices, and a small Volcanic Cone between "Il Telegrafo" and the "Terra Abbandonta," Ventotene.

a, *b*. Sea-level.
37–36. Scoria, dust, etc.
35. Doleritic lavas (lower).
34–28. Lower pumices and other explosive eruptive products.
27. Doleritic (upper) scoria forming section of toe of small volcanic cone.
26–8. Upper pumices and other explosive eruptive products.

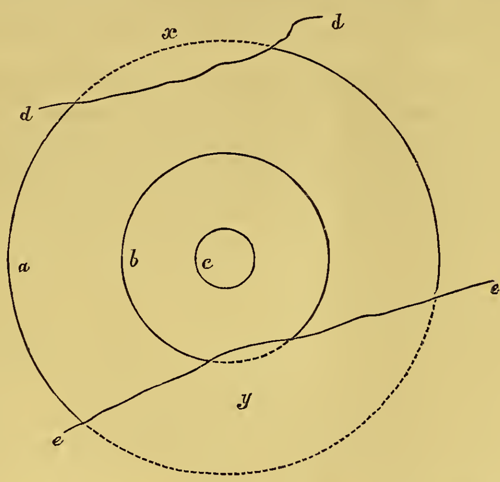


Fig. 3.—Diagram of the Sections of a Volcanic Cone seen in Cliffs of Ventotene.

a. Toe; *b*. rim and *c*. vent; *x*. and *y*. parts removed; *d*, *d*. North-west and *e*, *e*. S.E. coast-lines.

With (25) recommenced a series of explosive eruptions (25–8), which culminated in a gigantic one represented by the different pumices, scoriaceous pumices and tuffs (7–4). Of course it is impossible to say at what point all these pumice and dust deposits were erupted, and it is not improbable that they were derived from different eruptive centres. The last seems to have been very near at hand, for at Ventotene it attains a thickness of 10 m. or more and is distinctly if at all represented at Santo Stefano. It is probably by this eruption that the greatest destruction was wrought in the old cone, and that the crater apex extended down into the subjacent metamorphosed rocks. In fact, the explosive products at Santo Stefano are generally smaller and finer than at Ventotene, and seem therefore to have been derived from a centre or centres nearer the latter island.[1] A grave error has crept into Prof. Judd's "Volcanoes," where the lavas are represented as a stratum covering the tuffs of the island, instead of the reverse.

These different pumice deposits are chiefly derived from a basic magma, probably having the same composition as the doleritic lavas of the island. Of far greater interest from a physical point of view is the regular sequence of the different ejectamenta in each explosive eruption, which I first pointed out at Vesuvius, and have confirmed in a very large number of volcanic deposits. In each we find comparatively vitreous pumice at the bottom followed by micro-crystalline pumice or scoriaceous pumice, and finally a dust bed. Whilst the divisions show a rapid increase of extratelluric "formed material" as the eruption progressed, the intratelluric minerals have not increased in number, the whole confirming the conclusion that the hydration of the igneous magma was limited to near the earth's surface.[2]

The blown sand already mentioned consisted of a mixture of augite and other mineral grains with shell fragments and foraminifera. It must have been carried up on the slopes of the island by the wind from an old beach probably formed on the extensions of the last great tuff deposit, but now cut away. By percolation of carbonated waters, nearly all the subjacent rocks have been permeated and often cemented together or filled by calcareous concretions. We find the lavas near the sea-level also become amygdaloidal by the presence of tufts of aragonite crystals in the vesicles.

Very interesting is the presence of irregular compact white amorphous concretions, often attaining a weight of 50 or more grammes, and composed of almost pure magnesite. These are included in and between the masses of scoria of the buried cone of eruption. They are probably due to emanations at and subsequent to the eruption. I have noticed very similar ones in a vesicular doleritic lava of the east coast of Vulcano.

The next point to which I wish to draw the attention of geologists is the remarkable evidence of elevation to be seen in the island of Palmarola, which seems to have escaped the notice of recent visitors. In the middle of the island is a depression somewhat in the form of an amphitheatre, open to the west and shelving down to the small

[1] The quantity of these explosive ejectamenta is such that the scoria cone was entirely buried in them, so that its existence is only known by the exposures in the cliff sections. See Figs. 1 and 2.

[2] Q. J. G. S. 1884 and Proc. R. Dublin Soc. vol. v. July, 1886; Proc. Geol. Assoc. vol. ix.

beach. On the east coast this depression is, so far as my memory goes, at least seven metres high, and lies to the side of the Forcina dyke. It seems dependent upon the clay through which the dyke was injected being easily subject to erosion. This deposit looks much like a Pliocene clay, but my hurried and forced departure from the island prevented me from more fully investigating it, as also the actual height above sea-level of the lowest edge of the breach. Dolomieu, who visited the Ponza Islands in March of 1786,[1] says: "Cette Ile (Palmarole) est divisée en deux parties presque égales par un canal étroit qui la traverse vers la moitié de sa longueur, et dans lequel on passe en barque." Besides this clear statement he gives a map of the island showing the canal in the position of the amphitheatre depression, and the lowest breach in the east coast-line. At present the lowest part of this depression I noticed strewed with boulders covered with *Serpulæ* and other marine growths, looking quite fresh, but above sea-level. We have evidence here of a very striking kind, of a very considerable elevation during a period of little less than a century—as important I believe as any recorded. I regret that I did not make more detailed observations, but the unfortunate circumstances which caused my departure, together with the fact that it was only after my return that on looking at Dolomieu's map, the fact struck me. I hope, however, to carefully investigate the matter next summer, so as to make public such an important piece of geodynamical evidence. Of course we have other prehistoric evidences of elevation in abundance in these islands, and one in particular that struck me, namely, the occurrence of beds of well-rounded pebbles half-way up the cliff of Monte della Guardia at Ponza. But the elevation of an island from 5 to 10 metres or more in a century would be of inestimable value as a cardinal fact in geology, if fully confirmed.

II.—Terrestrial Magnetism as Modified by the Structure of the Earth's Crust, and Proposals Concerning a Magnetic Survey of the Globe.

By Dr. Edmund Naumann.

(*Concluded from the November Number*, p. 490.)

[PLATES XV.-XIX.]

I WILL now put forward some details, for it seems necessary that some proofs of what has been maintained in general should be given, and I shall therefore quote some examples of the intimate connexion between earth-structure and terrestrial magnetism. No diagrams could indicate the relations better than Locke's Magnetic Sections across the Hudson, which were taken at three different points of the Palisades, Snake Hill, Fort Lee and Patterson (see Plate XV.). The dip and intensity were in each case determined at a number of points along a line perpendicular to the range of cliffs,

[1] Iles Ponces, 1788, p. 128.

and the curves rise very suddenly to maxima just above the edges of the cliffs, which are composed of columnar diorite. This diorite is widely distributed and lies between masses of Triassic sandstone; the dip is slight and towards the west. On the east side of the cliffs Laurentian gneisses are exposed. The close proximity of formations so far apart in age must be caused by a great fault, and the perpendicular dislocation amounts at least to some thousands of feet. In Locke's opinion the very sudden rise and fall of the magnetic curves are due to the columns of diorite being magnetized by terrestrial induction, but I think there can be no doubt that the great fissure is the chief cause of the sudden changes.

Another beautiful example is afforded by Nipher's "Magnetic Survey of the State of Missouri."[1] The isogonic line of 7° 30′ describes a loop, in the centre of which lies the Pilot Knob, a hill 662 ft. high, and composed of porphyry, porphyry conglomerate, and layers of hard red sandstone. To the east is the knob connected with other porphyry hills. If we remember that the Pilot Knob can be nothing but an old volcano, whose subterranean core passes to great depths, we can well imagine how the hearthlike eruption may deflect electric currents from their direct track, and cause irregularities in the magnetic elements.

Marvellous coincidences between magnetic curves and lines of great geological disturbance are met with in Asia. It seems as if the Himalayan range exerted some controlling influence over the isogonic lines; some of these follow the direction of the mountain chains, and the way in which the 2° 30′ and 3° curves go high up the Brahmaputra valley and then turn back to the S.W. is very striking (see Plate XVI.). Rijckevorsel, the well-known surveyor of the Indian Archipelago, speaking on this subject, says, that "It is as if the land had some power of coercion over the isogonic lines."[2] I venture to submit that it is not the land which exerts this influence, but the great longitudinal ruptures indicated by the submerged mountain range. It may be that in a great portion of Asia the isogones coincide with lines of great geological displacement.

Another illustration in support of our theory may be taken in Europe. The district between the Carpathian Mountains and the Transylvanian "Erzgebirge" forms an almost circular basin; this region was surveyed by Kreil about forty years ago, and by Schenzel in 1875–76.[3] During the interval the isogones have (of course) changed their position, but still the two maps, one for the period

[1] Nipher, F., Magnetic Survey of Missouri. Fifth Annual Report, Trans. St. Louis Ac., vol. iv. No 3, p. 516. Chart of the Magnetic Variation in Missouri, St. Louis, 1880. Sold at Robert Beneck's, St. Louis. Chart of the Magnetic Variation in Missouri (photograph of a plaster chart), St. Louis, 1881.

[2] Rijckevorsel, Report to His Excellency the Minister of the Colonies on a Magnetic Survey of the Indian Archipelago, made in the years 1874–1877. Amsterdam, 1879.

[3] Schenzel, Beiträge zur Kenntniss der magnetischen Verhältnisse im Sudostlichen Ungarn, Repert. f. Experimental Physik, f. physikal Technik, f. math. u. astron. Instrumentenkunde, Herausgeg. v. Carl, München, 1877, Bd. XIII. s. 165.

of Kreil's observation, the other for the later epoch, show a most remarkable similarity. To the east, the isogonic lines are parallel to the Carpathians, and they turn round near Kronstadt and Fogarasch, just as the Transylvanian Alps do. The centre of Transylvania is traversed by a loop. We thus see that the isogones present a thoroughly natural form, and that their characteristic features remain unaltered, notwithstanding the secular changes of magnetism. This is certainly a very important result.

A considerable number of other illustrations might be quoted, but I am afraid of digressing too far, and must refer those who take a special interest in the matter to the above-mentioned paper, in which a discussion of all the magnetic surveys hitherto accomplished will be found. Many pages of it are devoted to the results of the Magnetic and Geological Survey of Japan, carried out under my direction during the years 1880–85. Those results are of special importance to our subject, and I may therefore be allowed to submit some observations which have come under my own experience. There is a most remarkable correspondence between the lines of equal declination and the principal lines of geological structure. In general the magnetic lines exhibit striking and unexpected irregularities, and these irregularities are found to be most intimately connected with the abnormal curvatures of the folds. The serious discussion which followed the reading of a paper of mine before the Seismological Society of Japan in 1882[1] showed how far these irregularities were unexpected. For my own part I was convinced from the very beginning of the Geological Survey, at a time when the magnetic data were still scanty, that there must be some connection between the phenomena caused by terrestrial magnetic force and the internal condition of the earth's crust or of the earth itself. With this point in view the magnetic investigations were commenced. In a comparatively short time the general magnetic survey, comprising no less than 200 complete observations at a like number of stations, was accomplished by Mr. Sekino, one of my former topographical assistants. The results are very satisfactory. It will be observed that the course of magnetic lines are influenced by the great transverse cleft called Fossa Magna (see Plate XIX.). This is a great depression, cleft, or fissure, running from the Pacific to the Japan Sea, in which a number of volcanoes have sprung up. Fujinoyame, for instance, the highest mountain of the Japanese Archipelago, is situated in this cross fissure. The Japanese chain consists of a long series of folds, running as a rule in the same direction as the island chain itself, but in the neighbourhood of the Fossa Magna these folds (which were probably raised by a force acting from the continent towards the Pacific) turn back as if they had been stopped by the great wedge of eruptive rocks lying below the Fossa Magna. In Mr. Sekino's Magnetic Map (Plates XVIII. and XIX.) the 5° isogone will be seen to circumscribe the Fossa Magna, for in that vicinity the curve forms a great wave whose crest is upturned

[1] Notes on Secular Changes of Magnetic Declination in Japan, vol. v. of the Trans. Seism. Soc. of Japan.

towards the Japan Sea. This curve, therefore, exhibits the same features as the axial line of the folds, and to a certain extent the isogones and the fold lines coincide. In a paper published in the Proceedings of the Royal Geographical Society,[1] containing a somewhat fuller account of the geology of Japan and of the distribution of magnetism in that country, I have said: "These results open out an entirely new field of research, and I hope that they may be an inducement to a continuation of similar investigations, so that some light may be thrown upon those still very obscure pages relating to the causes of magnetism and to the internal condition of the earth."

Since the publication of the above-mentioned memoir, letters of approval have been received from many well-known authorities, and a number of reviews, by no means unfavourable, have appeared. But in some cases I have been entirely misunderstood, and quite recently a violent attack has been made by Dr. Cargill G. Knott, of Tokio.[2] He says, that an inspection of the results of Sekino's survey, carried out under my direction, convinced him that it would be unsafe to deduce from them any definite conclusion as to the general magnetic characteristics of Japan, and to him it appeared "that the thing to be desired was a new survey, which might be called a preliminary survey of all Japan." These remarks tend to depreciate Mr. Sekino's observations, and are accompanied by several unfounded accusations. The latter I hope to prove unjustified by stating a number of facts, and as evidence that Mr. Sekino's survey is not to be despised, I have prepared several maps as follows:

Plate XVIII. is a combination of Mr. Sekino's and Dr. Knott's maps, from which it will be seen that there is no essential difference between the lines obtained by the two observers. If they do not exactly coincide, it must be borne in mind that the two maps relate to different epochs (Sekino, 1882–83; Knott, 1887), separated by four or five years. In discussing the question of secular change, Dr. Knott ignores the fact that the rate of change varies with time *and locality*, hence his method of comparison is unsatisfactory, and average differences are not allowed. Apart from adverse statements, I do not hesitate to welcome Dr. Knott's work, for his map is a good check on Mr. Sekino's observations, and shows that Sekino's survey *can stand* as a Preliminary Survey of Japan.

Plate XVII. is a combination of Dr. Knott's map with my Tectonic Map of Japan. Speaking of his own map Dr. Knott says that "two regions are to be noted as presenting magnetic irregularities; one is the great mountainous region about the Fossa Magna, and the other is between the 38th and 40th parallels. I quite agree with Dr. Knott even as regards the irregularities of Northern Honshin. They are mentioned in my paper on the Geology of Japan, in which I

[1] The Physical Geography of Japan, Proc.R.G.S. Feb. 1887.

[2] Cargill G. Knott, D.Sc. (Edin.), F.R.S.E., Professor and Aikitsu Tanakadate Professor of Physics, Imp. University of Japan, A Magnetic Survey of all Japan, carried out by Order of the President of the Imp. University, Journal of the College of Science, Imp. University Japan, vol. ii. part iii. Tokio, 1888.

make the following remarks: A kind of break of the isogone occurs between Sado and Sendai. This must be of special interest, as a geological dislocation line runs across Japan in this region. The irregularities are also referred to in a later pamphlet on magnetism. As regards *Dr. Knott's curves*—although some details of declination may be questioned—I think they *are a sufficient proof that the distribution of magnetism bears some relation to the great lines of geological structure.*[1]

When I undertook the Geological Survey of Japan, of which the magnetic survey was part, the steps taken were guided by previous experience.

The bulk of mariner's observations were gone through, and Ino's field books and maps consulted for compass-measurements. These studies enabled me to select the stations at which Mr. Sekino's observations were subsequently taken, in accordance with a definite scheme.

The Sado sinuation is roughly indicated on a small map published in 1882, and from my magneto-tectonic map (Plate XIX.) it will be seen that the selected stations keep fairly close to the ascertained magnetic curves. These facts are sufficient to show that the arrangement of stations was made with the utmost care. I am afraid that Dr. Knott's stations were not distributed so judiciously. It is greatly to be regretted that the second magnetic survey of Japan was carried out so independently, and without the valuable hints which might have been derived from previous investigations. Not even the field books of the Geological Survey were consulted. These books contain sketches by which the exact position of every station can be easily determined, and in accordance with the practice of Lamont the topographical data necessary for the redetermination of the places of observation were ascertained, in order that future observers might work on the same spots.

From the memoir on the second Magnetic Survey of all Japan we learn that of the 81 stations taken 27 *can be regarded* as coincident with stations of the previous survey. A few of these are only roughly coincident. I should digress too far by stating fully the reasons why I determined that the stations should be on the route followed by Messrs. Sekino and Kodari; it is sufficient to say that the test offered by the second Magnetic Survey justifies their distribution. At the same time, I cannot avoid stating that the new observers should have felt it their duty to devote special attention to the most interesting regions about the Fossa Magna, and between Sado and Sendai. Dr. Knott considers it very important to fairly distribute the stations over the whole country, and that it is necessary "to give volcanoes a wide berth, as these have been shown by previous observers to be a great source of disturbance,

[1] There is something very striking in Dr. Knott's representation. The centre of the great loop of 4° 20′, which will be noticed in the main island, coincides with the intersection of the great longitudinal and transverse fissures (Fossa Magna) of Japan. His curve of equal total force, and that of equal horizontal force, also prove that the Fossa Magna has some influence on the magnetic curves.

especially as regards the declination." Then, almost in the same breath, he searches for the causes of observed irregularities, and finds them in the distribution of volcanic rocks. Little or no attention seems to have been paid to the most interesting disturbance that must have existed at Ino's time (at the beginning of this century), and which Mr. Sekino's observations show to still exist, nor was the peculiar phenomenon exhibited by the magnetic block on the summit Morigoski examined; this is all the more surprising, as two stations of Dr. Knott's survey lie in the immediate neighbourhood of these remarkable places.

It may appear that I am dealing too minutely with Dr. Knott's paper, but I think the criticisms are justified by the interests of science. It is by no means satisfactory to see that so many fellow-workers on the field of science cannot build without pulling down, for it should be the serious duty of every one to advance from wherever a safe footing has been attained. Earnest and honest labour deserves respect rather than condemnation. Unfortunately it is usual for critics to introduce their subject with an exhaustive survey of all its faults, instead of commending its merits. The greater the effort made to ascertain its merits and appreciate them, the easier will it be to use existing knowledge as a foundation for future progress, and those who neglect this duty tend to check rather than promote the advancement of science.

Dr. Knott does not appear to be acquainted with my pamphlet, for if he had read it he need not have devoted so many pages to the rather antiquated chapter on Rock Magnetism; and if his knowledge of the Geology of Japan was more profound, his opinion as to the causes of irregularities being entirely superficial would be modified. In his paper we are taught that "the volcanic nature of the rocks is more than enough to account for all irregularities." Why? Perhaps because volcanic rocks are known to contain magnetic iron ore? If so, Dr. Knott should have remembered that the volcanic tuffs, widely distributed over the country, consist of the same materials as so-called volcanic rocks. In addition, as proved in my memoir, rock magnetism does not influence the curve-systems, nor do the values of the constants depend on the nature of the rocks developed in the neighbourhood.

In considering such questions the following points are important: how the earth's crust is composed of *masses* of rocks; how deep the fissures penetrate into the earth and establish connection with the interior of the globe; whether these fissures are closed or not, etc. In the locality under discussion there are two enormous fissures, intimately connected with the development of the great earth-wave whose crest appears as the Japanese island chain. One of these is longitudinal, and divides the whole mountain-range into inner and outer zones; the other is transversal, and divides the chain into two parts which stretch towards the north-north-east and west-south-west respectively. The transversal fissure is indicated by the Fossa Magna, and the longitudinal one curves back towards the Sea of Japan, where it intersects the former (see Plate XVII.). Enormous masses of molten matter have been ejected from these clefts, and it is not difficult to imagine that such enormous fissures have some influence upon earth currents, and consequently on the magnetic needle.

My former remarks on the reduction of the declination values to one hour are said to contain a "slight" inaccuracy, and Dr. Knott seems to think that no correction was applied to observations made at the northern stations. On this supposition he depreciates Sekino's observations, and, together with the supposed injudicious distribution of stations, it is used as an argument against the first Magnetic Survey.

The title of Sekino's Magnetic Map of Japan, which was exhibited at the Berlin International Congress of Geologists, and now belongs to the Geographical Society of Berlin, runs as follows, "On trouve les valeurs actuelles des observations indiquées près des stations par les mêmes coulers que les coleurs correspondantes. Les observations sur la declinaison seulement sont réduites en moyenne diurne." Before publishing my pamphlet on magnetism I wrote to Sekino asking him to give me the exact times at which each observation was taken, and he replied that the values in the list I kept were daily means. I am certain that before leaving Japan I gave instructions for a reduction of all declinations to be made, and hitherto I was convinced that this had been done, although the reduction for the northern stations could only be approximate. If Dr. Knott has any doubts about the matter, he may readily remove them by inspecting Sekino's field books, for, as stated above, these books were not written to be buried in the Archives of the Geological Survey, but were prepared for the use of future observers.

There are, I think, very few persons who have a good idea of the surface configuration of the earth, even where only a small part is concerned. In most cases heights are exaggerated in memory, and consequently the angles of inclination are taken far too great. How insignificant is the depth of the deepest part of the ocean when compared with the dimensions of the globe as a whole! Lamont has tested the question as to whether there is any change in the magnetic elements due to differences of level, and the results show the change to be imperceptible even for considerable differences of height. From this he concluded that the seat of terrestrial magnetism is not to be sought near the surface, but at enormous depths below the surface.

I may here be allowed to draw attention to a most interesting theory of Lamont. He admitted the frequent occurrence of irregularities in the systems of magnetic curves, and attributed them, not to the influence of magnetic masses contained in the crust, but to elevations and depressions, *i.e.* to irregularities, of the earth's nucleus.

His opinion may best be stated in his own words: "The magnetic curves represent the surface of the nucleus." If Dr. Knott had been well acquainted with these remote but classical investigations, he might have omitted the discussion of results given on page 214 of his Memoir.

In my pamphlet on Magnetism I have given a fairly complete list of the most important works on the subject, and I consider it necessary that every scientific investigator should have a profound knowledge of the literature of his subject; for when so qualified he need not discuss works which he has not studied carefully.

Amongst the works which I have had occasion to peruse during my studies in terrestrial magnetism, a memoir by C. A. Schott on the secular variation of magnetic declination in the United States and at some foreign stations, is of special interest. Any one who has devoted any attention to the subject of secular change, knows that it is one of the most complicated branches of terrestrial physics, and at first sight it seems very curious that by far the greater number of copies of the above memoir were sold to lawyers. The demand in law circles for the work which treated of a purely scientific subject was so great, that several new editions had to be issued; and the reason of this is to be found in the difficulties experienced in following the old boundary lines of landed property, which had been originally laid out by the magnetic compass. This case is a good example of how a purely scientific problem may suddenly and unexpectedly become one of great practical importance.

Schott's investigations tend to show that the secular variation is periodic, but unfortunately the observations do not extend over a complete cycle. He compares the secular change with the motion of a pendulum. In the United States south of the 49th parallel, a complete cycle requires $2\frac{1}{2}$ to $3\frac{1}{2}$ centuries, and during this interval the needle describes arcs varying from 3° to 7°; in Paris the amplitude is 33° and the period about $4\frac{2}{3}$ centuries.

Taken as a whole, the secular variation is perfectly systematic, and subject to remarkable laws which will well repay careful study, and being a phase in the life-history of our planet, the secular change may prove an excellent means of comprehending the internal condition of the globe.

In Japan the magnetic elements have undergone considerable changes since the beginning of the present century, as may be seen by comparing recent surveys with that of Ino Tadagoski, a Japanese astronomer, who, about that period, made a geodetic survey of his native country. This observer had heard and read in foreign books of the variation of the compass, but, nevertheless, he denied its existence, and even went so far as to attribute the declination observed by Europeans to errors in their compasses; he also maintained that the fact of his own needles always pointing due north, was owing to the superiority of his instruments, which were of his own construction. Thus he was led to believe that no variation of the compass existed. The average amount of secular change during the interval 1800 to 1880 is between 3 and 4 minutes of arc per annum. Dr. Knott maintains that at the present time there is no secular change in Japan, and if this be correct, it is an important and unexpected result. Let us see how far it may be relied upon.

As stated above, Dr. Knott uses a method which is a *contradictio in adjecto*, for if an average of differences be taken, and this average proves to be zero, as in the case considered, it does not necessarily follow that there is no secular variation in Japan, but the result can be explained by the well-known fact that the amount of secular change is different in different places, and may be positive in some, whilst it is negative in others.

From a comparison of Sekino's and Knott's maps, however, it may be seen that the isogonic lines have shifted very little indeed, and we agree with Dr. Knott when he says: "Within the period beginning with 1883 and ending 1887, there is practically no change, or if there is, it is a very small change indeed. It looks almost as if we were just passing through a time of maximum declination." This result is extremely interesting if we take into account what Fritsche has said about the line of zero declination when it passes through Mongolia. The value of the secular variation for stations lying near this part of the line is very small, and we may therefore conclude that the whole magnetic island of western declination covering a considerable part of Eastern Asia is at present in a nearly stationary condition.

When speaking of the diurnal means obtained from Sekino's survey, I quoted part of the explanation accompanying his magnetic map, and I now direct attention to another passage of that explanation, which runs as follows: "Il y a un nombre d'irrégularités considérables qui sont particulières à des régions isolées. Ce ne'st pas le caractère spécial de ces irrégularités qui est représenté dans la carte par les lignes en forme de cercle, mais simplement le lieu et l'extension." There is no doubt but that a complete magnetic survey of Japan will prove the existence of many small magnetic islands, which can at present only be vaguely indicated.

Dr. Knott's map does not show the Sado sinuation of the south-west curve as I have shown it, but represents the irregularity by an isolated line round the island. He prefers this form because—as he says—it is well known that the isogonic lines at or near islands often present irregularities of quite a local character. I am inclined to believe that this is not well known. I, at least, was not aware of it, except as regards oceanic islands which may—as Rijckevorsel says—appear to have some power of coercion on the isogonic lines. Oceanic islands, however, are indications of great submarine mountain ranges, which are generally accompanied by deep fissures in the earth's crust, but no power of coercion can be expected from an island which is merely a detached piece of the main land.

The problems presented by the magnetic islands of Japan can only be solved by a very detailed survey, and it is interesting to enquire what such a survey means. Quite recently a very detailed magnetic survey of part of the kingdom of Würtemberg has been carried out by Hammer, and he estimates that about 90 stations would be necessary for the whole kingdom. Taking this as a basis, Japan would need 1800 stations, Germany 2500, and Great Britain 1500 stations.

These numbers induce me to again refer to the distribution of stations in the first Japanese survey, objected to by Dr. Knott. In his survey observations were taken at 80 stations, and in the first survey 200 stations were selected. When compared with the requirements of a detailed scheme, both these numbers appear very modest. In such cases it is all the more necessary to distribute the stations judiciously instead of merely spreading them "fairly over the whole country," for it is only exhaustive surveys which can adopt the latter principle advocated by Dr. Knott. Similar remarks may apply in orographic surveys, for a reconnaissance requires quite a different distribution of stations to that needed for an elaborate undertaking in which time and money are not important. Having had some experience in reconnaissance surveying, I am well aware how carefully the stations must be selected.

The above numbers also give us an idea how very far we still are from having accomplished detailed magnetic surveys even of parts of the earth's surface; it is only in a few very limited districts in Missouri, Transylvania and Würtemberg that such surveys have been attempted. The whole question needs to be taken up internationally, and I trust that these lines may convince my readers of the great importance of the subject. Rich harvests may be expected from a field which can only be explored by the joint efforts of all the workers in this great cause, and the stimulus imparted by British scientists will be sure to find a ready response on the continent.

To many sciences the problem of terrestrial magnetism is the common focus, for physicists, geographers, topographers, meteorologists, astronomers, etc., and above all geologists, must be interested in it. In former times magnetic observations were commonly attached to astronomical ones, and astronomers were in charge of the observations, whilst at present the subject forms a branch of physiography, and the observatories are usually connected with meteorological establishments. The latter arrangement seems to be the most satisfactory one, and great interest is taken in the question by meteorological societies and offices on the continent, particularly at Hamburg, Berlin, Vienna and Munich.

To come to the practical side of the question, I beg to propose that an International Congress be held, say in London, at or about the time of the next British Association meeting. This Congress might decide numerous questions, still unsettled in the minds of the majority of observers, and may pass resolutions prescribing uniform schemes on which magnetic surveys should be carried out. It should also endeavour to induce the various Governments to take an active part in promoting the magnetic survey of their respective countries.

Dr. Naumann's paper is illustrated by Plates XV.–XIX.

Plate XV. Locke's Magnetic Sections; Palisades of the Hudson and Patterson, New Jersey.

Plate XVI. Magnetic Curves of the Himalayas.

Plate XVII. Tectonic Map of Japan with Dr. Knott's Magnetic Curves.

Plate XVIII. Comparative Diagram of Mr. Sekino's and Dr. Knott's Magnetic Curves of Japan.

Plate XIX. Magnetic Tectonic Chart of Japan by Dr. E. Naumann.

III.—On the Lower Silurian Felsites of the South-East of Ireland.[1]

By Frederick H. Hatch, Ph.D., F.G.S.

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

THE felsites of the south-east of Ireland are shown on the maps of the Geological Survey [2] to extend over considerable areas in counties Wicklow, Wexford and Waterford. Like the Welsh felsites they are contemporaneous with Lower Silurian (Ordovician) strata, and were probably erupted on an old sea-bottom. They are accompanied by abundant deposits of tuffs and breccias, the component fragments of which consist mainly of felsite.

A chemical examination of one of the felsites, made when I was preparing a petrographical description of the more important igneous rocks for a memoir on Sheets 138 and 139 of the Irish Geological Survey, showed it to be a soda-felsite; [3] and this discovery induced me to make a more extended examination of these felsites. A number of specimens from different localities were collected and sliced; and a chemical analysis of those that promised interesting results was kindly undertaken by Mr. J. Hort Player (to whom I here tender my best thanks). The object of this paper is to communicate these results and to discuss them in connection with the microscopic characters of the rocks.

The main point brought out by chemical analysis is the almost entire absence of lime, and the presence of potash and soda in varying proportions: in other words, the lime-soda series of felspars is unrepresented in these rocks, which must therefore contain either a varying proportion of potash-felspar (orthoclase) and soda-felspar (albite) or one or more felspars of a potash-soda series (anorthoclase).

According to the relative proportion of potash and soda the rocks are roughly separable into the three following groups:

(I.) Those in which there is a large excess of potash over soda, the latter being present only in small quantity. These may be termed *potash-felsites.*

(II.) Those in which the soda, though present in considerable quantity, is yet subordinate to the potash. These may be termed *potash-soda-felsites.*

(III.) Those in which the soda is in excess. These may be termed *soda-felsites.*[4]

[1] Read at the Newcastle Meeting of the British Association, Sept. 13th, 1889.
[2] Sheets 130, 139, 148, 149, 158, 167, 168, 169, 178, and 179.
[3] Geol. Mag. 1889, p. 70.
[4] Should the soda be in but slight excess of the potash, the rock might be termed a *soda-potash-felsite.* The term *keratophyre* (originally suggested by Gümbel) has been applied by Lossen to a rather indefinite group which includes rocks similar in character to those in Group III. The term soda-felsite appears more applicable to these rocks.

GROUP I. (*Potash-felsites.*)[1]

	1. (I. 113.)	2. (I 172.)	3. (I. 110.)	4. (I. 111.)
SiO_2	70·8	71·0	66·2	85·2
Al_2O_3	15·1	14·2	13·6	7·4
Fe_2O_3	1·0	·8	3·3	·5
FeO	·6	·7	4·6	·4
CaO	·2	trace	trace	trace
MgO	1·1	1·1	1·8	·4
K_2O	9·1	9·6	7·9	4·4
Na_2O		·7	·1	·9
Loss on ignition	1·6	1·5	2·6	·6
Total	99·7	99·6	100·1	99·8
Sp. G.	2·606	2·606	2·619	2·622
Orthoclase percentage[1]	54·2	57·1	47·1	26·2
Albite percentage	0	5·9	·8	7·6

GROUP II. (*Potash-soda-felsites.*)[2]

	5. (I. 81.)	6. (I. 126.)	7. (I. 169.)	8. (I. 109.)
SiO_2	70·6	74·8	75·6	73·6
Al_2O_3	15·3	13·9	12·8	13·8
Fe_2O_3	·7	·5	—	·5
FeO	1·7	1·0	1·9	2·4
CaO	·8	trace	·1	·6
MgO	·8	1·1	·4	·7
K_2O	6·1	5·7	5·6	4·3
Na_2O	2·7	2·2	3·0	3·2
Loss on ignition	·9	1·2	·5	·6
Total	99·6	100·4	99·9	99·7
Sp. G.	2·645	2·600	2·626	2·658
Orthoclase percentage	36·4	33·9	33·3	25·7
Albite percentage	23·8	18·6	25·4	27·1

GROUP III. (*Soda-felsites.*)[3]

	9. (I. 83.)	10. (I. 80.)	11. (I. 114.)	12. (I. 96.)
SiO_2	73·0	71·2	77·8	71·6
Al_2O_3	16·7	16·8	13·2	16·9
Fe_2O_3	·5	·8	·2	·3
FeO	1·3	1·5	·7	·9
CaO	·5	·8	trace	2·2
MgO	·7	·9	trace	·6
K_2O	2·2	2·0	2·1	1·3
Na_2O	4·2	4·7	5·1	4·7
Loss on ignition	1·2	1·5	·6	1·1
Total	100·3	100·2	99·7	99·6
Sp. G.	2·607	2·606	2·634	2·607
Orthoclase percentage	13·0	11·9	12·5	8·5
Albite percentage	35·6	39·9	43·2	39·9

[1] The whole of the potash has been calculated as orthoclase from the formula $K_2O. Al_2O_3. (SiO_2)_6$; and the soda as albite from the formula $Na_2O. Al_2O_3. (SiO_2)_6$.

[2] See also three analyses of felsites from the counties of Wicklow, Wexford, and Waterford by the Rev. S. Haughton (Trans. Roy. Irish Acad. vol. xxiii. part ii. 1859, p. 615).

[3] See also two analyses of soda-felsites from the Waterford coast by the late J. A. Phillips (Phil. Mag. 1870, vol. xxxix. p. 12; GEOL. MAG. June, 1889, p. 288), and an analysis of a Wicklow soda-felsite by the author (GEOL. MAG. Feb. 1889, p. 70).

Notes on the foregoing Groups.

Group I.—1. (I. 113.)—Half a mile south-east of Cairn on Castletimon Hill, Co. Wicklow. Sheet 130.

Compact grey felsite, of irregular fracture. Under the microscope shows felsitic (cryptocrystalline) structure, but with frequent patches of more coarsely crystalline (microcrystalline) matter. No porphyritic crystals.

2. (I. 172.)—One mile west of Great Newtown Head, Co. Waterford. Sheet 179.

Compact brown felsite, of irregular fracture. Under the microscope shows a cloudy unindividualized substance, containing a number of ill-defined spherular clots, mostly aggregated in strings. These bodies have no radially fibrous structure, presenting between crossed Nicols a speckled or dappled depolarization instead of the characteristic black cross, and cannot therefore be regarded as true spherulites. They doubtless represent, however, some incipient form of crystallization. The remainder of the ground-mass shows a confused, patchy devitrification. The rock contains no crystals and is probably a devitrified pitchstone.

3. (I. 110.)—Castletimon-ford, right bank, Co. Wicklow. Sheet 130.

Compact, grey, mottled felsite, fracturing easily; the joint-faces stained with oxide of iron.

Felsitic or cryptocrystalline structure with an occasional porphyritic crystal of non-striated felspar (orthoclase). Between crossed Nicols the devitrification of the ground-mass shows itself in the presence of innumerable minute spherular bodies, each giving a black cross. Chlorite is present in scattered scales.

4. (I. 111.)—Castletimon-ford, left bank, Co. Wicklow. Sheet 130.

Very compact, light grey felsite; brittle and splintery, fracturing easily along joints, the faces of which are stained yellow with oxide of iron, resulting from the decomposition of pyrites which occurs in small quantities in this rock.

Under the microscope the structure is truly felsitic or cryptocrystalline, there being no porphyritic crystals present.

Group II.—5. (I. 81.)—Quarry on road from Woodenbridge to Aughrim, $1\frac{1}{4}$ mile north-west of Woodenbridge, Co. Wicklow. Sheet 139.

Compact grey felsite, spotted white with small crystals of felspar. Iron pyrites in disseminated specks.

Under the microscope: Cryptocrystalline ground-mass, embedding numerous porphyritic crystals of striated felspar. The twinning is on both types (pericline and albite). Microperthite structure is occasionally shown.

6. (I. 126.)—Kilmacrea Wood, $1\frac{3}{4}$ mile north-west of Redcross, Co. Wicklow. Sheet 130.

Compact, grey, mottled felsite.

Under the microscope: Structure varying between cryptocrystalline, in which the constituent granules are not distinctly separable, and microcrystalline in which each granule can be clearly distinguished. Here and there occur a few larger grains of quartz and felspar, but not sufficiently separated from the ground-mass to constitute a true porphyritic structure.

7. (I. 169.)—Boulder on coast, near Annstown, Co. Waterford. Sheet 178.

Compact dark grey felsite, well banded (fluidal structure).

Under the microscope: Felsitic ground-mass with confused and patchy devitrification. Embedded in the ground-mass are large porphyritic crystals of quartz and felspar, the former corroded, the latter presenting both single and double twin-striation.

8. (I. 109.)—One mile south-east of Ballynacor Cross-roads, Co. Wicklow. Sheet 130.

Compact back felsite; fracture irregular.

Under the microscope: Confused felsitic ground-mass, depolarizing in patches, with isolated porphyritic crystals of striated felspar.

Group III.—9. (I. 83.)—Quarter-of-a-mile east of Coatsbridge, on the road from Woodenbridge to Aughrim, Co. Wicklow. Sheet 139.

A grey almost phanerocrystalline felsite, with slight parallel structure (probably secondary and due to the earth-movements that have affected this region).

Viewed between crossed Nicols the ground-mass has an intricate mosaic-like appearance produced by the uniform distribution of minute prisms of felspar among the rounder granules of quartz. The porphyritic felspar, which is not abundant, occurs in broad rather irregular grains, presenting sporadic twin-striation.

Scales, shreds and streaks of both muscovite and chlorite are rather abundant.

10. (I. 80.)—Half-mile north-west of Woodenbridge, on the road from Woodenbridge to Aughrim, Co. Wicklow. Sheet 139.

A grey almost phanerocrystalline felsite, like No. 9.

Under the microscope: Microcrystalline ground-mass, with porphyritic grains of quartz and felspar, the former much corroded and rounded, the latter showing occasional twin-striation.

11. (I. 114.)—Ridge, immediately south-east of cairn on Castletimon Hill, Co. Wicklow. Sheet 130.

Compact felsite, of light-grey colour, but with dark mottlings.

The micro-structure of this rock is extremely varied: at one place cryptocrystalline, presenting the characteristic dappled "felsitic" appearance between crossed Nicols; at another, almost coarsely microcrystalline, the grains of felspar and quartz being clearly distinguishable. The structure is, however, nowhere truly porphyritic.

12. (I. 96.)—Old Quarry, Little Rock, Arklow, Co. Wicklow. Sheet 139.

Light-coloured felsite, spotted white with porphyritic crystals of felspar.

Under the microscope this rock is seen to consist of fairly large porphyritic crystals of quartz and felspar embedded in a microcrystalline ground-mass. The latter is made up of a uniform minutely granular aggregate of quartz and felspar, together with minute flakes and scales of muscovite and chlorite.

The quartz occurs in round and corroded grains, of which two or three are often closely aggregated. The felspar is present in broad rectangular crystals, presenting good crystallographic contours. The crystals occasionally show dual twinning; more frequently, however, the twinning is polysynthetic, the crystals being striated either in one direction alone (albite type) or in two directions at right angles to one another (albite and pericline types). A slight development of zonal structure is here and there to be observed. In no case was the extinction-angle found to exceed 20°.

Group I. comprises felsites containing few or no porphyritic crystals; they are composed mainly of a truly cryptocrystalline or felsitic aggregate. The few porphyritic crystals are not striated, and consist doubtless of orthoclase.

Groups II. and III. embrace felsites in which a striated porphyritic constituent is more or less abundant. On the other hand, the felspar of the ground-mass can be safely referred to orthoclase, as in Group I. And it seems likely that the fluctuation in the percentage of potash and soda in these rocks may be due to a variation in the relative proportion between a porphyritic albite-felspar and the orthoclase-felspar of the ground-mass. It is not impossible, however, that the porphyritic felspars may belong to a triclinic potash-soda series (the anorthoclase series of Rosenbusch[1]), analogous to the soda-orthoclase or soda-microcline described by Förstner[2] in the liparites of Pantellaria, by Brögger[3] in the augite-syenite of Southern Norway, and by Miers and Fletcher[4] from Kilimanjaro. In all these cases, however, the analyses show the presence of 2 or 3 per cent. of lime, which, with the notable exception of the Little Arklow Rock (No. 12), is almost entirely absent from the Irish soda-felsites. Unfortunately the felspar-grains in the latter are too small for

[1] Mikros. Physiog. vol. i. (1885), p. 550.
[2] Zeitsch. f. Kryst. vol. viii. (1884), p. 125.
[3] Die Silurischen Etagen 2 and 3, 1882, p. 261.
[4] Min. Mag. vol. vii. (1887), p. 131.

mechanical separation with a view to chemical analysis. Isolation with the Borotungstate solution was indeed tried by Mr. Player, but without success. Lossen[1] states that the porphyritic crystals, in the keratophyres described by him, are, in great part, mechanical admixtures of orthoclase and albite, similar to microperthite; but in the rocks under consideration I have been able only in quite isolated instances to record the presence of micro-perthite structure.

The rocks embraced in Group III. are slightly more crystalline than the others, the ground-mass being in general microcrystalline instead of cryptocrystalline. No. 12 (Little Arklow Rock) indeed has been placed by Haughton[2] among his soda-granites; but the structure of this rock can scarcely be termed granitic; at most it could only be called microgranitic (in Rosenbusch's sense of the term), since it consists of porphyritic crystals imbedded in a microcrystalline ground-mass.

It only remains to point out that the modern equivalents of these ancient felsitic lavas are the rhyolites or liparites and pantellerites, which have been subdivided by Rosenbusch[3] into potash-liparites, soda-liparites and pantellerites, sanidine being the porphyritic constituent characteristic for the first, albite for the second, and anorthoclase for the pantellerites. The main difference between the liparites and the felsites lies in the character of the ground-mass, the glassy base of the former being replaced in the latter by the cryptocrystalline aggregate known as *felsitic matter*.[4]

Some of the rocks, especially those of Group I., show indications of having consolidated as true glasses (pitchstone or obsidian), as has been proved to be the case in several instances among the felsites of Shropshire and Wales by the valuable researches of S. Allport[5] and F. Rutley,[6] who have succeeded in detecting distinct traces of perlitic and spherulitic structure in these rocks. The Welsh felsites are of the same age (Bala) as the Irish rocks, and probably belong to the same series of volcanic outbursts.

IV.—Physiography of the Lower Trias.[7]

By T. Mellard Reade, C.E., F.C.S., F.R.I.B.A.

Introduction.

THE origin of the Triassic rocks of Britain is a question that has excited from time to time much interest and varied speculation. The entire absence of fossils in the Lower Trias or Bunter Sandstone has led the majority of geological reasoners to look to causes

[1] Jahrbuch d. k. Preus. Geol. Landesanst. für das Jahr 1884 (1885), p. xxxii.

[2] Trans. Roy. Irish Acad. vol. xxii. pt. ii. (1859), p. 609.

[3] Mikros. Phys. vol. ii. 1887, p. 528.

[4] Nothing of the nature of *microfelsite* (in Rosenbusch's sense) has been observed by me during the examination of these rocks.

[5] On the Pitchstones and Perlites of the Lower Silurian District of Shropshire, Q.J.G.S, vol. xxxiii. (1877), p. 449.

[6] On Perlitic and Spherulitic Structures in the Lavas of the Glyder Fawr, N. Wales, Q.J.G.S. 1879, p. 508; and in Memoir of Geol. Survey on the Felsitic Lavas of England and Wales.

[7] Read at the Brit. Assoc., Newcastle-on-Tyne, in Section C. (Geology), Sept. 1889.

other than marine action for an explanation of its characteristic features. The late Mr. Godwin-Austen was of opinion that the whole of the Triassic rocks were laid down in freshwater lakes which, passing through the brackish stage, become finally saturated with saline matter through evaporation exceeding the inflow of fresh water. It has been felt, however, by other geologists, that this theory, while accounting fairly well for the upper deposits of the Triassic age, does not fit in with the phenomena of current bedding, the presence and distribution of the numerous quartzite and other well-rounded pebbles, and the comparative absence of marl-beds, which distinguish the Lower Trias or Bunter Sandstones.

Hence some well-qualified observers, following Professor Bonney,[1] prefer to consider that the mass of the sandstones have been laid down by rivers and point to Central Asia, as a region where the same accumulations are now taking place. The late Mr. John Arthur Phillips suggested that much of the sandstone displaying the well-rounded or "millet-seed" grain, supposed to be the distinguishing characteristic of the upper and lower beds or divisions of the Bunter Sandstone, was accumulated by wind action, it being maintained that the individual grains could not have been worn to so spherical a form by any other agent.[2] A combination of these two views seems to constitute the prevailing if not the finally accepted theory of the origin of a large proportion of the Triassic Sandstones of Britain.

My attention, which has for a long time been attracted by these interesting speculations, was some time since more specifically directed to the subject. Having for engineering and other purposes to examine considerable areas of the Triassic deposits of the North-west of England, the opportunity of further prosecuting the inquiry was eagerly seized.

The Triassic and immediately overlying and underlying rocks of the North-west of England and the Midland Counties [3] were for the purposes of the Geological Survey classified by Professor Hull as follows:

TRIASSIC SERIES.

- A1. Rhætic or Penarth beds occurring at Copt Heath and the South-west of England.
- A2. New Red Marl. Red and Grey shales, and marls sometimes micaceous, with beds of rock salt and gypsum containing *Estheria* and Foraminifera (Chellaston).
- A3. Lower Keuper Sandstone. Thinly laminated micaceous sandstones and marls (waterstones); passing downwards into white, brown or reddish sandstone, with a base of calcareous conglomerate or breccia.
- C1. Upper Mottled Sandstone. Soft bright-red and variegated sandstone (without pebbles).
- C2. Pebble Beds. Harder reddish-brown sandstone with quartzose pebbles, passing into conglomerate with a base of calcareous breccia.
- C3. Lower Mottled Sandstone. Soft bright-red and variegated sandstone (without pebbles).

[1] Presidential Address, Geological Section of British Association, 1886.

[2] On the Constitution and History of Grits and Sandstones, Q J.G.S. 1881, p. 27.

[3] Triassic and Permian Rocks of the Midland Counties of England, Memoirs of the Geol. Survey, 1869, p. 10.

PERMIAN SERIES.	1. Upper Permian.	Red marls with thin-bedded fossiliferous limestones (Manchester).
	2. Lower Permian	Red and variegated sandstone (Collyhurst, Manchester). Reddish-brown and purple sandstones and marls with calcareous conglomerates and trappoid breccia (Central Counties).

Previous to Prof. Hull's investigations no subdivisions had been recognized in the Lower Trias or Bunter Sandstone, but that geologist, as the result of an extensive survey, considered that there were well-marked lithological differences in the beds which justified a classification into three horizons, namely, — 1 Lower Mottled Sandstone; 2 Pebble Beds; 3 Upper Mottled Sandstone. It is upon this scheme that the Geological Survey maps were and have since been constructed.

Considering the difficulties of the survey, much of the country being deeply drift-covered, the maps have fairly represented the geology of the areas surveyed, especially in those localities where the outcrop could be studied. It is in those places where the nature of the rocks could only be ascertained by boring that the weak points of a classification founded on lithological differences has naturally developed itself.

In view of the numerous borings for water supply and for other purposes since made in Lancashire and Cheshire, certain modifications have had to be made in the colouring of the maps showing the distribution of the subdivisions of the Bunter, and in some cases it is impossible to make the maps conform to nature and be logically consistent with the classification. Far be it from me to in any way seem to detract from the merits of the early attempts to conquer difficulties, especially where *any* classification is surrounded with pitfalls as it is in this case. It is a trying time for the geological surveyor when he is asked to predict the strata likely to be met with in a given bore-hole, yet this is what is demanded from a geological map; and if it occasionally errs, can we wonder?

Characteristics of the Triassic Sandstones.

For the purposes of this paper it will not, however, be necessary to discuss these refinements of subdivision. I propose to treat principally of the Bunter Sandstone and its mode of origin, and with this object in view it will be sufficient to look upon it as a massive agglomeration of siliceous sandstones of varying fineness or coarseness of grain, sometimes rounded, sometimes angular, more or less coloured by peroxide of iron, and often cemented together by secondary silica, or having crystalline growths thereon in optical continuity with the original quartz of the grain, even though the grain may have been previous to deposition well rounded by attrition of the surface. Within the interstices of the stone, and probably combined with the colouring matter, is a deposit of calcareous matter consisting of carbonate or sulphate of lime, sufficient, after continual circulation of water in the rock when brought about by artificial means, such as pumping, to impart a considerable amount of temporary and permanent hardness to the water.

If we add to these characteristics the occurrence of well-rounded pebbles of liver-coloured and of clear translucent quartzite, white vein quartz, and other hard rocks, from the size of walnuts to an occasional specimen having a longer diameter of four or five inches, we shall have exhausted our lithological description.

It is, however, to be specially noted that these pebbles occur often sparsely distributed through the rock, sometimes in nests, and in other cases in such numbers as to deserve the name of "conglomerate beds" given to them by Professor Hull.

So far as my experience goes, the liver-coloured quartzite pebbles are confined to the Bunter Sandstones; but I have not been able to satisfy myself so far that these pebbles occur at a definite horizon in the Bunter, except locally speaking. Indeed, I am much inclined to believe that in some cases the theory of the pebbles being confined to a central subdivision has led to a misinterpretation of these rocks.

Speaking broadly, there is a distinct lithological difference between the Keuper and the Bunter; for although in most cases it would not be possible to distinguish the rocks in local specimens, we cannot point to any rocks in the Bunter which would be mistaken by a practical man for Storeton or Grinshill building-stone. The transition from the Bunter to the Keuper is also more marked than between beds of the Bunter, nor is there in the Bunter any equivalent of the Waterstones of the New Red Marl.

The Bunter is evidently a sandstone deposit, while the Keuper, often beginning with a conglomerate bed, shades off into a lithologically distinct stone succeeded by thin-bedded sandstones, and finally by the great deposit of saliferous marls. These physical peculiarities are well known to geologists who have worked these rocks; but it is necessary for my argument to restate them in this connected form.

Theory of the Origin of the Triassic Rocks.

Hitherto I have said nothing of the topographical relations of the Triassic rocks; but as the distribution of the sandstones specially bears upon their origin, this cannot be neglected. Unfortunately of the arid sandy region of Central Asia, which it is suggested best explains the mode in which these Triassic Sandstones have accumulated, not much is known.[1]

If, however, the Bunter Sandstone is a riverine deposit, we would expect it to follow well-marked topographical features. Although there have been great orographic changes, some folding, and much faulting since the Triassic age, certain great features, such as the Pennine Chain, still remain in a modified form.

If we try in imagination to reconstruct a river, valley or valleys, or even a sandy plain, representing the deposits as they are conceived

[1] The following papers bearing upon the subject are well worthy of study: "On the Nature and Probable Origin of the Superficial Deposits in the Valleys and Deserts of Central Persia," W. T. Blanford, Q.J.G.S. 1873, pp. 493–502. "Alluvial and Lacustrine Deposits and Glacial Records of the Upper Indus Basin," F. Drew, *Ibid*, pp. 441–71.—"Journal Across Central Asia," by Lieut. Younghusband, describing Gravels from the Altai Mountains and Sandhills, 900 feet high, "Nature," 1888, May 17, pp. 65–6.

to have been laid down on the riverine hypothesis, we are met with numerous difficulties, which I for one find it impossible to solve. The Triassic Sandstones are found on both sides of the Pennine Chain; they occupy valleys in older formations such as the Vale of Clwyd, where they are flanked by Silurian hills, and in the Vale of Eden by the Carboniferous: and everywhere they appear to follow what seem to be the remains of the orographic contours of the ancient land. So far as my experience goes, there is a general tendency for the sandstones to thin off against these boundaries of more ancient rocks, even where these boundaries are represented by faults. No doubt the Triassic deposits formerly overlapped their present boundaries to a considerable extent; but there is a limit to this where they abut against high ground, for there is every reason to believe that the pre-Triassic rocks preserve in many respects their pre-Triassic orography.

My study of the origin of mountain-ranges has convinced me of the permanence of the more pronounced orographic features of a country, or what may be called lateral-pressure upheavals, which, while modified by faulting and denudation, can only after a lengthened period be finally destroyed by these combined agencies. From these considerations it is highly probable that the Triassic rocks which remain represent the deeper part of the basins in which they were laid down, and that they never encroached extensively on the Pennine Chain or the high land of North or South Wales.

In the case of more extensive and widespread deposits it is the thickest parts that, being upheaved into mountain ranges, have been most quickly destroyed by denudation. The Triassic rocks have not been affected in this manner, and therefore retain in a certain degree the basin-like form in which they were deposited.

One of the most remarkable features of the Triassic Sandstones is, speaking broadly, the persistency with which their lithological characters hold out over extensive areas, and their apparent independence of the bed-rock on which they lie, or that of the hills bounding the valleys containing them. Very few pebbles of the surrounding rocks are found in the Pebble-beds of the North-west of England, and it is mostly in the Midland Counties where any considerable proportion of local rocks occur in the conglomerate beds. On the other hand, the Permian beds underlying them are often largely made up of local rocks; instance the limestone breccia of Alberbury, composed almost wholly of fragments of Carboniferous Limestone, or the somewhat similar "Brockram" of the Vale of Eden.

Could we with any certainty localize the origin of the materials of the sandstones, a considerable step would be made towards unravelling this knotty problem; but even as regards the contained quartzite pebbles, one set of observers contend that they came from the north, another from the south, while a third considers that they have been derived from the destruction of rocks in Mid England.[1]

It would certainly seem, whatever be the direction from which

[1] See Bonney, Address to the Geological Section of British Association, 1886, and Geol. Mag. 1883, p. 199; 1888, p. 55.—Harrison, Proc. Birmingham Phil. Soc. 1882, vol. iii. p. 157.—Hull, Geol. Mag. 1883, p. 285.

the pebbles have travelled, that they are the product of other areas, and this will hold good, whether they resulted from the direct destruction of quartzite rock, or are of secondary derivation from a pre-existing conglomerate.

In framing a theory of the origin of the Bunter Sandstone, it appears to me that we cannot altogether detach it from a consideration of the underlying Permian.

Before these Permian deposits were laid down, and during the time of accumulation, extreme denudation of the Carboniferous rocks took place, and much of the material was derived from them; but on the incoming of the Trias, the materials became of a more uniform character, and were to a large extent of distant origin. It is not, however, improbable—nay, it is extremely likely—that the drainage or leaching of the Carboniferous rocks may have supplied the peroxide of iron with which the grains are coated, and which gives the sandstones their distinctive colour. We know also, for the records are unmistakable, that an enormous mass of Carboniferous sandstones and grits have been stripped from the Pennine Chain by denudation, and it is not unreasonable to ask what became of the resultant sand during Triassic times. The same may be said of the Old Red Sandstones of Herefordshire and the Quantocks. It would indeed seem incredible if these important formations did not yield their quota of sand to the Trias, though the absence of Carboniferous sandstone boulders in the Trias is remarkable. May they not have been ground to sand by currents which we know were capable of rounding the hard quartzite pebbles? It appears to me that neither the distribution, the uniform character, nor the great thickness of the Bunter Sandstone, accords with the subaerial river-delta theory.

No instance that I am aware of has been recorded of the finding in Triassic Sandstones of anything like a river-channel. It is difficult to conceive of a river unless fed from some very peculiarly constructed rocky area bringing down nothing but sand. The Nile does not do it; on the contrary, it covers the desert sands with fine mud. On the other hand, the subaerial building up of sandstones, proved by the boring at Bootle to be over 1200 feet thick, does not seem to be, considering what has been preserved of the orographic features of the time, a very plausible supposition.

While considering with many other geologists that the lacustrine theory of the origin of the Bunter Sandstones may be dismissed as altogether inadequate to account for the great prevalence of current bedding, the presence of well-rounded quartzite and other pebbles, and the absence of marl except in occasional thin beds, the substituted riverine theory seems to me to fail for the reasons already given. So far I have indulged principally in destructive criticism, proverbially the easiest sort of work, but not on that account less necessary in an attempt to arrive at truth. I have, however, elsewhere already indicated an alternative theory,[1] which I submit in more detail for the consideration of my brother geologists.

[1] Physiography of the Triassic Period, "Naturalist," pp. 108–111, April, 1889.

If, as I have reason to believe, the Triassic deposits of the North-west of England as they now exist fill up the sites of pre-Triassic basins and valleys, the absence of underlying Permian rocks over a large area surrounding Liverpool is a remarkable fact. The Bunter Sandstone was proved to be at least 1200 feet thick in the Bootle boring, and the additional 200 feet of sandstones and marls below that depth did not present any decided Permian characteristics. They became gradually more calcareous and of a deeper purple colour.

It is on the margin of the Triassic deposits that the undoubted Permians occur, and these facts would seem to point towards an unconformity between the Trias and the Permian. If this be a legitimate deduction, the Permian rocks must have been largely removed by denudation from these valleys before the Trias was laid down.

Whence then came the physical change which turned the valleys into areas of deposit? If they were filled up in the way the sub-aerial delta theory requires, we shall have to postulate the existence of very high land, probably of a granitic nature, for a river could not pile up a homogeneous delta of sand and pebbles from 1200 to 2000 feet thick without having a considerable gradient. If then such a plateau or Alpine range then existed, what has become of it? Why should it have been destroyed, when a lesser orographic feature like the Pennine Chain remains?

If, however, we look upon the areas in Lancashire and Cheshire occupied by the Triassic rocks as *subsided valleys* forming arms of the sea in Triassic times, and we can show with a reasonable degree of probability that sandstones having the characteristics of the Bunter could be laid down under such conditions, we shall have advanced a considerable step towards a solution of the problem.

I have shown that tidal action affects the bottom of the sea to the profoundest depths,[1] and is especially effective in embayments and straits. The Trias of Cheshire and partly that of Lancashire lies in an embayment between the Carboniferous mountains of Wales and the Carboniferous hills of Lancashire and Cheshire, and this is connected with the Birmingham Triassic Basin and the strait-like neck of Trias at Bridgenorth.

Indeed, if a subsidence of England and Wales were to take place now to the extent of 400 feet, most of the Triassic deposits would be submerged, and the embayment, though more extensive, would apparently follow or be concentric with the Triassic boundaries. This has long appeared to me a remarkable fact, and a strong testimony of the permanence of certain orographic features of the earth's surface. In this connection we must not lose sight of the possibility of a great extension of the Triassic Sandstones existing under the bed of the Irish Sea. Of this there is the strongest probability from the known existence of bordering deposits of Trias on the coasts of England, Scotland, and Ireland, sending offshoots up the valleys in the way already described.

[1] Tidal Action as a Geological Cause, Proceed. of L'pool. Geol. Soc. 1873–4; Tidal Action as an Agent of Geological Change, Phil. Mag. May, 1888.

But where have the bulk of the materials travelled from? If we look to the geological structure of the lands to the north, there do not appear to exist rocks in sufficient quantity of a nature to supply the great mass of quartzose sand constituting so large a bulk of the Trias. The English Channel, judging from the islands dotted about it and the peninsula of Cornwall, appears to be a granitic and gneissic area, and it is possible that much of the Triassic Sands may have travelled from this locality. To bring this material through subaerial denudation within the distributing grasp of the tides a regional elevation of a thousand feet would be largely effective. It would become a land area supplying quartz-grains to build up the sandstones and decomposed felspar as a contribution to the marls.

From the indestructibility of the quartz-grains they would last longer and travel farther than the other mineral constituents of the rock. Concurrently with this elevation the land occupied now by the Triassic deposits must have been relatively depressed, giving entrance to the sea in the way already sketched out.

It may possibly be urged in objection to this view that there is no connection between the Lower Trias of the South-west of England and that of the Midlands. We know, however, that there is as regards the Upper Trias along the Severn Valley, and it is quite likely that to the east of this line the Lower Trias may underlie the Lias[1] and Oolites. The lie or disposition of the overlying formations favours this idea, and there are no borings to disprove it. Any one who has practically attempted to prove continuity by borings over even a limited area knows how uncertain the method is.

It is also not impossible that the anticlinal ridge—not necessarily an impassable barrier of Palæozoic rocks—connecting the Mendips in Somersetshire with the Belgian Coal-fields, so sagaciously pointed out by the late Mr. Godwin-Austen, may have yielded contributions to the Trias, for the existence of Old Red Sandstone in this ridge under London has been proved.

May not some of the quartzite pebbles have had their origin here also? for, as already stated, they diminish in size and number as we go northwards. Even at Market Drayton in Shropshire the pebbles in the conglomerate are more numerous and larger than in Cheshire or Lancashire. Pebbles of quartzite containing fossils similar to those of Budleigh Salterton are reported by Mr. Jerome Harrison and others as occurring in the Trias of the Midlands and in the drift derived therefrom. The boulders and pebbles of Budleigh Salterton also appear to be larger on the average than those of the Midlands, which facts seem to point to a common derivation and a longer travel of those of the Midlands.[2]

[1] See records of some remarkable borings in Woodward's "Geology of England and Wales," second edition, facing p. 612, also the accompanying Geological Map of England and Wales.

[2] See Quartzite Pebbles of the Drift and Triassic Strata of England, Proc. of Birmingham Phil. Society, vol. iii. p. 157 (1882); On the Triassic Rocks of Somerset and Devon, W. A. E. Ussher, Q.J.G.S. vol. xxxii. p. 367 (1876); Notes on the Classification of the Triassic Beds of the South-West of England, H. B. Woodward Geol. Survey Memoir on E. Somerset and Bristol Coalfields; Red Rock Series of the Devon Coast, Rev. A. Irving, Q.J.G.S. 1888, p. 149.

Then again, as before stated, although Carboniferous Sandstone boulders are scarce in the Trias of the North-west of England, we cannot reasonably ignore the fact that massive sandstones and grits exist in the Pennine Chain, which have been subjected to vast denudation. Considering that the strong current bedding indicative of turbulent water action is one of the characteristics of the Triassic Sandstones, and one of its difficulties, may we not reasonably assume that Sandstone boulders would soon get ground to sand? There is very little of the marginal boundary of the Trias left in the North-west of England, and it is in this fringe that Sandstone boulders would most likely occur. Marginal deposits of local rocks seem to have been preserved in Somerset and Devon.[1]

Given these materials, tidal action, as I have proved in the papers referred to, is quite capable of selecting, distributing, and accumulating them in the form in which they appear in the Triassic deposits.

On this theory we are not limited to depth, *as the tidal wave produces currents acting through the full depth of the water from the surface to the bottom,* and current-bedded sandstone might be laid down by this agent at a depth of many hundred feet and over very extensive areas.

These ideas relating to the physiography of the Triassic period have been placed before the Geological Section of the British Association simply as suggestions for their consideration. The subject is beset with difficulties, but in solving such a problem all possible agencies must be tried and discussed.

A new hypothesis also has this merit, that it guides men's thoughts into fresh channels, and it is only by observations renewed again and again on various theoretical lines that the truth can be at last reached. There is, doubtless, one objection that will be urged against the theory here set forth, namely, that it does not account for the entire absence of fossils in the Bunter Sandstone, while the subaerial river-delta theory does.

This, doubtless, is one of the many difficulties of the question; but on the other hand if marine fossils had been found, the difficulty of interpretation would not have existed, nor would it had the sandstone contained fresh-water remains. This argument, although possessing considerable force, is only one of negative evidence proverbially unsafe. Also, if we admit marine action, it does not exclude that of the winds. Æolian deposits would be certain to be extensively developed on the margin of such sand-laden waters, and thus sandstones, which do not contain pebbles, have much rounded grains and are irregularly current-bedded may be due to wind-action.

As regards the Keuper Marls, the dessicated lake theory fits in well with their characteristics, and it may be that the Keuper Sandstones show the gradual passage from marine to fresh-water conditions. The upper beds of the Keuper Sandstones show well-developed ripple-marks which are not common, but are not absolutely absent in the Bunter. The replacement of massive by thin sandstone beds, and the intercalation of shales, together with the

[1] See papers already quoted.

presence of pseudomorphs of chloride of sodium, show that a new condition of things set in with the Keuper. In conclusion, I may point out while on negative evidence that the absence of saline deposits in the Bunter is on the other hand against the subaerial river-delta hypothesis, as the sandy deposits to which they are compared often eventually absorb the rivers which create them; and this applies to the North of Africa as well as to the Asiatic example.

NOTICES OF MEMOIRS.

The Geology of Devon, Facts and Inferences, from the Presidential Address to the Devonshire Association. By W. H. Hudleston, Esq., F.R.S., Sec.G.S., etc. August, 1889.

Part II.

(*Concluded from November Number*, p. 514.)

Tavistock Country.

THE geological phenomena in the neighbourhood of Tavistock are of such interest that I cannot do better than close this address with a brief allusion to some of the features of the west side of Dartmoor, and the adjacent country.

It is a region which has always presented peculiar difficulties, but the new line of railway in course of construction may help to clear matters up. The subject can be grouped under four headings: (1) The structure of the country; (2) the nature of the basic igneous rocks, or "greenstones"; (3) Dartmoor; (4) the metalliferous deposits.

(1) *The structure of the country* on the west side of Dartmoor differs considerably from that on the east side, more especially in the fact that the Devonian beds are represented as dipping towards the sea instead of away from it; at least this is the case for several miles immediately north of Plymouth. Further towards the north, in the direction of Tavistock and beyond, there would seem to be a complexity of structure unusual even for Devonshire. Consequently the boundary between the Devonian and Carboniferous, as laid down in the Survey Map, may be subject to considerable revision. Mr. Worth astonished us lately at the Geological Society by the statement that the town of Tavistock is actually on the Carboniferous, and yet that, owing to a complex series of foldings, the Devonian rocks are brought up on both sides. I know of no spot in the United Kingdom where the geological boundary-lines seem to be so much under discussion at the present moment.

Although Mr. H. B. Woodward, in the map attached to the "Geology of England and Wales," follows De la Beche in assigning the Brent Tor district to the Carboniferous, it has long been claimed as Devonian by some geologists. These views are perhaps the result of Mr. Rutley's interesting work on the schistose volcanic rocks west of Dartmoor, described as consisting of alternations of lava-flows, tuffs, and tufaceous sediments. That this class of rock, locally known in its vesicular form as "honeycomb dunstone," was of a volcanic nature, had long ago been recognized by De la Beche; but it was the late Mr. John Arthur Phillips who first clearly demonstrated, in his classical papers on the Cornish "greenstones," that many of these beds were actually lava-flows. Mr. Rutley went a step further, and considered that he had found in Brent Tor a fragment of one of the old volcanic necks. His famous diagram, with its column of ashes flattened by the wind, described by himself as as "a chimæra which may embody a certain amount of truth," is familiar to all geologists. Nay so graphic was the picture, and so convincing the arguments, that a certain Mr. Thorpe fancied that he had corroborative evidence of the prevalence of the south-west wind in Devonian times, because, forsooth, he had found lapilli from Brent Tor in the joints of a limestone at Newton Abbot.

Let us express a hope that before the Association next meets at Tavistock the boundaries between the Devonian and Carboniferous may have been made as clear as noonday, and accurately laid down on a six-inch map, which shall itself be a model of chartography.

(2) We must now take into consideration the *nature of the basic igneous rocks,* commencing with those which are interbedded, most of which are now said to be of Devonian age. Before doing so it will be necessary to say a few words about the "killas," a very loose term better understood by miners than geologists. Judging from Mr. Worth's remarks on the stratigraphical relations of the Devonian rocks of South Devon, most of the "killas" of this district belongs to the grey and drab slates intersected by lodes and elvans, which was described by Conybeare as the metalliferous series: above this comes a group more variable in its nature, which is especially characterized by interbedded volcanic rocks, and Mr. Worth suggests that the Brent Tor series may belong to this group: above these again are the purple and green slates immediately underlying the Plymouth limestone. The main point to notice is, that the whole of this slaty series is regarded as below the Plymouth limestone. Consequently it must belong to the lower part of the Middle Devonian, and possibly to even lower beds. Mr. Rutley, if I recollect rightly, regarded the Brent Tor series as possibly in the Upper Devonian.

The interbedded basic igneous rocks, then, are placed by Mr. Worth a long way below the Plymouth limestone; whereas the late Mr. Champernowne, in an interesting posthumous communication to the Geological Society, was disposed to regard his Ashprington volcanic series as above the main limestone of that district. In reference to this difference of opinion two points seem to present themselves for consideration. Firstly, that the schalsteins need not be confined to any particular horizon in so thick a series as the Middle Devonian; secondly, that the phenomena of extravasation, whether interbedded or transgressive, is limited, with very unimportant exceptions, to the southern portion of the county, from whence the line of igneous products may be traced into Cornwall. Hence the area of erupted rock is local, and to a certain extent linear, and is probably not absolutely confined to any particular geological horizon.

The interbedded basic igneous rocks have been described by numerous authors, and their general petrographic features are fairly well known. In Northern Cornwall, according to Mr. J. A. Phillips, these ancient lavas are called "dunstones." Specimens analyzed by him were found to contain 42 per cent. of silica, over 20 per cent. of alumina, and the alkali is almost entirely soda: the amount of lime is nearly twice that of magnesia, and there is over 12 per cent. of protoxide of iron. From a chemical point of view these rocks, then, are allied to the basalts.

The intrusive "greenstones" are classed by Mr. Worth under three heads. They are sporadically developed, but seem to be most numerous and of the largest size in the vicinity of Dartmoor: they are believed to be older than the Dartmoor granite, which is said to alter them. If the Survey mapping is correct, the so-called gabbros between Marytavy and Wapsworthy occur in Carboniferous rocks, and must of course be younger than the beds into which they are intruded. These gabbros, Mr. Worth considers, are the vestiges of a widespread pre-Dartmoor igneous activity, producing basic rocks. He points out that their relations to the granite, both here and in Cornwall, are too persistent to be accidental, and he suggests that they may represent the basic forerunners of the more acidic granites. The age of the rocks into which the Marytavy "gabbros" have been injected still remains to be settled, but the notion that either they or the granites have brought up the lowest stratified rocks is not borne out by experience in other parts of the area round Dartmoor.

(3) Having now cleared the way a little by a brief glance at the containing rocks, we are in a position to attempt the study of *Dartmoor* itself, that supreme monument of the old eruptive forces. Dartmoor, as every one knows, is contained partly in Devonian and partly in Carboniferous rocks, and from the position of the *Posidonomya*-beds it is probable that the lower part of the Carboniferous adjoins the granite. Mr. Ussher, speaking of the beds on the northern and eastern flanks of Dartmoor, observes that the Culm-rocks dip off the granite above Belstone in a marked manner. He also says that the Culm-rocks on the north are roughly parallel in their strike to the margin of the granite, whilst on the east and west their strike is cut off, so to speak, by the granite or else deflected. These considerations are of importance as showing how the granite lies in its case.

From what has already been said, it is perfectly clear that this granite is in nowise connected with anything of the nature of an anticlinal axis bringing up older rocks. In fact on the east side, where it abruptly terminates, its relations to the adjacent country are almost those of a synclinal. On the Tavistock side its relations with the adjacent country are more obscure, owing to the stratigraphy of the district being as yet undetermined. Moreover, there is probably underground connection on this side, through Hingston Down, with the granite boss of Brown Willy.

The above considerations tend to show that the relations of the granite to the surrounding rocks are somewhat peculiar, and that it is not exactly easy to frame a theory to satisfy all the conditions. The composition, which is that of a normal potash granite, and the contact phenomena, are clearly against the notion of any large absorption of the containing rocks, such as are now accessible to observation. There has been much nonsense talked about granites being the result of the extreme metamorphism of the beds in which they occur. Mr. J. A. Phillips in his paper "On the Rocks of Cornwall in relation to Metalliferous Deposits"[1] showed very clearly that, although the different kind of killas vary materially in composition, under no circumstances could the mere re-arrangement of the constituents result in the production of granite.

He gives a table with the chemical compositions of ten varieties of Cornish killas, showing a range in silica from 33 to 68 per cent. and of alumina from 10 to 24 per cent. The alkali is mainly soda, and of this there is a considerable amount in some specimens, pointing to the conclusion that killas has been largely derived from the dissemination of very fine volcanic matter of a basic composition. This coincides with the prevalence of contemporaneous volcanic phenomena. It is worth noting that the roofing-slate of Delabole affords an exception to this rule, in containing more potash than soda.

As there is no reason to suppose that the early chemical history of the Dartmoor granite differs materially from that of the Cornish granites, their sources must have been deep-seated, and they must have originated under the ordinary conditions which produce the granitic magma, whatever those may be. The main questions remaining to be considered are the period and circumstances under which the Dartmoor granite assumed its present position.

There is no evidence at present, as far as I know, which would enable us to fix the period any nearer than the somewhat vague date "the close of the Carboniferous." Dr. Barrois says that many of the Brittany granites are of Carboniferous age. But in the case of Dartmoor it is probable that the great foldings of the Hercynian mountain-system had been mainly effected, and the synclinal of Devonshire formed, before the granite was insinuated. In position the mass of Dartmoor is outside the axis of the Cornish granite; if their alignment was followed the centre of Dartmoor would be about Hatherleigh. Hence the stratigraphical position differs somewhat from that of the Cornish granites, although possibly their age may be quite the same. It is enough to know that an immense physical revolution was effected all over the British Isles between the close of the Carboniferous and the beginning of the Permian, and the intrusion of the Devon-Cornwall granites must have taken place either then or in early "red rock" times.

Next, as to the circumstances under which the Dartmoor granite found its way into its present position. Last year Mr. Ussher treated

[1] Quart. Journ. Geol. Soc. vol. xxxi. p. 319.

this great question with characteristic ingenuity, and showed pretty conclusively that neither the punching theory nor the absorption theory would meet the facts of the case. De la Beche gave us a valuable hint, as indeed he was in the habit of doing, when he inferred that, owing to the volcanic activities which had prevailed in the area during the deposition of the Palæozoic series, a line of least resistance to a body of granite, impelled upwards, might have been formed. In this way the granite of the great bosses may have been forced through ground already weakened as the site of old volcanic vents—such as Brent Tor, we might add.

Of course, it must be remembered that the contacts we now see only represent a certain stage in the relations between the granite and its case. A million years ago, when the country was much higher relatively, the contacts may have presented a somewhat different phase, whilst it is certain that those who are able to inspect the contacts after another million years of atmospheric denudation, will at least get much nearer to the roots of the matter. As far as I am able to judge from Mr. Ussher's descriptions, there are indications of a considerable lateral thrust on the north and on the south side of the mass, parallel to the mean strike of the enclosing beds. This looks very much as if the main displacements which took place were lateral, the beds yielding to the pressure gradually, and thus helping to intensify the flexing of the district.

How far the evidence is in favour of Mr. Ussher's suggestion that Dartmoor is a laccolite, insinuated at the junction of Devonian and Carboniferous rocks, I am unable to say. This seems a somewhat ignominious termination to a career which patriotic Devonians have regarded as nothing less than the plutonic supply-pipe of a regular volcanic cone, more lofty than that of Etna. Possibly the two theories may be reconciled by regarding the supposed laccolite as a kind of reservoir, or local thickening in the pipe.

It was Professor Bonney who first set the Devonshire geologists on the look-out for the vestiges of the great Devonshire volcano. Not a mere Brent Tor this time, erupting its lavas into the Devonian Sea, but one of a line of lofty peaks of far later date. "Among the many excellent geologists and enthusiastic students of the West of England," said he, "is there no one who will undertake to replace the covering which has been stripped from the granitic bosses?" He also indicated that a thorough study of the "red rocks" of Devonshire would yield important results in this direction.

Mr. Worth is amongst those who have responded to this challenge, a circumstance to which allusion has already been made in dealing with the New Red question. It is somewhat singular that if there really was a volcanic cone covering the Dartmoor pipe, the traces of it should have to be sought at the eleventh hour in the "red rock" breccias. These ought to be full of unmistakeable fragments of old acidic lavas, and of the felsites which are structurally intermediate between such lavas and granite. Possibly the want of adequate petrographic knowledge may have hitherto retarded the discovery, and we naturally await the result of further investigations.

But Mr. Worth himself has supplied evidence which goes far to explain the presence of remnants of felsitic, and even of volcanic rocks, in accumulations more recent than the "red rock" breccias. Such remnants are much more likely to have been derived from the elvans, which form so characteristic a feature in the country between the Dartmoor and Brown Willy granites, and some of which probably reached the surface in a more glassy condition than the portions now accessible to operations. Besides, even the existing dykes are represented in some cases as developing a semi-vitreous ground-mass with porphyritically imbedded crystals.

Theoretically it is extremely probable that the granite bosses of Devon and Cornwall may have passed upwards into volcanic rocks, and that consequently they represent a line of eruptive vents which were possibly active in Permian times, or those immediately preceding. But the petrological evidence alone is not conclusive. If we suppose that the "red rock" breccias are of Triassic and not of Permian age, all, or nearly all, traces of the volcanoes might have been removed before the breccias were accumulated. Clearly the granite, with its characteristic crystals of orthoclase, had been laid bare when the beds containing Murchisonite were deposited.

As regards the composition of the Dartmoor granite, the accessory minerals such as schorl, and the proneness of portions to kaolinization, are especially noteworthy. This latter feature has a tendency to produce unequal weathering, and it is not at all improbable that the Tors are in a great measure due to the unequal weathering brought about by this cause. They represent portions which, in the hour of trial, were harder and perhaps chemically more stable, and consequently less liable to disintegration. The forms of the Tors, as was pointed out by Prof. Rupert Jones and more recently by Mr. Ussher, have been largely determined by the arrangement of divisional planes, the mass being intersected by what the latter calls impersistent cracks, running more or less horizontally and crossed vertically or obliquely by joints. Variation in the direction of these joints is accountable for much of the variety in the Tors themselves.

(4.) *The Metalliferous Deposits.*—The abundance of schorl, especially on the edges of the granite, and the kaolinization of the felspars, are indirectly connected with the last subject which it is proposed to bring to your notice; viz. the origin of the metalliferous deposits for which this region is so famous.

It is, I believe, admitted that the great east-and-west fissures through which the elvanite has been injected were formed after the consolidation of the main mass of the granite, though their chemical composition points to their having been derived from the same magma as the granite. The next step in this curious underground history appears to have been the formation of a series of empty fissures, most of them having a more or less east-and-west orientation. And now commenced a fresh set of phenomena which, in an extremely modified sense, may be said to be still in operation.

The fissuring of this region was probably due to reaction after the strain consequent on the system of folding, to which allusion has been so often made. When first this fissuring, or gaping of the rocks, occurred, there was a supply of molten silicates from below more than sufficient to fill up the void. But, as often happens in volcanic regions of modern date, the last stage of primary activity is represented by fissuring without injection of molten matter. A number of open cracks are thus formed, which favour the circulation of underground waters, often intensely heated, and not seldom passing off as condensed steam where they happen to reach the surface.

In Devonshire and Cornwall, the period when this phase was at its height occurred most likely in late Permian and early Triassic times.[1] But, as every one knows, there have been many periods of shifting amongst the rocks; and doubtless the country must have participated in the great Tertiary earth-creep which folded the Downs and the Isle of Wight, about the same time that the Alps were being raised into a mountain-chain. Each successive movement would be apt to produce modifications in the underground circulation, cramping it here and stimulating it there; and doubtless, as the temperature decreased, the solvent powers of the waters would diminish also.

To such underground circulation in old volcanic districts like this, most of the phenomena in connection with metalliferous veins are due, though it must always be remembered that here we see a plutonic phase of what were volcanic activities at higher levels in earlier times. Fifty years ago De la Beche and the first Surveyors evinced an intense interest in this subject, and in the Memoir already referred to many hypotheses of origin are discussed. Since those days the world has been revolutionized in more ways than one, and in no way more than in the transfer of mining enterprise. But the experiences of the last five-and-twenty years in the Tertiary volcanic districts of North America have not been lost upon the numerous able men who have been employed as engineers or surveyors in those highly metalliferous regions. The late John Arthur Phillips left a record of his great knowledge and experience in his excellent treatise on *Ore Deposits.* And I have no doubt that many here are more or less acquainted with the important works of the French *savant* Daubrée, whose "*Etudes synthétiques de Géologie expérimentale,*" and "*Les eaux souterraines aux époques anciennes,*" furnish us with an immense amount of information on the origin of metalliferous veins.

Briefly, it may be said that the underground circulation theory is the one most generally adopted, the chief difference of opinion being as to the relative importance to be assigned to *lateral secretion* and to *ascension* respectively; or, stated in simpler terms, whether

[1] Since the publication of portions of the address in the local papers, Mr. Thomas Collins, of Redruth, has written to say, "he considers there is evidence in the Tavistock district that the metalliferous deposits containing copper-ores had been formed in the Devonian rocks before the deposition of the main mass of the Carboniferous. The large copper-lodes of Mary Tavy, for instance, are in Devonian rocks, and cease altogether on coming into contact with the black schists of the Carboniferous." It is suggested that this may be due to faulting at the junction.

the vein-material comes from the sides or from below. It is reasonable to suppose that both sources may have contributed to the supply, though in certain cases a change in the deposits, accompanying a change in the country rocks, would seem rather to favour the notion of lateral secretion. Thus Mr. Phillips remarks, with regard to the Tavistock district, that the copper-ores are often associated with a blue clay-slate. If the slate becomes deeper in colour, iron-pyrites alone occurs; and if the rock becomes quartzose, even the pyrites disappear.

Whilst endeavouring to trace the source of the ores in metalliferous lodes we should bear in mind the experiments of Sandberger, who found that the heavy metals occur in the silicates of the crystalline rocks of every age. Augite and the magnesia-micas are especially rich, and the lithia-micas are noted as being stanniferous. The origin of tin-ores is probably different to that of the sulphuretted ores, though both are often best developed at the junction of igneous and sedimentary masses. This, of course, is partly accounted for by greater facilities for fissuring, and still more by an increase of heat, which is likely to promote the underground circulation, and above all to increase the solvent power of underground water.

The question of solution has always been a difficult one, and has inclined some people to adopt the notion of sublimation of the metallic sulphides. As an alternative theory we have had the reduction of sulphates by organic agency. But people are beginning to think that both these agencies may be dispensed with, and that, under peculiar conditions of heat, pressure, and dissolved gases and salts, the solvent powers of water may be largely increased. Anyhow, it is perfectly certain that metallic sulphides, such as cinnabar and pyrites, are being deposited from hot springs along with various forms of silica, both in California, and at Steamboat Springs in the State of Nevada. We may well believe that this latter place, of which an account was given in the Quarterly Journal of the Geological Society as long ago as 1864, represents with a certain amount of fidelity the conditions which prevailed in the upper portions of the metalliferous lodes of Devon and Cornwall during a period, not of maximum activity, but when a considerable deposit was taking place.

The solution and transport of tin-ores are capable of a different explanation. As is well known stanniferous deposits are not only very local, but are also accompanied by a peculiar group of minerals, such as topaz, schorl, axinite, and fluor, which contain a notable quantity of either Fluorine or Boron, and in the case of schorl of both these elements. Daubrée observed that this is the case wherever tin-ore has been found, and he suggested that, in the first instance, tin was brought up from what he calls the general reservoir of the heavy metals as a fluoride. The interesting chemical experiments connected with this ingenious hypothesis are detailed in his great work on Experimental Geology. According to these views stannic-fluoride and steam would decompose each other at a moderately high temperature, the result being a deposit of binoxide of tin or cassiterite. The liberated hydrofluoric acid, besides helping to form such minerals as schorl and other fluo-silicates and fluorides, would enter into the general circulation of the rocks, and thus tend to facilitate that kaolinization of the felspars which has produced so much china-clay on the south-west side of Dartmoor, and in the mass of the Hensbarrow granite.

It is also worth noting in this connection that, according to Dr. Le Neve Foster, the great flat lode of Carn Brea, near Redruth, is in the main a band of altered rock, and he is inclined to suspect that half the tin-ore in Cornwall is obtained from tabular masses of altered granite. In such cases there is no regular lode, but very fine cracks in the rock have evidently given access to stanniferous solutions, which have deposited oxide of tin more or less abundantly in the vicinity of such cracks, and materially changed the nature of the original granite.

The phenomena in connection with these impregnations of tin-ore appear to favour Daubrée's views; but such points are to be commended to the notice of local geologists, who alone can test their suitability to explain the facts which come before them. I would merely remark that too much stress should not be laid on such cases as those of deer's antlers having been found partly replaced by cassiterite in the old river-gravels. This has been effected at ordinary temperatures, most probably by the aid of alkaline carbonates arising from the atmospheric decomposition of felspars, and proves that the most insoluble minerals may be successfully attacked by agencies now or lately in operation, and their metallic element moved from point to point, but only in very small quantities.

It is to be feared that chemical questions such as these possess but little interest for the members of the Association, and I apologize for having introduced them, however briefly, before a general audience. But there are certain conclusions which we are able to draw without any special reference to chemistry. In the great metalliferous lodes we see the roots of old mineral springs and geysers, which spouted their water and steam into the air, and perhaps covered the surface of the ground with siliceous sinter. That was a time when the volcanic forces of this remarkable region were on the wane, and after the great outpourings of lava had taken place upon a surface of which every trace, perhaps, has been swept away. How long these hydrothermal agencies continued to be active we cannot tell; but it is by no means improbable that they were in operation throughout a considerable part of Mesozoic time, during which period the spoils of this western land, brought down by the ceaseless forces of denudation, partly found their way into the eastern sea, and thus helped to build up the deposits which were afterwards to be fashioned into the Secondary rocks of England.

REVIEWS.

I.—Chemical and Physical Studies in the Metamorphism of Rocks, based on the Thesis written for the D.Sc. Degree in the University of London, 1888. By the Rev. A. Irving, D.Sc. Lond., Senior Science Master at Wellington College. 8vo. pp. 138. Price 5*s*. [August 16, 1889.]

THE word "Metamorphism" as applied to rocks, in consequence of the various interpretations to which it has been subjected, is no doubt of great service to slippery disputants. By a judicious use of the term some writers can conjure up such a haze as most effectually to elude the pursuit of any critic who rashly endeavours to run them down. Dr. Irving wishes to put an end to this state of things by fixing such limitations to the meaning of the term as would, for instance, prevent people from quoting examples of an early stage of "metamorphism" from such rocks as the Old Red Sandstone Conglomerates of Scotland. In this thesis "metamorphism" is to be used to mean only changes in the internal structure of rock-masses. The author, however, qualifies this by subsequently stating that he is not dealing with the so-called rocks of the systematist, but rather with *principles*. Hence, he is disposed to ignore the restrictions and limitations which may be convenient in classifying rocks; and, as to text-books, they appear to arouse in his breast feelings akin to those of the Knight of La Mancha at the sight of a windmill.

In his general conclusion as to the diagenetic origin of the so-called "Archæan" rocks we are disposed to concur, although it is by no means improbable that many of these rocks may have had a very different and much later origin. But it is by no means certain that the arguments and peculiar nomenclature of the present work will be found, in the sequel, to have strengthened the diagenetic as opposed to the metamorphic theory. No doubt those who can thoroughly understand the book may derive considerable benefit from its perusal. At the same time, the chemical speculations of of this author, as to the earlier stages of rock-genesis, appear by no means equal in quality to those of Sterry Hunt, though this perhaps may be regarded as a matter of fancy, and other readers might arrive at a different conclusion. There is a considerable parade of chemical knowledge brought to bear upon these points.

The plan of the treatise is as follows:—

Paramorphism, or Mineral Change, includes Primary Paramorphism or Rock Genesis, and Secondary Paramorphism resulting from the gradual alteration of the conditions of rock environment. *Metatrophy* includes changes in the physical character of the rock-masses, whilst there is no essential change either in the rock-mass or in its constituents. *Metataxis* is a change of order of the constituents of the rock-mass of which the phenomena of slaty cleavage may be taken as a typical instance. The author then proceeds to deal with what he calls *Hyperpheric* Change, of which the dolomitization of limestones may be taken as an example. There is a section on Contact Metamorphism, which, together with general remarks on Metamorphism, and two Appendices, completes the work.

Dr. Irving is a professed disciple of Credner, and has made free use of his writings, as well as of the German literature of the subject generally, nor has he been forgetful of the writings of English petrographers in the construction of his treatise. In addition to this he combines his own considerable experiences as a geologist in the field and as a chemist in the laboratory. There can be no doubt, therefore, that much interesting and valuable matter is contained in these pages. Moreover, few will disagree with the statement in the preface that the truest teaching is that which stimulates the mind to active thought, not that which saves the student the trouble of seeking by loading the memory with second-hand knowledge. All this is excellent, but when he talks about a tendency to fetter the discussion of scientific questions by a spurious orthodoxy, Dr. Irving is again tilting at a windmill. The two schools which respectively put their trust in diagenesis and epigenesis enjoy the most perfect freedom of discussion at the Geological Society, and that they make ample use of it any one who is in the habit of attending the meetings can testify.

II.—The Geology of London and of Part of the Thames Valley. By William Whitaker, B.A., F.R.S. Vol. I. Descriptive Geology, pp. xii. 556, Folding Table. Price 6*s*. Vol. II. Appendices (Well-sections, etc.), pp. iv. 352. Price 5*s*. Geological Survey Memoir. 8vo. (London, 1889.)

NEVER before has the geology of any tract of country been described in such detail. We say this advisedly, bearing in mind other publications (the result of private or of official enterprise), whose object has been to describe as fully as possible the geology of particular areas. There is good reason why London should yield such ample information, and it is fortunate in having so enthusiastic and so careful an exponent of its geological record.

In the country around London there have been more numerous exposures of the strata than elsewhere, in the foundations for houses, not to mention the excavations for gravel, clay, and chalk, and the railway-cuttings. Moreover, not only has the surface structure been revealed in so many places, but the underground geology has been proved in the numerous wells and borings, several of the latter being very deep, and furnishing information of high geological interest. Hence no other part of the world could have contributed such a mass of geological facts.

To begin at the end of the work, we may mention that the records of well-sections (given in Vol. II.) number nearly 800; and in addition there are notes of numerous trial-holes and many other sections. This volume in itself will be of great practical value to well-sinkers and other engineers; but notwithstanding the mass of information he has so carefully arranged and tabulated, with all authorities indicated, the author still craves for more—asking for further information concerning any of the wells, and for records of any new sections.

Turning now to the first volume, we may note that the whole of Middlesex, and parts of Oxfordshire, Bucks, Herts, Essex, Berks, Surrey and Kent, are included in the country described. It is indeed the tract represented on Sheets 1, 2, and 7 (and northern portions of 6 and 8) of the Geological Survey Map. So far as regards the Chalk and Eocene strata (the description of which occupies about one-half of the volume), the work may be regarded as, in great measure, a new edition of Mr. Whitaker's Memoir on the Geology of the London Basin (Memoirs Geol. Survey, vol. iv.), although some portions of the area described in that Memoir are outside the limits assigned to the work before us.

The parts relating to the Glacial Drifts and newer deposits, filling the second half of the volume, are for the most part new, including as they do the description of the beds in the southern portion of Essex. In short, about two-thirds of the entire work may be considered as new.

A record of facts, valuable enough in questions of practical geology and as material from which scientific conclusions may be drawn, cannot of course furnish matter which even the most enthusiastic student would care to read steadily through. Details, however, are printed in small type, while general remarks on the more important facts, historical reviews, and conclusions are printed in larger type, These latter will be read with advantage and interest. The author indeed has so exhaustively studied the literature of the subject, that the reader, unless he be anxious to learn in more detail the theoretical views of other workers, need scarcely refer to the previous literature, for Mr. Whitaker has acknowledged all sources of information. It need hardly be said that the author takes an eminently practical and common-sense view on debateable subjects, and while his remarks are written in a judicial spirit, they are at the same time cheery and not seldom humorous.

Students of Mr. Whitaker's writings are aware that the author has not manifested much liking for purely theoretical or speculative geology, at any rate he has hitherto abstained more than many men with much less experience from expressing theoretical views. But now we are glad to find the author, in dealing with the River Drift, makes the following remarks (p. 329): "If, however, in the Historical Review of the subject, objection is often taken to the opinions quoted, and my own view is sometimes given in a by no means undecided manner, let it not be put down to the absolute loss of former modesty (and modesty should grow with knowledge); but to the fact that one is bound, in the present case, to state one's own opinion, derived from prolonged study of the beds, and to [avoid] the manifest unfairness of continuing to shelter oneself behind other observers; albeit the shield of Professor Prestwich is used with great advantage." No one has had the experience possessed by Mr. Whitaker in the area he now describes, and all will be glad to welcome the expression of his opinions.

Special interest is usually concentrated on debateable subjects, and although certain differences of opinion are maintained on the classification of some of the Eocene divisions, there is little dispute about the position of the beds; the literature of London geology has increased most largely by the discussion of the Thames Valley deposits and their relation to the Glacial epoch. More recently the subject of underground geology has aroused a great deal of attention, for the deeper borings have proved the presence of rocks not previously suspected to occur beneath the area.

Special interest may therefore be said to be divided between the Underground Geology and the Pleistocene Geology.

The former is becoming more and more a practical subject. Speculations on the behaviour of rocks, especially of Palæozoic rocks beneath thick accumulations of Secondary strata, are necessarily hazardous. Were the whole of the West of England smothered up with Chalk and London Clay (the South Wales Coal-field being exposed), we might know nothing of the Bristol Coal-field, if several deep borings had proved simply Old Red Sandstone in some places and Silurian rocks in others. This up to the present time has been practically the result of deep borings under the London area.

Mr. Whitaker gives a full account of all that has been previously written on the plain of older rocks that lies under London. He is careful to point out that there is no evidence of a ridge beneath the area, though it would seem there may be something of the sort northwards, for the older rocks come nearer the surface at Ware than they do beneath London or Harwich.

On the subject of most commercial importance he concludes (p. 46) "that Coal-Measures are likely to occur somewhere along the line of the Thames Valley, or in neighbouring tracts; and that those Coal-Measures are likely to yield workable coal. It is rash to attempt to foretell the future; but it seems to me that *the day will come when coal will be worked in the South-east of England.*"

The new boring at Streatham has given further particulars of the presence of the Great Oolite Series beneath the London area, and a full account of this important boring is now for the first time published.

By the aid of the many borings, Mr. Whitaker is enabled to discuss the underground range of the Jurassic and Cretaceous rocks, and it is somewhat remarkable to learn that there is no certain record of Lower Greensand in the area, though it must underlie the Gault near Risborough. From the Gault there is a gradual passage through the Upper Greensand to the Chalk; and this is an interesting fact when we remember that chalky conditions commenced in Gault times at Hunstanton.

In the description of the Cretaceous beds, the author acknowledges help from Mr. Jukes-Browne, and some modifications are made in the classification of the zones and rock-beds of the Chalk. Thus the Chalk Rock is assigned an independent position between Middle and Upper Chalk; the zone of *Belemnitella plena* is separated from the Melbourn Rock and put with the Lower Chalk; while the lowest zone of the Lower Chalk is termed the zone of *Ammonites varians.* Without the aid of these rock-beds but little progress could have been made in mapping the several divisions of the Chalk, for fossils in this, as in other formations, are not always to be found when most wanted.

The London Clay has not furnished much material for the believer in definite zones, for the fossils are alike through the formation, although some species are more abundant at certain horizons. Over large areas the London Clay appears to be practically barren of organic remains, indeed Mr. Whitaker mentions that he spent some days in examining new railway-cuttings in the London Clay in Essex, without meeting with any palæontological reward.

In dealing with the Eocene strata, Mr. Whitaker speaks of the practical importance of separating deposits that can be mapped distinctly even if there are no great palæontological distinctions in their fossils. This is quite right if we wish to interpret properly the rocky structure of a country, and show the relations of the strata to the form of the ground. The general remarks on the Lower London Tertiaries, and the full account given of the History and Literature of the subject, are for the most part new. Herein the author criticizes recent observations and views of Mr. Starkie Gardner, Mr. G. F. Harris, and others.

The Drifts that irregularly overlie the Bagshot Beds and older strata have given much trouble in determining their respective ages. But the process of minute correlation, which to some minds appears an essential basis for geological happiness, cannot always be carried out; and would lead to much unprofitable anxiety in the matter of Drifts. There may be no palæontological evidence, lithological characters may be of no avail, and, more serious still, there may be no stratigraphical evidence. Hence we can well understand the reason for a chapter on "Deposits of Doubtful Age." In some instances where outlying patches of gravel occur on London Clay, it is impossible to determine whether or not they are of Pliocene ("pre-Glacial") age, whether they are Glacial gravels newer or older than the Boulder-clay, or whether they may have been derived in comparatively recent times (during the denudation of the country) from any one of these accumulations, or from the pebble-beds of Bagshot age.

The broad general distinction in the gravels seems to be this. The pebble-beds of Eocene age are almost entirely made up of flint. The "pre-Glacial" (and possibly Pliocene) gravels are made up of flint and quartz pebbles. The Glacial gravels contain in addition many pebbles of quartzite, and sometimes derived Jurassic fossils: and they are rudely stratified and sometimes contorted. The River gravels contain all ingredients and are more distinctly stratified. But in Drift deposits there are many exceptions to every rule, and much of the Glacial gravel of Finchley is indistinguishable from the presumably older "Pebbly Gravel" of the Geological Survey.

The Clay-with-flints is also one of the accumulations of Doubtful Age, a residue left during many ages and forming now, by the slow decomposition of Chalk-with-flints by atmospheric actions, leaving the flints and earthy matter, together with clayey and loamy material washed from Tertiary strata.

The author makes many references to the terms Glacial, post-Glacial and pre-Glacial. The two latter terms (as he says) are inadmissible into schemes of classification from their having no definite significance; but they are conveniently used when our knowledge is very limited that is to say, when we find a bed that is older than Boulder-clay, and which cannot be definitely proved to be Pliocene; or when we find a bed that is newer than Boulder-clay, and yet not definitely Recent. As Mr. Whitaker remarks (p. 328), "Beds which are truly post-Glacial in a southern district, may be of the same age as others which are clearly Glacial in a northern one;" and these remarks apply to the Pleistocene Thames Valley Deposits.

We are glad to find that the author supports the view of the fluviatile origin of the Thames Valley gravels and brick-earths. The organic remains indeed clearly support this contention. The difficulties raised have been based on the mode of occurrence of the deposits; but it must be borne in mind that the greater part of the gravel is simply re-deposited Glacial gravel, ready made, and not, perhaps, transported any great distances by the river. In the course of the accumulation of the river-drifts, the river has deepened its channel, leaving terraces in some places at different levels; but there is no marked regularity in these terraces as we trace the course of the Thames Valley deposits from Maidenhead to London.

Following the account of the River Drift, we have a chapter on Alluvium, etc. We should have preferred to divide these subjects into Pleistocene and Recent Alluvial Deposits. It is true that, in the area described, the Alluvium is distinguished from the "River Drifts" by its fineness of texture, but that is a local feature, for in the higher courses of the Thames and its tributaries we find a good deal of Recent gravel; and Alluvium itself seems entitled to be called "River Drift," as much as the brick-earth and gravel of Pleistocene age. Instructive sections are given of the Alluvium shown in making the Tilbury Docks and in other places.

Chapters devoted to Physical Geology and to Economic Geology, etc., complete the first volume, and we may call especial attention to the remarks on Springs, Wells, and Water-supply. It is impossible here to enumerate all the matters of interest discussed in the volume, suffice it to say that no subject seems to have been neglected. The work is illustrated by many sections and some pictorial views, and with figures of flint-implements. Lists of fossils are also given. A small coloured index-map would have been useful, but we ought not to make the slightest complaint when we have such a wealth of information in two volumes, bound in cloth, for a total cost of eleven shillings! That London geology excites a good deal of scientific interest apart from its practical bearings, is shown by the large sale of Mr. Whitaker's Guide to the Geology of London, of which (we understand) a fifth edition has just gone to press, and this is an excellent introduction to the subject treated so fully in the volumes before us.

III.—Cosmic Evolution, being Speculations on the Origin of our Environment. By E. A. Ridsdale, A.R.S.M. 12mo. pp. 130. (London, H. K. Lewis, 1889.)

NOWADAYS we are considerably ahead of the Hebrew cosmogonist in the means for speculating on the origin of our environment; but still there is a large margin of the apparently "unknowable" left for future philosophers to minimize if they can. The recently established doctrine of Evolution favours speculations in this quarter, especially in the minds of those who have received their scientific training since this doctrine has become a faith.

The Geological Evolutionist is fortunate in being confined within certain limits both as regards time and space. But it is far otherwise with the Cosmic Evolutionist, who finds his conceptions rendered hazy by an Eternity which had no beginning and can have no end, and by a Space which is equally without limits. No wonder that in such speculations "the imagination" at times "is forced to overstep the safe boundary of reason" (p. 103). This is candid on the part of our author, whose object evidently is to arrive at the truth, so far as that is attainable by the finite mind of man.

It is not for us to review the "General Aspect" of Cosmic Evolution any further than by confessing our faith in the grand and philosophic conception of La Place as to the physical history of the Solar system. The author's inference also seems a fair one, "that the evolution of present matter from the fire-vapours of the Solar system was analogous to the evolution of the fire-vapours from the universal primordial vapour of all Space."

But we must now leave off playing at "high jinks" in the starry firmament, and stick, as far as we can, to our own planet. The evolution of the primordial forms of matter was doubtless attended with a gradual loss of heat (changed perhaps into planetary motion, since Energy cannot be lost), increase of density and diminution of chemical activity. If this principle is true, there will seem to be an almost unbroken connection between Inorganic and Organic Evolution. Indeed, it might almost be said that "the chemical evolution proceeded till it finally induced an environment wherein favourable forms were matured into Life."

What this chemical evolution is supposed to have been we are told in the first chapter, which may be regarded as a sermon preached upon the text of increase of chemical stability, or, as he puts it, the "survival of the most inert." This process has been going on from the earliest geological ages, so that "things must have been more lively, chemically speaking, in the Archæan period than now!" Moreover, it is probable, he says, that the bodies we call elements are merely arrangements of matter to suit the present environment, and that under different conditions they might be broken up. Change, then, ceaseless change, was the order of things. But the rate was much more rapid in the early stages, whilst, through the gradual survival of the more inert forms, it became slower. It was when this state of physical calm was fairly matured that the forces acting in the evolution of Living Forms were first able to come into play.

The Organic Aspect of Evolution.—The Earth being now fitted for it, a new and original force came into play; one different in its tendencies and unlike in its action to any of the previously-existing forces of Nature. "This force was LIFE. Ever since its first manifestation, while Inorganic Evolution has proceeded contemporaneously with it though in a milder and more subdued form, its power and scope of working has steadily increased."

Palæontology, as at present understood, certainly affords no record of that interesting period in the Earth's history, when the Organic was evolved out of the Inorganic. It is quite in accordance with the author's general views that such an evolution did take place, although he scarcely ventures to say so. He considers, likewise, that this growth of the Organic out of the Inorganic could only take place at one stage in the development of the Earth, and that, if such a thing were possible now, a serious blow would be struck at the doctrine of Evolution generally.

It is most probable that the origin of Life will remain amongst the things unknowable: all that Palæontology can do is to trace the evidence backwards as far as practicable. In this connection some might be disposed to disagree with the author as to the evidence afforded of the alleged approximation of the two branches of life—animal and vegetable. Excluding such doubtful forms as *Eozoon*, which few now regard as having any connection with *organic* structure, the earliest certain forms of Life in the Lower Cambrian exhibit a considerable amount of differentiation, rendering it probable that Life had become a factor in the Earth's history for a considerable period antecedent to this epoch. Hence it is by no means improbable that far more primitive forms existed which may have shown something of the approximation to which the author refers. But where are their remains now? Shall we seek them in the Monian, the Pebidian, or any other of the rival systems, which appear to occupy the ground between the Cambrian and the Archæan?

Although quite disposed to agree with the author in his general contention, there are some other statements of his in connection with Palæontology which seem open to criticism. He says (p. 48) that in early times, when the geological forces were more active, that stock had a tendency to survive whose members varied most. In a certain sense this may be so, but the history of the tetrabranchiate Cephalopoda presents us with an instance in the opposite direction. The steady-going *Nautilus*, though born long before his cousin the ever-changing *Ammonite*, alone survives. In fact, the author himself (p. 51) observes that a family succumbing either to slow alteration of the environment, or to inter-racial competition, always varies violently during the process. Indeed, the most sluggish genera, such as *Lingula*, but little affected, perhaps, by the environment, and still less given to inter-racial competition, have been much the same throughout all epochs. In such a case the "survival of the most inert" is applicable to certain forms of life. But this does not violate the still higher law, "the survival of the fittest"; it only serves to show that, under certain circumstances, even in the Organic world, the most inert may be the fittest to survive.

Whilst admitting that no force or forces, exactly similar to Life, are known in Nature, Mr. Ridsdale observes, that one or two of them are not so "utterly unlike as to render it necessary to postulate a supernatural interference with the course of Nature to account for its occurrence." Certainly, a logical evolutionist need not summon such a *Deus ex machina* as Creation to account for any phenomenon, even the admittedly obscure one of Life. The author thinks it may be possible in the future to bring yet closer the analogies between the Organic and Inorganic worlds, though up to the present time nothing very conclusive has been pointed out. Perhaps the nearest parallel is that force which determines crystalline structure. A similar idea, it will be remembered, was brought forward in a recent address to the Geological Society. W. H. H.

REPORTS AND PROCEEDINGS.

Nov. 6, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "Contributions to our Knowledge of the Dinosaurs of the Wealden and the Sauropterygians of the Purbeck and Oxford Clay." By R. Lydekker, Esq., B.A., F.G.S.

The first section of this paper was devoted to the description of the remains of Iguanodonts from the Wadhurst Clay near Hastings collected by Mr. C. Dawson. They were considered to indicate two species, for which the names *Iguanodon hollingtoniensis* and *I. Fittoni* had been proposed in a preliminary notice.

In the second section an imperfect metatarsus of a species of *Megalosaurus* from the Hastings Wealden was described, and shown to indicate a species quite distinct from the one to which a metatarsus from the Wealden of Cuckfield belonged. Two cervical vertebræ of a Sauropterygian from the Purbeck of the Isle of Portland were next described, and referred to *Cimoliosaurus portlandicus*, Owen, sp.

The concluding section described an imperfect skeleton of a large Pliosaur from the Oxford Clay, in the collection of Mr. A. N. Leeds, which indicated a species intermediate between the typical Kimeridgian forms and the genus *Peloneustes*. These specimens were considered as probably referable to *Pliosaurus ferox*. Evidence was adduced to show that *Pliosaurus Evansi*, Seeley, should be transferred to *Peloneustes*.

2. "Notes on a 'Dumb Fault' or 'Wash-out' found in the Pleasley and Teversall Collieries, Derbyshire." By J. C. B. Hendy, Esq. Communicated by the President.

The "Top Hard" Seam of the district is being worked in these collieries at a depth of 500 yards, where it has an average thickness of five feet, with a band of cannel in the middle. In the working it was found that the coal began to thicken, until it became double the usual size, the cannel also increasing in the "Top Seam," but in the Lower Seam running out altogether.

This double thickness of coal continued till the "Wash-out" was reached, when both coal and shaly roof disappeared, the space being replaced by sandstone similar to that of the beds overlying the shale. The clay floor of the Lower Seam had not been much interfered with, and this was followed for sixty yards, when the doubly thick seam was again met with, and on being followed gradually assumed its normal thickness.

No fossils have been noted in the "Wash-out" itself, the vertical extension of which is unknown.

3. "On some Palæozoic Ostracods from North America, Wales, and Ireland." By Prof. T. Rupert Jones, F.R.S., F.G.S.

The chief materials referred to were:—

1. Some good specimens of North-American Ostracoda from the Lower Helderberg and Cincinnati Groups in the British Museum, and the author's collection; these have given occasion for a critical revision and careful illustration of several forms.

2. In the 'Palæontology of New York,' vol. iii. 1859, several of the Palæozoic Ostracoda of New York State were described but not figured. Copies of some of the original drawings have been courteously supplied, with Dr. James Hall's permission, by Mr. J. M. Clarke, of Albany. They enlarge our knowledge of the Lower Helderberg fauna.

3. A large collection of Palæozoic Ostracoda, collected in the Lake Champlain district and elsewhere, sent by Prof. R. P. Whitfield, of New York, for examination by the author.

4. Other specimens belonging to the Utica Slate Series from Ontario, presented to the author by Dr John Young.

5. An interesting series of Lower Silurian (Ordovician species from near Welshpool, comprising a characteristic Cincinnati species, sent by Mr. J. Bickerton Morgan.

6. A rare Palæozoic Cytheroid Ostracod from Kildare, collected by Mr. Joseph Wright, F.G.S.

The specimens were described as nearly as possible in the order of their natural relationships and thus, besides adding to the known forms, they were shown to illustrate the modifications exhibited by the genera and species of these minute bivalved Crustaceans, both in limited districts and in different regions.

Amongst the forms described were the following new species and variety:—*Primitia mundula*, Jones, var. *cambrica*, nov.; *P. humilior*, sp. nov.; *P. Morgani*, sp. nov.; *P. Ulrichi*, sp. nov.; *P. Whitfieldi*, sp. nov.; *Entomis rhomboidea*, sp. nov.; *Strepula sigmoidalis*, sp. nov.; *Beyrichia Hallii*, sp. nov.; *Isochilina lineata*, sp. nov.; *I.? fabacea*, sp. nov.; *Leperditia Claypolei*, sp. nov.; *Xestoleberis Wrightii*, sp. nov.

The Rev. E. Tenison Woods.—We regret to record the death of this well-known Australian Geologist, which occurred at Sydney, New South Wales, on the 9th October, 1889.

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