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NEW SERIES. DECADE III. VOL. IV.
JANUARY—DECEMBER, 1887.

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NEW SERIES.

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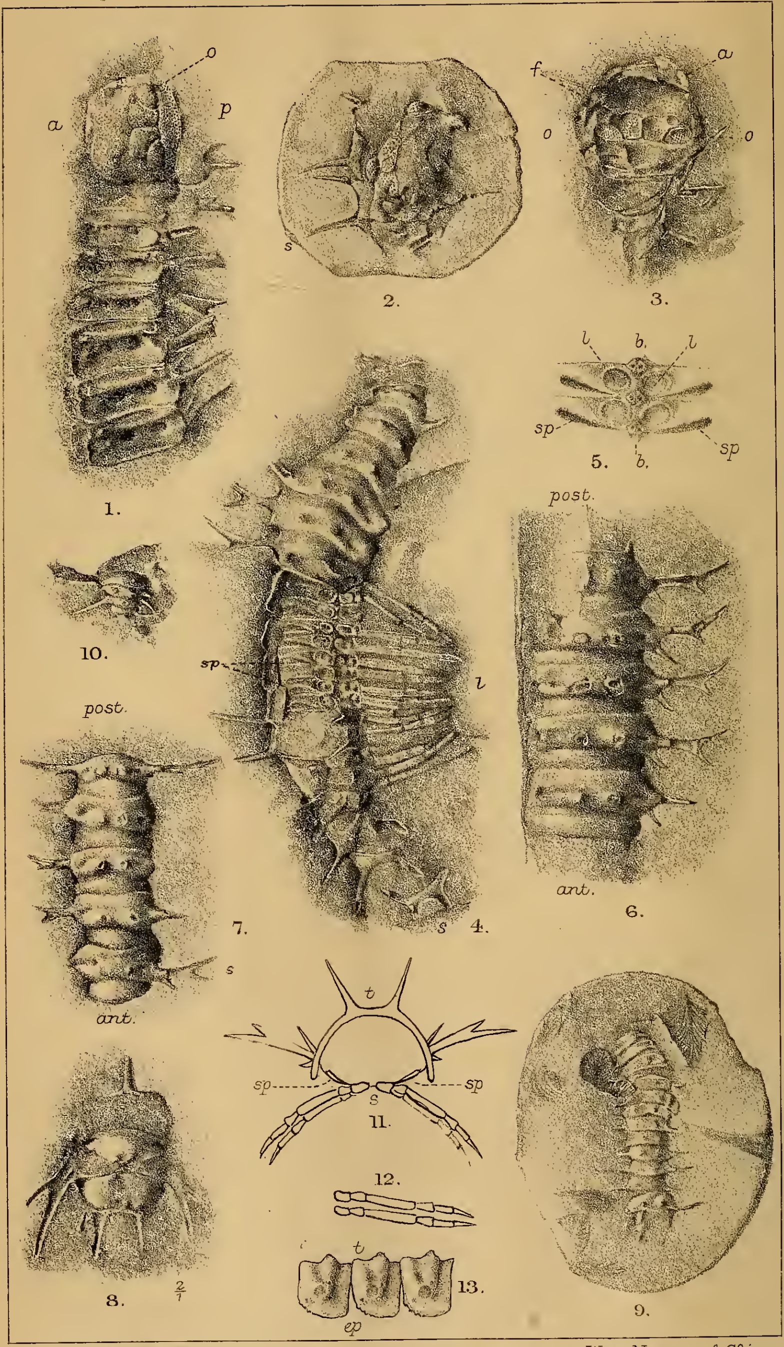
# LIST OF WOODCUTS.

# LIST OF PLATES.



G. M. Woodward del. et lith.
West, Newman & Cº imp.

Carboniferous Myriapods.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. IV.

No. I.—JANUARY, 1887.

## ORIGINAL ARTICLES.

### I.—On some Spined Myriapods from the Carboniferous Series of England.

By Henry Woodward, LL.D., F.R.S., F.G.S.

(PLATE I.)

PALÆONTOLOGISTS are largely indebted to Messrs. Meek and Worthen for their very careful researches in the Coal-Measures of Illinois, which have resulted in such large and valuable accessions to the fauna and flora of the Carboniferous formation. Not the least interesting of these has been the discovery of numerous organisms, which were first recognized and correctly described by them in 1868[1] as the remains of spined Myriapods.

The earliest record of the discovery of one of these curious terrestrial Arthropods in England will be found in "A History of Fossil Insects," etc., by the Rev. P. B. Brodie, M.A., F.G.S., 8vo. 1845, in the "Introductory Observations" to which Prof. J. O. Westwood drew attention to a figure (pl. i. fig. 11) in that work, representing a remarkable fossil preserved in a nodule of clay-ironstone from the Coal-measures, Coalbrook-dale, which he believed to be probably the remains "of some large Caterpillar furnished with rows of tubercles" (pp. xvii, 105, and 115, *op. cit.*). The specimen is preserved in the "Hope Collection," in the University Museum, Oxford (Woodcut Fig. 1).

The next specimen was figured and described by the late Mr. J. W. Salter, F.G.S.,[2] eighteen years later, who named it *Eurypterus* (*Arthropleura*) *ferox*, sp. nov., and referred to it as "one of the most curious *Crustacean* fragments on record," and as "part of the abdomen of a *Eurypterus*" (*op. cit.* p. 87). It was obtained from the clay-ironstone of the Staffordshire Coal-field at Tipton, from the shale over the "Thick-Coal" (Woodcut Fig. 2). Mr. Salter states that "another specimen occurs in the Hope Collection at Oxford."

So far back as 1859,[3] Prof. (now Sir) William Dawson, K.C.M.G., F.R.S., described a Chilognathous Myriapod from the Coal-measures of Nova Scotia, under the name of *Xylobius sigillariæ*.

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[1] Geol. Surv. Illinois, vol. iii. pp. 558—559.

[2] Quart. Journ. Geol. Soc. 1863, vol. xix. p. 86, fig. 8.

[3] Quart. Journ. Geol. Soc. vol. xvi. p. 268.

This form did not, however, appear to have been provided with spines, like those from Illinois, discovered by MM. Meek and Worthen.

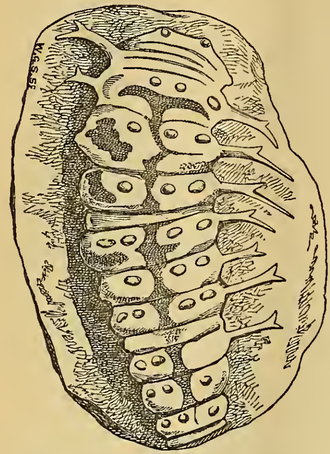

Fig. 1. *Euphoberia ferox*, Salter, sp.
= *Acantherpestes Brodiei*, Scudder.
(Copy of Brodie's original figure.)

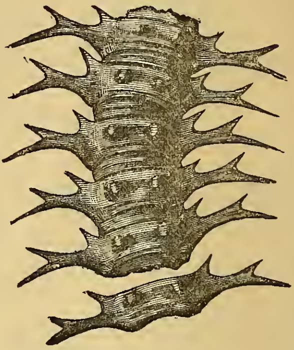

Fig. 2. *Euphoberia ferox*, Salter, sp.
(Salter's original woodcut.)[1]

[Having been kindly permitted by Prof. J. O. Westwood to examine the original specimen in the "Hope Cabinet," I am able to state that the supposed extra row of tubercles are not the bases of spines broken off, but are *depressions* in the tergum near the base of each of the great branched spines, and may be seen near the lateral borders of each somite, in every specimen of *E. ferox* which I have examined.]

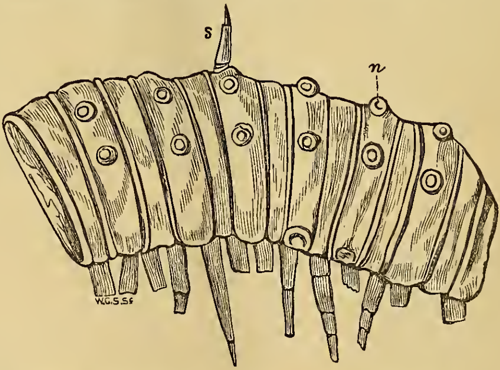

Fig. 3. *Acantherpestes major*, M. and W., Coal-measures, Illinois.

Neither did the specimen which I described in 1866,[2] from the Clay-ironstone of the Coal-measures, Kilmaurs, Ayrshire; which so closely resemble Dawson's specimen, that I referred it to even the same genus and species.

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[1] Not an accurate representation of the fossil described by Salter.
[2] Trans. Glasgow Geol. Soc. vol. ii. pp. 234–238, pl. iii.

Mr. S. H. Scudder, however,[1] has changed the name to *X. Woodwardii,* on the ground that the marks which I interpreted as probably the openings of tracheæ, are in reality "the scars or bases of spines, which appear as warts or tubercles in many of the Mazon Creek Myriapods; or, when viewed from the interior surface, as pits" (*op. cit.* p. 149).

In 1868, Messrs. Meek and Worthen[2] described several well-preserved remains of spined Myriapods from the Ironstone nodules of Mazon Creek, Illinois (see Woodcut, Fig. 3), which are placed by Scudder in five genera and twelve species (see *infra*).

In 1871, I figured another Myriapod from the Clay-ironstone of the Coal-measures, Kilmaurs, Ayrshire, under the name of *Euphoberia Brownii.*[3] In that paper I compared *E. Brownii,* mihi, with *E. armigera,* M. and W., and stated, "There are indications of pores, and also of the bases of tubercles or spines, along the dorsal line, but the latter are less perfectly preserved."

In 1882, Mr. S. H. Scudder[4] summarized our knowledge of the Myriapoda of the Carboniferous formation, and added several new species, in addition to proposing a classification for those already described.

Later on (1884[5]), Scudder described three species of a new genus of Myriapods (*Trichiulus*), and gave a description of another Myriapod which had first been noticed under the name of *Palæocampa anthrax* by Messrs. Meek and Worthen in 1866, and for which he proposed, in 1884, a new suborder, viz. PROTOSYNGNATHA.

This form of Myriapod is remarkable on account of the dorsal plates supporting several longitudinal rows of fascicles of needle-like spines, giving it the appearance of a hairy Caterpillar of the "Tiger-moth" (*Arctia caja*).[6]

The body-segments have a single dorsal and ventral plate, the latter bearing a pair of widely-separated, stout, fleshy legs, one pair to each segment behind the head. These stout fleshy legs of *Palæocampa* remind one of the legs of *Peripatus*, but that genus has no hard tergal covering to its segments, as was the case in the fossil form.

All the other Palæozoic Myriapods are included by Scudder in his suborder ARCHIPOLYPODA.

These Myriapods have a more or less cylindrical body, the head is slightly larger than the body-segments, being composed of probably three or more coalesced segments, and bearing, as in other forms, a single pair of antennæ, a pair of compound eyes, mandibles, maxillæ and having the first pair of post-cephalic appendages directed forward, probably to assist in the process of feeding. The dorsal portion (tergum) of each somite or segment of the body is composed

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[1] Mem. Boston Soc. Nat. Hist. 1882, vol. iii. no. v. p. 148.

[2] Amer. Journ. Sci. Arts, vol. xlvi. p. 25. See also Geol. Surv. Illinois, iii. 556.

[3] See GEOL. MAG. Vol. VIII. p. 102, Pl. III. Fig. 6 *a*, *b*, *c*.

[4] Mem. Boston Soc. Nat. Hist. vol. iii. no. v. pp. 143–182, pl. x.–xiii.

[5] Mem. Boston Soc. Nat. Hist. vol. iii. no. ix. 1884, "On two new and diverse types of Carboniferous Myriapods," pp. 283–297, pl. xxvi. and xxvii.

[6] Scudder's *Trichiulus villosus* was also covered with fine hairs; but this supposed Myriapod now proves to be the circinate vernation of a fern!

of only a single plate; but the ventral portion (sternum) is seen to be composed of two narrow parallel plates; and as each somite bears two pairs of legs, and two pairs of spiracles, it seems certain (says Claus) "that they may be regarded as double-segments,[1] formed by the fusion of two somites."

The raised anterior portion of the tergum of each segment is provided with a series of spines or tubercles, which, in some of the Mazon Creek specimens, are doubly-forked.

The class MYRIAPODA, at the present day, is divided as under, viz.:—

I. CHILOPODA (*Centipedes*). Antennæ simple, body depressed, dorsal and ventral plates horny, united by a membrane; the legs inserted in single pairs at the sides of the segments, with the exception of the first two pairs, which are converted into mouth-organs.

II. DIPLOPODA = CHILOGNATHA (*Millipedes*). Antennæ simple, body convex, or even cylindrical, the dorsal plates bent round so as to meet the narrow ventral plates nearly in the middle line of the body; each segment after the 5th or 6th with two pairs of legs.

III. PAUROPODA. With branched antennæ.

If we take the broadest possible lines for our guidance in the classification of animals, it seems that Scudder's PROTOSYNGNATHA will fall under the first of these divisions, viz.:—

Order I. CHILOPODA (*Centipedes*, recent).
Suborder PROTOSYNGNATHA (*Palæocampa*, fossil),

and his ARCHIPOLYPODA will in the same manner find a place under

Order II. DIPLOPODA (*Millipedes*, recent).
Suborder ARCHIPOLYPODA (all Palæozoic forms), with the following species:—

### 1. Family ARCHIDESMIDÆ, Peach.

Genus *Archidesmus*, Peach.
1. ,, *Macnicoli*, Peach, Old Red Sandstone, Forfarshire.
,, *Kampecaris*, Page.
2. ,, *Forfariensis*, Page, Old Red Sandstone, Forfar.

### 2. Family EUPHOBERIDÆ, Scudder.

,, *Acantherpestes*, Meek and Worthen, 1868.
3. ,, *major*, Meek and Worthen, Coal-measures, Illinois, U.S.
4. ,, (*Brodiei*, Scudder, Coal-measures, Coalbrook-dale.[2])
,, *Euphoberia*, Meek and Worthen, 1868.
5. ,, *ferox*, Salter, Coal-measures, Staffordshire.
6. ,, *horrida*, Scudder, Coal-measures, Illinois, U.S.
7. ,, *armigera*, Meek and Worthen, Coal-measures, Illinois, U.S.
8. ,, *Brownii*, H. Woodward, Coal-measures, Ayrshire.
9. ,, *granosa*, Scudder, Coal-measures, Illinois, U.S.
10. ,, *Carrii*, ,, ,, ,,
11. ,, *flabellata*, ,, ,, ,,
12. ,, *anguilla*, ,, ,, ,,

[1] *Not* originated from a fusion of two primitively distinct segments, but from a later imperfect division of each of the primitive segments into two, and the supply to each of the divisions of a primitive segment of a complete set of organs."—(Balfour, Embryology, vol. i. p. 392.)

[2] This is shown to be merely *E. ferox*, Salter, sp.; see ante p. 2, and infra p. 6.

Genus *Amynilyspes*, Scudder, 1882.
13. ,, *Wortheni*, Scudder, Coal-measures, Illinois, U.S.
,, *Eilecticus*, Scudder, 1882.
14. ,, *anthracinus*, ,, ,, ,,

### 3. Family ARCHIJULIDÆ, Scudder.

Genus *Trichiulus*, Scudder, 1884.
15. ,, *villosus*, Scudder,
16. ,, *nodulosus*, Scudder,
17. ,, *ammonitiformis*, Scud.
} Recently shown by Scudder to be founded on the circinate vernation of a fern. (See Mem. Boston Soc. Nat. Hist. vol. iii. No. xiii. p. 438, 1886.)
,, ? *Archiulus*, Scudder (*Julus*, Dohrn).
18. ,, *Brassii*, Dohrn, Rothliegendes, Lebach.
19. ,, *xylobioides*, Scudder, Coal-measures, Nova Scotia.
20. ,, *constans*, Frič ,, Bohemia.
21. ,, *costulatus*, Frič ,, ,,
22. ,, *pictus*, Frič ,, ,,
,, *Anthracerpes*, Meek and Worthen.
23. ,, *typus*, Meek and Worthen, Coal-measures, Illinois, U.S.
,, *Palæojulus*, Geinitz.
24. ,, *dyadicus*, Geinitz, Dyas, Saxony.
} Founded on the circinate vernation of a fern.
,, *Scolecopteris*.
25. ,, *elegans*, Zenker, Coal-measures Germany.
,, *Xylobius*, Dawson, 1859.
26. ,, *sigillariæ*, Dawson ,, Nova Scotia.
27. ,, *Woodwardii*, Scudder ,, Ayrshire.
28. ,, *similis*, Scudder ,, Nova Scotia.
29. ,, *fractus* ,, ,, ,,
30. ,, *Dawsoni* ,, ,, ,,
31. ,, *Chonionotus lithanthraca*, Jordan, Coal-measures, Germany.

In a table prepared by Mr. Scudder for Prof. Dr. Zittel's Handbuch der Palæontologie,[1] of the fossil Myriapods, he places all the Palæozoic forms (save one) in his suborder ARCHIPOLYPODA, namely, two Devonian species, thirty-one Carboniferous,[2] and four Dyas (?). The exceptional form belongs to his suborder PROTOSYNGNATHA.

He records one Diplopod from the Chalk-formation, seventeen CHILOPODA, and twenty-three DIPLOPODA, from the Oligocene: one of the latter from the Miocene and forty-nine recent.

In the past year (1886) the British Museum (Natural History Branch) acquired the well-known collection of the late Mr. Henry Johnson, F.G.S., Mining Engineer, of Dudley, who had devoted the best years of his life to the collection of the fossils from the Wenlock Shale of his native place and those of the surrounding Coal-fields, particularly the Clay-ironstone nodules of the Coal-measures of Coseley, near Dudley, from the "Binds" between the "Brooch" and "Thick-Coal." From these he obtained a rich collection of Crustacean and Insect remains and also many spined Myriapods.

I exhibited the Insects and Myriapods at the British Association Meeting, Birmingham, in Section C. (Geology); and I was favoured with an opportunity to examine the rich collection of Silurian and Carboniferous fossils in the Museum of Mr. C. Beale, of Lime Tree House, Rowley Regis, not far from Dudley. Mr. Beale kindly placed

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[1] Handbuch der Palæontologie von Karl A. Zittel, München. I. Abtheilung, II. Band, V. Lieferung—Myriopoda, Arachnoidea, und Insecta. Bearbeitet von Samuel H. Scudder (1885).

[2] These numbers must now be reduced by four Carboniferous and one Dyas species.

eight specimens of spined Myriapods in my hands, all enclosed in Clay-ironstone nodules similar to those in the Johnson collection.

Mr. Beale's specimens were obtained from the shales or Clay-bands at the top of the Brooch-coal, Sedgley, near Dudley.

These ironstone-nodules are considered to occupy a much higher horizon in the Coal-measures than those described by Prof. Prestwich in his Geology of the Coalbrook-dale Coal-field (Trans. Geol. Soc. Lond. 2nd ser. vol. v. pl. xli. 1840), but many of the organisms are identical from both areas.

### EUPHOBERIA FEROX, Salter, sp., 1863. (Pl. I.)

"A Caterpillar?" Westwood in Brodie's Fossil Insects, 1845, p. xvii, 105, pl. i. fig. 11.

*Eurypterus ? (Arthropleura) ferox*, Salter, Quart. Journ. Geol. Soc. 1863, vol. xix. p. 86 (woodcut, fig. 8, reproduced on p. 2, *ante*).

*Euphoberia ferox*, Meek and Worthen, Geol. Surv. Illinois, vol. iii. (Palæontology) ("A Myriapod!").

*Euphoberia ferox*, H. Woodward ("A Myriapod!"). See Brit. Foss. Crustacea, order Merostomata, Pal. Soc. Mon. 1872, p. 173.

*Euphoberia ferox*, Scudder, 1882, Mem. Boston Soc. Nat. Hist. vol. iii. no. v. p. 157.

*Euphoberia ferox*, H. Woodw., 1873, GEOL. MAG. Vol. X. p. 112 (and 2 woodcuts).

*Acantherpestes Brodiei*, Scudder, 1882, *op. cit.* p. 156.

I am disposed to refer the whole of the 20 specimens of spined Myriapods, now under consideration, from the Staffordshire Coal-field (most of which have both impression and counterpart preserved) to one species, namely, to *Euphoberia ferox.*

In my monograph on the MEROSTOMATA (Pal. Soc. 1872, p. 173) I placed Salter's "*Eurypterus ferox*" with the MYRIAPODA,[1] and in the genus *Euphoberia*, as suggested by Messrs. Meek and Worthen. In this conclusion Scudder agreed in 1882, but he eliminated the specimen referred to in "Brodie's Fossil Insects" as a "Caterpillar," although Salter and I had both considered it as *identical* with *Euphoberia ferox*, and he has placed it in the genus *Acantherpestes*, making for it a new species, *A. Brodiei.* There are, however, no grounds for either the generic or specific separation of this fossil from *E. ferox*, save the obscurity of the specimen and the indistinctness in character of the original figure, from which all the subsequent ones have been *merely copies.*

From the excellent materials now collected together, in which are included the Johnson and Beale Collections, also Brodie's and Salter's original specimens, lent to me for examination by the kindness of Prof. J. O. Westwood, M.A., from the Oxford Museum, and Dr. A. Geikie, F.R.S., from the Museum of Practical Geology, Jermyn Street, I hope to be able to give some additional details which may assist towards a complete knowledge of this remarkable spined Myriapod from the English Coal-measures.

In four of the specimens the head is seen, and in two of these the details can be clearly made out, but the remaining ones are somewhat obscure and imperfect.

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[1] Scudder, however, in his Memoir (*loc. cit.*), 1882, p. 157, cites me as still considering it to be a *Eurypterus*, whereas I most clearly state: "I am fully disposed to agree with Meek and Worthen, and to refer it to the *Myriapoda* and to their genus *Euphoberia*, feeling certain that it has *no relation whatever* to *Eurypterus*" (Pal. Soc. Mon. p. 173; GEOL. MAG. Vol. X. p. 112).

In one instance (Pl. I. Fig. 1) the head is associated with seven consecutive well-preserved somites or body-segments; in another instance with five segments; the other two examples have portions of segments only in association with the head, but of their identity I feel no doubt on comparison with the others.

The head is somewhat rounded in outline, the sides being compressed and the posterior border slightly incurved. The anterior portion of the head, which is tumid, is without divisions, and is not ornamented save for a minute granulation common to the general surface. The posterior half has a clear straight groove down the centre, and on either side is marked by two lateral curved grooves which subdivide the back of the head into four tumid lobes; the two subcentral ones are the largest and are arched in front so that they overlap the two outer lobes which lie within their lateral concavities.

At each antero-lateral angle of the two subcentral lobes there is a small rounded prominence marked by a corresponding circular pit on the inside of the head. These are no doubt the points of articulation for a pair of simple antennæ, and they are placed just in front of the compound eyes. These occupy the two small elevated lobes at the latero-posterior angles of the head, and are in almost similar relative position as in the head of the modern *Julus*. There are about ten rows of facets in each eye (Plate I. Fig. 3 *o*), and seven or eight facets in each row; the smallest facets being those nearest the centre of the head, and the largest towards the border. Behind the posterior lobes of the head is a simple granulated margin, one millimetre broad, running parallel with its posterior border. Breadth of head 14 mm., length 10 mm.

In addition to a very well-preserved detached head twisted half round, seen in Plate I. Fig. 1 (closely agreeing with that drawn on Plate I. Fig. 3), the same nodule retains the impression and counterpart of seven body-segments united together exposing their dorsal aspect. Each segment consists of a broad, raised, median ridge, bearing two subcentral bases of spines, the spines themselves having been broken off. They are, however, occasionally to be seen in sections of somites, as at the end of Figs. 4 *s*, and in 2 *s*.

This ridge extends to and unites with the lateral border, where it gives origin to a large unequally branched spine, the longest ramus of which measures 10 mm. (in Pl. I. Fig. 1); at the antero-lateral border of each somite there arises a simple pointed spine 4 to 5 mm. long, directed forwards, and a very minute simple spine on the postero-lateral border directed backwards. These larger spines were at least 5 or 6 mm. long, if not more, and they are seen to be hollow. They certainly varied slightly in character and in length in the same individual, as did also the segments upon which they were borne, according to their position in the animal's body.

Occasionally, as in Pl. I. Fig. 7 *s*, the ordinary forked marginal spine is seen to be trifid; but this I am persuaded is due to the single simple spine, which is usually found at its base, occurring rather higher up than usual, and is not a specific character.

The hindmost segment preserved in Fig. 1 measures 15 mm. in breadth and 6 mm. in length, and one of the anterior segments 12 mm. in breadth and 5 mm. in length.

Another specimen (not drawn) exposes seven body-somites in juxtaposition; the spines are wanting, save one perfect dorsal spine, which is seen attached to the seventh somite, and measures 5 mm. in height. The margin of the tergum of each somite is seen along the right side, and is rather more rounded behind and slightly pointed in front. (See Pl. I. Fig. 13, *ep.*)

The left side is buried in the nodule for about one-third of the surface of the terga. The seven somites together measure 50 mm. long, giving an average length of 7 mm. to each; but the somites are rather more widely separated than usual, so that probably 6 mm. each would be more correct.

Another (Plate I. Fig. 6), from Mr. Beale's collection, exposes five somites, one side displaying the large unequally branched spines, and the small simple antero-lateral spines at their bases, with a trace only of the small latero-posterior spine. On the other side the spines are broken off, showing their hollow shafts, and displaying the lateral border of the tergum of each segment, which is minutely serrated posteriorly. From these specimens I infer that these large spined Myriapods were less round in section than Scudder represents, and that the epimeral portion of each somite projected slightly outwards above its sternum. Length of five somites 35 mm., or averaging 7 mm. each; breadth 18 mm. (exclusive of spines, which would project 9 or 10 mm. beyond this on each side).

This specimen represents a part of the largest example known in England, being 2 mm. wider than Salter's *E. ferox* in the Jermyn Street Museum; but the length would be about the same. In Mr. Beale's specimen the somites are lying in one plane; in Salter's type they are highly curved, and the elevated ridge of each somite has been slightly broken away along its posterior dorsal line. By a misadventure, Figs. 6 and 7, Plate I. have both been drawn with the anterior extremities downwards, the other specimens being all drawn in the contrary direction, with the anterior end upwards.

Perhaps the most instructive specimen in the entire series is one from the late Mr. Henry Johnson's collection, from Coseley, displaying seventeen segments of one individual in the same nodule. The seven anterior somites exhibit their terga and also their branched spines very well (save the first, which is broken), the next succeeding seven somites exhibit a section of their terga, and expose the sterna of five somites seen from within, and the bases of the legs of the left side, and all the legs of seven somites on the right side.

In this specimen the legs, where fully exposed (Pl. I. Fig. 12), are 17 millimetres long; the first two or basal joints which unite with the sternum measure together 3 mm.; the third joint is the longest and widest (length 6 mm. and width $1\frac{1}{2}$ mm.); the fourth is 2 mm. long, the fifth is 3 mm., and the sixth is 3 millimetres.

At the base of each pair of legs, and lying in the median line of the sternum, a pair of minute pores (Pl. I. Fig. 5 *b*) or puncta are seen, which are described by Scudder as "a pair of supposed branchial supports;" but as each paired sternum is also perforated above the point of articulation for the legs (Pl. I. Fig. 5 *l*) with two spiracles in the form of oblong slits (four to each segment, Pl. I. Fig. 5 *sp.*), agreeing with the two pairs of legs, I fail to see any reason for the assumption that these minute pores, if pores they be, are the basis of gills (see also Pl. I. Fig. 4).

Even admitting that these forms may possibly have been sometimes either voluntarily (or involuntarily) aquatic in habit, yet such a suggestion, unsupported by any evidence in its favour, would hardly warrant one in establishing so anomalous a type as a Dipnoid order of Myriapods breathing both by external gills and internal tracheæ.

This specimen seems rather to favour the notion of a slight diminution in the size of the body-segments towards both extremities of the animal, although we are unable to state with certainty how many more somites are wanting in order to complete the body at either extremity.

In addition to the two specimens showing heads, Mr. Beale's collection has also furnished a single terminal segment, or pygidium, which is associated with a spined body-segment, showing it to belong to the same genus, and probably to the same species. The tail-plate is somewhat pentagonal in form, with two bifid curved spines, one on each lateral border, and four smaller simple spines, two on each side of the median line; the centre, which is transversely ridged, has two obtuse tubercles placed like the body-spines subcentrally; width of tail 6 mm., length 5 mm., length of longest lateral spine 11 mm., length of submedian spines 5 mm.

It is not improbable that this pygidium may have been associated with a form like that on Plate I. Fig. 7, or even Fig. 9; the details of its ornamentation agree with all, and its size with Fig. 7.

So many important points attach to a full consideration of these forms, that I reserve further figures, descriptions and comparisons for my Monograph on the Arthropods of the Coal period, to appear in a forthcoming Memoir of the Palæontographical Society, where I hope to discuss fully the question of species. I may then, possibly, separate Figs. 7 and 9 as distinct, but prefer at present to defer doing so, more illustrations being needed for my task.

Meantime I have to return my best thanks to Mr. C. Beale for the beautiful series of specimens with which he has so kindly entrusted me, and to which I hope to do more ample justice anon.

Before quitting these Carboniferous Myriapods, I desire, however, to draw special attention to a mere fragment of one from the Carboniferous Limestone of Grassington, Yorkshire, where it occurs in association with numerous remains of *Phillipsia Derbiensis* and a *Fenestella.* Only four somites are preserved, and these are evidently spinigerous after the manner of *Euphoberia*; but the spines are longer and more slender, and it does not seem quite certain that any of them were branched (see Plate I. Fig. 10).

I only propose to call attention to the remarkable fact of this form being found, not associated with Ferns and true winged insects, in Clay-ironstone nodules of probable freshwater origin, but in a pure crystalline limestone full of marine organisms, a most improbable gisement for a Myriapod! The specimen belongs to the Museum of Practical Geology, Jermyn Street, S.W.

### EXPLANATION OF PLATE I.

Remains of Spined Myriapods from the Coal-measures.

Fig. 1. *Euphoberia ferox*, Salter, sp. Coal-measures, Sedgley. (Mr. C. Beale's Collection.) Head with seven body-segments. *a.* anterior margin of head. *p.* posterior attached border. *o.* one of the eyes. (Beale Coll.)
,, 2. A detached head of another specimen showing the eyes and also segments with the spines preserved, but much crushed. (Beale Coll.)
,, 3. Another detached head showing the eyes (*o*), the attachment for the simple antennæ (*f*), one of the antennæ (*a*) close to the front of the head.
,, 4. A specimen of *Euphoberia* with 17 somites united in one animal. This specimen shows the legs and the spiracles (*sp*). (Hy. Johnson Coll.)
,, 5. A portion of the sternum with articulations of 4 legs (*l*) and the openings of 4 spiracles (*sp*); also the supposed "basis of branchiæ" (*b*).
,, 6. Another specimen showing 5 somites with lateral bifid spines and small marginal ones attached. (Beale Coll.)
,, 7. Another form, longer and narrower in proportion than Fig. 6, with 5 somites bearing lateral bifid and one trifid spine (possibly a new species?). (Hy. Johnson's Coll.)
,, 8. Terminal segment or 'telson.' (Mr. C. Beale's Coll.)
,, 9. Another and smaller example of *Euphoberia* with 12 connected somites (associated with leaves of *Neuropteris*), bearing one or more trifid spines (possibly a new species)?
,, 10. Fragment consisting of 4 somites bearing slender curved spines. Carboniferous Limestone, Grassington, Yorkshire. (Mus. Pract. Geol.)
,, 11. Ideal section through *Euphoberia ferox*, showing position of simple and bifid spines on tergum (*t*) and the legs and spiracles (*sp*) on the sternum (*s*).
,, 12. Two of the legs drawn separately from Fig. 4.
,, 13. Side view of three segments to show the profile of body-rings with their ridges and the bases of their spines. The lateral margin (*ep*) is seen to be slightly serrated along the posterior border.

Mr. Beale's specimens are all from the Clay-ironstone of the Coal-measures of Sedgley, near Dudley. Mr. Henry Johnson's are all from Coseley, near Dudley.

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## II.—The Culm Measures of Devonshire.

By W. A. E. Ussher, F.G.S.

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PROBABLY from the great preponderance of interest attaching to the Devonian rocks of North and South Devon the Culm Measure rocks, constituting the great central table land, have been to a certain extent overlooked. The attempt to subdivide them by ascertaining their different lithological characteristics, and observing to what extent these characteristics are peculiar to definite horizons, has seldom been made. We may, in fact, sum up the literature of the subject with one notable exception—the late Prof. J. Phillips in his "Figures and Descriptions of the Palæozoic Fossils of Cornwall, Devon, and W. Somerset"—as bearing upon the position of the series as a whole, or calling attention to some special point of interest.

Phillips, in the work referred to, pointed out the relative position in the series of the most characteristic or important members, such as the limestones, and the cherty beds of the Coddon Hill type. He also showed that these typical rocks had their equivalents along the southern margin of the great Culm Measure Synclinal.

Phillips gives the following grouping of the Culm Measures in the south part of their range.

Upper or Grit Group of Central Devon.
Upper Shale Group—A mass chiefly of dark shales, carbonaceous grits and shales, the lowest part being the Coddon Hill chert series.
Middle or Calcareous Group—Limestone, mostly black, irregularly bedded, associated with shales, often resting on trap rock and fossiliferous.
Lower Shale Group—Black argillaceous plate, or very laminar shale, not subject to slaty cleavage, and scarcely fossiliferous.

"Following the line of the carbonaceous group of North Devon to the east," says Phillips, p. 194, "it is lost under the superimposed red marls and sandstones; these range nearly north and south across the general strike of the carbonaceous group and conceal it . . . On the west the carbonaceous group occupies the coast from Fremington nearly to Tintagel, and on the south it follows a line much bent by the effect of the protruding granitic masses, especially of Dartmoor. In the centre of this great district no limestone occurs, and there are no other fossils than obscure marks of plants or mere carbonaceous stains; but on the southern border the limestone bands reappear almost exactly as on the northern side with similar mineral characters and accompaniments, and similar or identical organic remains; for example, at Trescott near Launceston, Lew Trenchard, Bridestow, and Okehampton."

Beds of Anthracite occur in the Culm Measures of North Devon in the neighbourhood of Chittlehampton, Tawstock, Abbotsham, and Alverdiscot; they are alluded to by Polwhele,[1] by Vancouver,[2] by Lysons,[3] by Sedgwick and Murchison,[4] and De la Beche;[5] the latter says: "Anthracite or Culm occurs in a few beds of very variable thickness between Greenacliff on the coast west from Bideford and Hawkridge Wood near Chittlehampton."

"Sufficient Anthracite was at one time raised near Greenacliff, in Barnstaple Bay, to burn with the limestone brought there from South Wales."

Mr. T. M. Hall (Trans. Dev. Assoc. for 1875), in a paper entitled "Notes on the Anthracite Beds of North Devon," says: "The widest culmiferous band is nearly 18 feet in width, but several smaller strings of the same material traverse the slates and shales.

"At Bideford, a few yards north of the Railway Station, may be seen the black shales forming the outcrop of the veins which, until a very recent period, were worked to a considerable extent. . . . About a mile east of this spot the present works, consisting of a shaft and level adit, are still carried on for the purpose of obtaining the softer varieties of Anthracite, which when ground to powder are sold as a pigment under the name of Bideford Black."

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[1] History of Devonshire, p. 55 (1797).
[2] General View of the Agriculture of the County of Devon, p. 266 (1808).
[3] Magna Britannia Devon (1822), p. 266.
[4] On the Physical Structure of Devonshire (1840).
[5] Report on Geol. Corn. Devon, etc. (1839), p. 513.

Mr. Hall gives the following list of fossil plants obtained from the North Devon Culm Measures:—

*Asterophyllites foliosa.*
,, *galioides.*
,, *longifolia.*
*Bowmanites* (fruit of Calamite).
*Calamites arenaceus ?*
,, *cannæformis.*
,, *nodosus ?*
,, *Steinhauerii.*
,, *undulatus.*
*Cyperites bicarinata.*
*Lepidodendron.*
*Lepidophyllum intermedium.*
*Neuropteris cordata.*
,, *gigantea.*
*Neuropteris heterophylla.*
,, *Loshii.*
*Pecopteris lonchitica.*
,, *muricata.*
,, *Serlii.*
*Poacites cocoina.*
*Sigillaria.*
*Sphenopteris acuta.*
,, *latifolia.*
*Spenophyllum* sp. (?).
*Sternbergia.*
*Stigmaria ficoides.*
A single shell of the genus *Anthracosia* also found near Bideford.

Mr. H. B. Woodward informs me that *Cœlacanthus* has been found at Instow.

In Lower Culm Measure Shales at Waddon Barton near Chudleigh, ? Mr. Reid obtained four species of *Phillipsia*, *Goniatites sphæricus*, *Orthoceras striolatum*, *Posidonomya Becheri*, *Avicula lepida*, *Chonetes deflexa*, *Spirifera Urii*, etc.[1]

In a survey of the Triassic rocks of Devon extending over several years, I had ample opportunities of observing the Culm Measures on their borders; but it was not till the years 1876 and 1877 that I had the opportunity of studying the Culm Measure area in a less desultory manner, my researches being confined to the districts east of a line between Hartland Point and Okehampton.

In this area I discovered that the Culm Measures were broadly divisible into three groups, which, however, owing to the passage of one group into another, and to local intercalations, and to a great extent to the innumerable flexures of the beds, cannot be separated by hard and fast lines. Whether such a separation could be effected on a 6-inch scale map I cannot say, but it would entail an infinite amount of labour. The following is the general succession:—

Upper—Eggesford type.—Hard rather thick, even-bedded grey grits, slaty beds and shales.
Middle—Morchard type.—Thick-bedded grey, greenish, and reddish sandy grits, associated with marly splitting shales, irregular grits, slates, and shales.
Lower ... ... ... ... { Dark grey shales, with grit beds, seldom thick, and generally even, slaty, and splintery shales (type St. Davids Exeter).
Even-bedded cherty shales and grits (of Coddon Hill type).
Limestones and dark-grey shales.

In general facies these groups are quite distinct, thus the even bedding and regular appearance of the fine-grained grey grits of Eggesford is very distinct from the irregularly associated grits and shales of the underlying beds, whilst the massive bedded sandstones and marly shales which occur in them about Zeal Monachorum, and other places on the north of the Crediton Valley, give the Middle Series or Morchard Bishop type of beds a very different general

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[1] For a further list of the Waddon Barton Fossils, including the Trilobites, described by me, see Geol. Mag. Decade III. Vol. I. 1884, p. 539.—H. W.

aspect from the lower series, although splintery shales (of the St. Davids Exeter type) appear to be interstratified with them in places.

Upon the one-inch map it is perfectly impossible to work out the structure except in a broadly general way; there is no room on a small scale map to indicate the numerous folds, and it is quite impossible to ascertain the effect and magnitude of the faults.

The great Culm Measure Synclinal is not a simple curve, the beds troughed by it being crenulated, so to speak, into an infinity of small folds, and in this crinkling process they have no doubt been forced to accommodate themselves to an area so much smaller than that of their pristine extent, that we may suppose overthrust faults very likely to have occurred, and, coupled with natural impersistence of lithological horizons, lenticular association of grit and shale masses and structural peculiarities such as may frequently be found in the Middle, and sometimes in the Lower Culm Measures; these considerations tend not a little to obscure the relations of the beds.

*Lower Culm Measures.*—On their northern outcrop the beds forming this series occupy a very much narrower tract than that to the south. Their northern outcrop is about two to three miles in breadth; their southern outcrop varies very considerably, its breadth from Dartmoor northward through Okehampton being about five miles, whilst on the east of Dartmoor it is about 15 miles, and about the same on the west of Dartmoor through Lidford; but it must be remembered that this estimate in the southern part of the area is necessarily based on the old geological Map, and that both in northern and southern districts the Lower Culm Measures may occur far beyond the limits assigned to them, through repetitions by faults or anticlinal axes in the areas occupied by the Middle Culm Measures.

The Lower Culm Measures, owing to the occurrence of limestones and of the remarkable buff and grey shales and cherty grits of the Coddon Hill type in them, and to their connection with the Upper Devonian beds, naturally excited more interest and attention than the other members of the series, except the Anthracite beds of the Middle Culm Measures of the north; but I do not think, at least in the northern area, that they can be subdivided in anything like persistent groups. If, for instance, we take the faulted and much-flexured limestone patches of West Leigh,[1] Hockworthy, Whipcoats, and Kitton Barton, it is not difficult to determine their boundaries; but to establish their connection in a continuous series is by no means easy. Furthermore, when we follow their horizon westward, although we can have no hesitation in regarding the limestones of Bampton and of Ven near Barnstaple, as the same series, the entire absence of continuity for such considerable distances forbids the hypothesis of a persistent calcareous horizon, which could only be proved by systems of faults of which we could not hope to obtain sufficient proof. From their local development, and very partial occurrence, both in the northern and southern areas, I regard the limestones as lenticular masses in the shales and grits.

[1] *Vide* Trans. Dev. Assoc. for 1878 and 1879, Fossils in Culm Measures Limestone, etc., by Rev. W. Downes.

Again, the peculiar baked appearance of the Coddon Hill beds is more or less local, although appearing at such wide intervals as the Northern and Southern Culm Measure areas, wherein their characteristic appearance was severally noticed by Phillips; and the limestones may be said to occur in them, the reddish even Goniatite shales of the West Leigh area belonging to this group.

Referring to the Coddon Hill beds, pp. 189, 190, Phillips says:—"The beds, which in this range overlie the shales and limestones of Swimbridge and Venn, are a whitish or grey or black chert in thin striped beds. . . . With these lie white arenaceous and argillaceous layers, mostly very soft, and sometimes cleavable, other parts show black and reddish shales. In these laminated beds lie Goniatites, Orthoceratites, Terebratulæ, and Posidoniæ. The debitumenized condition of these white shales parallel to the black bituminous shales of Swimbridge is remarkable; aud it is a fact repeated not only on the Northern range near Bampton, but also on the southern range near Launceston and Lew Trenchard. In a quarry on this range near Tawstock, Major Harding found *Turbinolopsis pauciradialis*" (*Petraia celtica*).

To take one or two examples from many furnished by my notes: The Venn limestones are exposed in two adjacent quarries; in the smaller one they are very much disturbed, being probably affected by two faults; they appear to overlie beds of the Coddon Hill type. In the larger quarry even-bedded dark grey limestones dip 35° W.; at 60°, they are interleaved in places by shaly parting. One of the beds is covered on its surface with impressions of *Posidonomya* (*Posidonia*) *lateralis*, and less frequently *P. Becheri* and *P. tuberculata*.

Near Eastcombe, west of Tawstock, thin beds of fine grit and thick shale of whitish buff and dark grey colours, split up by numerous even joints into small angular pieces, are quarried for "gravel." The joints, as is usual in beds of the Coddon Hill type, are local contraction-cracks of individual beds.

The flexures and contortions of this series are too numerous to furnish any generalized observation as to the relations of the beds, and space fails me to enter into local details.

In the south of the area, notwithstanding the local repetition of the calcareous horizon, and of beds equivalent to the Coddon Hill series, there is some difference in the general characters of the Lower Culm Measures; thus slaty grey shales which, from their typical exposure on St. David's Hill, Exeter, I have called splintery shales of the St. David's type, are by no means uncommon in them, also beds of a nodular or concretionary character; the grits vary from thin and even, to rather thick irregular beds.

Phillips thus describes the Lew Trenchard section: "Argillaceous and arenaceous laminar beds, white or coloured by oxide of manganese, which correspond to those of Coddon Hill in North Devon, contain *Calamites*, *Asterophyllites*, *Neuropteris*, and a *Goniatite*, . . . below are quarries of black limestone" with "shaly partings rich in *Posidoniæ*" in the upper part. No Goniatites found in the limestone. Phillips points out the occasional presence of oolitic structure in the limestones of this series.

The junction between the Lower Culm Measures and Upper Devonian slates of North Devon is very seldom visible, but there are cases, as in the railway cutting near Dulverton Station, where we pass from shales distinctly belonging to the Culm Measures to shales lithologically indistinguishable from them in which *Petraia celtica* was obtained.

Phillips says, p. 189, "The exact circumstances of the passage from the upper part of the Pilton group to the lower part of the Carbonaceous group . . . are scarcely anywhere completely seen in North Devon. There is usually a longitudinal valley on the line of junction which obscures the phenomena. Fremington Pill is perhaps the best locality for observation of this passage." As to the junction between Culm Measures and Devonian in South Devon, it is one of the questions of the future. Phillips points out appearances of unconformity between the Petherwin beds (Upper Devonian) and Lower Culm Measures at Landlake, south of Launceston, *op. cit.* p. 196, and I do not think that the comparative absence of the Upper Devonian strata has been accounted for in South Devon. On the broad questions of correlation many plausible suggestions have been made; but if the Pilton beds are unquestionably representative of the Lower Carboniferous Slate of Ireland, what becomes of that representation in South Devon? Is it possible that the Upper Devonian Slate series is in South Devon represented by Lower Culm Measures, through that Division attaining a much greater thickness in the southern area? It may be that the greater extension of Lower Culm Measures in the southern area is due to low dips or more constant repetition by faults and flexures, see F. Rutley "On the Schistose Volcanic Rocks of Dartmoor," Q. J. G. S. vol. xxxvi. p. 287, 1880, and Harvey B. Holl, Q. J. G. S., vol. xxiv. p. 407, 1868.

*Middle Culm Measures.*—These rocks occupy the coast from Westward Ho to Portledge Mouth. The breadth of their outcrop from Northam to Wear Giffard in the longitude of Bideford is about four miles; their southern outcrop from the Triassic valley of Crediton northward embracing Morchard Bishop, Iddesleigh, Meeth and Petrockstow, is from 4 to 5 miles in breadth.

Fig. 1.

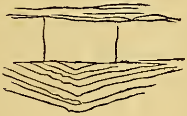
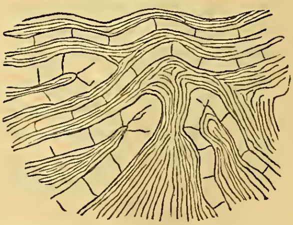


Fig. 2.



The Middle Culm Measures are a very variable series, their special characteristics are rather coarse sandstones, which, near Zeal Monachorum and other places in their southern outcrop, occur in beds about five feet thick, and are associated with marly splitting shales or red finely micaceous mudstones. In the north part of the area the marly shales are less frequent, and hard thick-bedded whitish sandstones and siliceous grits occur. Through the very irregular association of the slates, shales and grits which form the major portion of this series, many structural peculiarities are presented, especially in the very irregular manner in which the constituent beds have yielded to the strains to which they have been more than once subjected since their deposition. The accompanying diagram represents a case of contortion in the cliff near Westcot, the occurrence is presented in a space of about seven square feet. Near it we have a bed of greenish grey grit lying across the edges of a trough in the subjacent shales (Fig 2).

The coast from Portledge Mouth towards Westward Ho shows successively reddish-brown and lilac grits, grey grits, blackish shales and grey grits, dark grey shales and slaty beds, hard grey grit forming an anticlinal, shales with thin beds of grit, massive grey grits and grey shales. It was from this part of the coast that the diagrams were taken,—irregular concretionary grits on a thick bed of whitish grit at about 85 chains from Portledge Mouth, upon thick beds of grey sandy grit broken by irregular joints, upon massive beds of grey quartz-veined grit associated with dark grey shales forming a fine anticlinal, hard coarse grey grits and dark grey shales flaking off in splintery fragments in places, under these beds dark shales with thin even beds of grit, possibly Lower Culm Measures, come on, they appear to be faulted against massive beds of grey grit, one bed being eight feet in thickness. The above represents the coast section for more than a mile and a half; in that space we have about 18 well-marked anticlinal and synclinal curves, not to mention numerous lesser flexures, and two appearances of fault.

Space fails me to particularize the continuation of the coast-section in the direction of Westward Ho. From Peppercombe to Clovelly the coast is formed for the most part of beds of the Eggesford type, Upper Culm Measures.

From Clovelly to Hartland Point the coast has not been observed, but from its projection it would appear to consist of Middle Culm Measures, of which the following is the downward succession at Hartland Point: Light greenish grit; on dark grey slates and shales with beds of greenish grit; thick bed of brown grit; reddish schistose beds and shaly mudstones splitting in sub-cuboidal pieces like marl, associated with thin beds of grit; thick beds of hard lilac grit with shale; dark grey shale; even-bedded quartz-veined grey grits; dark grey indurated shale; hard grits with dark grey shale partings; bed of grey quartz-veined grit; dark grey shales and schistose beds. The beds are contorted.

The Eggesford grits or Upper Culm Measures form a much more regular and less variable series than the beds hitherto described; they form a band of six or seven miles in breadth. They are well exposed in the railway cuttings near Eggesford, in the Torridge Valley about Great Torrington and in the coast near Clovelly. It is impossible on the one-inch scale to convey any idea of the many flexures in them, every section almost, of a few yards in length, affording an indication of disturbance.

Between Clovelly and Portledge Mouth the Upper Culm Measures consist of grey, lilac-grey and reddish thick-bedded even grits, with interstratification of dark grey shale. The even-bedded character of this series renders the flexures in the cliffs very apparent, especially when dark grey shale bands are affected by them, as at 31 chains from Clovelly Pier where sharp inverted curves are shown, V shaped flexures are visible about 14 chains from the Pier, and from 18 to 22 chains from the Pier the beds are contorted and faulted. At about 70 chains from Clovelly beautiful examples of marine tunnelling are afforded by the Black Church rock, in which two tunnels have been excavated along the bedding, and by a neighbouring reef in which the sea attacked the opposing strike surface, the tunnel being roofed by a massive bed dipping landward.

Fig. 3.

To enter more fully into the many inverted and ordinary curves exposed in this interesting coast would be beyond the purport of this paper. I have not attempted to give a digest of the numerous notes I have made of the Culm Measure area, nor do I think it would be possible to do so; but I trust that I may have succeeded in directing attention to a large district practically unknown to geologists, and in showing that, in spite of the confusing complexity of detail, it is possible to obtain something like a definite sequence. To make out the structure thoroughly would require years of patient labour on the 6 inch scale, and is in no sense feasible in holiday rambles; but there are curious structural phenomena which would amply repay the labours of the casual visitor.

## III.—Notes on "Cone-in-Cone" Structure.

By W. S. Gresley, F.G.S.

In Decade III. Vol. II. of the Geological Magazine, for 1885, at page 283, an abstract of a paper on "Cone-in-Cone" by Mr. John Young, F.G.S., of Glasgow, was given. The author of this interesting paper has kindly presented the writer with a copy of it, to which, since it was read in Glasgow last year, has been added some additional remarks, together with two very beautiful plates, by 'photogravure,' in illustration of some of his typical Scottish specimens.

The result of Mr. Young's labours in this connection have warranted him in arriving at the following conclusion respecting the origin and formation of cone-in-cone structure, which, briefly stated, is this :—That the formation is due to the "upward and successive escape of gases generated in the lower portion of the stratum in which the structure is found, probably by the decay of organic matter in the deposit whilst still in the process of formation and in a soft, sedimentary condition; each ebullition of gas being marked by a new or successive layer of sediment within each cone." "That the cones, large and small, have their apices invariably directed towards the lower portion of the stratum."

As, in the course of the last year or two (due chiefly to the occurrence of some interesting examples of cone-in-cone in the breccias of the Permian? series in Leicestershire, see Q. J. G. S. vol. xli. Proceedings, page 109, and the "Midland Naturalist," vol. ix. No. 97 [new series]), the writer has given some attention to this interesting rock-structure, his observations in the field and elsewhere have brought to his knowledge several important facts, and such as have reluctantly prevented him from accepting Mr. Young's theory.

Although Mr. Young has gone very fully into the question, he does not appear to have noticed one or two important points often seen in cone-in-cone structure, which I will now endeavour to describe.

Fig. 1

$\frac{1}{2}$ nat. size.

Fig 2.

4 times nat. size.

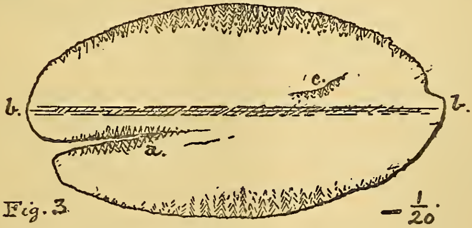
(*a*) In the case of large, strong, well-developed cones, often four or five inches in length (see Fig. 1), and generally composed of compact siliceo-ferruginous sandstone in the Coal-measures, which I will call 'master cones' because they seem to cut out the feebly developed ones in their upward expanding growth; the walls, or substance of the cones, or conical-shaped cups or portions of such (for whole hollow cones are rarely met with), often as much as a quarter of an inch in thickness between the usual concentric layers of corrugations more or less filled with clayey material, are themselves composed of cone-in-cone formation (also possessing their clay-filled serrations); the bases of the cones abutting upwards upon the clay wrinkles which separate each great cone or part of a cone. A reference to

Fig. 2 will probably better explain what is intended to be noticed above. It represents a portion of a vertical section of one of the master cones enlarged about four times. The specimen is from a bed of clay-ironstone occurring above the fire-clays of the Western division of the Leicestershire Coal-field — a horizon which has furnished the writer with more than one illustration of the way in which cone-in-cone structure occurs.

But further, I would point out that the concentric serrations between the cones, and shown as adhering to the exterior surface of one of them at *c*, Fig. 2, are also composed of scaly or semi-cone-in-cone structure. This, though of minute development, can readily be detected with a pocket lens, especially upon partially weathered samples. The bases of these tiny flakes seem to terminate against the serrations of the master cones, and upon the sides of the cone-structure forming their walls (see Fig. 2). In short, this specimen (and doubtless it is a typical one) appears to be wholly built up of 'cone-in-cone,' of at least three separate and distinct developments, *a*, *b*, and *c*. For this curious three-fold structure I fail to see how the ebullition-of-gases theory can satisfactorily account.

With reference to the question of cone-in-cone found upon the under as well as the upper surface of a stratum or a concretionary mass, Mr. Young would have us believe that when this does occur it has probably been due to the shrinkage of the mass, such contraction having actually carried the coned surface round to the underside. I think the following instances of reversed or double cone-in-cone at once upset his theory.

(*b*) In a stratum of blue shale or 'bind' at the village of Donisthorpe in the Leicestershire Coal-field, occur some large concretionary masses—often several tons in weight—of hard and compact fine-grained siliceo-ferruginous sandstone, locally called 'cank,' whose upper and lower surfaces are often largely covered with cone-in-cone formation. That upon the under surface, however, is always the most feebly developed. Now, as the coned surfaces are always most strongly formed in the centre of the mass, or, in other words, as the edges towards *b b* (see Fig. 3, which represents a transverse section) are almost devoid of cone structure, it is at once apparent that the cones upon the under side cannot have been brought into their present position by any known process of shrinkage or curling up, or downwards, of the nodules. Besides, in one instance, we have at *a*,



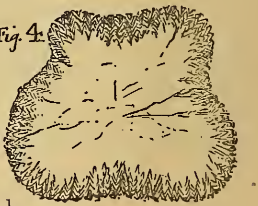
a double cone-in-cone development on the surfaces of a large crack or cavity in the side of the specimen; whilst at *c*, in the interior of the same nodule, occurs a small and rather feeble development of the same structure, in no way connected with the top and bottom cone-in-cone layers. Again, as the band marked *b b*, which is a layer of three or four inches of argillaceous ironstone, is crowded with well-preserved leaflets of *Neuropteris gigantea*, surely these organic remains must have greatly suffered had contraction of the mass taken place to any extent, which is not the case.

(*c*) Very good hand-samples of whole disc-shaped clay-ironstone nodules, exhibiting on both flat surfaces well-formed cone-in-cone structure, are preserved in the Geological Museum of Owens College, Manchester, and here again we find that this structure is much more strongly developed on one side than on the other, and that the coned surfaces are confined to the central parts of the nodules, as shown in Fig. 3, which is roughly half the size of the Manchester specimens. As these nodules were not labelled, I cannot give their locality, etc.

(*d*) In the Museum of the Yorkshire College of Science, Leeds, there is a small specimen of earthy limestone from the Wealden beds, Brixton Bay, Isle of Wight, upon whose upper and lower surfaces cone-in-cone formation is seen—very minute upon the underside—the upper one commencing in contact with a layer of fossil bivalve shells whose uneven surface corresponds with that of the apices of the cones.

(*e*) I have quite recently noticed in the shale "baring" of the fire-clay opencast workings in the Leicestershire Coal-field singular nodular masses of hard flinty fine-grained stone (a worthless variety of clay-ironstone), one of which is shown in cross-section in Fig. 4. Upon the surface of this specimen the cone-structure has the appearance of having been subjected to considerable shrinkage, as the cones or rather wedge-shaped scales of cone-in-cone structure, occur in curious wrinkles or ridges upon the general surface of the stone. As these singular examples were not seen *in situ*, I cannot say which sides were uppermost in the shale.

Fig. 4.



$\frac{1}{10}$

(*f*) Again, occurring in the same stratum are some large concretionary somewhat tabular-shaped masses of the same kind of rock as that last noticed, and having a kind of clay-ironstone band running through their centres (see Fig. 5). These nodules are sometimes several tons in weight. Now, forming the entire upper *and lower* portions of these singular stones are cone-in-cone structures as shown in the sketch; and occupying zones lying between the cone-in-cone portions and the rather sharp edges or peripheries of the masses, both upon upper *and lower* surfaces, are formations of innumerable little spheres or spherulitic concretionary masses, and, as it were, grown together,—very perfect and distinct upon the surface, but rapidly dying out towards the interior of the stone, and apparently grading into the cone-in-cone formation on the one hand and disappearing in the opposite direction, namely :—towards the periphery of the nodule (see Fig. 5).

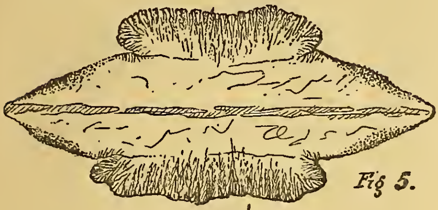


Fig 5.

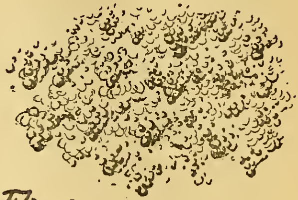


Fig 6.

A peculiarity in the appearance or arrangement of this spherulitic structure is that the surface of it often takes a beautiful wavy or fantastic stalagmitic form, giving the idea that the substance of the structure was in a semi-fluid condition during formation of the botryoidal structure. The aspect is not altogether unlike a number of flat bunches of very small grapes, disposed in more or less regular rows or terraces one above another (see Fig. 6). The globules or spheres forming the apices or lowest points of these little wavy ridges are always the largest or most perfectly developed of the individual groups or bunches. These tiny spheres contain a considerable percentage of lime, as do the cone-in-cone masses which are encircled by them.

With respect to the mineral constituents of cone-in-cone rock, Mr. Young seems to hold that calcareous matter was essential to its existence. As many of my specimens are not affected by the acid test, the lime, if originally present, has been since removed.

It may be interesting to remark here, that cone-in-cone structure occurs in the Upper Cambrian rocks—the Skiddaw slates—near Shap. Were it necessary, I could instance other interesting examples of cone formation, but from what has been said it will be obvious that, notwithstanding my admission of Mr. Young's perseverance and care in having worked out so much and given a very reasonable explanation of cone-in-cone, which, had it not been for the discovery of the double and the complicated instances, I should certainly have accepted as the probable correct one, I am compelled to discard it as not being sufficient to account for all the observed facts.

It is exceedingly improbable that this kind of cone-in-cone structure can have been formed in one way as regards the upper layers of it; and in another way as to those found with their bases pointing downwards. I myself have no explanation to advance. The structures observed are, however, very complex, they seem to deserve a closer examination than they have yet been subjected to, not in the field only, but in the laboratory and also microscopically.

Fig. 1, natural size. Vertical section of portion of three 'master' cones.

Fig. 2, × 4. Enlarged view of part of a 'master' cone. *a.* showing the cone structure in its walls. *b.* and *c.* the semi-cone formation of the clay serrations on the back of the 'master' cone.

Fig. 3, one-twentieth natural size. Transverse section of a large concretionary mass of compact siliceous ironstone, exhibiting cone-in-cone structure upon both upper and under surfaces, as well as in the interior of the mass, at *a* and *c*. The band *b*, *b*, is clay ironstone crowded with leaflets of *Neuropteris gigantea*.

Fig. 4, one-tenth natural size. Transverse section of a nodule of compact siliceous ironstone, entirely coated with cone-in-cone structure.

Fig. 5, one-tenth natural size. Transverse section of a large concretionary mass of close-grained ferruginous sandstone exhibiting cone-in-cone structure upon upper and under surfaces, and also a peculiar double arrangement of a spherulitic formation surrounding the cone-in-cone areas.

Fig. 6, one-twentieth natural size. Shows the appearance, on the surface of nodule in Fig. 5, of the spherulitic structures occupying the areas surrounding the cone-in-cone masses.

## IV.—ON A DIAMANTIFEROUS PERIDOTITE, AND THE GENESIS OF THE DIAMOND.

By Prof. H. Carvill Lewis, M.A., F.G.S.

(Abstract of a Paper read at the Birmingham Meeting of the British Association for the Advancement of Science, September, 1886.)

THE discovery of diamonds at Kimberley, South Africa, has proved to be a matter, not only of commercial, but of much geological interest. The conditions under which diamonds here occur are unlike those of any other known locality, and are worthy of special attention.

The first diamond found in South Africa was in 1867, when a large diamond was picked out of a lot of rolled pebbles gathered in the Orange river. This led to the "river diggings" on the Orange and Vaal rivers, which continue to the present time.

In 1870, at which time some ten thousand persons had gathered along the banks of the Vaal, the news came of the discovery of diamonds at a point some fifteen miles away from the river, where the town of Kimberley now stands. These were the so-called "dry diggings," at first thought to be alluvial deposits, but now proved to be volcanic pipes of a highly interesting character. Four of these pipes or necks, all rich in diamonds, and of similar geological structure, were found close together. They have been proved to go down vertically to an unknown depth, penetrating the surrounding strata.

The diamond-bearing material at first excavated was a crumbling yellowish earth, which at a depth of about 50 feet became harder and darker, finally acquiring a slaty blue or dark green colour and a greasy feel, resembling certain varieties of serpentine. This is the well-known "blue ground" of the diamond miners.

It is exposed to the sun for a short time, when it readily disintegrates, and is then washed for its diamonds. This "blue ground" has now been penetrated to a depth of 600 feet, and is found to become harder and more rock-like as the depth increases.

Quite recently, both in the Kimberley and De Beers mines, the remarkable rock has been reached, which forms the subject of the present paper.

The geological structure of the district and the mode of occurrence of the diamond has been well described by several observers. As Griesbach, Stow, Shaw, Rupert Jones, and others have shown, the diamond-bearing pipes penetrate carbonaceous strata of Triassic age, which are known as the Karoo formation.

The Karoo beds contain numerous interstratified sheets of dolerite and melaphyre, also of Triassic age, and the whole reposes upon ancient mica-schists and granites. The careful investigations of Mr. E. J. Dunn demonstrate that the diamond-bearing pipes inclose fragments of all these rocks, which fragments show signs of alteration by heat. Where the pipes adjoin the Karoo shales, the latter are bent sharply upwards, and the evidence is complete that the diamond-bearing rock is of volcanic origin, and of Post-Triassic age.

The diamonds in each of the four pipes have distinctive characters of their own, and are remarkable for the sharpness of their crystalline form (octahedrons and dodecahedrons), and for the absence of any signs of attrition. These facts, taken in connection with the "blue ground," indicate, as Mr. Dunn has pointed out, that the latter is the original matrix of the diamond.

Maskelyne and Flight have studied the microscopical and chemical characters of the "blue ground," and have shown that it is a serpentinic substance containing bronzite, ilmenite, garnet, diallage, and "vaalite" (an altered mica), and is probably an altered igneous rock, the decomposed character of the material examined preventing exact determination of its nature. They showed that the diamonds were marked by etch figures, analogous to those which Prof. Gustav Rose had produced by the incipient combustion of diamonds, and that the "blue ground" was essentially a silicate of magnesium impregnated with carbonates.

The "blue ground" often contains such numerous fragments of carbonaceous shale as to resemble a breccia. Recent excavations have shown that large quantities of this shale surround the mines, and that they are so highly carbonaceous as to be combustible, smouldering for long periods when accidentally fired. Mr. Paterson states that it is at the outer portions of the pipes where the "blue ground" is most heavily charged with carbonaceous shale, that there is the richest yield of diamonds.

Mr. Dunn regards the "blue ground" as a decomposed gabbro, while Mr. Hudleston, Prof. Rupert Jones, and Mr. Davies regard it as a sort of volcanic mud. Mr. Hudleston considers that the action was hydrothermal rather than igneous, the diamonds being the result of the contact of steam and magnesian mud under pressure upon the carbonaceous shales, and compares the rock to a "boiled plum-pudding."

The earlier theories as to the origin of the diamond have, in the light of new facts, quite given way to the theory that the diamonds were formed in the matrix in which they lie, and that the matrix is in some way of volcanic origin, either in the form of mud, ashes, or lava.

The exact nature of this matrix becomes, therefore, a matter of great interest. The rocks now to be described are from the deeper portions of the De Beers mine, and were obtained through the courtesy of Mr. Hedley. They are quite fresh, and less decomposed than any previously examined. Two varieties occur, the one diamantiferous, the other free from diamonds, and the lithological distinction between them is suggestive. The diamantiferous variety is crowded with included fragments of carbonaceous shale, while the non-diamantiferous variety is apparently free from all inclusions, and is a typical volcanic rock.

Both are dark, heavy, basic rocks, composed essentially of olivine, and belong to the group of peridotites. Both are of similar structure and composition, differing only in the presence of inclusions. The rock consists mainly of olivine crystals lying porphyritically in a serpentinic ground-mass.

The olivine is remarkably fresh, and occurs in crystals which are generally rounded by subsequent corrosion. The principal accessory minerals are biotite and enstatite. The biotite is in crystals, often more or less rounded, and sometimes surrounded by a thin black rim, due to corrosion. Similar black rims surround biotite in many basalts. The biotite crystals are usually twinned according to the base. The enstatite is clear and non-pleochroic. Garnet and ilmenite also occur, the former sometimes surrounded by biotite, and the latter often partly altered to leucoxene. All these minerals lie in the serpentinic base, originally olivine. This rock appears to differ from any heretofore known, and may be described as a saxonite porphyry in which the base is not holocrystalline.

The diamond-bearing portions often contain so many inclusions of shale as to resemble a breccia, and thus the lava passes by degrees into tuff or volcanic ash, which is also rich in diamonds, and is more readily decomposable than the denser lava.

It seems evident that the diamond-bearing pipes are true volcanic necks, composed of a very basic lava associated with a volcanic breccia and with tuff, and that the diamonds are secondary minerals produced by the reaction of this lava, with heat and pressure, on the carbonaceous shales in contact with and enveloped by it.

The researches of Zirkel, Bonney, Judd, and others, have brought to light many eruptive peridotites, and Daubree has produced artificially one variety (lherzolite) by dry fusion, but this appears to be the first clear case of a peridotite volcano with peridotite ash.

Perhaps an analogous case is in Elliott County, Kentucky, where Mr. J. S. Diller has recently described an eruptive peridotite which contains the same accessory minerals as the peridotite of Kimberley, and also penetrates and incloses fragments of carboniferous shale, thus suggesting interesting possibilities.[1]

## V.—NOTE ON A BED OF RED CHALK IN THE LOWER CHALK OF SUFFOLK.

(A paper read before the British Association, Birmingham.)

By A. J. JUKES-BROWNE, B.A., F.G.S.

THE section exposing this stratum was discovered during an excursion made last June by Mr. W. Hill, F.G.S., and the author. It occurs in a quarry near West Row Ferry, about two miles west of Mildenhall;

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[1] Since this paper was read, additional evidence that diamonds originate by the action of peridotites on carbonaceous rocks has been collected from many localities. The most instructive examples are from New South Wales, where the diamond gravels lie near the contact of basalts or serpentine with Carboniferous rocks, the serpentine here being an altered olivine enstatite rock. At the Bingera diamond-field a mass of eruptive serpentine is almost surrounded by Carboniferous rocks containing coal-seams. In Western America, also, the diamantiferous gravels are near higher ground, where serpentines and carbonaceous rocks occur together. Possibly a clue may be thus afforded for more systematic search.

here a band of red marly chalk is seen near the entrance, dipping westward at a low angle, but soon becoming horizontal and running along the whole face of the quarry, till it is cut off by a fault, which brings up lower beds on the southern side.

The complete section at the deepest part of the pit, not far from the entrance, is as follows:—

| | Feet. |
|---|---|
| Soil and rubble of yellowish chalk ... ... ... ... ... ... ... | 4 |
| Pink marly chalk, weathering into yellow rubble towards the outcrop ... ... ... ... ... ... ... ... ... ... ... ... ... | 3 |
| Hard nodular grey chalk ... ... ... ... ... ... ... ... ... | 2½ |
| Grey shaly chalk ... ... ... .. ... ... ... ... ... ... ... | 2 |
| Very hard grey nodular and gritty chalk, containing large *Ammonites*, *Belemnitella plena, and Terebratula semiglobosa*... ... ... | 1 |
| Thin-bedded whitish chalk (*O. vesicularis*) ... ... ... ... ... | 2½ |
| Hard greyish chalk ... ... ... ... ... .. ... ... ... ... | 2 |
| Softer thin-bedded chalk (*Holaster subglobosus*) ... ... ... ... | 6 |
| Hard lumpy yellowish rock ... ... ... ... ... ... ... ... | 0½ |
| | 23½ |

At the western end of the pit, where the red band is further from the surface, the following is the section exposed:—

| | Feet. |
|---|---|
| Chalky soil ... .. ... .. ... ... ... ... ... ... ... ... ... | 1 |
| Rough yellowish gritty chalk ... ... ... ... ... ... ... ... | 4 |
| Red marly chalk, brick-red at the top, pink below, and passing down into grey marly chalk with hard lumps ... ... ... ... | 5 |
| Hard grey rocky and nodular chalk ... ... ... ... ... ... ... | 2 |
| Soft grey shaly chalk, seen for ... ... ... ... ... ... ... ... | 1 |
| | 13 |

The red chalk breaks into small angular blocks, the edges of which are pinkish white, and all the joint-planes are bordered by whitish bands, about a third of an inch thick; facts which seem to indicate that the percolation of water from the surface has effected a certain amount of decoloration, and that the whole was originally of one uniform colour, darkest at the top, and becoming lighter in tint towards the base.

With regard to the stratigraphical position of these beds, we ascertained that the quarry lies between the outcrops of the Totternhoe Stone and the Melbourn Rock, and is opened in a shallow synclinal trough, so that there must be an anticlinal to the east of the pit and a second outcrop of the red chalk with an easterly dip along a line nearer to Mildenhall, but of this no indication was found. The Totternhoe Stone is found at Isleham, and traces of it occur near West Row, about three-quarters of a mile N.W. of the "red chalk quarry"; the Melbourn Rock is seen between Worlington and Mildenhall, and its outcrop appears to run round Mildenhall at a distance of about a mile and a half from West Row Ferry. *Holaster subglobosus* is found in the lower part of the section at West Row, and the occurrence of typical *Belemnitella plena* points to a high horizon in that zone; the existence of this Belemnite here is indeed an interesting and noteworthy fact, for the typical forms have never yet been found in Suffolk or Cambridge, except at the very summit of the Lower Chalk, From the red chalk itself we obtained no fossils. It is clear, therefore, that the horizon of the red band is about the centre of the zone of

*Holaster subglobosus*, and at least 100 feet above the base of the Chalk Marl; and, further, that it has no connection whatever with the red rock which forms the base of the Chalk at Hunstanton and in Lincolnshire.

It is well known, however, that the Lower Chalk of Lincolnshire contains two other bands of red chalk, and the author's examination of this district for the Geological Survey enables him to compare the Suffolk and Lincolnshire sections in detail. The following account of the Lincolnshire beds is given with the permission of the Director-General, and in anticipation of the Explanation of the Survey Map (Sheet 84), which is now in the press.

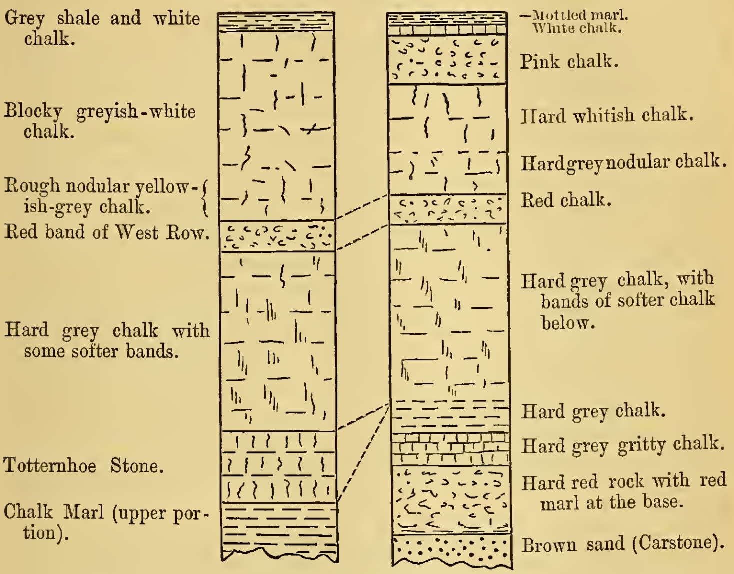
In Lincolnshire, as at Hunstanton, the red (Hunstanton) rock forms the basement bed of the Chalk, and is overlain by four or five feet of hard grey sandy chalk (Inoceramus beds). These are succeeded by about 70 feet of grey chalk with many layers of hard nodular rocky chalk, and including two bands of pink chalk, one (the lower) being in some places of a decided red colour, while the upper band is generally of a yellowish pink tint. The lower band is of a loose and marly nature inclosing hard lumps, which are generally of a lighter tint inside; it varies in thickness from 4½ to 7 feet, and sometimes it is only the central part of the band which is of a decided red colour, the upper and lower parts shading into pink and grey; *Holaster subglobosus* occurs both in and below this band, together with a few other fossils, but *Belemnitella plena* has not yet been found in Lincolnshire. The upper band consists of much harder and more evenly bedded chalk; it is generally about seven feet thick, and varies in tint from light-pink to yellowish-white; it is overlain by a course of hard white chalk surmounted by a band of soft mottled marl, which is usually two feet thick, and exhibits tints of red, grey, and buff. Above this are beds of hard yellowish-white chalk, which seem to represent the Melbourn rock; these contain *Inoceramus mytiloides* and *Rhynchonella Cuvieri*.

From the above description it will be seen that the West Row bed closely resembles the lower of the two red bands which are seen in the quarries near Louth, and as this occurs very nearly on the same horizon, I have little hesitation in correlating them with one another as homotaxial beds, though they may not be identical, because they do not appear to be continuous across the intervening space in Norfolk and Lincolnshire.

Figs. 1 and 2 are comparative vertical sections, showing the position of these bands of red chalk in Suffolk and Lincolnshire, both being drawn to a scale of 16 feet to the inch; the exact distance of the West Row chalk below the Melbourn rock can only be estimated approximately, but the Lincolnshire section is drawn from actual measurements taken in quarries at Louth. The upper portions of the two sections are similar, but the lower parts are very different. The base of the Chalk Marl is not seen in Suffolk, but the Marl is known to be between 60 and 70 feet thick, whereas in Lincolnshire there is only some 20 feet of grey and red chalk to represent the combined thickness of the Totternhoe Stone, Chalk Marl and Gault.

With regard to the horizontal extension of the red chalk in Suffolk we obtained but little evidence. North of Mildenhall there is either a cross fault or a decided sinking of the beds in the direction of the strike, so that near Lakenheath the whole of the Lower Chalk lies below the surface of the Fens. The valley of the Little Ouse or Brandon River appears, however, to coincide with a line of fault, for the Lower Chalk comes to the surface again on the north side of the valley by Hockwold and Feltwell in Norfolk, and rises to a height of at least 60 feet above the level of the fen.

FIG. 1. SUFFOLK. FIG. 2. LINCOLNSHIRE.



Scale—32 feet to one inch.

At Feltwell we were fortunate enough to find a small exposure of reddish chalk in the bank of a dry pond by the roadside, a quarter of a mile N.E. of St. Mary's Church; as it overlies a band of very hard nodular rock, below which a softer greyish white chalk is visible, there can be little doubt that it is the same band of red chalk, and that the section here is similar to that at West Row.

Beyond this we did not meet with any indications of red chalk, but it is quite possible for the band to extend some distance farther north without being seen, for large areas are covered with glacial and post-glacial deposits, and the pits near Stoke-Ferry are all either above or below the horizon on which I have placed this particular band.

At the same time it should be mentioned that the red bands in the Lincolnshire chalk only extend over an area of 12 or 15 miles in length, and are not found at the southern extremity of the Wolds. Whether they are really absent over the intervening space, or whether the beds themselves continue, but gradually lose their distinctive colour, and so become indistinguishable from the rest of the grey chalk, is a difficult point to decide, and one upon which I do not at present offer an opinion.

It only remains to add that nothing like the uppermost pink band of Lincolnshire was seen either in Suffolk or Norfolk, all the quarries exposing the horizon where it would occur exhibiting only whitish chalk, passing down gradually into grey chalk.

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## VI.—COMPARATIVE STUDIES UPON THE GLACIATION OF NORTH AMERICA, GREAT BRITAIN, AND IRELAND.

By PROF. H. CARVILL LEWIS, M.A., F.G.S.

(Abstract of a paper read at the Birmingham Meeting of the British Association, September, 1886.)

OBSERVATIONS extending over several years upon glacial phenomena on both sides of the Atlantic had convinced the author of the essential identity of these phenomena; and the object of this paper was to show that the glacial deposits of Great Britain and Ireland, like those of America, may be interpreted most satisfactorily by considering them with reference to a series of great *terminal moraines* which both define confluent lobes of ice and also often mark the line separating the glaciated from the non-glaciated areas.

The paper began with a sketch of recent investigations upon the glaciation of North America, with special reference to the significance of the terminal moraines discovered within the last few years. The principal characters of these moraines were given, and a map was exhibited showing the extent of the glaciated areas of North America, the course of the interlobate and terminal moraines, and the direction of striation and glacial movement. It was shown that apart from the great ice-sheet of North-eastern America, an immense lobe of ice descended from Alaska to Vancouver's Island on the western side of the Rocky Mountains, and that from various separate centres in the Cascade, Sierra Nevada, and Rocky Mountains, there radiated smaller local glaciers.

The mountains encircling the depression of Hudson Bay seemed to be the principal source of the glaciers which became confluent to form the great ice-sheet. In its advance this ice-sheet probably met and amalgamated with a number of already existing local glacial systems, and it was suggested that there was no necessity for assuming either an extraordinary thickness of ice at the Pole, or great and unequal elevations and depressions of land.

Detailed studies made by the author in Ireland in 1885 had shown remarkably similar glacial phenomena.

The large ice-sheet which covered the greater part of Ireland was composed of confluent glaciers, while distinct and local glacial systems occurred in the non-glaciated area. The principal ice-sheet resembled that of America in having for its centre a great inland depression surrounded by a rim of mountains.

These appear to have given rise to the first glaciers, which after uniting poured outwards in all directions. Great lobes from this ice-sheet flowed westward out of the Shannon and out of Galway, Clew, Sligo, and Donegal Bays, northwards out of Loughs Swilly and Foyle, and south-eastward out of Dundalk and Dublin Bays; while to the south the ice-sheet abutted against the Mullaghareik, Galty, and Wicklow mountains, or died out in the plains.

Whether it stopped among the mountains or in the lowlands, its edge was approximately outlined by unusual accumulations of drift and boulders, representing the terminal moraines. As in America, this outer moraine was least distinct in the lowlands, and was often bordered by an outer fringe of drift several miles in width.

South of an east and west line extending from Tralee to Dungarvan is a non-glaciated zone free from drift. Several local systems of glaciers occur in the south of Ireland, of which by far the most important is that radiating from the Killarney mountains, covering an area of 2000 square miles, and entitled to be called a local ice-sheet. Great glaciers from this Killarney ice-sheet flowed out of the fiord-like parallel bays which indent the south-westernmost coast of Ireland. At the same time the Dingle mountains, the Knockmealdown and Comeragh mountains, and those of Wexford and Wicklow furnished small separate glaciers, each sharply defined by its own moraine.

No evidence of any great marine submergence was discovered, although the author had explored the greater part of Ireland, and the eskers were held to be phenomena due to the melting of the ice-sheet and the circulation of subglacial waters. The Irish ice-sheet seemed to have been joined at its north-eastern corner by ice coming from Scotland across the North Channel. All the evidence collected indicates that a mass of Scotch ice, reinforced by that of Ireland and England, filled the Irish Sea, over-riding the Isle of Man and Anglesey, and extending at least as far south as Bray Head, south of Dublin. A map of the glaciation of Ireland was exhibited, in which the observations of the Irish geologists and of the author were combined, in which was shown the central sheet, the five local glacial systems, all the known striæ, and the probable lines of movement as indicated by moraines, striæ, and the transport of erratics.

The glaciation of Wales was then considered. Wales was shown to have supported three distinct and disconnected local systems of glaciers, while at the same time its extreme northern border was touched by the great ice-lobe of the Irish Sea. The most extensive local glaciers were those radiating from the Snowdon and Arenig region, while another set of glaciers radiated from the Plinlimmon district and the mountains of Cardiganshire, and a third system originated among the Brecknockshire Beacons. The glaciers from each of these centres transported purely local boulders and formed well-defined terminal moraines. The northern lobe, bearing granite boulders from Scotland and shells and flints from the bed of the Irish Sea, invaded the northern coast, but did not mingle with the Welsh glaciers. It smothered Anglesey and part of Carnarvonshire on the one side and part of Flintshire on the other, and heaped up a terminal moraine on the outer flanks of the north Welsh mountains. This great moraine, filled with far travelled northern erratics, is heaped up in hummocks and irregular ridges, and is in many places as characteristically developed as anywhere in America. It has none of the characters of a sea-beach, although often containing broken shells brought from the Irish Sea. It may be followed from the extreme end of the Lleyn Peninsula (where it is full of Scotch granite erratics), in a north-easterly direction through Carnarvonshire, past Moel Tryfaen, and along the foot of the mountains east of Menai Strait to Bangor, where it goes out to sea, re-appearing further east at Conway and Colwyn. It turns south-eastward at Denbighshire, going past St. Asaph and Halkin mountain. In Flintshire it turns southward and is magnificently developed on the eastern side of the mountains, at an elevation of over 1000 feet between Minera and Llangollen, south-west of which place it enters England. There is evidence that where the ice-sheet abutted against Wales, it was about 1350 feet in thickness. This is analogous to the thickness of the ice-sheet in Pennsylvania, where the author had previously shown that it was about 1000 feet in thickness at its extreme edge and 2000 feet thick at points some eight miles back from its edge. The transport of erratics coincides with the direction of striæ in Wales as elsewhere, and is at right angles to the terminal moraines.

The complicated phenomena of the glaciation of England, the subject of a voluminous literature and discordant views, had been of high interest to the author, and had led him to redouble his efforts towards its solution. He had found that it was possible to accurately map the glaciated areas, to separate the deposits made by land-ice from those due to icebergs or to torrential rivers, and to trace out a series of terminal moraines both at the edge of the ice-sheet, and at the edge of its confluent lobes. Perhaps the finest exhibition of a terminal moraine in England is in the vicinity of Ellesmere in Shropshire. A great mass of drift several miles in width, and full of erratics from Scotland and from Wales, is here heaped into conical hills which enclose "kettleholes" and lakes, and have all the characters of the "kettle moraine" of Wisconsin. Like the latter, the Ellesmere moraine here divides two great lobes of ice, one coming from Scotland, the other from Wales. This moraine may be traced continuously from Ellesmere eastward through Madeley, Macclesfield, to and along the western flank of the Pennine chain, marking throughout the southern edge of the ice-sheet of northern England. From Macclesfield the same moraine was traced northward past Stockport and Staley Bridge to Burnley, and thence to Skipton in Yorkshire. North-east of Burnley it is banked against the Boulsworth Hills up to a height of 1300 feet in the form of mounds and hummocks. South and east of this long moraine no signs of glaciation were discovered, while north and west of it there is every evidence of a continuous ice-sheet covering land and sea alike. The striæ and the transport of boulders agree in proving a southerly and south-easterly direction of ice-movement in Lancashire and Cheshire.

From Skipton northward the phenomena are more complicated. A tongue of ice surmounted the watershed near Skipton, and protruded down the valley of the Aire as far as Bingley, where its terminal moraine is thrown across the valley like a great dam, reminding one of similar moraine dams in several Pennsylvania valleys. A continuous moraine was traced around this Aire glacier. Another greater glacier, much larger than this, descended Wensleydale and reached the plain of York. The most complex glacial movements in England occurred in the mountain region about the Nine Standards, where local glaciers met, and were overpowered by the greater ice-sheet coming down from Cumberland. The ice-sheet itself was here divided, one portion going southward, the other in company with local glaciers, and laden with the well-known boulders of the "Shap granite," being forced eastward across Stainmoor Forest into Durham and Yorkshire, finally reaching the North Sea at the mouth of the Tees. The terminal moraine runs eastward through Kirkby Ravensworth towards Whitby, keeping north of the Cleveland Hills, and all eastern England south of Whitby, except Holderness, appears to be non-glaciated. On the other hand, all England north of Stainmoor Forest and the River Tees, except the very highest points, was smothered in a sea of ice.

There is abundant evidence to prove that the ice lobe filling the Irish Sea was thicker towards its axis than at its edges, and at the north at its southern terminus, and that it was reinforced by smaller tributary ice-streams from both England and Ireland. It may be compared with the glacier of the Hudson River valley in New York, each having a maximum thickness of something more than 3000 feet. The erosive power of the ice-sheet was found to be extremely slight at its edge, but more powerful farther north, where its action was continued for a longer period. Towards its edge its function was to fill up inequalities rather than to level them down. It was held that most glacial lakes are due to an irregular dumping of drift, rather than to any scooping action, observations in England and in Switzerland coinciding with those in America to confirm this conclusion. Numerous facts on both sides of the Atlantic indicate that the upper portion of the ice-sheet may move in a different direction from its lower portion. It was also shown that a glacier in its advance had the power of raising stones from the bottom to the top of the ice, a fact due to the retardation by friction of its lower layers. The author had observed the gradual upward passage of sand and stones in the Grindelwald glacier, and applied the same explanation to the broken shells and flints raised from the bed of the Irish Sea to the top of Moel Tryfaen, to Macclesfield and to the Dublin mountains. The occurrence of stratified deposits in connection with undoubted moraines was shown to be a common phenomenon, and instances of stratified moraines in Switzerland, Italy, America, and Wales were given. The stratification is due to waters derived from the melting ice, and is not proof of submergence. It was held that, notwithstanding a general opinion to the contrary, there is no evidence in Great Britain of any marine submergence greater than about 450 feet. It was natural that an ice-sheet advancing across a sea should deposit shell fragments in its moraine.

The broad principle was enunciated that wherever in Great Britain marine shells occur in glacial deposits at high levels,[1] it can be proved both by striæ and the transport of erratics that the ice advanced on to the land from out of the sea. The shells on Three Rock Mountain near Dublin, and in North Wales and Macclesfield, all from the Irish Sea; the shells in Cumberland transported from Solway Firth; those on the coast of Northumberland brought out of the North Sea; those

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[1] *i.e.* higher than about 450 feet.

at Airdrie in Scotland carried eastward from the bottom of the Clyde; and those in Caithness from Moray Firth, were among examples adduced in proof of this principle. The improbability of a great submergence not leaving corresponding deposits in other parts of England was dwelt upon.

It was also held that there was insufficient evidence of more than one advance in the ice-sheet, although halts occurred in its retreat. The idea of successive elevations and submergences with advances and retreats of the ice was disputed, and the author held that much of the supposed interglacial drift was due to subglacial water from the melting ice.

The last portion of the paper discussed the distribution of boulders, gravels, and clays south of the glacial area. Much the greater part of England was believed to have been uncovered by land-ice. The drift deposits in this area were shown to be the result in part of great freshwater streams issuing from the melting ice-sheet, and in part of marine currents bearing icebergs during a submergence of some 450 feet. The supposed glacial drift about Birmingham, and the concentration of boulders at Wolverhampton, were regarded as due to the former agent; while the deposits at Cromer and the distribution of Lincolnshire chalk across southern England was due to the latter. The supposed esker at Hunstanton was believed to be simply a sea-beach, and the London drift deposits to be of aqueous origin. Thus the rival theories of floating icebergs and of land glaciers were both true, the one for middle and southern England, the other for Scotland, Wales, and the north of England; and the line of demarcation was fixed by great terminal moraines. The paper closed with an acknowledgment of indebtedness to the many geologists of England and Ireland, who had uniformly rendered generous assistance during the above investigation.

## VII.—Note on the Facetted Pebbles from the Olive Group of the Salt Range, Punjab, India.

By R. D. Oldham, A.R.S.M.,
of the Geological Survey of India.

At the last meeting of the British Association certain facetted pebbles derived from the Olive group of the Salt Range, and presumably of glacial origin, were exhibited and commented on.[1] Some doubt appears to have been expressed as to their being due to glacial action. The following notes on these pebbles and the bed they were derived from may prove of interest.

The boulder bed of the Olive group in the Salt Range consists of a fine-grained, thin-bedded, shaly matrix, usually of that shade of green from which the name of the group is derived; through this are scattered blocks of hard crystalline and metamorphic rock, of all sizes, from an inch or less to several feet in diameter. They are too abundant for their occurrence to be explained by the action of drift wood, nor is there any sign of cabonaceous matter in the bed; there is no indication of volcanic action, and, as many of the fragments must have travelled scores, if not hundreds of miles, we are

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[1] See Geol. Mag. 1886, Decade III. Vol. III. pp. 492, 494, 574.

compelled to allow that their occurrence in their present position is primarily due to the action of floating-ice. So much has long been allowed by all who know the bed.

Of these blocks of stone an appreciable proportion show a flattened striated surface, exactly like that produced by glacial action; but a peculiarity of this boulder bed is that a very large proportion of those blocks which show this feature are not striated on a single face only, but on several; and in some cases the original form of the pebble is so completely obliterated, and the facets meet on so clean-cut an edge, that the pebble assumes almost the appearance of a crystal. Something similar to this is known in the Boulder-clay of England; instances were quoted at the British Association, and I have myself seen a pebble from the Boulder-clay of the Midland Counties so striated on three faces; but these surfaces did not meet in a sharp edge, like those so commonly met with in the Salt Range specimens.

Having shown that the occurrence of these pebbles in their present position is due to the action of floating-ice, we have next to consider whether their peculiar form is also due to the action of ice, and if so whether as coast-ice or in the form of a glacier.

A suggestion was made at the British Association that the facetting might be due to the action of wind-blown sand; this, however, I cannot admit. Without egotism I may say that I have had opportunities of studying the erosive action of blown sand such as fall to the lot of few geologists. I have seen numbers of stones facetted by the sand blown against their different faces as they were overturned from time to time through one cause or another; but I have never seen anything which, to a practised eye, resembled these Salt Range pebbles any more than these latter do a crystal of felspar.

Where blown sand acts on a rock sufficiently hard or fine-grained, a polished surface, marked with numerous fairly parallel scratches in the direction of the prevailing wind, is produced. These scratches, however, could not be confounded with glacial striæ; for they are such as would result from particles of grit getting into an artificial polisher, and are very different from the clean and finely-cut scratches produced by glacial action. Where the rock is softer, it is often cut into grooves parallel with the direction of the prevailing wind; these, too, are not like the grooving produced by ice, but broad shallow channels separated by sharp-crested ridges, giving the rock an appearance as if it had been roughly dressed with a carpenter's gouge. In any case there is an entire absence of anything approaching to a sharp edge except in the direction of the wind, all angles oblique or transverse to that being rounded off. Now the facetted pebbles and boulders of the Salt Range show by the direction of the striæ on them that in almost every case the facets are due to some cause acting in a direction more or less transverse to the line along which they meet; consequently the facets cannot be due to the action of blown sand, which would have rounded off any angle so situated with reference to the direction in which the sand was drifted.

The number of stones showing one or more striated surfaces prevents us from ascribing their origin to a movement of the soil-cap, while the steadiness of direction of the striæ on each face shows that the fragment must have been firmly held, and, in the case of the smaller ones, it is difficult to see how they could have been so held except by being imbedded in some material which, like ice, would adapt itself completely to the shape of the pebble.

The striated faces bear no resemblance to slickensides, and as the fragments seldom touch each other in the bed, but are separated by a greater or less thickness of the fine-grained matrix, any attempt to explain their origin by friction of the pebbles against each other subsequent to deposition is inadmissible; moreover, there is no exceptional disturbance of the beds, and the striated fragments are as common where they lie nearly horizontal as where they are tilted.

The only other agency by which the facets could have been produced is that which is at first sight suggested by the appearance of the pebbles, viz. *ice*, and it only remains to see whether this was in the form of coast-ice or glaciers. Here we must leave the domain of certainty, and enter on that of probability.

Prof. J. Milne has shown [1] that, as far as the live rock is concerned, many of the appearances usually considered characteristic of glacier action may be produced by coast-ice; but in the present case we are not concerned with what happens to the rock *in situ*, but with the effect produced on the loose pebbles and boulders caught up in the ice and ground on the solid rock. At first sight the number of striated faces on many of these pebbles would seem to point to the action of coast-ice, for, after every melting of the ice, the pebble would probably be fixed each winter in a fresh position, and offer a different face for abrasion; but it is doubtful whether the facets do not indicate a greater pressure and a greater constancy of direction of motion than could be given by coast-ice, and it is still more doubtful whether they could be produced during a single winter, which on this supposition is all that can be allowed for each facet.

A much stronger objection is the entire absence of any sign of the action of water on some of the pebbles. Had the facets been due to the action of coast-ice forming in winter and melting again in summer, the pebbles would every year have been exposed for a longer or shorter time to the action of waves, and the sharp, clean-cut junction of the facets which we find would have been more or less abraded; so that, if the shape of these pebbles is due to the action of coast-ice, it must have been perennial. I need but point out that coast-ice lasting through winter and summer implies a much severer climate than is needed to account for glaciers descending to the sea; *a priori* then the latter is the more probable hypothesis as requiring the least climatic change, besides being more in consonance with the evidence derived from the appearance and mode of occurrence of the boulders and pebbles showing signs of glacial action.

I have now shown that these boulder beds owe their origin primarily to the action of floating-ice, that the shape of the facetted fragments must be due to glacial action, that some at least of them

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[1] Geol. Mag. Dec. II. Vol. IV. p. 293 (1877).

can never have been exposed to the action of waves on a sea-beach, and that consequently they must have been shaped either by perennial coast-ice rising and falling with the tides, or by a glacier which descended to the sea and there gave off icebergs. In either case they imply a change of climate which, if we bear in mind that the fragments have all come from the southwards, and in many cases from long distances, is of a degree and kind difficult if not impossible to explain in accordance with accepted theories.

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## VIII.—The Lower Palæozoic Rocks near Settle.

By J. E. Marr, M.A., F.G.S.

THE rocks of this area have been previously described by Professor Hughes (Geol. Mag. Vol. IV.), and some notes upon the same were subsequently submitted by myself to the British Association at York in 1881, and published in the Proceedings of the Yorkshire Geological and Polytechnic Society (Proc. Y. G. & P. S. n.s. vol. vii.).

Further work was carried on this year, in company with a party of Cambridge geologists, under the guidance of Prof. Hughes, and I have to thank him and them for much information, and for the opportunity of examining many specimens.

Firstly, I would correct one or two errors in my previous paper.

In the section in Austwick Beck, a considerable thickness of black shales is indicated between the conglomerate and the calcareous band with *Phacops elegans*. These black shales are really below the conglomerate, which latter appears in each limb of the anticlinal represented in the section, though *much attenuated*, and the black shales have yielded Bala fossils, including *Orthis testudinaria*, Dalm.

The only deposit between the conglomerate and the bed with *Phacops elegans* consists of two or three inches of leaden-grey shales, in which no fossils have been yet found.

The beds marked 5 in the section already referred to, and described as pale green shales, are really a portion of the same series as 6, and contain identical fossils with it, and the difference of colour is simply due to weathering.

We must therefore strike the beds 3 and 5 out of the list of those which I correlated with the Stockdale shales (Valentian), and admit that these are represented at Austwick only by the conglomerate, the leaden-grey shales, and the zone of *Phacops elegans*. That these thin beds represent the whole of the Valentian of other areas is doubtful, and it is possible that the representatives of the Coniston mudstones are here absent, and that the pale slates only are represented. That this may be the case is further indicated by the fact that *Phacops elegans* does occur in the higher Valentian beds, as in the Tarannon shales of Onny River, for I have recognized this species in the Jermyn Street Museum from that locality.

I may now proceed to a more detailed description of the different deposits in ascending order, as seen in the small valley near Austwick, through which Crummack Beck runs, and in the main Ribble Valley to the north of Settle.

As I do not wish to introduce new names, I shall speak of the beds by the names given to similar beds in the Lake District, with which they have already been correlated, or ought, in our opinion, to be so.

A. *Coniston Limestone* series.—These beds are largely developed in the neighbourhood of Austwick. The probable succession is as follows:—

1. Calcareous blue shales, weathering olive-brown.
2. Ashes.
3. Blue, shivery shales.
4. Blue, flaggy, Brachiopod shales.

Conglomerate of succeeding series.

The calcareous blue shales (1) are well seen at the angle of the road below Norber Brow, where they are very fossiliferous. We have obtained from this locality the following fossils:—

*Diplograptus* (like *pristis*, His.).
*Dicellograptus anceps*, Nich.
*Stenopora* sp.
*Tentaculites anglicus*, Salt.
*Ateleocystites* sp.
*Trinucleus seticornis*, His.
*Dindymene ornata*, Linnrs. ?[1]
*Cybele Loveni*, Linnrs.
*Lichas laxatus*, M'Coy.
*Turrilepas*.
*Phacops* (*Pterygometopus*) sp.
*Leptæna transversalis*, Wahl.
,, *sericea*, Sow.
*Orthisina* sp.

The same beds appear to be represented in a stream south of Wharfe. From this locality fossils have been collected by the Rev. A. Pagan, amongst which are—

*Ateleocystites* sp.
*Phacops* (*Pterygometopus*) sp.

similar to those of Norber Brow.

The ashes (2) have as yet not furnished us with any fossils.

The blue shales (3) occur at Wharfe Mill Dam, and near a barn on the other side of the lane. In them we have found:—

*Trinucleus seticornis*, His.
*Illænus Davisii*, Salt.
*Calymene Blumenbachii*, Brongn.
*Leptæna transversalis*, Wahl.

The blue shales (4) which occur immediately below the conglomerate of Valentian age have yielded, as already stated, *Orthis testudinaria*, Dalm., along with a species of *Strophomena*.

B. *Stockdale Shale Series*.—I have nothing to add to the remarks made upon these beds, except to give a fuller list of fossils, which includes—

*Petraia*, sp.
*Phacops elegans*, Bœck & Sars.
*Cheirurus bimucronatus*, Murch.
*Encrinurus punctatus*, Brünn.
*Leptæna quinquecostata*, M'Coy.

All these occur in the thin bed of hard calcareous mudstone, which has been described as the zone of *Phacops elegans*, and which is almost entirely made up of fragments of Trilobites.

C. *Lower Coniston Flags*.—These beds immediately succeed the *Phacops elegans* zone of the preceding series, and are well developed in

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[1] A fine specimen of *Dindymene* was discovered by Mrs. T. McK. Hughes, which is unfortunately somewhat distorted by cleavage. Until other specimens are found we refer it provisionally to *D. ornata*, Linnrs., though it will probably have to be separated eventually. Only eight body-rings occur.

the Crummack Valley. They consist of laminated blue, slightly gritty flags, with

*Monograptus priodon*, Bronn.
*M. personatus*, Tullbg. ?
*M. cultellus*, Törnq.
*Retiolites Geinitzianus*, Barr.
*Orthoceras.*

D. *Grits.*—These beds, the Grits A c 2 of Prof. Hughes' section, are largely developed in both valleys. They have as yet furnished no fossils.[1]

E. *Upper Coniston Flags.*—Seen at Studrigg, on the east side of the Crummack Valley, and in Dryrigg, Arco Wood, and Combs Quarries in Ribblesdale. They resemble, in lithological characters, the Lower Coniston Flags, but the fossils are different.

At Studrigg *Monograptus Roemeri*, Barr., was found by one of Prof. Hughes' party, and the Ribblesdale quarries have yielded :—

*Monograptus colonus*, Barr.
,, *bohemicus*, Barr.
*Favosites fibrosus*, Goldf.
,, *alveolaris*, Goldf.
*Actinocrinus pulcher*, Salt.
*Pentamerus ?*
*Orthoceras primævum*, Forbes.
*Trochoceras giganteum*, Sow.

F. *Grits.* — Mentioned by Prof. Hughes as occurring above the Flags (E) at Studfold Low Pasture, on the east side of Ribblesdale. These are the highest Lower Palæozoic beds seen in this area.

*Comparison with other Areas.*—The general resemblance between the beds of this district and those of the Lake District, whether we take into account lithological or palæontological characters, is so striking, that there is little or no difficulty in correlating the beds of the two areas. The following table shows the probable equivalents :—

| SETTLE DISTRICT. | LAKE DISTRICT. |
|---|---|
| Coniston Limestone Series. | Coniston Limestone.[2] |
| Absent ?[3] | Ashgill shales. |
| Absent ? | Coniston Mudstones. |
| Conglomerate ? | Pale slates. |
| Phacops elegans zone ? | |
| Lower Coniston Flags. | Brathay Flags. |
| Grits. | Lower } Coldwell beds. |
| Moughton Whetstones ? | Middle |
| Upper Coniston Flags. | Upper Coldwell beds. |
| Grits (Studfold). | Coniston Grits. |

The most interesting feature of the rocks of the Settle District is the approach to the characters of the Scandinavian beds.

The Coniston Limestone series is much more shaly than the typical

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[1] It is possible that the remarkable whetstones near the head of the valley, which have not been detected in situ, are interstratified with the grits. Amongst the fossils contained therein are :—

*Monograptus dubius*, Suess.
*M. Nilssoni*, Barr.
*M. uncinatus*, Tullb. ?
*Orthoceras primævum*, Forbes.

[2] The beds with *Dicellograptus anceps* have not been detected in the Lake District proper, but similar beds occur at Melmerby Scar, on the west slope of the Pennines.

[3] Unless the beds with *Orthis testudinaria*, immediately below the conglomerate, are the equivalents of the Ashgill shales.

Coniston Limestone, and indeed is intermediate in lithological character between that Limestone and the Trinucleus Shales of Sweden. Palæontologically it is connected with the latter by the occurrence within it of *Diplograptus* like *pristis*, *Dicellograptus anceps*, *Trinucleus seticornis*, *Dindymene ornata ?*, *Cybele Loveni*, and *Turrilepas*.

The Lower Coniston Flags have the fauna of the Cyrtograptus Shales, though *Cyrtograptus* has not yet been found in them. Our fossils are derived from near the base of this series, and that they occur in beds about the horizon of the lower part of the Cyrtograptus Shales is possibly indicated by the occurrence of *Monograptus cultellus*, of which, however, only one specimen has hitherto been found in the Settle District. A further examination of these Lower Coniston Flags, at points more remote from the base, will probably be rewarded by the discovery of other species of Graptolites.

That the Moughton Whetstones are really intermediate in position between these Lower Coniston Flags and the flags in the quarries of Arco Wood, Dryrigg, etc., seems proved by the occurrence in them of *Monograptus dubius*, *M. uncinatus?* and *M. Nilssoni*, all of which are found at the base of the Cardiola beds of Sweden, whilst the higher parts of the Cardiola beds contain fossils identical with those of Arco Wood, etc., including *Monograptus colonus*, and *M. bohemicus*. The zone with *M. dubius*, etc., has, so far as I am aware, been hitherto unrecorded in Britain, and the probable corresponding beds in the Lake District are not of a nature suitable for the preservation of Graptolites.

The Swedish affinities of these Settle rocks will probably be further proved, when more work has been carried on in the district, and from the simplicity of the sections, the area can confidently be recommended to the notice of any geologist who wishes, by patient work, to assist in establishing the zones of the Lower Palæozoic rocks of our country.

## NOTICES OF MEMOIRS.

### PAPERS READ BEFORE SECTION C. (GEOLOGY) BRITISH ASSOCIATION MEETING, BIRMINGHAM, 1886.

### I.—MANGANESE MINING IN MERIONETHSHIRE. By C. LE NEVE FOSTER, D.Sc., F.G.S.

MANGANESE ore is now being worked in the Cambrian rocks at several places near Barmouth and Harlech. It occurs in the form of a bed varying from a few inches to three feet in thickness; the average thickness is one foot to one foot and a half. The undecomposed ore contains the manganese in the form of carbonate, with a small proportion of silicate; but at the outcrop it is changed into a hydrated black oxide. Some of the outcrops of the manganese bed are erroneously marked on the Geological Survey Maps as mineral veins, though Sir Andrew Ramsay was of opinion that the deposits were not true lodes. Recent workings show plainly that the deposits are truly stratified beds, or possibly various outcrops of one and the same bed, extending over a considerable area.

The ore contains from 20 to 35 per cent. of metallic manganese, and is despatched to Flintshire and Lancashire for the manufacture of ferro-manganese. The new Merionethshire mines are the first instance of workings for carbonate of manganese in the British Isles.

## II.—On the Stratigraphical Position of the Salt Measures of South Durham.

By G. A. Lebour, M.A., F.G.S., Professor of Geology in the Durham College of Science, Newcastle-upon-Tyne.

THE beds above the main mass of the Magnesian Limestone in Durham are seldom exposed at the surface, as the south of the country is covered by a thick spread of drift. The presence of salt deposits having, however, been proved some years ago in the adjoining part of Yorkshire near Middlesbrough, several borings for working them in the form of brine were soon put down in the flat country between the Tees and the coast south of Seaton Carew. There are now altogether some fifteen or sixteen such borings, most of which have reached beds of salt at depths varying from 600 feet to over 1200 feet. These have thrown much light upon the rocks, hitherto scarcely known in this part of England, which lie between the Rhætic and the great Permian Magnesian Limestone of Durham. The author exhibited sections of these beds, and gave reasons for suggesting that much of the Salt Measures of this district is probably the representative of the Upper Permian or *Rauchwacke* of Germany.

The following table summarizes fairly the classification tentatively suggested by the author :—

| | |
|---|---|
| *Avicula contorta* beds (proved in Eston shaft and boring) ... | Rhætic. |
| 7. Red and green marls, with gypsum (known only south of Tees) ... ... ... ... ... ... ... ... ... ... | Upper Trias. |
| 6. Red sandstone ... ... ... ... ... ... ... ... ... | |
| *Unconformity* (?) | |
| 5. Red sandstones and marls ... ... ... ... ... ... ... | (? Lower) Trias. |
| *Unconformity* (?) | |
| 4. Red marly sandstones, marls, with lenticular beds of anhydrite, gypsum, and salt, and fœtid limestone in variable bands towards the base ... ... ... ... ... | Upper Permian. (Rauchwacke). |
| 3. Main Magnesian Limestone ... ... ... ... ... ... | Middle Permian. |
| 2. Marl slate with fish-bed ... ... ... ... ... ... ... | |
| 1. Yellow sands ... ... ... ... ... ... ... ... ... | Lower Permian. |
| *Unconformity.* | |
| Carboniferous Rocks. | |

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## III.—Geysers of the Rotorua District, North Island of New Zealand.

By E. W. Bucke.

THE author of this paper has recently returned from the Lake district of New Zealand, where he spent eighteen months, and had exceptional opportunities for making observations upon the volcanic phenomena of the district. The largest geyser in New Zealand, that of the White Terrace of Rotomahana, is now destroyed; the three next in size are those of Pehutu, Waikiti, and Wairoa, all of which are situated close together at the back of the native village named Whakarewarewa, about three miles to the south of the Rotorua township, and these are particularly described in the present communication. The author was able to determine by soundings the depth of the tubes of several geysers of this district, and in the case of an extinct one, that of Te Waro, he was let down the tube. He found that this tube, at a depth of 13 feet from the surface, opened into a chamber 15 feet long, 8 feet broad, and 9 feet high, and that from one end of this chamber another tube led downwards to an undetermined depth.

Living entirely among the natives for many months, and speaking their language, the author was able to test the power claimed by the natives of being able to predict the outbursts of the geysers. He is convinced that by constant observations on the direction of the wind and the condition of the atmosphere, the natives have learnt to prognosticate the movements in all these hot springs with wonderful accuracy. He was also able to prove that during the whole time of his residence in the district certain of the geysers were only in eruption when the wind blew from a particular quarter.

## IV.—On an Accurate and Rapid Method of Estimating the Silica in an Igneous Rock. By J. H. Player, F.G.S., F.C.S.

THIS paper describes a method of estimating the silica in igneous rocks by

1. Fusing the finely ground rock with a flux prepared by mixing carbonates of potash and soda and nitrate of potash.
2. Disintegrating the glass so obtained by the action of strong nitric acid.
3. Driving off nitric acid at a temperature just below 250°, thus rendering all silica insoluble.
4. Treating with hydrochloric acid, to leave the silica with some impurity, for weighing after calcination.
5. Separating the impurity by means of ammonium fluoride and weighing it.

# REVIEWS.

## Observations sur les Groupes sédimentaires les plus anciens du nord-ouest de la France. Par M. Hébert. (Extrait des Comptes rendus des Séances de l'Académie des Sciences, tom. ciii., Séance du 26 Juillet, 1886.)

IN this memoir, Professor Hébert submits to the Academy a view of the Geology of North-Western France which differs in some points from previous interpretations. Brittany and Western Normandy present difficulties such as have perplexed British geologists in many of the tracts occupied by the older rocks. French writers are agreed that in North-Western France there are (omitting the true crystalline schists) (1) a granite, (2) a great formation of phyllite, and (3) a series of purple conglomerates and (?) shales (*schistes*). The last-named group is overlain by the *Grès Armoricain*, and over this sandstone come shales and slates, with *Acidaspis Buchii*, and more than one species of *Placoparia*. These *Placoparia* beds, with the same *Acidaspis*, occur in our Salopian area, not far above the grits of the Stiper Stones; so that the *Grès Armoricain* may be safely regarded as Arenig. But below this horizon, the interpreters of Brittany geology find the materials for widely diverging opinions. The theory of M. Hébert may be thus summarized.

The oldest of the three rock-masses is the granite. It furnishes numerous rolled blocks to a conglomerate in the phyllite series, and it never penetrates the adjoining strata in veins. At its junction with the phyllite, the granite is in the state of sand, and the phyllite also is decomposed. The stratified rocks of the district are indeed penetrated by veins; but these consist of "*granulite*" (not granite), and they ramify through both granite and sedimentaries alike; in the former they are called pegmatite, in the latter granulite proper. They behave like true eruptive rocks, and are welded to the walls of the adjacent phyllite, which they harden and modify at the contact.

The phyllite is next in age, but is older than the purple series. M. Hébert submits twofold evidence for this contention. (1) The purple series includes beds of rounded fragments of a quartz which is identical with certain quartz-veins in the phyllite. One of these varieties, a black quartz, is at Coutances quarried in the phyllite, and is found not far off in the conglomerate of the purple group. (2) While the phyllite usually dips at high angles, or is tilted to the vertical, the purple series lies at much lower dips, and these relations are sometimes seen where the two groups are in contact. M. Hébert concludes that the phyllites are Archæan; but he would confine the term to this formation, which he regards as the oldest sedimentary group, "le premier *terrain*." The granite and the crystalline schists are thus left unclassified. The phyllite is regarded by M. Hébert as the equivalent of the less crystalline of the Pre-Cambrian rocks of Anglesey, and of the beds which, according to Prof. Green, underlie the Cambrian conglomerates of Llanberis.

The purple conglomerates and (?) shales, separated by a marked discordance from the phyllite series, are placed in the Cambrian.

It would be rash for a stranger to the district to express an opinion on a question of such evident difficulty as the one before us. M. Ch. Barrois, writing only last year (1885), is at variance with M. Hébert on the main points discussed, and he will doubtless take up the cudgels which he can wield so well. The issue, whatever it be, should have an important bearing on the geology of the Channel Islands, recently brought to our notice by the Rev. Edwin Hill, and it may tend to smoothe, or the reverse, the troubled waters of the Archæan controversy.

It would aid our future studies in this direction if a precise meaning were attached to certain terms used in M. Hébert's paper, especially to the words "phyllites" (les phyllades), "schist," and "grauwacke."

Ch. Callaway.

## REPORTS AND PROCEEDINGS.

I.—November 17, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. A letter from the Lieutenant-Governor of the Falkland Islands, communicated by H.M. Secretary of State for the Colonies:—

"Government House, Stanley, Falkland Islands,
3rd June, 1886.

"My Lord,—I regret to have to report that a slip of the peat-bog at the back of the town of Stanley, similar to that which occurred in November, 1878,[1] but about two hundred yards to the

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[1] See Quart. Journ. Geol. Soc. vol. xxxv. Proc. p. 96.

westward of the scene of that accident, took place last night. A stream of half-liquid peat, over a hundred yards in width, and 4 or 5 feet deep, flowed suddenly through the town into the harbour, blocking up the streets, wrecking one or two houses in its path, and surrounding others so as completely to imprison the inhabitants. Fortunately, as the night was wet and stormy, almost every one was within doors, and the few who were in the wrecked houses escaped in time. One child was, unfortunately, smothered in the peat, whose body has been recovered, but no other casualties are known to have occurred. An old man is, however, reported to be missing this morning, and it is feared he may also have perished, as part of his house is almost filled with peat. . . . . The slip was caused, apparently, by the unusually heavy rains which have fallen during the last few days, and which the drains constructed by Mr. Bailey, the Surveyor, in 1878, proved insufficient to carry off. Deeper and wider cuttings will now be made, and I trust that the recurrence of any similar catastrophe may thus be prevented. The town of Stanley is, however, from its situation and the mass of peat-bog on the high ground behind it, always to some extent exposed to danger of this nature in times of unusually heavy rainfall.—I have, etc.

"(Signed) ARTHUR BARKLY.

"The Right Hon. Earl Granville, K.G.. &c., &c., &c."

2. "On the Drifts of the Vale of Clwyd, and their relation to the Caves and Cave-deposits." By Prof. T. M'Kenny Hughes, M.A., F.G.S.

The author divided his subject as follows:—I. Introductory Remarks; II. The Drifts, viz. (i.) The Arenig Drift, (ii.) The St.-Asaph Drift, (iii.) The Surface-Drifts; III. The Caves, viz. (i.) The Caves themselves, (ii.) The Cave-Deposits; IV. Conclusion.

He exhibited a table showing the tentative classification he proposed. II. (i.) The Arenig Drift, he said, might be called the *Western Drift*, as all the material of which it was composed came from the mountains of Wales; or the *Great Ice-Drift*, as it was the only Drift in the vale which contained evidence of direct ice-action. He traced its course from the Arenig and Snowdon ranges, by striæ on the solid rock and by the included fragments, a large proportion of which were glaciated. There are no shells in this drift.

II. (ii.) The St.-Asaph Drift might, he said, be called the *Northern Drift*, as it was the deposit in which fragments of north-country rocks first appeared; or the *Marine Drift*, as it was, excepting the recent deposits at the mouth of the estuary, the only drift in the vale which showed by its character and contents that it was a sea-deposit. It contained north-country granites, flints, and sea-shells, of which he gave lists. Most of them are common on the adjoining coast at the present day, a few are more northern forms. None of the rocks are striated, except those derived from the Arenig Drift (i.).

II. (iii.) The Surface-Drifts included the older and newer alluvia of the rivers, the Morfa Rhuddlau Beds or estuarine silt, the recent shore-deposits or Rhyl Beds, and all the various kinds of deposits known as talus, trail, rain-wash, head, run-of-the-hill, etc., of which, in so long a time, very thick masses have accumulated in many places. He explained some methods of distinguishing gravels according to their origin.

Turning to the subject of Caves, he thought they should be careful not to confound (III. i.) the question of the age and origin of the caves themselves with (III. ii.) that of the deposits in the caves. He then described some of the more important caves of the district, explaining the evidence upon which he founded the opinion that the deposits in Pontnewydd Cave were postglacial palæolithic. He arrived at the same conclusion with regard to the deposits in the Ffynnon Beuno Caves. Combating the objections to this view which had recently been urged, he pointed out that the drifts associated with the deposits in those caves cannot have ben formed before the submergence described under II. (ii.), because they contained north-country fragments and flints, and that, even if they were of the age of the submergence, they would not be preglacial; that they cannot have been formed during the submergence, as the sea would have washed away the bones, etc., from the mouth of the cave, and its contents must have shown some evidence of having been sorted by the sea. He considered that the greater part of the material that blocked the upper entrance of the upper cave belonged to the surface-drifts described under II. (iii.), and were, as they stood, almost all subaerial.

He further pointed out that, so far as palæontologists had been able to lay before them any chronological divisions founded on the mammalia, the fauna of the Ffynnon Bueno Caves agreed with the later rather than with the earlier Pleistocene groups.

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II.—December 1, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read :—

1. "On a new Genus of Madreporaria — *Glyphastræa*, with remarks on the *Glyphastræa Forbesi*, Edw. & H., sp., from the Tertiaries of Maryland, U.S." By Prof. P. Martin Duncan, M.B., F.R.S., F.G.S., etc.

The specimens of *Septastræa Forbesi*, Edw. & H., were examined many years ago, and the author had always a doubt about their generic position. Lately a very well-preserved specimen has been received, which when compared with those in the National Collection and carefully studied, is found to have a columella and a remarkable dome of endotheca at the top of the base of the calicular fossa, resembling the well-known structure in *Clisiophyllum*.

Two opposite primary septa become very narrow, extend inwards, form, with another structure, a narrow linear columella, and thus produce the appearance of a continuous lamella. The other primaries and some of the secondary septa reach this long structure, and the endotheca stretches between the ends of the septa, their sides, and the columella, and closes up the interseptal loculi. The epithecal dissepiments are dome-shaped at the base of the calice, and are ornamented with sparsely distributed granules: superficially a corresponding granulation occurs on the narrow and also on the wide marginal parts of the septa.

There is a groove between the calices, and it corresponds with the imperfect junction of the corallite walls. Fissiparity occurs and also gemmation.

Natural sections show a narrow ribbon-shaped columella.

The examination of the perfect specimens proves that whilst they cannot be understood without sections, sections alone would never enable the palæontologist to realize the elaborate superficial structures. It was pointed out that weathering utterly destroyed the generic and specific characters, and the author ventured to caution the students of the Madreporaria against describing weathered and worn specimens of any types, and not to depend entirely upon sections.

The new genus *Glyphastræa* includes Astræidæ of the Goniastræoid alliance with fissiparity, gemmation and a ribbon-shaped columella. *Septastræa Forbesi* becomes *Glyphastræa Forbesi*, Edw. & H., sp.

2. "On the Metamorphic Rocks of the Malvern Hills." Part I. By Frank Rutley, Esq., F.G.S., Lecturer on Mineralogy in the Royal School of Mines.

Part I. is the result of conclusions arrived at in the field. Part II. will be devoted to a microscopic description of the rocks.

The author referred especially to the paper by the late Dr. Holl, whose work he, in the main, confirmed. Dr. Holl's object was to demonstrate that the rocks which had hitherto been treated as syenite, and supposed to form the axis of the hills, were in reality of metamorphic origin, and belonged to the Pre-Cambrian. Mr. Rutley restricted his observations to the old ridge of gneissic syenite, granite, etc., which constitutes the main portion of the range, and reversing the order of his predecessor, commenced at the north end of the chain.

He considers that the beds of crystalline rock, mostly of a gneissic character, in the old ridge have been disposed in a synclinal flexure, which stretched from the north end of the chain to the middle of Swinyard's Hill, where they receive an anticlinal flexure, and are faulted out of sight. The length of this synclinal fold would be over 5½ miles. The lithological evidence is in favour of the rocks forming the north part of Swinyard's Hill being a repetition of those on the Worcestershire Beacon. We might expect to find the older beds having the coarsest granulation, and being even devoid of foliation, and this is what occurs on the Malverns, where the northern hills are made up of the coarsest rocks, with finer schistose beds towards the south; the exception is at Swinyard's Hill; hence there are two groups of coarsely crystalline rocks at either extremity of the presumed synclinal. The contrast between these and the fine-grained rocks of the other portions of the range has already attracted attention. The most northern of the coarse-grained masses is cut off towards the south by a fault near the Wych, while the other lies between a fault on the north side of the Herefordshire Beacon and the before-mentioned fault on Swinyard's Hill.

The metamorphic rocks of the Malverns seem, therefore, to be divisible into three series extending from the North Hill to Key's End. A Lower, of coarsely crystalline gneissic rocks, granite, syenite, etc., a Middle, of gneissic, granitic and syenitic rocks of medium and fine texture, and an Upper, of mica-schist, finely crystalline gneiss, etc. A diagrammatic section shows the distribution of these; the northern block, extending as far as the Wych, consists of the Lower and the lower part of the Middle; the central block, from the Wych to the fault in Swinyard's Hill, consists chiefly of the Lower and upper Middle, but with a portion of the Lower at the south end. The southern block, south of the fault on Swinyard's Hill, consists wholly of the Upper series.

How far the foliation of these rocks and their main divisional planes represent original stratification must, the author thought, remain an open question. It has been held that the strike of foliation lies parallel to the axes of elevation; but this is far from being the case in the Malverns. Still, a once uniform strike may have been dislocated by repeated faulting.

The author further discussed the general question of how far foliation may or may not coincide with planes of sedimentation. He admitted that the absolute conversion of one rock into another by a process of shearing has been shown to occur, but doubted its application in this case. Although he is inclined to believe that the divisional planes, with which the foliation appears to be parallel, may be planes of original stratification, yet, as a matter of fact, they are nothing more than *structural planes of some sort*, between which the rocks exhibit divers lithological characters.

3. "On Fossil Chilostomatous Bryozoa from New Zealand." By Arthur W. Waters, Esq., F.G.S.

The fossil Bryozoa described in the present paper are from the localities of Petane, Waipukurau, Wanganui, and some simply designated as from the neighbourhood of Napier. The first three represent deposits of a well-known position, which was considered Miocene by Tenison-Woods, but which Professor Hutton (Quart. Journ. Geol. Soc. vol. xli.) has more recently called Pliocene. Some others, sent over as from "Whakati," are thought to be from Waikato.

The genus *Membranipora*, which is largely represented from near Napier, is not one of the most useful palæontologically, because the shape of the opesial opening only, and not the oral, is preserved, and also the appearance of the zoœcia is often remarkably modified by the ovicells, which, however, are frequently wanting, and in many well-known species have never been found.

The author pointed out that in the commoner and best-known species of Bryozoa the amount of variation is recognized as being very great, and considered that in the face of this there is too great a tendency to make new species on slight differences which may be local variations, and that even in some cases, instead of the description referring to a species, it may be that only a specimen has been described.

A list of New-Zealand Bryozoa has been drawn up by Professor Hutton, and our knowledge of the New-Zealand and Australian Bryozoa is being constantly increased by MacGillivray, Hincks, and others; nevertheless, enough is not yet known to fix the exact age by means of the Bryozoa alone, but the large number of species entirely identical with those living in the neighbouring seas, and the general character of the others, show that the deposits must certainly be considered as of comparatively recent date.

Out of the 78 species or varieties, 61 are known living, 29 of these from New-Zealand seas, 48 from either New-Zealand or Australian waters, and 28 have been found fossil in Australia. Judging from these alone, it would seem that some authors have assigned too remote an age to the deposits. The new forms described were:—

*Membranipora occultata*
*Monoporella capensis*, var. *dentata.*
—— *waipukurensis.*
*Micropora variperforata.*
*Mucronella tricuspis*, var. *waipukurensis.*
—— ——, var. *minima.*
—— —— *firmata.*
*Porina grandipora.*
*Lepralia semiluna*, var. *simplex.*
—— *bistata*
*Schizoporella cinctipora*, var. *personata.*
—— *tuberosa*, var. *angustata.*
*Cellepora decepta.*
———, sp.

## CORRESPONDENCE

### ON THE OCCURRENCE OF PHOSPHATIC NODULES IN THE LOWER GREENSAND, EAST OF SANDOWN.

Sir,—When working near Sandown, in company with Mr. H. Keeping, we observed several beds of phosphatic nodules in the Lower Greensand; these do not appear to have been previously noticed, no mention being made of them in the Survey or other memoirs on the district. Mr. Bristow describes some "concretionary masses or bodies" which occur in Fitton's bed No. xvi. at Rocken End, near Black Gang: these may represent some of the nodule beds at Sandown.

The phosphates are of a light brown colour, and occur at four horizons. The three lowermost are very distinct, and come between 160 and 200 feet from the top of the Lower Greensand, whilst the fourth is some distance higher up. The second band from the bottom is about seven inches in thickness, and from it the following fossils were obtained:—*Ammonites biplex*, Sow. *A. cordatus*, Sow. *Pleurotomaria* sp. *Cardium striatulum?* *Lucina* sp. *Myacites* sp. *Cytherea rugosa?* *Arca contracta*, Phill. They are all much rounded, and difficult to determine. In this bed there are also fragments of various rocks, such as quartzite, lydian stone, etc., the first of which greatly resembles those in the Budleigh Salterton pebble bed. The nodules in the upper band are much smaller, and are associated with a great many quartz pebbles.

The phosphates and fossils of the lower beds are very similar to those of Brickhill and Potton in Bedfordshire, Wicken in Cambridgeshire, and Tealby in Lincolnshire. The second bed noticed above is sufficiently thick to be worked for commercial purposes, but the strata dip at such a high angle, that but little of the phosphates could be profitably obtained.

The Geological Survey is now engaged in the district, and the exact horizons at which the nodules occur will no doubt be given in their sections.

H. Woods.

Woodwardian Museum, Cambridge.

### THE PEA GRIT OF LECKHAMPTON HILL.

Sir,—The letter of my friend, Mr. E. Wethered, in the last number of the Magazine, requires some notice from me. Mr. Wethered takes exception to a remark in my paper on the basement-beds of the Inferior Oolite, that the beds between the Pea Grit proper and the

Cephalopoda-bed have been included by the late Dr. Wright and others in their published works in the term "Pea Grit," and he refers me to the paper by Dr. Wright on the so-called sands of the Inferior Oolite" as showing that I am in error. I have referred to the paper cited, and find that in the section (Fig. 1) only one bed is shown as including the Pea Grit and the underlying beds, although in the explanation at foot it is called "Pea Grit and ferruginous oolite," and marked A B C; but the description in the following page is headed "Pea Grit (Inferior Oolite)," and under this heading the beds A B and C are described: the description of A and B appears, however, to be substantially the same.

In Dr. Wright's latest work "Monograph on the Lias Ammonites" the section of Leckhampton Hill is repeated (fig. 11, page 151); and on reference to the description (p. 152), I find the heading is "Pea Grit (Zone of *Harpoceras Murchisonæ*, Inferior Oolite)," the subdivision being the same as before, and the description being wholly under this heading.

I think the meaning is clear, namely, that it was intended that the term "Pea Grit" should apply to all the beds, although, for the purpose of giving a more accurate description, a subdivision of them was convenient.

Mr. Wethered refers me to Dr. Wright's section of Cleeve Hill, but the extract is incorrectly given, doubtless an error in printing.

| | | |
|---|---|---|
| For— | | |
| Pea Grit ... ... ... ... ... ... ... ... | 21ft. | 30 in. |
| Coarse ferruginous oolite ... ... ... ... ... ... | 22ft. | 5 in. |
| Read— | | |
| Peat Grit, No. 21 ... ... ... ... ... ... ... | 30ft. | 0 in. |
| Coarse ferruginous oolite ... ... ... ... ... ... | 5ft. | 0 in. |

The correct reading confirms my statement, except as regards the lower 5ft.

The section of Cleeve Hill is also repeated in the monograph on the Lias Ammonites (fig. 12, p. 155), and in the description (p. 161) the beds are called "Pea Grit," and the three subdivisions are described in much the same language as is used in the description of the beds at Leckhampton.

Edwin Witchell.

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## CORRECTION OF MIOCENE INSECTIVORA.

Sir,—With your permission I will avail myself of the Geological Magazine to correct an error into which I have been led by the writings of others in part i. of the "Catalogue of Fossil Mammalia in the British Museum" (1875).

On page 19 of that volume I followed Dr. O. Fraas[1] in identifying the Auvergne *Plesiosorex soricinoides* (*Erikaceus soricinoides*, of Blainville) with *Parasorex socialis*, Meyer, of Steinheim. Having recently, however, had cause to consider further the affinities of the Miocene Insectivora, I have been led from an examination of the figures given by Fraas and De Blainville to the conclusion that the identifications made by the former writer are totally erroneous. The Steinheim *Parasorex socialis* is, as Fraas states, closely allied to

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[1] "Fauna von Steinheim," p. 4 (1870).

*Tupara*, while *Plesiosorex soricinoides* is a totally different form, whose affinities, as stated by Pomel, are rather with *Myogale*. I am further led to conclude that Fraas' identification of *Erikaceus arvernensis* of De Blainville, with *Plesiosorex soricinoides* is likewise erroneous, and that the fauna is probably identical with *E. arvernensis* of Gervais.[1]

The specimen entered in the Museum Catalogue under the name *Plesiosorex* must therefore be named *Parasorex*, and the former genus referred to the *Talpidæ*. This error will be noticed in the supplement to be published in part v. of the Museum Catalogue; but as the publication of that part will be several months hence, I have thought it advisable to correct the error as soon as possible.

HARPENDEN, *Dec.* 10, 1886. R. LYDEKKER.

### ON THE OSBORNE BEDS.

SIR,—I wish to correct a mis-statement of my views respecting the position of the Osborne Beds, which appears in the Report of the International Geological Congress for 1885, and also I find is reproduced in Mr. Jukes-Browne's new Handbook of Historical Geology. My opinion has always been that the Osborne Beds should have been a part of the Bembridge Series, and not a separate member.

Woodwardian Museum,
Cambridge.
H. KEEPING.

### THE COLLINGHAM OR SCARLE BORING.

SIR,—In the recently issued Report of the British Association for 1885, pp. 388, 389, the original inaccurate account of this boring is reproduced, and I am credited with the alternative figures given in a second column.

Permit me to state that I have published no account of the boring, and that the figures alleged to be mine do not coincide with the section preserved among my papers, viz.:—

| | | |
|---|---|---|
| | Gravel ... ... ... ... ... ... ... ... ... | 21 feet. |
| | Lias ... ... ... ... ... ... ... ... ... | 29 |
| | Rhætic ... ... ... ... ... ... ... ... ... | 15 |
| | Keuper Marls ... ... ... ... ... ... ... | 688 |
| | Keuper Sandstone... ... ... ... ... ... ... | 205½ |
| | Bunter "Pebble Beds" ... ... ... ... ... | 319 |
| | Lower Bunter ... ... ... ... ... ... ... | 223 |
| Upper Permian 380½ | Marls ... ... ... ... ... ... ... ... ... | 118½ |
| | Limestone ... ... ... ... ... ... ... ... | 43½ |
| | Marls ... ... ... ... ... ... ... ... ... | 150 |
| | Limestone ... ... ... ... ... ... ... ... | 68½ |
| Lower Permian 139 | Sandstone ... ... ... ... ... ... ... ... | 20 |
| | Marl Slates ... ... ... ... ... ... ... ... | 118 |
| | Breccia ... ... ... ... ... ... ... ... | 1 |
| | Coal Measure Shales ... ... ... ... ... ... | 12 |
| | | 2032 |

The site is not in the parish of Scarle, Lincolnshire, but in Collingham, Notts.

W. H. DALTON, F.G.S.,
Late H.M. Geological Survey.

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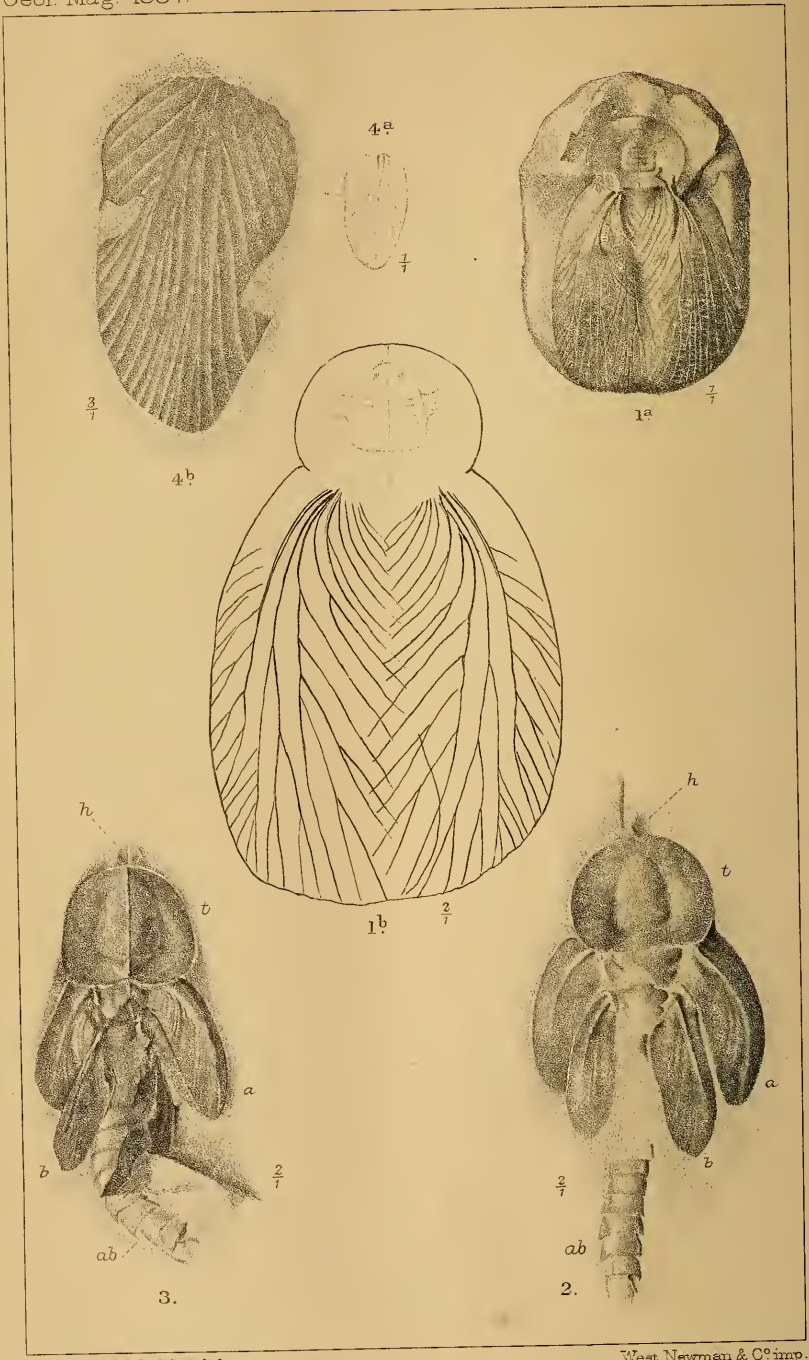
[1] See "Cat. Foss. Mamm. Brit. Mus." pt. i. pp. 17, 18.

Geol. Mag. 1887. Decade III. Vol. IV. Pl. II.



G. M. Woodward del. et lith.
West, Newman & Co. imp.

British Palaeozoic Cockroaches.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. IV.

No. II.—FEBRUARY, 1887.

## ORIGINAL ARTICLES.

### I.—Some New British Carboniferous Cockroaches.

By Henry Woodward, LL.D., F.R.S., F.G.S.

(PLATE II.)

THE early appearance in geological time of terrestrial Arthropods has always been to me a subject of deep interest, and I have been fortunate in noticing several of these in the pages of this Magazine and elsewhere.[1]

The oldest insect at present recorded is the impression of an Orthopterous wing referred to the family Blattidæ, obtained from the Silurian sandstone of Jurques, Calvados, France, about the horizon of the May Hill Sandstone (Middle Silurian). M. Charles Brongniart, its discoverer, observes that what is especially remarkable about this fossil, and which distinguishes it from all other Cockroach-wings, living or fossil, is the length of the anal vein, and the narrowness of the axillary area.

This primitive insect has been named by him *Palæoblattina Douvillei.*[2]

The occurrence of Cockroaches in the Coal-measures of Germany (Wettin) was announced by Germar as early as in 1842.[3]

The only example heretofore met with in England was obtained by Mr. James W. Kirkby (and described by him in the Geol. Mag. 1867, Vol. IV. Pl. XVII. Figs. 6–8, pp. 388–390), from the Coal-measures, opposite Claxheugh, near Sunderland; but little attention seems to have been given to its discovery.[4]

By far the most important Memoir on Palæozoic Cockroaches which has yet appeared is that by Mr. Samuel H. Scudder, of

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[1] See on *Eophrynus* (*Curculioides*) *Prestvici*, Buckl. sp., Geol. Mag. 1871, Vol. VIII. Pl. XI. pp. 385–388.

On *Architarbus subovalis*, H. Woodw. *op. cit.* 1872, Vol. IX. Pl. IX. p. 385.

On *Brachypyge carbonis*, H. Woodw. *op. cit.* 1878, Dec. II. Vol. V. Pl. XI. p. 434. [I described this form as a Crustacean; but it has since been suggested to me by Mr. S. H. Scudder that it was more probably the abdomen of an Arachnide nearly related to *Eophrynus*.—H. W.]

On *Lithomantis carbonarius*, H. Woodw. Quart. Journ. Geol. Soc. Lond. 1876, vol. xxxii. pl. ix. pp. 60–64.

On *Eoscorpius carbonarius*, H. Woodw., *op. cit.* 1876, pl. viii. pp. 57–59.

On "Spined Myriapods," Geol. Mag. 1887, No. I. p. 1. Pl. I.

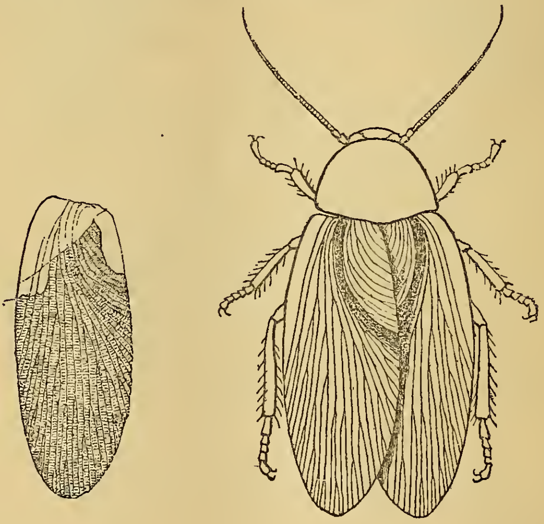
[2] "Comptes Rendus," Acad. des Sciences, Paris, No. 29, Decr. 26, 1884.

[3] See Münster's Beiträge zur Petrefactenkunde, Stuttgart.

[4] Mr. S. H. Scudder has since named it *Etoblattina mantidioides*, Mem. Boston Soc. Nat. Hist. 1879, vol. iii. pt. i. No. 3, pp. 72–73 (woodcut).

Boston, who has not only described all the species that have come to his hands from the Coal-measures of N. America, but many European ones also, and has given us "a complete revision of the species of both worlds" (see Mem. Boston Soc. Nat. Hist. Boston, 1879, 4to. vol. iii. pp. 23–134, and plates 2–6).

According to a still later summary on "The Cockroach of the Past" (published as an appendix to "The Structure and Life-History of the Cockroach (*Periplaneta orientalis*)," by Prof. L. C. Miall and Alfred Denny, London, 1886, 8vo.), Mr. Scudder gives the number of Carboniferous *Palæoblattariæ* at 70 species.



1. 2.

Figs. 1 and 2.—*Progonoblattina* (*Blatta*) *helvetica*, Heer (Swiss Cockroach), from the Coal-measures of Erbignon.

1. Wing, of the natural size. 2. The animal restored.

Reproduced from Prof. O. Heer's Primæval World of Switzerland, London, 1876 (translated by W. S. Dallas, F.L.S.), 2 vols. 8vo. p. 20, fig. 16*c*.

It must, however, be borne in mind that our knowledge of this ancient type of Orthopterous Insect is derived almost entirely from its wings; and upon the well-marked variations which the principal veins present in their arrangement (see Fig. 3).

Scudder, who adopts the terminology proposed by Prof. Oswald Heer, of Zurich, writes:—"These principal veins are six, counting the marginal vein, which here merely thickens the anterior border, as one; and starting from the anterior margin, they are the *marginal*, *mediastinal*, *scapular*, *externo-median*, *interno-median*, and *anal*. The general disposition of these veins is as follows:—The 'mediastinal' and 'scapular' veins, with their branches, which are superior (*i.e.* part from the main vein on the upper or anterior side), terminate upon the anterior margin. The 'interno-median' and 'anal' take the opposite course, and their branches are inferior, or, at least, directed towards the inner margin; while the 'externo-median,' which is interposed between these two sets, terminates at the tip of the wing, and branches indifferently on either side."

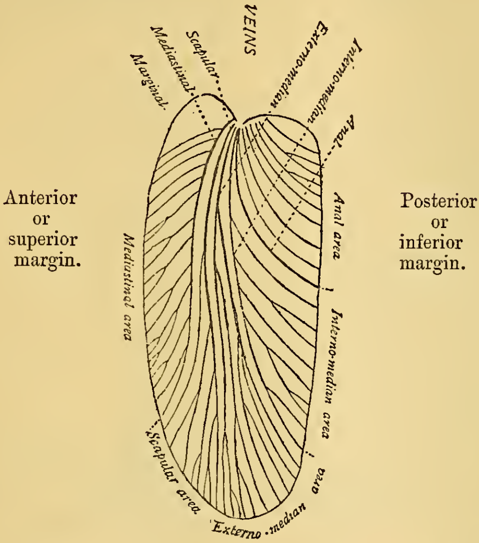


FIG. 3.—Schematic view of left wing of Palæozoic Cockroach, showing the veins and areas (after Scudder).

"Now these veins are all present in both front and hind wings of Palæozoic Cockroaches, and also in the hind wings of existing species; but in the front wings or *tegmina* of the latter, the number is never complete, the externo-median vein being always amalgamated either with the scapular, or with the interno-median, and the mediastinal frequently blended with the scapular vein" (Scudder).

The following is a list of the genera and species of BLATTIDÆ from the Carboniferous formation hitherto described, arranged under the families and genera suggested by Scudder.

PALÆOBLATTARIÆ.

*Mylacridæ*—

| | | | |
|---|---|---|---|
| *Mylacris* | *bretonense*, Scudder, | Coal-measures, | Sydney, Cape Breton. |
| ,, | *Heerii*, Scudder, | ,, | ,, ,, |
| ,, | *pennsylvanicum*, Scudder | ,, | Cannelton, Penn. U.S. |
| ,, | *Mansfieldi*, Scudder | ,, | ,, ,, |
| ,, | *anthracophilum*, Scudder | ,, | Colchester, Illinois, U.S. |
| ,, | *antiquum*, Scudder | ,, | Port Griffith, Pittston. |
| ,, | *lucifugum*, Scudder | ,, | ,, ,, |
| ,, | *carbonum*, Scudder | ,, | Cannelton, Penn. U.S. |
| ,, | *ovale*, Scudder | ,, | ,, ,, |
| ,, | *priscovolans*, Scudder | ,, | ,, ,, |

| | | |
|---|---|---|
| *Promylacris ovale*, Scudder, | Coal-measures, | Mazon Creek, Illinois, U.S. |
| ,, *rotundum*, Scudder | ,, | ,, ,, |
| *Paromylacris rotundum*, Scudder | ,, | ,, ,, |
| *Lithomylacris pauperatum*, Scud. | ,, | Pittston, Penn. U.S. |
| ,, *pittstonianum*, Scudder | ,, | ,, ,, |
| ,, *angustum*, Scudder | ,, | ,, ,, |
| ,, *simplex*, Scudder | ,, | Danville, Illinois. |
| *Necymylacris heros*, Scudder | ,, | Cannelton, Penn. U.S. |
| ,, *lacoanum*, Scudder | ,, | Pittston, Luzerne Co. Penn. |
| BLATTINARIÆ. | | |
| *Etoblattina mantidioides*, Gold. | ,, | Durham, England. |
| ,, *didyma*, Rost | ,, | Manebach. |
| ,, *manebachensis*, Gold. | ,, | ,, |
| ,, *primæva*, Scudder | ,, | Auerswald, Saarbruck. |
| ,, *labachensis*, Scudder | ,, | Lebach ,, |
| ,, *insignis*, Gold. | ,, | ,, |
| ,, *euglyptica*, Germ. | ,, | Wettin, Saxony. |
| ,, *affinis*, Gold. | ,, | Lobejün. |
| ,, *flabellata*, Germ. | ,, | Wettin, Saxony. |
| ,, *anthracophila*, Germ. | ,, | ,, ,, |
| ,, *Dohrnii*, Scudder | ,, | ,, ,, |
| ,, *anaglyptica*, Germ. | ,, | ,, ,, |
| ,, *carbonaria*, Germ. | ,, | ,, ,, |
| ,, *russoma*, Gold., | ,, | Lobejün. |
| ,, *leptophlebica*, Gold. | ,, | ,, |
| ,, *parvula*, Gold. | ,, | ,, |
| ,, *spectabilis*, Gold. | ,, | ,, |
| ,, *lanceolata*, Sterzel | ,, | Lugau. |
| ,, *venusta*, Lesq. | ,, | Arkansas. |
| ,, *Mazona*, Scudder | ,, | Mazon Creek, Illinois. |
| ,, *Lesquereuxii*, Scudder | ,, | Appalachian. |
| *Archimylacris parallelum*, Scudder | ,, | Pennsylvania. |
| ,, *acadicum*, Scudder | ,, | Pictou, Nova Scotia. |
| ,, *paucinerve* | | |
| *Anthracoblattina winteriana*, Gold. | ,, | Saarbrück. |
| ,, *Remigii*, Dohrn. | ,, | Cusel, Rhenish Bavaria. |
| ,, *spectabilis*, Gold. | ,, | Wettin, Saxony. |
| ,, *dresdensis*, Gein. | ,, | Klein-Opitz, near Dresden. |
| *Gerablattina Goldenbergii*, Mahr. | ,, | Manebach. |
| ,, *clathrata*, Heer | ,, | ,, |
| ,, *Mahri*, Gold. | ,, | ,, |
| ,, *weissiana*, Gold. | ,, | Brücken, Rhenish Bavaria. |
| ,, *intermedia*, Gold. | ,, | Wemmetsweiler. |
| ,, *Geinitzii*, Gold. | ,, | Lobejün. |
| ,, *Münsteri*, Gold. | ,, | Wettin, Saxony. |
| ,, *producta*, Gold. | ,, | ,, ,, |
| ,, *Germari*, Gutb. | ,, | ,, ,, |
| ,, *scaberata*, Gold. | ,, | Attenwald. |
| ,, *latinervis* | ,, | Saxe-Weimar, Ilmenau. |
| ,, *fascigera*, Scudder | ,, | Pittston, Pennsylvania. |
| ,, *balteata*, Scudder | ,, | W. Virginia and Ohio. |
| *Hermatoblattina wemmetsweileriensis*, Gold. | Coal-measures, | Saarbrück. |
| ,, *Tischbeini*, Gold. | ,, | ,, |
| *Progonoblattina Fritschii*, Heer | ,, | Manebach. |
| ,, *Helvetica*, Heer | ,, | Valais, Swiss. |
| *Oryctoblattina reticulata*, Germar | ,, | Wettin. |
| ,, *occidua*, Scudder | ,, | Mazon Creek, Illinois. |
| *Petrablattina sepulta*, Scudder | ,, | Sydney, Cape Breton. |
| ,, *bretonense*, Scudder | ,, | ,, ,, |
| *Anthracoblattina Scudderi*, Gold. | ,, | Saarbrück. |

Three of the specimens about to be described (namely, Pl. II. Figs. 1, 2, 3), are in nodules from the Clay-ironstone band, between the "Brooch" and the "Thick-coal" at Coseley, near Dudley, and form a part of the valuable collection made by the late Mr. Henry Johnson, F.G.S., Mining Engineer, of Dudley, now preserved in the British Museum of Natural History, Cromwell Road, London.

The remaining specimen (Plate II. Fig. 4*a*, *b*) was placed in my hands some years since, by the kindness of Mr. James W. Kirkby, who obtained it from the Upper Coal-measures, near Meithil, on the Fifeshire coast.

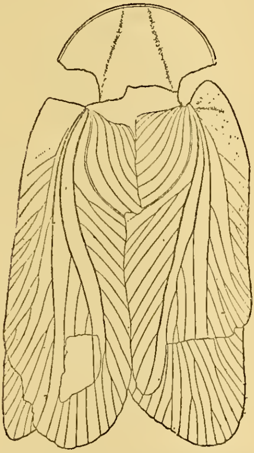


FIG. 4.—*Etoblattina Mazona*, Scudder (1½ times nat. size), Carboniferous, Illinois (after Scudder).

ETOBLATTINA JOHNSONI, sp. nov. (Pl. II. Figs. 1*a*, 1*b*.)

With the exception of *Blattina insignis* of Goldenberg from the Coal of Saarbrück, and *Etoblattina Mazona*, Scudder, from the Carboniferous of Illinois (Woodcut Fig. 4), this is one of the most perfect Cockroaches yet discovered in the Coal. The specimen is exposed in a small oval clay-ironstone nodule, so fortunately split open, as to show an equally well-preserved impression and counterpart of the fossil. The pronotum or prothorax is rounded in front, being 13 millimetres broad and 8 mm. long, and is divided into two parts by a straight line, clearly visible both on the impression and counterpart; the central part of the shield has a slightly raised pyriform area, pointed in front and broadly truncated behind; the surface is transversely wrinkled and bears a pair of minute spots near the anterior point. The hinder border of the shield is rounded and somewhat deeply emarginated on the median line.

The mesothorax is 8 mm. broad, but its length cannot be seen, being covered by the wings.

The paired wings measure 25 mm. in breadth and 28 mm. in length (they were probably about 3 mm. longer, but their edges are lost on the border of the nodule). The metathorax and abdomen are not visible, being covered by the closely-folded wings.

It has been a matter of no small difficulty to the artist accurately to trace out the venation of the wings in this specimen. When a single wing is preserved on the surface of a piece of shale, its veins can usually be traced distinctly; but when two pairs of superposed wings have to be studied, they present, after compression, a somewhat complex problem to unravel. I believe, however, that the outline (Pl. II. Fig. 1*b*, and 1*a*, nat. size) gives a fairly accurate representation of the veins. The wing is oblong-ovate in form; the 'mediastinal' vein commences at the proximal end of the wing, about 3 mm. within the border, and runs almost parallel with the superior marginal vein, but gradually bends towards, and unites with it, at 20 mm. from its commencement. It gives off, at first, several single branches, followed by five equidistant bifurcating ones; the 'scapular' vein takes its origin at the proximal end, close to the 'mediastinal' vein, and after pursuing a course nearly parallel to it, it terminates on the anterior distal margin of the wing, 25 mm. from its commencement, giving off five simple branch-veins from its superior border. The 'externo-median' vein takes its rise from the inferior side of the 'scapular' vein, about half-way in its course, and extending to the extremity of the wing, it gives off one single superior and one bifurcated inferior branch.

The 'interno-median' follows the course of the conjoined 'externo-median' and 'scapular' veins, arching towards the inferior or interno-median margin of the wing, giving origin in its course to six inferior branch-veins about equidistant from each other, the first (proximally) being bifid, the second simple, the third, fourth and fifth bifurcated, and the sixth simple. The anal area of the wing is strongly marked by the arched anal vein which is branched, and is followed by about five simple similarly arched veinlets, whose origin appears to be along the inner proximal border of the wing.

The whole surface of the wings exhibits a very delicate tracery produced by the slighly-elevated microscopic net-work of cross-veins, which need the aid of a magnifying glass to reveal, and are not attempted to be represented in our Plate.[1]

Several of the species of *Etoblattina*, figured by Scudder, present a general resemblance in form and in the distribution of the veins to our specimen; but they differ materially in the area which the branches of each principal vein occupies. There is not one in which the 'scapular' and 'externo-median' veins rise half-way down the wing from a common main trunk. This is a character which has been frequently observed in the veins of the front wings, or *tegmina*, of existing species (Scudder). It would require, however, a far larger series of specimens than we possess, and at least several examples of each species (a consummation devoutly to be wished for, but not the least likely to be fulfilled), before one could venture to speak with any degree of confidence of species founded on such fragmentary evidence as we at present possess.

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[1] Mr. Scudder's artist has successfully reproduced this wonderful and complex lace-structure in *Etoblattina venusta*, Lesquereux (Scudder, *op. cit.* pl. 6, fig. 12, p. 70).

I have much pleasure in dedicating this species to the memory of its discoverer, the late Mr. Henry Johnson, F.G.S., Mining Engineer of Dudley, than whom I have never known a more earnest and enthusiastic worker, a more assiduous collector, or one who more willingly lent his specimens for scientific purposes to those who requested their loan.

The specimen was obtained from an ironstone nodule from Coseley near Dudley, and is now preserved as a part of the "Johnson Collection" in the British Museum (Natural History).

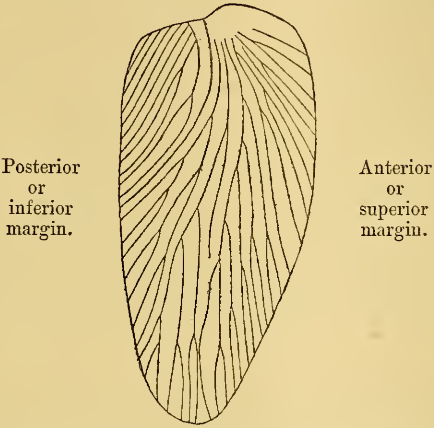

Fig. 5.—Right wing of *Mylacris anthracophilum*, Scudder, × 2 nat. size, Carboniferous, Illinois (after Scudder).

Lithomylacris Kirkbyi, sp. nov. Plate II. Fig. 4*a*, *b*.

This specimen consists of a single detached left wing preserved on the surface of a piece of thin purple shale from "Bed No. 33" in the Upper Coal-measures near Meithil, on the coast of Fifeshire. This shale-bed, which overlies the lower coal and thin limestone, contains, with rootlets, rare specimens of species of *Neuropteris, Pecopteris,* and *Cyclopteris,* along with an *Anthracomya.*[1]

Although the border of the wing is somewhat imperfect, sufficient is preserved to show its general form, and the venation of the wing stands out in distinct relief on its surface.

Outline of wing pointed-ovate, slightly flattened on its superior border; length of wing 15 mm., breadth 8 mm. The 'mediastinal' vein occupies rather more than a fourth of the entire area of the wing; it extends to about two-thirds of the length, where it unites with the superior margin of the wing; it branches six times, one of these branches has three forks. The 'scapular' vein extends nearly to the extremity of the wing; it remains single for over one-fourth of its length, and then branches into three veins, the middle one of

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[1] For a full account of this area see a paper "On the Upper Beds of the Fifeshire Coal-measures," by Edward W. Binney, F.R.S., and James W. Kirkby, Esq. (Quart. Journ. Geol. Soc. Lond. 1882, vol. xxxviii. pp. 245-256, pl. vi.)

which is again forked. The 'externo-median' vein continues parallel to the scapular vein, for a slightly longer distance before it branches at the extremity of the wing into three inferior veins, two of which are again forked. The interno-median vein occupies about one-fourth the entire area of the wing; it gives off three almost equidistant inferior branches, none of which appear to be forked. The anal vein is nearly straight, and has three other almost parallel oblique simple veins occupying the anal area.

The wings of the *Mylacridæ* have the veins spreading in a fan-shape and appearing to arise in a single point, or near a single point, close to the base of the wing. (See Woodcut Fig. 5, *ante* p. 55.)

On comparing our English specimen with Scudder's figures on plate v. of his memoir, already referred to, one is struck with the general likeness they present; but the wings of *Mylacris* seem to be all more complex in the forking of the secondary or branch-veins than in our specimen, which agrees best with Scudder's genus *Lithomylacris*, and with such species as *L. Pittstonianum* (pl. v. figs. 4 and 10 *op. cit.*) or *L. simplex* (fig. 5, *op. cit.*); but our form is certainly distinct from any species figured by Scudder. I have great pleasure in dedicating this *the second English form of Blatta met with by him*, to its discoverer, Mr. James W. Kirkby, of Ashgrove, Leven, Fife, N.B., who has contributed so largely by his researches to increase the fauna and flora of the Carboniferous series of Great Britain.

### Leptoblattina exilis, gen. et sp. nov. Pl. II. Figs. 2 and 3.

The species about to be described is represented by two examples, each of which is in a nearly perfect state as regards the greater part of the insect, but neither specimen exhibits the legs (save only a fragment of one). In both specimens there is a portion of the head preserved (more being exposed in Fig. 3 than in Fig. 2).

The prothorax (or pronotal shield) is preserved entire in both, and the meso- and metathorax, followed by ten abdominal segments more or less distinctly to be made out, and having a pair of appendages (*cerci*) attached to the 10th segment in both (but only drawn by the artist in Fig. 3).

Two pairs of wings are seen in both specimens, springing from the lateral borders of the meso- and metathorax, with their outlines fairly exposed (especially so in Fig. 2). The total length of the original of Fig. 2 (which, like Fig. 3, is drawn twice natural size) is 35 mm.

*Head.*—The head is very small and somewhat bluntly pyramidal in form, and measures 2 mm. in breadth at its base, where it disappears beneath the pronotum, and is 2 mm. in length. There is a suture visible down the centre (in Fig. 3*h*), which divides the two epicranial plates, at the sides of which the eyes would be seen; in front of the epicranium a small projection no doubt represents the *clypeus* with the labrum at its extremity. (This is only indistinctly shown in Plate II., which was drawn and *printed off*, before the final touches of the needle developed these additional points of interest.)

*Thorax.*—The prothorax, or *pronotum*, is circular in outline in front, the sides being slightly compressed and the posterior border rather incurved near the centre (in Fig. 3); but this incurving of the posterior border is not seen in Fig. 2, so that it may be due to a slight lateral compression of the pronotal shield in the former specimen. In confirmation of this suggestion it may also be stated that the one specimen (Fig. 2) displays no median suture (or ridge) on the shield, whilst the other (Fig. 3), which is incurved on its posterior border, is also distinctly marked by a sharp ridge down its centre. Both specimens display the same indentation around a central pyriform slightly raised, area (similar to that observable on the pronotum in Plate II. Fig. 1).

Length of the pronotum, 7½ mm.; breadth, 9 mm. The mesothorax is about 1 mm. broader than the metathorax; they are nearly of equal length and closely resemble each other in form, being broader in front than behind, and indented upon the lateral margins, to give attachment to the wings. Breadth of mesothorax 6 mm.; length 3½ mm.; breadth of metathorax 5 mm.; length 3½ mm.

The *Abdomen* consists of ten somites; the first is narrower than the rest, and the second is the longest; the whole measure 16 mm. in length, and about 3 mm. or a little more in breadth. There is evidence in Fig. 2 (uncovered with the needle-point, since figuring) of epimeral pieces to the 7th, 8th, and 9th segments on one side, which, repeated on the other side, would add 2 mm. to the breadth of the abdomen, making the total breadth 5 mm. The cerci are 3 mm. in length, the articuli cannot be seen; they are broader in the centre, curved and pointed at the extremities.

*Wings.*—The wings are remarkably short in proportion to the total length of the body, and the anterior ones are strongly arched along the superior margin. The upper wings measure 11 mm. in length, and the lower or under wings 10 mm. Breadth of upper wings 5 mm., and of lower wings 4 mm.

Owing to some slight difference in the lithological character of the clay-ironstone composing these nodules, rendering them slightly coarser in texture than that which enclosed Fig. 1,—or else, as is more probable, the wings themselves were actually composed of thicker chitine in which the more minute veins were less delicately delineated;—whatever the cause, it is certainly much more difficult to decipher the venation of the wings in these specimens than in the other examples figured above.

We see in the upper wings, or tegmina, of both Figures 2 and 3, one very prominent vein, traversing the whole length of the wing, almost parallel with the superior margin; this is evidently the mediastinal vein. Only the very faintest traces of branches along the superior border of this vein can be detected in Fig. 2, on the right-hand wing. The anal vein can be made out pretty clearly in the wings of both specimens (see Pl. II. Figs. 2 and 3), it extends down to about one-third the length of the inferior border of the wing. The separation of the intermediate area into interno-median, externo-median and scapular, is most difficult to follow. The interno-median appears to occupy the largest area, and gives off very numerous branches which fork near the margin of the wing. The venation is most distinct upon the under wings, but these, although the most interesting, cannot be seen so fully as the upper ones, being partly covered by the latter.

*Detached limb.*—Near the extremity of the abdomen of Fig. 3 lie the detached tibia and tarsus of one of the limbs. It can be just made out with its numerous distal segments.

There can, I think, be no doubt that these two specimens from the Dudley Coal-field, which, in the narrow elongated form of the abdominal somites, present so remarkable a divergence from the living Cockroaches, are very closely related to (though probably not specifically identical with) Dr. F. Goldenberg's *Blattina insignis*, figured and described by him in his work, entitled "Fauna Sarepontana Fossilis" (4to. 1873, I. Heft, taf. ii. fig. 14, p. 17), from the Coal-measures of the Skalley Shaft, Saarbrück.

Dr. Goldenberg's *Blattina insignis* has the same general form of the pronotum and wings, and is characterized by the same slender abdominal somites, but it is very much smaller in size than our English specimens; and if reliance may be placed upon the sketch of the venation of one of its wings (sent by Goldenberg to Scudder, and reproduced by the latter author in his Memoir, 1879, *op. cit.* pl. iv. fig. 9), the details of the wings do not agree; but this, like the outline given of the wing itself, may very well be subject to revision.

Mr. S. H. Scudder has arranged all his American *Blattinæ* and also all the old-world forms under new genera, and has placed Goldenberg's *Blattina insignis* with a note of interrogation under *Etoblattina.* This seems waste of energy merely to remove a species from one genus to place it *doubtfully* in another. Now that its characters are more fully revealed to us, it is apparent that its place is not in *Etoblattina*, but in a distinct genus which might be appropriately designated *Leptoblattina*, for the reason sufficiently apparent in the foregoing remarks.

*Leptoblattina exilis*, like *Etoblattina Johnsoni*, was obtained by the late Mr. Henry Johnson, F.G.S., from the clay-ironstone of Coseley, near Dudley, and the specimens are now, with the rest of the treasures of the Johnson Collection, preserved in the British Museum of Natural History, Cromwell Road, London, S.W.

## EXPLANATION OF PLATE II.

Fig. 1*a*. *Etoblattina Johnsoni*, H. Woodw., sp. nov. (nat. size). Clay-ironstone, Coal-measures, Coseley, near Dudley (Johnson Coll.).
,, 1*b*. The same, enlarged twice nat. size, to show venation of wings.
,, 2. } *Leptoblattina exilis*, H. Woodw., gen. et sp. nov. (twice nat. size). Same
,, 3. } locality as Fig. 1 (Johnson Coll.). *h*, head; *t*, pronotum; *ab. abdomen.*
,, 4*a*. *Lithomylacris Kirkbyi*, H. Wood., sp. nov. Bed 33, Upper Coal-measures, Meithil, Fifeshire, from the collection of J. W. Kirkby, Esq.
,, 4*b*. The same wing enlarged twice nat. size.

## II.—IN BRITTANY WITH THE GEOLOGICAL SOCIETY OF FRANCE.

By the Rev. E. HILL, M.A., F.G.S.,
Tutor of St. John's College, Cambridge.

THE French Geological Society last year made Finistére the object of their annual excursion, and by their kindness I had the great pleasure of joining the party. As Brittany is so interesting a region, already very accessible by railways, and soon to become even more so, it has occurred to me that a brief account of the excursion may be acceptable to our English geologists, and at any rate afford them an index to some localities which will well repay a visit.

It will be convenient to preface with a table of the strata, according to the nomenclature and classification of Dr. Barrois.[1] He arranges the beds of this region as follows:

CARBONIFEROUS.

Coal-measure Schists and Conglomerates.
Schists and Sandstones of Chateaulin.
Porphyrite Tuffs.
Porphyry Conglomerates and Tuffs.

DEVONIAN.

Nodular Schists of Porsguen.
Schists and Limestones of Néhou.
White Grit of Landevennec.
Schists and Quartzites of Plougastel.
Limestone of Rozan (with *Strophomena Looiensis*).

SILURIAN.

Nodular Schists (with *Cardiola interrupta*).
Ampelite Schists (with Graptolites).
White Sandstones.
Slaty Schists of Angers.
Armorican Grits (Grés a scolithes).
Red Conglomerates and Schists of La Chevre.

CAMBRIAN.

Schists and Conglomerates of Gourin.
Phyllades of Douarnenez (or of St. Lo).

PRIMITIVE.

Schists of Groix.
Mica-Schists of Audierne.
Granitic Gneisses of Pont-Scorff.

Dr. Barrois regards the Cambrian Schists of Gourin as corresponding to Barrande's Etage C; any identification of the beds below must at present be conjectural.

Among the eruptive rocks the granite of Pontaven is Cambrian or Pre-Cambrian; the porphyroid granites of Rostrenen and Huelgoat are of Carboniferous age; the granites with two species of mica (granulites) of Quimper, Le Faouet, and Morlaix, are also Carbon-

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[1] See "Aperçu sur le constitution géologique de Finistére" in the June number of "Le Guide Scientifique" (Paris, J. Michelet, 25, Quai des Grands Augustins; London, J. A. Berly, 3, Deronda Road, Herne Hill, S.E.).

iferous and posterior to the last. The kersantons cut the (Carboniferous) Chateaulin schists and are the latest of the eruptive rocks.

Quimper was our rendezvous. On the afternoon of Aug. 19, after the first meeting, a stroll was taken along the promenade on the left bank of the stream to look at outcrops of 'Petrosilex' seen there. This is much crushed and a confident opinion on it is not easy to form. Then walking out of the town to the west, we saw, first in the town a conglomerate of Carboniferous age, then successively along the high road a coarse white gneiss, a mica-schist well exposed in a road cutting, finally a granite. These rocks are said to occur in this alternate fashion over a vast tract of country. Returning, we deviated a little to examine a diorite dyke.

Proceeding by rail to Chateaulin, we commenced the next day by examining the schists of Chateaulin here worked for slates. They closely resemble the slates (also of Carboniferous age) of Vernayaz and Salvan (Switzerland). No fossils occur here; the position of the rocks is established by a few impressions found in some limestone beds towards the base of the series. At Port-Launay below Chateaulin a steamer was waiting, placed at our disposal by the Port Admiral of Brest, and embarking, we commenced our descent of the river. After some hours of pleasant transport and pretty scenery, a landing was made on the right bank near Terenez, where the quartzites of Plougastel are exposed, and where the grits of Landevennec can be seen to succeed them conformably. We walked along the strand for a mile or two, and found our boats waiting to re-embark the party nearly opposite Landevennec.

The boats again transferred us from the steamer to the shore in the Riviere de l'Hopital, at the spot on the right bank marked as Moulin de Mer. There is a tide mill here, whence the name, with large and good machinery; a breakfast spread in a spacious loft was very welcome. East of the mill and behind it is a fine quarry of kersanton and porphyry. The schists of Néhou are here cut by a mass consisting of kersanton between two bands of porphyry, but the relative age of these two igneous rocks can be determined better by a section described below. From Moulin de Mer, walking west through Logonna and seeing at an estuary the schists of Porsguen, we collected the rare rock quartz-kersanton in a rocky beach at Goulet-quer, and were again put on board the steamer. Kersanton, so frequent in this district, was named after a shallow quarry in this neighbourhood, now, however, disused and overgrown.

We were landed for the last time this day, about three miles to the N.N.W., at a promontory near Porsguen, to see a most beautiful section. It is in the sea-cliff on the east side of the promontory, and shows the schists of Porsguen, porphyry (micro-granulite) overlying them, and a dyke of kersanton breaking through both. The black sedimentary rocks are little altered, but tremendously crushed by this double intrusion, and show a rude cleavage set up across the old fissile bedding. Time not allowing a purposed visit to the Isle Longue, our steamer took us through the vast landlocked gulf that is called Brest Roads (Rade de Brest) direct to the quay at Brest itself.

On the following day the same steamer, again devoted to our service, carried the party south across the Roads to a little pier at Le Fret. Vehicles were ready, but as soon as they had taken us across the embankment to the S.E., we left them and walked along the strand eastwards, to see the outcrops of the schists of Porsguen and to collect Devonian fossils at a spot about 300 yards from the road. Returning, we were driven through Crozon across the isthmus to a very lovely bay, combining the broad beach of Sandown with the tall cliffs of Ilfracombe, and possessing every qualification for a watering place except accessibility. A good hotel is named from the neighbouring village of Morgat; and this name is the one used by geologists in referring to the cliff-section, the most complete which we saw in the excursion. We commenced by walking to the south, to see in succession the Schists with Graptolites (fossiliferous); the slates of Angers; the Gres Armoricain or Gres a Scolithes fossiliferous about 100 yards above the pier of the little fishing port; and (if time had permitted) the Red schists of Cap de la Chevre which form the base of the Silurians here. The succession is clearer on this side than on the north side of the bay. Returning and passing along the upper edge of the cliffs, we traversed repetitions by several folds of the complete Silurian system with part of the Devonian, as high as the quartzites of Plougastel, which here form some of the most striking cliffs. After walking three or four miles, and crossing by an embankment the estuary called Aber to Rosan, we were shown at the neck of the peninsula that forms the Isle d'Aber, a singular series of stratified diabase tuffs. They are placed by Dr. Barrois between the uppermost Silurian and lowest Devonian beds (Schistes a Nodules and Calcaire de Rozan). Proceeding along the cliffs past Kerglintin and further east some two miles or more, where the path passes along a cliff slope, we saw the Gres a Scolithes succeeded by the Red schists, and these passing down into a singular quartz conglomerate so veined with quartz that I was slow in being convinced of its true nature. Then descending into the little bay, we saw rocks of an entirely different aspect: the Phyllades of Douarnenez belonging to the Cambrians; and the few active geologists, who, after so long and rapid a walk on a broiling day, were 'in at the death,' threw themselves down on the sand and commenced a lively discussion on the evidences of the succession, which my knowledge of French was insufficient to follow. The carriages were waiting for us as Tal-ar-groes, about three miles to the N.W., and took us to our steamer, which brought us back to Brest. We arrived at so late an hour that, had the rules of entry into a fortified town been strictly carried out, we should have had to dispense with supper and bed.

After a morning of rest, an afternoon of. railway back through Chateaulin and Quimper took us to Quimperlé. Next day we started early for a very interesting excursion. Crossing at first gneiss with an intrusion of 'granulite,' we drove west as far as Pontaven. Here about one kilometre to the south, on the left bank of the river, we examined in shallow quarries the granite of Pontaven, supposed to be of Pre-Cambrian age. The granite is not perfectly homogeneous, but has some faint appearance of structure or incipient foliation, and I noticed a seam that to me resembled a line of crush. Scattered masses tend to weather into oval boulders. North of the village, a short distance on the right bank, we saw granite closely followed by a much contorted rock; a gneiss or mica-schist in contact with the granite. This gneiss is regarded as rather later than that of Quimperlé.

Returning as far as Riec, and then diverging south-east, we passed rocks of varying nature, named as sometimes granitic gneiss, and sometimes gneissic granite, till where a new road has been made for a mile or two skirting the estuary of the Belon, a series of fine sections are furnished. Any geologist interested in the question of mica-schist and gneiss originating out of igneous rocks should especially study the sections in a cutting which succeeds an embankment made for the road.

Thence we drove through Moelan and Clohars to the mouth of the river Ellé, from Quimperlé, and descended to the sandy beach at Port Clohars (gay with bathers, country people, the tourist is unknown). Here the cliffs to the east afford fine exposure of a succession of stratified rocks regarded as Pre-Cambrian in age. Some are hornblende schists, fairly compact; some are extremely coarse-grained rock, that seemed to me an arkose of a coarse gneiss, and are by no means highly indurated: there are also some quartzite beds, and some chlorite schists, besides an intrusion or two. These beds recur in similar order, so that there are probably repetitions by faults; unfortunately I had not time to study this most interesting section, and had to be satisfied with viewing it in a simple traverse. We rejoined the carriages at St. Julien, and returned to Quimperlé, obtaining good specimens of the Quimperlé gneiss (gneiss of Pontscorff), after passing under the railway, at the entrance to the town.

On Tuesday morning our procession of vehicles defiled from the town to the north-east along the road to Le Faouet. Granite was examined at Le Combout, but nothing remarkable was seen till when, within two miles of Le Faouet, we left the carriages and passed the very interesting church of St. Fiacre. Making our way eastwards by footpaths we came out on another high road, near the mill of Rochepierou, to view the (Cambrian) Phyllades of St. Lo, at or near their junction with a granite (granulite): the only sections are small roadside outcrops. Thence we walked to Le Faouet, which was made a lively scene by the occurrence of a fair that day. Between this place and Gourin 'granulite' is passed at Pont du duc, and a rather fine-grained granite at Le Saint. Gourin is said to be the critical point for deciding on the conformability or otherwise between the conglomerates of Gourin and the phyllades of St. Lo; but the evidence is I believe only circumstantial. Grey schists are well seen near a rivulet just before entering Gourin, and the conglomerates in a quarry about 1½ miles east of the town on the road leading to Plouaray. We again saw the red conglomerate north-east of the town, and then a section of the Schistes d'Angers. The road gave some good scenery in its traverse of the low ridge called the Montagnes Noires, but whatever else of interest there may be between these and Carhaix was lost in the shades of evening and night.

Two days were spent at Carhaix, occupied by two long excursions eastwards to Rostrenen and Goarec respectively, to study the phenomena of metamorphism on each side of the great intrusion of the Rostrenen granite. Deviating from the direct road to pass through Paule, we were there shown the first signs of alteration in (Carboniferous) Chateaulin schists. Near Glomel the change had gone further, and small but perfect crystals of andalusite had been formed. We walked about two miles west of Glomel on a road, and then turning north down a lane about half a mile collected in a quarry near Bressillion andalusite in altered (Devonian) schists of Plougastel, thence returning south-west and south, saw near Kervennan the same mineral developed in the (Silurian) schists of Angers, while at Rostrenen itself, just outside the village, we collected the beautiful porphyritic granite that is the agent of all this change. The porphyritic crystals of felspar reach a large size, and in decomposed rock they lie as pebbles in a sand. To the south of the village, in a large rock on the side of the road, near Kerbescont, the schists of Plougastel reappear altered into leptinolite.

Beyond Rostrenen (this was on the second day), about the kilometre stone marked 17, a fragment of schist is seen actually included in granite; further on, sandstones belonging to the Chateaulin schists occur little altered, and about one mile before reaching Plouguernével, a small excavation on the road-side shows an actual contact; a mass reposing in a trough of the granite, with an isolated piece completely surrounded. Further on, they are seen again in a pit with a pond, less altered as being further from the granite.

At Goarec, at the east end of the village, on the north side of the road, is a quarry in a rock unlike anything we saw elsewhere, and said to resemble the Porphyroides of the Ardennes. It is supposed to pass into the schists, but its relations are not seen here. South-east from Goarec along the high road the Schistes d'Angers are seen in fine crags. Quitting the route at Bon Repos, and denying ourselves more than a distant glance at the picturesque abbey, we crossed the canal and entered on an extensive wood. After following the canal bank a mile or more, we turned south to reach the abandoned Forges des Salles, just beyond which in the wood is a quarry in some highly cleft 'schistes a chloritoid.' On the roadside three or four miles further (east side, just before the group of houses called St. Brigitte), is a shallow quarry in a kind of slate, which while showing only traces of cleavage, and containing fairly abundant and quite recognizable fossil impressions (Trilobites, *Orthis*, etc.), is also full of fine crystals of andalusite, which lie in the closest proximity to the fossils.

Quitting Carhaix on the 27th August, and driving to the N.W., cuttings made for the road show sections of Chateaulin shales with some indistinct remains of plants. Beyond Poullaouen are some fine dykes of kersanton, and further on a small one of microgranulite; thus intrusions of both these rocks must have been going on as late as in Carboniferous times. For the kersanton, there is some evidence that it did not occur earlier; no pebbles of it are found in conglomerates which include all the other igneous rocks; as for instance at about four kilometres before reaching Huelgoat, in a conglomerate belonging to the base of the Carboniferous series. In a quarry about a mile from the road, at Bruguec north of Kerrion, a microgranulite tuff again proves that the eruptions of this rock towards the end of the Devonian age continued into the Carboniferous.

The mine of Huelgoat has had a long and interesting history, but now is abandoned. In the walls near it are a few fragments of the Roche Verte, a green breccia, which has been the subject of much discussion, but is now considered to be a bed below the Chateaulin schists, and above those of Porsguen (Porphyrite tuffs of the Table). From beyond the mine a path leads for some miles through a beautiful wood by the bank of a water channel at a high level on the hill-side to the quaint little town of Huelgoat.

The porphyroid granite of Huelgoat resembles that of Rostrenen, and belongs to the same (Carboniferous) age. The great rocking stone called the Roche roulante, distant about half a mile, is worth a visit, and just below it is a quarry in the granite which there contains abundantly pinite. Thence we regained the Carhaix road, and returned along it some two kilometres to the east to see the contact of the granite with Porsguen schists. A dyke of microgranulite cuts the granite a little before reaching the junction. The schists are indurated into a rock which has been called Cornien, and the alteration is certainly considerable. We turned north along the main road towards Morlaix to reach, after 3 or 4 kilometres, a long shallow quarry in quartzites of Plougastel, here altered by the granite, and went about a quarter of a mile up a footpath (not marked on the map) to Le Vern for schists of Angers rendered crystalliferous. At An Avallennou on the high road, the Grés a Scolithes is seen little altered. We returned a few hundred yards and took a lane to the south-west, which soon led us over the granite. After some three kilometres it brought us out at Ty le Brennou, where Plougastel schists are seen at their contact with the granite, and where a quarry in a field west of the high road gives a beautiful section of the junction. This completed for the Huelgoat granite what had been done on the previous days for the Rostrenen granite, an examination of the effects produced on all the beds broken through. The parallel bands of strata which cross the country from east to west are in each case interrupted by the great intrusion, and the resulting alteration in each case surrounds the igneous mass as a sort of aureole or halo, intensest at the boundary and dying away at a mile or so from it.

Our last day was devoted to the neighbourhood of Morlaix. In the morning we drove southwards along the road which leads at first south-west from the centre of the town (past the post-office). About a mile from the town, and a quarter of a mile east of the road (at

Buvette a Pont Neuf), a moorland hill affords a few Devonian fossils in a grit belonging to the schists of Morlaix. Further along the road occur schists of Plougastel altered by granite (of Pompol). A quarry on the west side of the road, about two miles from the town, shows garnets and chloritoid in the altered schists. About a mile further, in another quarry about 100 yards west of the road, behind some houses (Le Fume?), the schists have become leptinolite. The road-sections, a little beyond, of granite tongues running into schists, are as fine as I ever saw.

An afternoon excursion from Morlaix took us a circuit north of the town. We passed on the right bank of the river singular bedded rocks (Schists of Morlaix), with a granite dyke cutting them, and made deviations to see the quarry of Kerscou and its wonderful junction of granite and schist (a strip of black shale, 30 feet long by 18 inches broad, is included as if torn off), and at a hamlet called Ploujean a unique porphyry dyke. Thence regaining the main N.N.E. road we passed in a valley a diabase dyke badly seen in road-sections, followed by some conglomerates, and arrived at the head of the estuary of the Dourdu, where, by walking half a mile along the northern strand, we were to have seen a limestone conglomerate; but a tide of phenomenal height obstinately continued to rise and entirely barred our progress. Quartz conglomerates were again seen in the road along the slopes above, and about the 5 kil. stone from Morlaix, in shallow quarries for road metal, the Grès a Scolithes. Thence returning through St. Antoine, and driving east for several miles, we traversed the whole basin of the Morlaix schists, until we again encountered the Grès rising from under them. In a shallow quarry in the midst of fields, and almost buried from sight, we were shown the locality where a few rare fossils have proved its Cambrian age. This ended the excursion.

The guiding idea in its arrangement was to show first the complete series of unaltered beds, and afterwards the modifications which these rocks present around the invading masses of granite. I cannot attempt to reproduce in any way the interesting discussions on these phenomena which occurred between the distinguished geologists of the party. From my own observations I come back with the strengthened conviction that it was no causes of this kind which gave origin to the crystalline schists.

I desire to take this opportunity of expressing my gratitude to the members of the party, and especially to its President, Dr. Barrois, both for the opportunity of joining the excursion, and for the particular kindness and attention bestowed on me at every possible occasion.

## III.—NOTE ON SPECIMENS OF THE RAUENTHAL SERPENTINE.

By Professor T. G. BONNEY, D.Sc., LL.D., F.R.S.

IN the very valuable work on "British Petrography" by my friend Mr. J. J. H. Teall, now in process of publication, there is a rather full notice of an interesting serpentine which occurs in the Rauenthal (Vosges), and has been investigated by Herr Weigand.[1] According to the latter author, as summarized by Mr. Teall,[2] this serpentine "has been formed by the alteration of a hornblende rock, and the change has been accompanied by the removal of lime and the development of a chlorite, in which the original alumina of the hornblende is retained."

Such an origin for a serpentine would of course be perfectly possible, supposing that a certain amount of silica was also removed; for the formation of the mineral serpentine from malacolite and other non-aluminous varieties of pyroxene is familiar; but inasmuch as masses either of pure hornblende or pure pyroxene[3] are certainly very rare, we should expect such a serpentine to be extremely local in its occurrence, and (like the pyroxene-serpentine) rather abnormal in aspect. Hence it will be well for the student of "British Petrography" to remember that, if Herr Weigand be correct, the origin assigned to the Rauenthal serpentine is not likely to interfere with the general rule that normal serpentines result from the alteration of peridotites. But is Herr Weigand quite correct, and does not his statement require a little limitation? I confess that his paper has awakened some suspicions in my mind which are confirmed by the examination of specimens, procured by Mr. Teall from Stürtz of Bonn, and by him kindly placed at my disposal.

First, as regards the results of Herr Weigand's studies of the rock. In his paper, which is a most conscientious piece of work, he gives us, in addition to an analysis of the white mica-like constituent—a chlorite—an analysis (A) of the soluble portion of the rock (*i.e.* practically all but the chloritic constituent, not generally abundant), a bulk analysis (B) of the whole rock, and an analysis (C) of the amphibolite into which the serpentine is said to pass. These are as follows:—

| | A. | B. | C. |
|---|---|---|---|
| $SiO_2$ | 37·706 | 36·944 | 46·407 |
| $Al_2O_3$ | 0·201 | 1·353 | 6·727 |
| $Fe_2O_3$ | 10·428 | 6·868 | 4·649 |
| FeO | —— | 3·956 | 2·107 |
| CaO | 1·677 | 1·393 | 10·642 |
| MgO | 36·602 | 36·022 | 26·252 |
| $H_2O$ | 13·386 (diff.) | 13·089 | 3·584 |
| | 100·000 | 99·625 | 100·368 |

Now a glance at A and B shows that either the one or the other would be a very fairly normal analysis for an ordinary serpentine.[4] As usual the silica and magnesia are nearly equal in amount; there is about the ordinary proportion of iron oxides and water. The percentage of lime, though not large, would lead us to suppose that augite or hornblende rather than enstatite had been

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[1] Tschermack, Min. Mitt. 1875, p. 175.

[2] British Petrog. p. 112.

[3] I find that the diallage rock at Lendalfoot, described by me, Q.J.G.S. vol. xxxiv. p. 778, is not quite free from olivine. This too is a comparatively small mass.

[4] That is to say, a rock which has resulted from the alteration of a rock consisting of olivine with a certain amount of a magnesian bisilicate. A serpentine formed from a perfectly typical dunite should have MgO in excess of $SiO_2$.

associated with the dominant olivine of the original rock, that is, that it had been one of the varieties of peridotite, which approach nearest to picrite, and by some would even be included under that name.[1] If we can take the amphibolite as in any way representing the parent rock of B, we see that not only must we remove a considerable amount of lime (almost enough, so far as figures go, to make up the difference in water), but we must get rid of a considerable proportion of alumina, and a large amount of silica.[2]

If these substances have been removed, it is a little strange that we do not find traces of them in the form of veins and similar deposits in the rock itself. But Herr Weigand does not mention any, and I find none in the specimens before me. It may, however, be objected to this mode of reasoning, that the amphibolite does not fairly represent the rock from which the serpentine (B) was formed, but only a rock which was closely related to it; and, having regard to the "badly mixed" condition of many of the basic igneous rocks—such as the peridotites and picrites—the objection is not unreasonable. Let us then see whether the difficulty would disappear if we were dealing with some other variety of hornblende rock. Clearly we must select as its constituent mineral a hornblende poor in alumina, rich in magnesia. In all the analyses quoted by Dana in his Mineralogy, the percentage of silica (as we should expect in a bisilicate) is greatly in excess of magnesia. Even antholite, which, by its richness in iron and poorness of lime, would be the most suitable constituent of the mother-rock of the Rauenthal serpentine, has at most $SiO_2 : MgO = 584 : 314$.[3] Thus a consideration of Herr Weigand's analyses alone suggests that either the specimens analyzed or the specimens examined microscopically were abnormal, or there had been some slight error in the one or the other investigation.

I proceed now to the result of my own examination of Mr. Teall's two specimens. Slides have been cut from each, two from one (that which he kindly gave me), one from the other. After careful study of these, while I agree with Herr Weigand that the original rock has contained a variety of hornblende, and that some of this has been altered into a serpentinous mineral, I can come to no other conclusion than that the dominant constituent in each is a serpentine formed from olivine.

On examining one of the slides cut from my specimen,[4] we see that it is chiefly composed of two constituents rather irregularly dis-

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[1] For myself I think it better to apply the term *picrite* to the rather indefinite group which is intermediate between the true peridotites (or felsparless rocks where olivine dominates) and the olivine-dolerites. Olivine + augite and olivine + hornblende need names.

[2] Suppose, for purposes of comparison, we assume that no magnesia has been removed. In (B) $Al_2O_3 : MgO = 14 : 360$; in (C) $Al_2O_3 : MgO = 67 : 263$. These proportions expressed in decimals are ·038 and ·254. Again in (A) $SiO_2 : MgO = 369 : 360$—almost equal; in (C) $SiO_2 : MgO = 464 : 262$—about 17 : 10.

[3] Anthophyllite would also be a very suitable mineral, but it is evident that we are not dealing here with a rhombic mineral, but one which much resembles tremolite.

[4] These happen to be slightly thicker than Mr. Teall's slide, so that the distinction of the constituents is rather more conspicuous.

tributed. The one—almost colourless—clearly is or has been a hornblende, as described by Herr Weigand. It shows, even when converted into serpentine, the characteristic cleavages parallel to ∞ P in cross-sections and the parallel lines formed by these in longitudinal sections. Occasionally portions of the mineral still remain unaltered. The other constituent is a pale sap green in colour; it consists of a rather irregular network of a doubly refracting mineral, with interspaces chiefly occupied by an isotropic mineral. This meshwork can be readily seen by transmitted light, but is rendered more distinct by using crossed Nicols, when the 'strings' appear either white or pale golden yellow. This structure, and this mineral or association of minerals are perfectly familiar to me as the result of the alteration of olivine; there are various minute structural differences between the isotropic parts of this and the most highly altered portions of the other mineral, which it is almost impossible to describe without entering into details which would be tedious, but which become readily apparent to a practised eye after a little study, so that while I will not undertake to say that I can distinguish every grain of the two constituents, I have no hesitation as to distinguishing them in at least five-sixths of the rock. Hence I cannot admit the general accuracy of my friend's statement, founded upon Herr Weigand's paper: "Microscopic examination shows that the rock differs markedly from normal olivine serpentine. It consists of a transparent green or colourless substance,[1] in which the irregular 'maschenstructur' due to the separation of the iron oxide along the original cracks of olivine is absent." But the "maschenstructur" of a serpentine derived from olivine is not *due* "to the separation of the iron oxide," but "to the original cracks" (*i.e.* the imperfect cleavage planes) of the mineral itself. It is, indeed, very commonly exhibited in great perfection by the deposition of iron oxide, which plays the part of an injection in an organic structure; but it is quite a mistake to suppose that the iron oxide is *always* separated and deposited in this way.[2] The 'mesh structure' in the Rauenthal rock is not seldom divided down the middle by a line (indicating the original cleavage plane); this is sometimes made more distinct by a slight deposit of iron oxide, and the minuter structures of these strings agree perfectly with those in a normal serpentine. Thus the above-quoted sentence would be more correctly worded as follows:—"It consists of a transparent green *and* a colourless substance," and the remainder of the sentence would then apply to the latter of these, viz. the altered hornblende. As to the relative amounts of the two minerals, it is difficult to speak exactly, as they are rather irregularly mixed; but in no case, I think, does the hornblendic constituent dominate in the field of view under a one-inch objective, and on the

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[1] I observe that very commonly there is a slight green band between the cracks (cleavages) of this mineral, as though a liquid had been injected from without. I have noted the same thing in the case of the pyroxenic minerals present in other serpentines. The mineral may be derived from the olivine and "injected" during the hydration of the olivine, which process must set up considerable strains and pressures.

[2] See, for instance, Wadsworth's Lithological Studies, pl. iv. fig. 4. The decided green colour is probably due to imperfect separation of the iron.

whole I have no doubt that in my slides the peridotic constituent is distinctly in excess. Hence either our specimens are exceptional, or Herr Weigand has examined slides cut from an exceptional specimen, or he has failed to distinguish the two minerals. So far as I can form an opinion from the woodcut given in his paper, I confess that I incline to the last solution, for I think that even there I can see indications of a difference in the constituents. In any case it is, I think, clear, that the Rauenthal serpentine is only a variety of the group of serpentines derived from the alteration of olivine-hornblende rocks, of which we have excellent examples at Mullion, Pradanack, and other localities at the Lizard.[1] To some of these indeed the Rauenthal rock has, both macroscopically and microscopically, a considerable resemblance. All that we can assert is that occasionally (possibly) the white hornblende is rather exceptionally abundant, and that (as sometimes occurs elsewhere) a peculiar variety of chlorite is locally developed.

I may take this opportunity of calling attention to another statement on p. 119 of Mr. Teall's work, which I believe to be not quite accurate. Speaking of the occurrence of felspar in the Lizard serpentines, Mr. Teall says, "It is present also in slides of a variety of serpentine from the Rill Head, near Kynance, lent to the author by Mr. Waller," to which he appends the note, "The author has recently visited the district and ascertained that serpentine containing felspar forms a large portion of the Rill Head. The original rock, therefore, was of the nature of a picrite." It would not, of course, be surprising if a little felspar occurred in a mass of serpentine, and I had already noticed at Gue Graze (on the same coast further to the north) a decomposed mineral which I thought might be felspar, as is mentioned by Mr. Teall in the passage from which I have quoted, though it would be more correct to say, "Professor Bonney records it (felspar) as [probably] occurring at Gue Graze," as will be seen on reference to my description of the Gue Graze rock (Quart. Journ. Geol. Soc. 1877, p. 918). But in regard to the Rill rock I do not consider the mineral mentioned by Mr. Teall to be felspar. No doubt it occasionally closely resembles a plagioclastic felspar, both in its earthy decomposition and its lamellar twinning; but after carefully examining my own slides (including one cut from a specimen kindly given me by Mr. Teall, and one which Mr. Waller freely placed at my disposal, I am distinctly of opinion that the mineral is not felspar. This earthy decomposition (which weighed much with me in examining the Gue Graze rock) is, I now find, not unfrequent in colourless minerals belonging to the pyroxene group, and the mode in which the transparent parts of the crystal are attacked appears to me to be different from that in which kaolinization proceeds in a felspar. There are also some minute structural peculiarities in the mineral, which to my eye recall a member of the above-named group and not a felspar. The twinning, which however is not very common, is no doubt curiously like that of a plagioclastic felspar; but similar twinning does occur, though rarely in augite or diallage (Fouqué and

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[1] As mentioned in my paper, Q.J.G.S. vol. xxxix. p. 23.

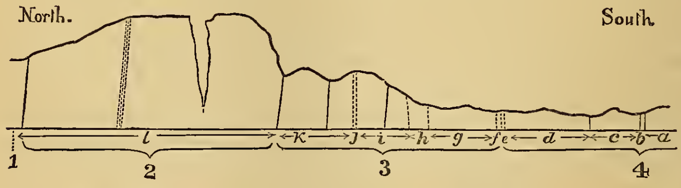
Lévy, Roches Eruptives, p. 358). Hence I feel convinced, after repeated examination, that the presence of felspar in this Rill rock cannot be asserted on the evidence before us, and that it consists chiefly of olivine (more or less altered into serpentine) and augite (diallage). Further north the pyroxenic constituent appears to be commonly a colourless hornblende. It is possible that this mineral is also present in the Rill rock, and I think I have detected a grain or two of rhombic pyroxene.

## IV.—On the Discovery of the *Nummulina elegans* Zone at Whitecliff Bay, Isle of Wight.

By H. Keeping,
of the Woodwardian Museum, Cambridge.

WHEN visiting Whitecliff Bay, Isle of Wight, last September, I was so fortunate as to find exposed on the shore at low-water, the whole of the various strata from the Brook Bed of the Bracklesham, to the Bembridge Limestone inclusive. I have visited this locality many times, but have never before seen the Barton Series exposed. On my return to Cambridge, I mentioned the subject to Prof. Hughes, and he suggested that I should make another visit in order to obtain a larger collection of fossils; but on this second occasion, I was surprised to find that the whole of the strata, which I had seen on the shore in September were now covered with sand to the depth of twenty inches. Therefore, seeing that nothing could be done on the shore, I set to work at the cliff, and succeeded in finding the same beds there.

For the sake of reference I have copied a part of Professor Prestwich's[1] section, which I consider so good that it would be difficult to improve upon it, except by adding details of zones since discovered: these are shown by the dotted lines. In ascending order



1. L. Headon. Brockenhurst Bed. 2. Upper Bagshot. 3. Barton Series. 4. Bracklesham Series.

Section in Whitecliff Bay, Isle of Wight.
Scale 1 inch = 150 feet.

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[1] On the Tertiary Formations of the Isle of Wight, Quart. Journ. Geol. Soc. vol. ii. p. 223, plate ix. 1846.

the beds seen, commencing with the Brook Bed of Bracklesham, are as follows:—

(*a*) Brook Bed.

(*b*) Grey sandstone or Tellina bed of Selsea.

(*c*) *Nummulina variolaria* zone, measuring about 20 feet, being quite full of these small Foraminifera.

(*d*) Dark green sandy clays, with glauconite grains. This part of the series I consider to be the equivalent of the beds just above the *Nummulina variolaria* zone of Stubbington and Hunting Bridge in the New Forest, which has been described by the Rev. O. Fisher.[1] I could find no fossils sufficiently well preserved for identification in this part of the series. Thickness about seventy feet.

(*e*) A thin band of dark earthy-coloured sand, rather coarse: this I did not find on the shore at low-water, where, however, I have no doubt it occurs. *Ostrea flabellula* is fairly abundant in it. The thickness is seven inches.

This brings us to the bottom of the *Nummulina elegans*[2] zone, which therefore is now shown to be of such wide extent and constant occurrence that it seems more convenient to adopt the Rev. O. Fisher's[3] classification, and take this horizon as the basement of the Barton Series.

(*f*) *Nummulina elegans* zone, consisting of rather dark green and blue glauconitic sandy clays, much crowded in places with *Nummulina elegans*. I was much interested in finding this rich bed for the first time in this locality, as the Bracklesham and Barton Series have not been found before in juxtaposition with sufficient fossil evidence. There cannot now, however, be any doubt of the existence of the Barton as well as the previously known Bracklesham at Whitecliff Bay, as at that locality the fossils give abundant evidence of the existence of each. The following are the fossils from the *Nummulina elegans* zone, which has a thickness of thirteen inches:—

*Typhis pungens*, Brand.
*Fusus bulbus*, Brand
*Cominella Solandri*, Edw.
*Pleurotoma exorta*, Brand.
*Voluta luctatrix*, Brand.
——— *digitalina*, Lam.
*Mitra parva*, Sow.
*Calyptræa trochiformis*, Lam.
*Dentalium striatum*, Sow.
*Bulla*, sp.
*Corbula pisum*, Sow.
*Crassatella sulcata*, Brand.
*Cardium semigranulatum*, Sow.
*Leda minima*, Sow.
*Ostrea flabellula*, Lam.
*Nummulina elegans*, Sow.

The specimens of *Nummulina elegans* at Whitecliff Bay are, I think, somewhat finer than those at either Alum Bay or Highcliff.

(*g*) Pale blue and yellow sandy clays, with very few and badly preserved fossils. Thickness, 54 feet.

(*h*) A stiff laminated clay, with occasionally dark patches. Few or no fossils. Thickness, 18 feet.

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[1] Quart. Journ. Geol. Soc. vol. xviii. 1862, p. 65.

[2] Formerly called *N. Prestwichiana*, but the recent researches of Prof. Rupert Jones prove it to be *N. elegans*. See his paper read before the Geological Society, December 15th, 1886.

[3] *Op. cit.*

(*i*) Grey and pale blue clays, with light fawn-coloured bands near base. Thickness, 36 feet.

(*j*) Imperfect ironstone band not well seen. Thickness, 3 feet.

(*k*) Blue sandy clays, with mottled brown patches of soft earthy ironstone near the base. Thickness, 50 feet, the upper fifteen feet of which consists of a bluish sandy clay, and contains the following fossils:—

*Terebellum sopitum*, Brand.
*Voluta humerosa*, Edw.
*Pyrula nexlis*, Lam.
*Natica*, sp.
*Calyptræa trochiformis*, Lam.
*Ostrea flabellula*, Lam.
*Pecten carinatus*, Sow.
——— sp.
*Lima*, sp.
*Avicula media*, Sow.
*Arca*, sp.
*Pectunculus deletus*, Brand.
*Limopsis scalaris*, Sow.
*Nucula bisulcata*, Sow.
*Chama squamosa*, Brand.
*Cardium porulosum*, Brand.
*Lucina gibbosula*, Lam.
*Crassatella tenuisulcata*, Edw.
*Cypricardia* sp.
*Cardita oblonga*, Sow.
*Cytherea tenuistriata*, Sow.
*Tellina ambigua?* Sow.
*Corbula ficus?* Brand.
*Panopæa intermedia*, Sow.
*Shizaster D'Urbani*, Forbes.
*Ditrupa plana*, Sow.

For the convenience of collectors, I give the following measurements taken along the cliff at high-water, commencing with the Bracklesham Sandstone, which can always be seen, so that the strata under consideration can be found at any time:—

| | | |
|---|---|---|
| Bracklesham Sandstone to the *N. elegans* zone .................. | 126 | feet |
| *N. elegans* zone to top of Barton.................................... | 161 | ,, |
| Top of Barton to top of Upper Bagshot............................ | 186 | ,, |
| Lower Headon ............. ............................................ | 19 | ,, |

The Whitecliff Bay section is almost complete from the Chalk to the top of the Bembridge Series, as it not only shows a good exposure of Barton Clays, but also the Brockenhurst and Roydon zones (Middle Headon). It is therefore by far the most perfect section of the Tertiary formation in England.

I am indebted to Prof. Rupert Jones for examining the specimens of *Nummulina*, both from the Bracklesham and Barton Series; he considers *N. elegans* to be the only species found in the Barton, the so-called *N. variolaria*, found some forty feet above the true *N. elegans* zone, being only a thickened form of *N. elegans*. There seems, therefore, to be only one species in the Barton and two in the Bracklesham Series.

It will be seen that a few of my measurements differ slightly from those given by Professor Prestwich: this is due to the latter having been made along the cliffs, while mine were taken on the shore at low-water.

The specimens referred to in the above paper are preserved in the Woodwardian Museum, Cambridge.

## V.—Note on the Gault and Chalk Marl of West Norfolk.

By A. J. Jukes-Browne, B.A., F.G.S., and W. Hill, F.G.S.

UNTIL the appearance of the article by Messrs. C. Reid and G. Sharman in the Geological Magazine for February, 1886, p. 55, no one had ever thrown a doubt on the existence of true Gault in Norfolk. The grounds on which these gentlemen venture to doubt its existence are these :—

(1) No clear line of separation between the Gault and Chalk Marl, and no phosphatic bed marking the base of the latter, could be found by the Geological Surveyors.
(2) They give a list of unphosphatized fossils from the marly clay of West Dereham, which they regard as a Chalk Marl fauna.
(3) The phosphatic casts of Gault species they regard as derived fossils.

From these premises, and without any attempt to determine the horizon of the Totternhoe Stone, which would fix the upper limit of the Chalk Marl, they come to the conclusion that the whole of the so-called Gault in Norfolk is Chalk Marl, and not really Gault.

We have recently endeavoured to follow the subdivisions of the Chalk through the western parts of Suffolk and Norfolk, and having visited the localities mentioned by Messrs. Reid and Sharman, we wish to record our entire dissent from their conclusions, and to give our reasons for maintaining the existence of Gault in West Norfolk.

(1) In the first place we found that the upper part of the Chalk Marl changes its character as it is traced northwards, and becomes a hard greyish chalk, passing, in fact, into the "hard chalk," which Messrs. Reid and Sharman speak of as resting upon "the Chalk Marl." At Stoke Ferry, twenty-two feet of this hard "Chalk Marl" is exposed below the representative of the Totternhoe Stone; its full thickness is probably about thirty feet, and between it and the level of the springs on the border of the [Gault] clay plain, there may be ten or fifteen feet of soft Chalk Marl. Now the width of the clay plain near West Dereham is about two miles, and an easterly dip of only 1° would give a thickness of fifty-nine feet. That this calculation is within the mark is proved by a boring at Wretton, west of Stoke Ferry, the particulars of which were obtained by Mr. Whitaker, and which gives a thickness of sixty feet of clay at a spot which is certainly below the summit of the clay. If, therefore, the whole of this clay is to be referred to the Chalk Marl, we must add it to the thickness of the overlying beds above mentioned in order to get the total thickness of this stage; doing this we obtain a minimum of 100 feet, and a possible thickness of 120 feet for the Chalk Marl of Norfolk. Near Cambridge its thickness is about sixty feet, and we are therefore asked to believe that it has expanded to double its thickness in a direction in which all the beds are evidently and admittedly thinning out.

(2) In the next place we cannot allow that the assemblage of unphosphatized fossils obtained from the clay is such as to merit the name of a "Chalk Marl fauna." Nearly all of them are species which range from the Gault to the top of the Lower Chalk, and are therefore of no use in deciding the exact age of the bed containing them. The only species on which any argument can be founded are *Belemnites attenuatus*, *B. minimus*, and *Ostrea acutirostris*.

The Belemnites are decidedly Gault forms, and do not, so far as we know, occur in true Chalk Marl, where Belemnites are not common, though *B. ultimus* occurs sometimes; it is true that all three are often regarded as varieties of one species, but that makes no difference to the fact of the two varieties being specially characteristic of the Gault.

*Ostrea acutirostris* has not, I believe, previously been found below the Chalk Marl, but it is not a common shell anywhere, and is believed to occur in Upper as well as in Lower Chalk, so that it is evidently a species which has a long range.

The statement that *Ostrea vesicularis* has not been discovered below the Chalk is quite erroneous, for it is a common shell in the Upper Gault of Folkestone and elsewhere.

(3) Lastly, the clay above the "coprolite bed" at West Dereham has the lithological characters and general appearance of Gault. It is by no means unusual for the lower part of the Gault to contain fossils in the form of phosphate casts, more or less rolled and worn; such phosphatized fossils are particularly abundant within twenty feet of the base of the Gault in Buckinghamshire, and in the same county the passage-beds between the Gault and Lower Greensand often contain large lumps of sandy phosphate, which resemble those of the junction-bed at West Dereham. There is nothing therefore in the character or contents of the West Dereham clay that is incompatible with its being true Gault. For the reasons above stated we must maintain that all the previous authors were right in accepting the sections near West Dereham as proving the existence of Gault in that part of West Norfolk. How much farther north the Gault extends is another question which we are endeavouring to ascertain, and such evidence as we can obtain will be embodied in a paper which we intend to bring before the Geological Society. We shall also endeavour to account for the apparent passage between the Gault and the Chalk Marl; but we may remark that at Shouldham we found what appears to be the true glauconitic base of the latter, above the clay which Mr. Reid describes as containing *Belemnites* and *Plicatula*.

[*Postscript.*—Since the above was written we have had a boring made in the quarries at Stoke Ferry to a depth of fifty-five feet, and have proved the existence of a bed of Chloritic Marl at the base of the Chalk Marl, and resting on blue clay; the total thickness of the Chalk Marl there is seventy-three feet, and it must be remembered that below this there is at least sixty feet of Gault.]

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## VI.—NOTE ON THE FOLIATION OF THE LIZARD GABBRO.

By Colonel C. A. McMahon, F.G.S.

THE appearance of Professor Bonney's letter in the December Number of the GEOLOGICAL MAGAZINE, in which he suggests that Mr. J. J. Harris Teall's proposed explanation of the cause of the foliation of the Lizard gabbro "ought to be regarded as an hypothesis on its probation, and should not be quoted as an undoubted fact," emboldens me to offer some remarks on the subject.

Mr. Teall suggests that the "foliation in the Lizard gabbro is the result of pressure" acting "after the consolidation of the rock;" or, as he puts it shortly in another place, the foliation is "a secondary structure due to earth-movements acting upon the *solid* rock." [The italics are mine.]

Mr. Teall does not expressly state, in his interesting and valuable paper, how the pressure acts so as to produce the results described; but we are told that at Pen Voose "massive gabbro passes over into gabbro schist at a fault plane," and "the foliation in the gabbro is such as would be produced by a shearing motion parallel with the fault plane."

Are we to understand that foliation has been produced by mere mechanical crushing, and consists of the rearrangement of minerals already formed sliding over each other's backs—a sort of mineralogical leap-frog—in consequence of a "shearing motion parallel with the fault plane;" or are we to understand that the "shearing motion" was transmuted into heat, and the heat so produced resulted in the fusion and subsequent recrystallization of the component minerals?

On either supposition I shall be glad to know how the foliation of the "veins and dykes of gabbro" to the north of Coverack, and the "small dykes of gabbro in the serpentine near Karakclews," is to be accounted for? Do all these veins and dykes concur with fault planes, or do they ramify in all directions in the usual manner of intrusive veins? If they coincide with fault veins, how is it that they are not always foliated? Mr. Teall states that the Coverack veins, and the small dykes near Karakclews, are "often foliated" (which implies that sometimes this is not the case); and further, that "not seldom one may see the transition from massive gabbro to gabbro schist taking place in the space of a few inches." If the veins and dykes in question coincide with fault planes, this occasional failure of "shearing motion" to produce foliation seems to need explanation. On the other hand, if some of the foliated veins and dykes do not coincide with fault planes, I fail to see how the "shearing" hypothesis can account for the foliation.

Again, if the foliation is accounted for on the supposition that the shearing motion developed heat, and recrystallization took place on the subsequent cooling of a rock in which molecular motion had been set up by the heat so developed, I do not at present understand how masses of gabbro "more than a hundred yards in width" (p. 487) have become, "with a few local exceptions, foliated throughout" their "entire mass." If the heat produced was sufficient to fuse the rock, why was its structure, on reconsolidation, not granitic, as it presumably was on its first consolidation, and as the dykes, sheets, and veins of ordinary eruptive rocks are?

Most geologists with field experience will doubtless be able to point to numerous instances of such eruptive dykes, and sheets, that have consolidated under enormous pressure, but which, notwithstanding, do not show a trace of foliation.

The above, I think, are difficulties which need clear explanation before the hypothesis can be accepted that pressure acting on a *solid* rock is sufficient to account for the foliation of the Lizard gabbro.

In the mean while, I venture to offer another explanation for consideration.

After having studied what used to be called the granitoid-gneiss of the Himalayas for some time, I came to the conclusion, from the stratigraphical, petrological, and microscopic facts observed, that what is now called the gneissose-granite of the Himalayas was erupted through lines of fracture in a *partially consolidated* condition.

I do not wish to apply that explanation to all cases, but I suggest a modification of it to account for the foliation of the Lizard gabbro; namely, that the latter was produced by "shearing motion" on the rock after its consolidation had advanced considerably but was still incomplete. This, it seems to me, would account for the observed facts better than any hypothesis yet proposed for acceptance; it would account for the foliation being generally marked at the contact of the gabbro with other rocks along joint planes; it would account for any signs of crushing in the gabbro that the microscope may reveal; and indeed for all the observed facts so far as I am acquainted with them. The great depth to which the foliation sometimes extends might, on this hypothesis, be accounted for either by supposing that the "shearing motion" continued for a long time; or, better still, that it was repeated frequently at intervals of sufficient duration to allow the marginal portions of the gabbro to cool and consolidate. Very slight movements parallel with the fault-plane would be sufficient, on the latter supposition, to produce foliation to a great depth.

If the foliated veins and small dykes, alluded to by Mr. Teall, do not run with fault planes, the foliation might be explained on the supposition that they were, like the gneissose-granite of the Himalayas, intruded in a viscid. or semi-plastic condition, when the shearing of the main mass of the gabbro along the fault planes was going on. Traction action on an imperfectly consolidated mass would in this case account for the foliation observed.

The fact that in some of the dykes a rapid passage from a foliated to a granitic structure is observed, is of course a difficulty in the way of any hypothesis; but I suggest that on my hypothesis it is capable of explanation. In the first place, I think it might reasonably be supposed that the cooling, and consequent consolidation, of the rock proceeded more rapidly in some parts of the dyke than in others. Rocks are rarely perfectly homogeneous; we often find variations in density, and hardness, within short distances even in some rocks of apparently homogeneous composition—a difference not due to weathering, but which weathering, and the agents of erosion, speedily find out. Then the power of conducting heat must have varied much in the bounding rocks. From these two causes the solidification of parts of a dyke might have been in advance of neighbouring portions, and have resisted the shearing motion more than the latter. The portions in which solidification was most advanced might thus have retained their granitic structure, whilst the less solid parts might have yielded to the shear and have become foliated.

In the second place, I think it possible that shearing motion might result in the development, or what would come to the same thing, the retention of heat (owing to variations in the conducting power of the surrounding rocks), more in some spots than in others; and thus some parts of the dyke might become more fused than other portions, and might lose the foliated structure previously imparted by the shearing motion. The heat thus generated, or retained, would account for the assumption of a granitic structure in portions of a dyke, but not for the foliation of the other portions.

Mr. Teall considers "that the most convincing proof that the foliated structure is the result of movement after the consolidation of the rock is furnished by its relation to fault planes. A rock must necessarily be solid before it can be faulted." But we learn from Mr. Teall's paper that there must have been a lengthened series of earth-movements at the Lizard; thus he speaks of the "superposition of the effects of distinct movements"; the fractures therefore, to which he alludes, may have taken place after the consolidation of the rock; and after the foliation had been produced. Do all the faults in the gabbro present foliated margins? I gather from Mr. Teall's article (read with Professor Bonney's paper in Q.J.G.S. vol. xxxiii.) that this phenomenon is principally to be observed at the junction of the gabbro with other rocks. But even if some of the faults *in* the gabbro do present this phenomenon, I do not see why, in those exceptional cases, the faulting should not have taken place before the *complete* consolidation of the gabbro. If the fault ran through the rocks above and below the gabbro, the gabbro would surely have divided in the line of the fault as readily as a layer of jam between slices of sponge cake does when the cake is broken. If the gabbro was not completely rigid where thus divided, the shear might have produced a foliated structure in the portions exposed to the tearing effects of the rupture.

In conclusion, I would invite the attention of the readers of the GEOLOGICAL MAGAZINE to the sketches of two foliated gabbro veins in the Lizard serpentine drawn by Professor Bonney (figs. 2 and 4), which will be found at pp. 893, 897, of his paper in vol. xxxiii. (1877), Q.J.G.S. Professor Bonney, in his letter published in the December Number of your MAGAZINE, tells us that the serpentine is "free from all indications of mechanical disturbance." This being so, it seems physically impossible that the foliation of the gabbro in the veins depicted in his paper can be due to "shearing movements" acting on a "solid rock." Furthermore, it will be observed that the foliation in one of the veins (fig. 2) not only runs with the two sides of the vein, but also with the boundary of the terminal end (*vide* the illustration). Professor Bonney tells us that the foliation runs "roughly parallel to the longer sides of the vein, except towards the top, where it tends to become parallel to the upper surface." This is what I should expect to see if gabbro in an imperfectly consolidated, or semi-plastic condition were forced into, or through, an opening in the serpentine rock; but it is, to me, totally incomprehensible on the hypothesis of "shearing motion parallel with a fault plane."

## NOTICES OF MEMOIRS.

### I.—Preliminary Note on the Ordovician Rocks of Shropshire.

By Professor C. Lapworth, LL.D., F.G.S.

[A Paper read before the British Association, Birmingham, Section (C) Geology, September, 1886.]

IN this note the author gave a brief review of the history of discovery and opinion respecting the Lower Palæozoic rocks of Wales and the West of England, and pointed out that the results developed of late years by British and foreign geologists made it evident that Murchison's Silurian System, as defined in the later editions of "Siluria," was in reality composed of three distinct geological systems, and that of these three the only one which belonged to him by right of discovery and correct description was the so-called Upper Silurian, which was therefore the only true *Silurian System.* The lowest known fossiliferous system (the Primordial Silurian of Barrande) was not discovered by Murchison, but by Sedgwick, who regarded it as the lower half of his own *Cambrian System,* and it ought, as a matter of justice and convenience, to retain that name only. The intermediate system (claimed as Lower Silurian by Murchison, and as Upper Cambrian by Sedgwick) belonged to neither, for its life-types are wholly distinct from those of the true Cambrian below and of the true Silurian above. This distinction must be recognized by a distinct title. The Silurian was named by Murchison after the ancient British tribe of the *Silures,* who inhabited South Wales, where its rocks attain their fullest development. The rocks of the disputed intermediate system, however, are most fully developed in North Wales—the land of the equally ancient tribe of the *Ordovices.* The author had proposed in 1879 that the middle system should be entitled the *Ordovician System,* after this old tribe, and this name is gradually coming into use among geologists.

During the last few years the sequence and fossils of the Ordovician strata of Shropshire have been studied in detail by the author, and their igneous rocks, both interbedded and intrusive, have been worked out by Mr. W. Watts. In this note a general summary of his own conclusions was communicated by the author, and illustrated by maps, sections and lists of characteristic fossils.

Ordovician strata occur in two distinct sub-areas in Shropshire, viz. in the district of Shelve and Corndon to the west of the Longmynd, and in the Caradoc district to the east of that range. In both districts these strata are overlain unconformably by the basement beds of the Silurian, *which rest transgressively upon every zone of the Ordovician in turn.*

In the Shelve and Corndon district the Ordovician rocks repose at once upon the highest known strata of the local Cambrian, and are arranged in the following ascending order:—

SHELVE SERIES.

(*a*) *Stiper Group*, consisting of the well-known Stiper Quartzites and their associated strata.
(*b*) *Ladywell Group*, composed of the dark shales and flagstones of Mytton, Ladywell and Hyssington, with *Dichograptidæ* and *Ogygia Selwynii*, etc.
(*c*) *Stapeley Volcanic Group*, andesitic lavas, ashes and interbedded shales.

MEADOWTOWN SERIES.

(*a*) *Weston Group of Grits*, flagstones and dark shales.
(*b*) *Middleton Group*, composed of dark shales, with *Didy. Murchisoni*, and calcareous flagstones, with *Ogygia Bucchi* and *Asaphus tyrannus*.
(*c*) *Rorrington Group*, of intensely black shales, with *Cœnograptus gracilis* and *Leptograptus*.

CHIRBURY SERIES.

(*a*) *Aldress Group*, composed of the *Spy Wood* calcareous *grit*, and the *Aldress* Graptolitic shale.
(*b*) *Marrington Group*, including the *Hagley* volcanic ashes and shales, and the *Whittery* ashes and overlying shales.

The only Ordovician rocks occurring east of the Longmynd are those forming the local *Caradoc Series* of the author (the Caradoc formation of geologists). The basement beds of this series rest *unconformably* upon all the older rocks of the district—upon the so-called Uriconian, Longmyndian, Wrekin Quartzite, and Shineton Shales, and its component zones are each covered up unconformably in turn by the basement beds of the Silurian. This isolated Ordovician Series is composed of the following members:—

CARADOC SERIES.

(*a*) *Hoar Edge* Conglomerate, grits and limestone; (*b*) *Harnage Shales*; (*c*) *Chatwall Sandstone*; (*d*) *Longville Flags*; and (*e*) *Onny*, or *Trinucleus Shales*.

The Shelve series answers generally to the strata commonly designated *Arenig*; the Meadowtown series includes the typical members of Murchison's *Llandeilo*; and the Chirbury and Caradoc series correspond broadly to Sedgwick's *Bala* formation of North Wales.

Some of the most characteristic fossils of each of the Ordovician sub-formations and zones were given, and it was shown how naturally the physical and palæontological sequence agrees with that of the corresponding Ordovician rocks of Britain and Europe. The peculiar physical conditions of the Shropshire area in Ordovician times, as indicated by the very different lithological characters of the strata upon the opposite sides of the Longmynd, was pointed out; and the evidences for the geological horizons and relationships of the volcanic rocks indicated in outline. In conclusion, it was pointed out that the clearness and simplicity of the sequence, and the highly fossiliferous nature of its strata, render it tolerably certain that this Shropshire succession will form the general standard to which all other British Ordovician strata must ultimately be referred.

### II.—TRANSACTIONS OF THE CUMBERLAND AND WESTMORLAND ASSOCIATION. No. XI. 1885–86.

THIS part contains notes on "The Mineral Springs near Keswick," by J. Postlethwaite (pp. 142–145.) They comprise saline waters at Brandley Mine and Saltwell Park, and a chalybeate spring at Woodend Mine, near Threlkeld. Mr. T. V. Holmes contributes some remarks on "Purple-grey Carboniferous Rocks and the Whitehaven Sandstone" (pp. 146–148). He points out that purple-grey rocks, similar to the Whitehaven Sandstone, occur on almost every horizon throughout the Carboniferous series in Cumberland.

## REVIEWS.

### I.—M. DOLLO'S NOTES ON THE DINOSAURIAN FAUNA OF BERNISSART.

THE remarkable preservation of a Fauna of Wealden reptiles at Bernissart has been utilized with admirable skill, so that the skeletons, though necessarily extracted in fragments, have been again reunited in the anatomical relations of the bones, in the Brussels Museum, under the able direction of M. de Pauw.

The animals thus displayed in a perfection which no other reptile fauna in Europe can surpass have been the subject of a series of valuable preliminary memoirs by M. Dollo, published during the last few years in the Bulletin du Musée Royal d'Histoire Naturelle de Belgique. The object in issuing these notes, in anticipation of the full description which is to follow, is professedly to gain from the criticism of scientific men suggestions which may aid in the perfection of the final monographs. I gladly avail myself of this opportunity for drawing attention to the excellent work which M. Dollo has thus far performed; and at the same time offer a few suggestions upon points where a difference of opinion seems to me legitimate.

The great interest of this work centres in the Dinosaurians, which were examined by M. Boulanger, and referred to the *Iguanodon Mantelli*, and a new species named by him *Iguanodon Bernissartensis*, in days before M. Dollo commenced his labours.

The author begins by contrasting the differences between these two forms. Separating the characters of the animals, we are able to define the two types thus: *Iguanodon Mantelli* is a relatively small and slender animal, with a skeleton nearly twenty feet long. Its skull, 50cm. long, is relatively elongated, being moderately deep, and three times as long as wide. The anterior nares are long narrow vacuities, half as long as the lower jaw, and descending anteriorly for some distance over it. The orbit for the eye is rather longer than deep. The temporal vacuities, seen from above, are long narrow slits, which diverge anteriorly. The scapula is relatively slender and elongated, being eight times as long as wide. The coracoid is pierced by a foramen placed near to the scapular suture. The posterior border of the coracoid is rounded—the sternal elements are relatively small. The fore limb is half the length of the hind limb. The humerus is relatively short. The manus is nearly one-fourth of the length of the limb. The ungual phalange of the first digit, which forms a sort of spur, is one-third the length of the longest digit. The metacarpal bones are compressed together laterally, indicating a relatively narrow extremity. There are five sacral vertebræ. The pre-acetabular process of the ilium is nearly one-half the length of that bone. The pre-pubis is short, thin, and expanded; its length, depth and thickness being expressed, in millimetres, by the numbers 400, 200, 10. The large lateral trochanter of the femur is in the middle of the length of the bone. The tibia is relatively long.

On every one of these points of structure the animal named *Iguanodon Bernissartensis* differs, so that the animal may be defined in comparison with *I. Mantelli* as being more massive in all its proportions; and it is about thirty-three feet long. The skull is relatively broad, the width being half its length, which measures 65cm. The anterior nares do not descend so low upon the lower jaw, while the length of the anterior narine is contained three times in the length of the lower jaw. The orbital vacuity is elongated vertically. The temporal fossa are each wide and four-sided in form. The scapula is relatively stouter and shorter, being six times as long as wide. The coracoid is pierced by a foramen, which takes the form of a notch, opening posteriorly towards the humerus. The sides of the bones are excavated, and their posterior borders diverge, as if to receive sternal elements. The large sternal bones are relatively strong. The fore-limb is two-thirds as long as the hind limb, so that the proportions of the extremities are more nearly equalized. The humerus is relatively longer, and the manus shorter, being scarcely one-fifth the length of the limb. The first digit has its spur-like, inwardly directed, terminal phalange, half as long as the longest digit. The metacarpal bones are sub-quadrate in transverse section. There are six vertebræ in the sacrum. In the pelvis, the pre-acetabular part of the ilium is only one-third of its total length. The pre-pubis is long, massive, and straight. Its length, depth and thickness being expressed in millimetres by the numbers 700, 170, 40. The large lateral trochanter on the femur is situate in the lower third of the bone. The tibia is relatively shorter.

The author then goes on to discuss the taxonomic value of these differences, considering three hypotheses. First, whether the two varieties are to be attributed to age; secondly, whether the differences may be individual or sexual; and, thirdly, whether they afford evidence of two species, or indicate two genera. M. Dollo concludes that the differences enumerated constitute a species. This conclusion is based on a consideration of the characters by means of which various authors have defined the genera which are allied to *Iguanodon*; and on an estimate of the characters by which the three known species, at present referred to *Iguanodon*, have been characterized. Those species cannot, however, be completely compared. The *Iguanodon Mantelli* has five sacral vertebræ, and the pre-acetabular part of its ilium is half the length of the bone. *Iguanodon Prestwichi* has four sacral vertebræ. *Iguanodon Seelyi* has the ilium three times as long as its pre-acetabular portion; but its sacrum is not at present known.

The author then goes on to show that the differences of proportion between the principal bones of the fore and hind limbs in the type specimen of *Iguanodon Mantelli*, and the smaller *Iguanodon* in Brussels, amount to only a small percentage; and compares the type slab from the Lower Greensand of Maidstone with the Brussels animal, with the following results:—

| | Ilium. | Femur. | Tibia. | Scapula. | Humerus. | Radius. |
|---|---|---|---|---|---|---|
| Maidstone spm.... | 0·75 | 0·81 | 0·75 | 0·72 | 0·47 | 0·45 |
| Brussels spm. ... | 0·71 | 0·71 | 0·67 | 0·62 | 0·43 | 0·37 |

showing that the Brussels animal is somewhat smaller, and that the proportions of the fore and hind limb are not quite the same. He then discusses the nomenclature of the larger type, and recognizes its extremely close correspondence with the *Iguanodon Seelyi* of Hulke, with which he would have had apparently no hesitation in identifying it, but for the following remarkable passage, in which Mr. Hulke states "I had long possessed evidence that *Iguanodon* had a scuted hide; but until the acquisition of these remains, such evidence was very fragmentary. In cutting away the rock from the larger bones of the hind limb, I found beneath it a layer of bony tissue, separated from the endoskeleton by a deeper layer of rock, enclosing much black carbonaceous matter. From its position with reference to the endoskeleton, it was obvious that the outer layer of bony tissue was exoskeletal—was in short a dermal mail." Mr. Hulke further describes these bones as irregularly polygonal, with a surface slightly pitted, some of them 2cm. thick and 7cm. in diameter. M. Dollo finds evidence of the integument, but no trace of bony armour, which he thinks should separate the species, but maintains that if the large Brussels form is identical with the *Iguanodon Seelyi*, priority must be claimed for Boulanger's name, *Iguanodon Bernissartensis*.

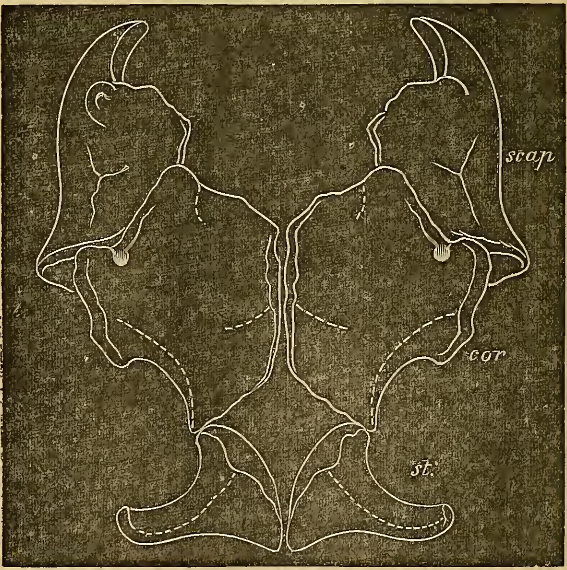
The author follows Marsh in placing *Iguanodon* in the Ornithopoda, but makes a criticism, which was valuable at the time, in opposition to the view that clavicles formed a characteristic of the group, urging that the bones which were thus identified by Marsh are elements in the sternum. The note concludes with a definition of the order Ornithopoda, and its families, a definition of *Iguanodon*, and definitions of the three species.

There is no doubt that M. Dollo is substantially in harmony with Mr. Hulke in his views concerning the classification of these Dinosaurs. But I ventured, when the description of the *Iguanodon Prestwichi* was read before the Geological Society in 1880 to express an opinion that the characters of the sacrum, of the astragalus, and os calcis, the relation of the fibula to the tibia and other osseous characters, could only be regarded as generic characteristics. More mature consideration has only deepened my conviction that the *Iguanodon Prestwichi* is not an *Iguanodon* in the sense in which the term *Iguanodon* should be used as a generic distinction. There would be an end of zoological method if organic differences of the magnitude which divide this animal from the *Iguanodon Mantelli* could be classed as specific characters. The earlier writers made species in this way; but it was by the institution of a method altogether distinct from that used in the modern study of existing life. I believe it to be imperative that no such difference of method should prevail in the study of existing and extinct animals, and therefore contend that, since the structures which I have named differentiate the Kimmeridge Clay animal so that it would have been referred to a new genus had it been an existing animal, we have no choice but to class it as a genus, though no name has as yet been proposed to designate its characteristics. Similarly, when the Memoir on *Iguanodon Seelyi* was read before the Geological Society, two years later, I suggested that it would have been safe to have constituted it also as a new Dinosaurian genus. I therefore find myself differing from M. Dollo, not so much upon the results of his own work, as upon matters in which he depends upon and has the support of one of our most accomplished and most cautious comparative anatomists. But when the value of the characteristics of these two *Iguanodon* types, which M. Dollo has so well contrasted, is estimated, I am tempted to ask, is there any living reptilian genus which in the skeletons of its species comprises so wide and varied an assemblage of differential characters? If the differences were limited to one series of characteristics, or to one region of the body, we might accept them as specific; but when they range through all parts of the skeleton, so as to imply many differences in the soft parts of the body, I cannot but reiterate that the close correspondence between *Iguanodon Bernissartensis* and *I. Seelyi* sustains my earlier belief that the larger Belgian type constitutes a new genus. The form of the head, of the nares, of the orbit, of the temporal vacuities, of the pre-dentary bone, in *Iguanodon Mantelli*, all seem to me generic characters; and the elevation of the nasal bones into a sharp crest may be of similar importance, seeing its relation to the nasal crest or horn in *Ceratosaurus*. These characters are sustained by the proportions of the several parts of the ilium, the form of the prepubic bone, the shape of the femur and position of its third trochanter, no less than by the characters of the scapular arch and the metacarpal bones. The taxonomic value of these characters should be beyond question.

If I am right in my exposition that two of the three species which have hitherto been referred to *Iguanodon* belong to new genera, then it necessarily follows that I am unable to accept either the data with which M. Dollo works, or the conclusions at which he arrives in consequence, in so far as this concerns the classification. It is unnecessary to define my view by suggesting names for these genera now. Some bones of the *Iguanodon Seelyi* type may have been referred to *Pelorosaurus* in Mantell's collection, but the genus *Pelorosaurus* has no existence, and should be erased from catalogues as having been founded upon a humerus of *Cetiosaurus*.

In his second note M. Dollo limits himself to a discussion of the sternum. He describes the pair of large triangular bones with elongated processes which were found in association with the scapular arch, bones of the fore limb, and sternal ribs, and believes himself justified in concluding that they are in their natural undisturbed position in contact with the coracoids, and therefore combats the conclusion of Professor Marsh that they are the clavicles. In the remainder of the paper the author goes on to cite the descriptions of the sternal bones in other Dinosaurs, which have been given by other writers.

I give in outline the sternal apparatus as restored by M. Dollo.



Scap.—scapula. Cor.—coracoid. St.—sternal bones.

But I am unable to accept his arrangement of the bones. Fully admitting that the bones which he terms sternal are in natural contact with each other in his slab (pl. xii. fig. 2), I am unable to admit that they are in natural contact with the coracoids. Mr. Hulke has been more fortunate in obtaining a better preserved example of the sternal apparatus of *Iguanodon Mantelli* (figured in the Quart. Journ. Geol. Soc. August, 1885), and he regards the bones cited by Dollo as a pair of sternal ossifications, comparable to the immature sternum of a Struthious bird, as being clavicles—a conclusion previously arrived at by Mr. William Davies, and adopted by Professor Marsh. I first studied the specimen described by Mr.

Hulke in 1870, and failed to form any decisive opinion on its interpretation, till I saw it again after Mr. Hulke's paper had been read. Mr. Hulke regarded the fossil, which he described, as consisting of the clavicle and interclavicle of *Iguanodon*. And, in a restoration, the clavicles are shown divided from each other by the interclavicle, which has its chief extension posterior to them. The clavicles are represented as also articulating with the scapula; while the coracoids, represented as passing behind the clavicles and anterior part of the interclavicles, articulate for a short distance with the sides of the interclavicles, and afterwards with a hypothetical sternum, which is supposed to pass behind the interclavicle. I regret to find myself unable to adopt any one of these determinations. First, what Mr. Hulke regards as sutures defining the specimen into clavicles and interclavicles, I regard as fractures in the specimen. The bones, which for the moment I will distinguish as the sternal elements of Dollo, I regard as being in close median contact, as in the Belgian specimen already cited. I am unable to admit that these bones articulated with the scapula, because I have never seen a facet on any *Iguanodon* scapula, which could have received such a bone. While the surfaces on Mr. Hulke's fossil sternum, which are supposed to have articulated laterally with the coracoids, seem to me to have given attachment to sternal ribs. It is manifest from evidence in the British Museum that the specimen found by Mr. Beckles, and figured by Mr. Hulke, and represented in the British Museum by an excellent cast, includes another ossification, extending beyond the sternal bones of Dollo. Professor Cope has some interesting observations on this subject in the American Naturalist for February, 1886. First he suggests that the bones in dispute are neither clavicles nor sternum in the ordinary sense of the term, but the pleurosteal elements in the sternum, which were developed so that the long process extended backward and outward, as in the sternum of a fowl. It happens that *Diclonius mirabilis* has these elements perfectly preserved, and closely resembling in form and arrangement the same bones in *Iguanodon Mantelli*. Professor Cope, however, identifies his sternum with the sternum of *Monoclonius crassus*, so that he would place the coracoid bones in direct articulation with these sternal bones, almost in the position in which Dollo placed them originally. Professor Cope was unaware of the true structure of the sternal apparatus, described by Mr. Hulke, or he would not have proposed to bring the coracoids into connection with osseous surfaces, which in that fossil are manifestly separated by a broad, thin, ossified mass, from any other bone. Nevertheless, I entirely agree with Professor Cope that the bones in dispute are not clavicles, and further, that the specimen to be understood must be turned upside down, in the way which he suggests. I am also prepared to accept these sternal elements as approaching more nearly to the pleurosteal elements in the sternum of a bird than to any other ossification, in so far as they are posterior to the articulations for the sternal ribs; but in position they are essentially the xiphoid bones, which have preserved as marked and as distinctive an individuality in the sternum of Dinosaurs, as in the plastron in Chelonians. The sternal ossification, anterior to these xiphoid elements, which is seen in the fossil figured by Mr. Hulke, is thin, and is not commonly preserved. The anterior extremity of this Dinosaurian structure is at present unknown. The posterior xiphoid ossification may have been connected with the prepubic bones, in much the same way as the abdominal ribs of Crocodiles extend down to the pubic bones.

In the third paper M. Dollo discusses the attitude of the *Iguanodon.* First, there is the view originated by E. D. Cope that they progressed chiefly upon their posterior limbs, in the manner of the Ratitæ, of which they were supposed to be the parent stock. Secondly, I have accepted the bipedal progression, but denied that these Dinosaurs are the ancestors of Birds. And, thirdly, Sir R. Owen regards them as having been exclusively aquatic, with the body carried in a horizontal position. In support of the upright position, it is urged that there is a remarkable correspondence between the pelvis of *Iguanodon* and that of Ratite Birds; while the difference in structure between the fore and hind limbs of *Iguanodon*; the relative dimensions of the head and thorax as compared with quadruped reptiles; the nature of the vertebral column; and the Wealden footprints described by Beckles and other writers furnish conclusive evidence. Each of these points is considered in detail.

The author begins by discussing the pelvis, and endeavours to combat the views of Sir R. Owen, and to prove that the ilium of *Iguanodon* agrees in the most striking manner with the homologous element in Birds. I am not concerned to do more than urge that the author rather undervalues the resemblances to the ilium of a Crocodile. If we begin with the geological history of the Dinosaurian ilium, and trace it in development through successive generic types of evolution, I do not see how the conclusion can be resisted that the Dinosaurian ilium is a modification of the Crocodilian ilium, which only resembles the ilium of a bird in such ways as indicate a modification of the Crocodilian plan. This plan of the Dinosaurian ilium, as seen in such types as *Zanclodon* and *Thecodontosaurus,* is remarkable for the mass of the bone lying behind the acetabulum, as in Crocodiles. The form of the post-acetabular part is wonderfully alike in both groups. And the difference begins with the Dinosaurian elongation of the pedicle for the pubis, which throws the bone upward, and the concurrent elongation of the preacetabular process, which at first is so short as not to extend in advance of the acetabulum. Even when the latter process is elongated, as in *Iguanodon Mantelli,* or *I. Bernissartensis,* it never loses trace of its origin, or approximates to the ilium of a bird in form, any more than in osteological connections; though the ilium of *Stegosaurus* makes perhaps as near an approximation to the Ratite contour as is seen in a Dinosaur. The ischium and pubis of *Iguanodon* are treated by M. Dollo in the same spirit, with the conclusion that the ischium in Dinosaurs, and especially in *Iguanodon,* shows a strong avian resemblance, while in the pubis there is perfect agreement. This conclusion is open to exactly the same criticism as we offered concerning the ilium. If the only Dinosaurs known were such types as *Morosaurus, Atlantosaurus, Brontosaurus,* and the allied types described by Professor Marsh, no doubt could exist that the Dinosaurian pelvis was not avian. Nor would its avian resemblances have been sustained by the discovery of such types of animal as have been named *Ceratosaurus, Allosaurus,* and *Cœlurus.* Yet it is perfectly true that if *Iguanodon, Camptonotus,* and *Laosaurus,* were the only known Dinosaurs, an avian resemblance might be recognized in the ischiac and pubic bones. But the very fact that these bones vary their forms and change their resemblances within the same order, so as to be avian in some genera, and not avian in others, robs the resemblance of all taxonomic importance, and demonstrates that the character of an order or sub-class cannot at the same time be both avian and not avian. The resemblances accordingly sink to the value of sub-ordinal characters, by which some Dinosaurs may be differentiated from others, and are thus proved, I think, to owe their remarkable avian forms to conditions of existence. Exception is taken by M. Dollo to certain details in Mr. Hulke's restoration of the pelvis of *Iguanodon,* stating that in *Iguanodon Mantelli* the pubis is not inclined ventrally inward and forward, but, on the contrary, ventrally forward and outward, like the rudiment which exists in birds. There is no symphysis pubis. The post-pubis is not continued to the extremity of the ischium, and is therefore not applied against it in the distal region. M. Dollo also takes exception that the Brussels specimens show by the way in which processes from the ischium extend in front of the pubis, two foramina, instead of the one shown in Mr. Hulke's restoration. M. Dollo is certainly correct with regard to the structure in the genus represented by *I. Bernissartensis*; but he has presented no evidence that Mr. Hulke was incorrect in his restoration of the pelvis of *Iguanodon.* He objects to the identification of the pre-pubis of *Iguanodon* with the small process which is similarly placed in birds, by showing that the supposed pre-pubic structure is developed from the ilium in the common fowl, and cannot therefore be homologous with the pre-pubis of *Iguanodon* and other Dinosaurs. The author enters into many details to contest the views which have been advanced by Sir Richard Owen concerning the interpretation of the pelvis of Dinosaurs, and does good service in bringing under the notice of continental writers the more modern interpretations which, we may say, without any disparagement to M. Dollo's originality, have long been current in this country.

H. G. Seeley.

(*To be continued.*)

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## II.—United States Geological Survey: Bulletin No. 28. The Gabbros and associated Hornblende Rocks occurring in the Neighbourhood of Baltimore, Md. By G. H. Williams. Pp. 59 and iv. Plates. (Washington, 1886.)

THIS is a valuable contribution to American petrology, and many of the conclusions established must have a special interest for

British geologists also. The author has minutely studied, in the field and by microscopical and chemical analysis, the conversion of a pyroxenic to a hornblendic rock. The rocks occur (Chapter I.) in an oval district 50 square miles in area, breaking through the gneissic rocks to the west and north-west of Baltimore. The pyroxenic type (*Hypersthene-gabbro*, Ch. II.) is a massive rock consisting essentially of bytownite, diallage, hypersthene, and some brown hornblende. The typical hornblendic rock (Ch. III.), which the author names *Gabbro-diorite,* is either massive or schistose. It contains green hornblende, often true uralite but in part compact, and bytownite showing incipient saussuritization and also breaking up into epidote near the contact of the felspar with adjacent hornblende.

Chapter IV. deals with the genetic relations of these two very different rocks. In the field they are found to be inextricably involved, and to graduate imperceptibly into one another. The average analyses of the two agree closely, though considerable variations of composition occur under each type. Microscopical examination of the transition-zone reveals the nature of the changes that have taken place. Both the diallage and the hypersthene of the gabbro are seen to pass gradually into green hornblende, but in different ways. The conversion of the diallage is apparently a true paramorphosis, this mineral and the resulting hornblende giving closely similar analyses. The hypersthene, on the other hand, for its amphibolization, must take up alumina and lime from the felspar, and in the earlier stages of the change the mineral is bordered at its contact with the felspar by a double rim, the inner zone of fine colourless fibres, the outer dark green and comparatively compact. This is analogous to what has been observed when olivine passes into amphibole.

The evidence of the metamorphism of gabbro into diorite in this district is complete at all points. The author regards augite and hornblende as dimorphous, the former representing the stable form of the molecules at high, the latter at low temperatures. Augite being unstable at low temperatures will tend to revert to hornblende under any influence which facilitates molecular motion. Pressure, though a potent condition in many instances, is not regarded as necessary. The concluding chapter is devoted to the description of certain associated olivine-bearing rocks and serpentines. The chief type of olivine rock is described as a felspathic peridotite: besides olivine, bronzite and diallage, it contains up to five per cent. of bytownite, partly zeolitized. The olivine and pyroxenic constituents exhibit the usual secondary actions, and the double rim of amphibole is also found at the contact of the olivine and felspar. The structure is remarkable, the olivine being the latest-formed mineral, in which the pyroxenes occur porphyritically. The most abundant type of serpentine in the district is one containing tremolite, probably secondary after pyroxene. In some cases a further change of amphibole into talc is observed. A. H.

### III.—TERRAINS PALÉOZOIQUES DU PORTUGAL. ETUDE SUR LES BILOBITES ET AUTRES FOSSILES DES QUARTZITES DE LA BASE DU SYSTÈME SILURIQUE DU PORTUGAL. Par J. F. N. DELGADO, Chef de la section des travaux Géologiques. 4to. pp. 113, with 43 phototype plates. (Lisbonne, 1886.)

IN central and northern Portugal the problematical bodies known as *Bilobites* or *Cruziana* are the most ancient fossils known; they occur in great abundance in beds of grit and quartzite, at an horizon probably corresponding to the Arenig grits of this country, and to the "grès armoricain" of Normandy and Bretagne. M. Delgado, in this elaborate memoir, discusses in detail their characters and probable origin, and gives full descriptions of the varieties of form which they present. A striking feature of the work is the magnificent series of plates, in which the fossils have been phototyped, for the most part natural size, and they represent very clearly and faithfully their peculiar features.

M. Delgado maintains the same views respecting these bodies as MM. de Saporta and Marion, and upholds, with much skill, the opinion that they are the impressions of algæ. It cannot be said, however, that these Portuguese examples afford any fresh evidence, sufficiently decisive to decide the question as to their origin, and whilst giving due weight to the arguments so skilfully brought forward by the author, we do not think they are sufficient to counterbalance those which[1] Dr. Nathorst has lately re-stated, viz. that the impressions have been produced by the infilled tracks and burrowings of marine animals. G. J. H.

## REPORTS AND PROCEEDINGS.

I.—December 15, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "Notes on *Nummulites elegans*, Sow., and other English Nummulites." By Prof. T. Rupert Jones, F.R.S., F.G.S.

The author finds in the "Sowerby Collection," now in the British Museum, the original specimens on which Sowerby founded his *Nummularia elegans* (1826, Min. Conch. vol. vi. p. 76). These are partly specimens from that part of the bed "No. 29" of Prof. Prestwich's section of Alum Bay[2] (Quart. Journ. Geol. Soc. vol. ii. (1846) p. 257, pl. ix. fig. 1), which is known to be the lowest of the Barton series; and partly some in a stone said to be from Emsworth, in Hampshire. The former are the same as those named *Nummulites planulata*, var. *Prestwichiana*, by Rupert Jones in 1852; and the latter are *N. planulata*, Lamarck (1804), and probably foreign. Thus *N. elegans* has priority over *Prestwichiana*; and as this last was determined by De la Harpe to be a variety of *N. wemmelensis*, Van den Broeck and De la Harpe, this variety should be var. *elegans*. The author thinks that, on broad zoological principles, *N. planulata* might still be regarded as the species; but, in view of the careful differentiation worked out by De la Harpe, he accepts the "specific"

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[1] GEOL. MAG. 1886, p. 409.

[2] See Mr. H. Keeping's Article, *ante*, p. 70.

standing of "*wemmelensis*" as useful among *Nummulites*; but "*Prestwichiana*" has to give way to "*elegans*" for the peculiar "Barton" variety. A bibliographical history of the long-misunderstood *N. elegans*, Sowerby, description of this form and of *N. variolaria* (Lam.), notes on *N. lævigata* (Brug.), and an account of their range in England, complete the paper.

2. "On the Dentition and Affinities of the Selachian Genus *Ptychodus*, Agassiz." By A. Smith Woodward, Esq., F.G.S.

The genus *Ptychodus*, owing to the detached condition in which the teeth are usually found, has hitherto been imperfectly understood. Agassiz referred it to the Cestraciontidæ on account of a supposed resemblance in the arrangement of the teeth, and Owen's researches on their microscopic structure served to confirm this view. On the other hand, several writers have pointed out characters tending to show affinity between *Ptychodus* and *Rhynchobatus*.

More recently, however, Prof. Cope and the author had shown that the supposed affinities between *Ptychodus* and the Cestraciontidæ were only apparent, and in the present paper additional evidence was brought forward.

The author proceeded to describe several specimens of *P. decurrens* in the British Museum, and in the collection of Mr. H. Willett, of Brighton, one of the latter, especially, containing, what had been previously entirely unknown, the dentition in part of both jaws. These specimens showed that each jaw contained six or seven longitudinal rows of teeth on each side of the median row, and that the genus must be referred to the true Rays, and not to the Cestraciont Sharks, though the precise family to which *Ptychodus* belongs was more difficult to determine. On the whole, the writer was disposed to assign it a place either amongst the Myliobatidæ or in their neighbourhood. The microscopic structure of the teeth was shown to be insufficient, by itself, to show their affinities.

3. "On a Molar of a Pliocene type of *Equus* from Nubia." By R. Lydekker, Esq., B.A., F.G.S.

A small collection of Mammalian remains from near Wadi Halfa had recently been placed in the author's hands; some of the bones were mineralized similarly to those of the Upper Pliocence of the Val d'Arno, or the Lower Pleistocene of the Narbadda valley. Amongst others the most interesting is a right upper cheek-tooth of *Equus* but little worn. It evidently does not belong to any of the late Pleistocene or Recent species of the genus, but to the more generalized group comprising *E. sivalensis*, etc.: though, bearing in mind the impossibility of distinguishing many of the existing species of the genus by their teeth alone, its absolute specific identity is not asserted. We may infer, then, that the ossiferous beds of Wadi Halfa are not improbably of Pliocene age, since this group of Horses, both in Europe, Algeria, and India, had totally disappeared after the period of the Forest-bed. Moreover, it is of interest, in view of previously expressed opinion, to find in the Tertiary of Nubia a species of this primitive group of *Equus* which is apparently more nearly allied to the Siwalik than to the European species.

II.—Jan. 12, 1887.—Prof. Judd, F.R.S., President, in the Chair.

The President announced the sad loss which the Society had sustained since the last Meeting, by the death on 4th January of Mr. John Arthur Phillips, F.R.S., who had been for several years a valuable member of the Council, and one of the Vice-Presidents of the Society.

1. "The Ardtun Leaf-beds." By J. Starkie Gardner, Esq., F.G.S., F.L.S.; with Notes by Grenville A. J. Cole, Esq., F.G.S.

The description of these beds by the Duke of Argyll thirty-five years ago indicated that enormous tracts of Trap in the Inner Hebrides were of Tertiary age. Prof. Edward Forbes, who described the leaves, inclined to the idea that they might be Miocene; but in estimating the value of this conjecture, we must remember that at the time the existence of Dicotyledonous leaves of similar aspect, but of undoubtedly Cretaceous age, was quite unsuspected, and that no typical Eocene flora had then been properly investigated or described. Prof. Heer, however, adopted the opinion that the age of this formation was Miocene, and unfortunately extended its application to formations containing similar floras in Greenland and elsewhere. One object of the present communication is to show that, instead of belonging to the Miocene, these floras are of Eocene age, and in fact older than the Thanet beds. The other object is to redescribe the plant-beds, and to show that they are part of a rather extensive series of sedimentary rocks intercalated among the Traps.

The rapid accumulation of knowledge as to the distinguishing characteristics of Cretaceous, Eocene, and Miocene floras has rendered the attainment of the former object at least possible, and it is of the greater importance, since the error in determining the age of the fossil floras of Ardtun and Antrim, and of a part of the Arctic flora, is a great impediment to further progress. Instead of all these immense thicknesses of beds belonging to the Miocene, they have their base somewhere in the so-called Cretaceous series; 400 feet higher up we are about the horizon of the Thanet Beds; while at 1000 feet up the flows were contemporaneous with the Bracklesham and Barton deposits. The first acid eruptions were Miocene, as shown by the floras preserved in Iceland.

The author described the various exposures from his own observations and Mr. Cole's notes. At Ardtun the Traps are surmised to be parts of once continuous flows, still represented at Staffa and Burgh, but broken through by an intrusive sheet. The leaf-beds are varied in composition, the richest being very friable, while the best matrix is a limestone as fine as lithographic stone, in which plant-remains are few, but exquisitely preserved. They are overlain by thick deposits of river-gravel, chiefly composed of flint or silicified chalk, but in which Mr. Cole has detected fragments of sanidine like that of Ischia or the Rhine, and of trachyte. At Carsaig the gravels are coarser and less evenly bedded, and the sandy matrix apparently is entirely made up of flint. The coarse gravels are flanked by sands and indicate a rapid flow of water, occupying a valley not less than a mile across. The Ardtun gravels indicate a less rapid but more extensive river. The section at Burgh is very like that at Ardtun, with the addition of an extensive ash-bed at the base, with sand instead of gravel, and with many hundred feet of Trap above. In the Wilderness there is a small outcrop of Chalk-rubble, less than 300 square feet in extent, and evidently redeposited. Some distance under this is Greensand *in situ,* then Lower Lias, and lastly Poikilitic sands. This descriptive part of the paper concluded with some remarks on the estuarine formation between the Chalk and Upper Greensand at Beinn Jadain in Morven, which the author investigated in the hope of finding plant-remains belonging to that interesting age. He doubts that the Chalk is *in situ,* and considers the evidence of age to be not quite conclusive.

The second part of the paper deals with the palæontological evidence. The evidence, if confined to the plants of Ardtun, was said to be scarcely worth serious discussion, and the analysis was extended to the far richer plant-bed at Atanekerdluk. The identifications of these with Miocene plants of Europe were discussed *seriatim,* and shown to be groundless, or only applied to such prevailing types of leaves as are common to widely distinct genera, and occur in floras recent as well as fossil, and which cannot be superficially distinguished in even a living state. The strong resemblance and even identity of the best-characterized forms with the older Eocene plants has been, on the other hand, hitherto ignored. The most strongly marked types of Greenland, and which recur in Antrim, are met with in the Heersian of Gelinden and at no other horizon, and amply suffice to fix the date of the Antrim floras. The Mull flora, as its aspect indicates, is still older, and consequently earlier than the Thanet Beds of England. Independently of positive evidence, the absence of any late Tertiary types, even of the Leguminosæ, which abound as low down as the Reading Beds, sufficiently indicates their extreme antiquity.

2. "On the Echinoidea of the Cretaceous Strata of the Lower Narbadá Region." By Prof. P. Martin Duncan, M.B., F.R.S., F.G.S.

A collection of fossils from the Limestone near Bág, in Western India, made by Colonel Keatinge, was described by the author in the Quarterly Journal of the Society for 1865, and shown to be of Upper Greensand or Cenomanian age. The country was subsequently examined, and a sketch-map made by Messrs. Blanford and Wynne, who found near Bág the following beds in descending order beneath the Deccan and Malwa traps :—Coralline limestone, Argillaceous limestone, Nodular limestone, Sandstone. All were conformable, the whole thickness of limestone did not exceed 50 feet, and the fossils obtained by Colonel Keatinge were shown to have been exclusively derived from the Argillaceous limestone. All the beds were referred to the same Cretaceous sub-division.

Good topographical maps having been prepared, the area was remapped by Mr. Bose, who obtained several additional fossils from the Coralline and Nodular limestones, and a few from the upper beds of the Sandstone. He accepted the Cenomanian age for the Argillaceous limestone, but referred the overlying Coralline limestone to a

Senonian age, and the underlying Nodular bed to the Gault, whilst he regarded the Sandstone at the base as probably Neocomian.

Mr. Medlicott, Director of the Geological Survey of India, in compliance with the author's request, had sent to him the Echinoidea collected by all the geologists named, and, on examination, the collection was found to comprise the following eight species:—*Cidaris*, sp. nov., *Salenia Fraasi*, *Cyphosoma cenomanensis*, *Orthopsis*, sp. nov., *Echinobrissus Goybeti*, *Nucleolites similis*, var., *Hemiaster cenomanensis*, and *H. similis*. All the known forms were found in beds of Upper Greensand age in the Lebanon, Europe, etc., except the *Nucleolites*, which was a Chloritic-marl species. Of the eight species all were found in the Argillaceous limestone, five in the Coralline, and two in the Nodular limestone, the last two, *Hemiaster cenomanensis* and *H. similis*, occurring throughout. Under these circumstances there appeared no reason for assigning the beds of limestone to different stages of the Cretaceous system.

3. "On some Dinosaurian Vertebræ from the Cretaceous of India and the Isle of Wight." By R. Lydekker, Esq., B.A., F.G.S.

The author, in 1877, described some Dinosaurian caudal vertebræ and a femur from the Lameta beds of India (Middle or Upper Cretaceous), and as he was unable to find any described forms that resembled them, he proposed for them a new genus, which he called *Titanosaurus*. Two species were represented. After noticing the principal characters of the Indian specimens, he showed that some caudal vertebræ in the British Museum, collected by the late Mr. Fox from the Wealden of Brook, in the Isle of Wight, agreed in form with those found in India, and were, in fact, intermediate in some respects between the two Indian species. An inquiry into the associated remains at Brook indicated that the caudal vertebræ in question probably belonged to *Ornithopsis*, and this probability was supported by the structure of certain American fossil genera placed by Marsh in the same suborder, Sauropoda, of the Dinosauria. In any case there is great probability that at least one of the Indian and the Isle of Wight vertebræ should be referred to the same genus.

Some other instances of fossil vertebrates appearing in Indian beds of a rather later geological age than in Europe were noticed.

4. "Further Notes on the Results of some Deep Borings in Kent." By W. Whitaker, Esq., B.A., F.G.S.

This paper contained some details on the borings at Chattenden Barracks and at the Dover Convict Prison, in addition to those already published in the Quarterly Journal of the Society for 1886. Sections of the new borings, one at Strood, the other at Lydd, were also given.—The Chattenden boring has been successful in reaching the Lower Greensand, and a supply of water had been obtained. This result showed that on the section accompanying the previous paper the beds of the Lower Greensand should have been carried rather further to the northward.—The Dover boring was abandoned at 931 feet from the surface. The examination of the specimens showed that the thickness formerly assigned to the Lower Greensand should be reduced to 31 feet, the upper five feet referred to that stage belonging to the base of the Gault, whilst the bottom, 13 feet, together with an additional 69 feet, mostly of clay, subsequently cut through, were, for reasons given, assigned to the Wealden series and probably to the Hastings beds. The results of these additional details went to show (1) that, though the Lower Greensand itself was rather thicker at Chatham than at Dover, comprising two divisions, the Folkestone and the Sandgate beds at the former place, and only the Sandgate at the latter, the Lower Cretaceous beds, as a whole, were much thinner at Chatham, owing to the disappearance of the Wealden series; and (2) that in passing to the eastward the Weald clay thinned out before the Hastings beds, instead of the reverse, which was previously suggested.—The Strood and Lydd sections were merely of importance as furnishing details. The paper concluded with some remarks on the best site for additional borings at Dover, in order to prove the deeper-lying rocks.

## CORRESPONDENCE

### THE FFYNON BEUNO CAVE.

Sir,—So much interest has been shown in the Ffynon Beuno Cave, and especially in the determination of the age of the bed from which Dr. Hicks and Mr. Luxmoore obtained the flint implement, that I trust you will allow me space in the Geological Magazine for a few remarks on the mammalian remains which have been found, and concerning which, as it seems to me, Dr. Hicks is under a misapprehension. In a note to Dr. Hicks's paper, published in the December Number of this Magazine (p. 567), he alludes to a remark made by Prof. Hughes on the same subject (November, p. 492), and says: "Prof. Hughes's palæontological argument is found on examination to be almost equally inapplicable, as a very large proportion of the animals occur in the Norfolk Forest Bed, which is acknowledged by all to be of Pre-Glacial age. The fact that some others have not been found in the caverns probably indicates that they did not migrate into the area."

The evidence to be derived from the list of mammals given by Dr. Hicks on p. 571 would certainly lead one to the conclusion that the deposits, from which they were obtained, were of Pleistocene age. It is quite true that most of these species have been found in the Pre-Glacial Forest Bed of Norfolk, and it is probable that others of them will yet be found; although at present the Lion, Reindeer, and Woolly Rhinoceros are conspicuously absent from the Forest Bed fauna. On the other hand, the whole of these Ffynon Beuno cave mammals are met with in acknowledged Pleistocene deposits. And further, it must be remembered, that the forms which are common to the Ffynon Beuno cave and the Forest Bed are those which link on the Forest Bed to the Pleistocene times; and not those which are characteristic of the Pre-Glacial fauna. This brings us to another, and perhaps the most important point, and that is the entire absence of characteristic Pre-Glacial forms from the Ffynon Beuno cave.

Some of the most characteristic species of the Pre-Glacial Forest Bed are *Rhinoceros Etruscus, Trogontherium Cuvieri, Myogale moschata, Elephas meridionalis,* and several large Deer such as *Cervus Sedgwickii,* *C. verticornis*, *C. poligniacus*, *C. Savinii*, etc., and the finding of any one of these forms in the Ffynon Beuno deposit would be strong evidence in favour of its Pre-Glacial age; but not one of them has been found.

With regard to the stratigraphical evidence of the age of this deposit, I have nothing to say: but the mammalian fauna would certainly lead one to assign to it a Pleistocene and not a Pre-Glacial origin.
E. T. Newton.

## PHOSPHATIC NODULES OF THE SALT RANGE, INDIA.

Sir,—Dr. H. Warth, of the Indian Civil Service, writes from Dehra Dún, under date 17th Nov. 1886, referring to certain nodules of Phosphate of Lime, which he found in overlying shales associated with the Salt Range Coal at the localities of Pid, Dandôt, etc. He speaks of these phosphatic nodules as being "nearly equal in purity" to the "bed" of phosphate of lime at Mussoorie Hill-station, which, so far as I am aware, he was the first to notice in this connexion; having sent me some samples from the locality nearly a year ago.

From this locality, it would seem some inferior specimens had been sent home for examination, by order of Government, the London results giving only one-ninth of the quantity of phosphoric acid found by Dr. Warth's own analysis of better specimens. As to the Salt Range nodules which he has also analyzed, I extract from his letter, viz.:—

"Analysis of phosphatic nodules with hemispherical pores all over the surface from the Pid, Dandôse Colliery, etc., in the Eastern Salt Range; scattered in the shales which overlie the Eocene Coal Seam, and sometimes replacing shells.

| | | | |
|---|---|---|---|
| | Insoluble silica, etc. | 4 | per cent. |
| $(P_2O_5)$ | Phosphorus pentoxide | 30 | ,, |
| $(CO_2)$ | Carbon dioxide | 4 | ,, |
| $(SO_3)$ | Sulphur trioxide | 2 | ,, |
| (Cl) | Chlorine | trace | |
| $(Al_2O_3)$ | Aluminium Oxide | trace | |
| (FeO) | Ferrous Oxide | 2 | ,, |
| (MG) | Magnesium Oxide | 2 | ,, |
| | Balance, Calcium Oxide, water, organic matter and loss | 56 | ,, |
| | | 100." | |

The importance of the occurrence of the valuable mineral phosphate of lime in India leads to the hope that Government will take steps to have the Himalayan limestone zones specially explored with regard to such deposits and to their worth.
A. B. Wynne.

# OBITUARY.

## HENRY MICHAEL JENKINS, F.G.S.

Born 30 June, 1841; Died 24 December, 1886.

We have to record with deep regret the loss of a valued friend and sometime colleague in the Editorship of this Magazine (1865), who has passed away at the close of the old year whilst still in the prime of life, with the hope of at least many more years of work before him.

Henry Michael Jenkins was born at Fairwater Mills, Ely, near Llandaff. His father, Mr. John Jenkins, an energetic and clear-headed corn and flour merchant, died whilst his son was yet an infant, and his mother having been married to Mr. Box, corn merchant, young Jenkins was in due time sent to Mr. Browning's school near Bath. He showed great aptitude for business affairs, first in his step-father's office, then as barter-clerk on a voyage to the west coast of Africa, undertaken for his health (for he early developed symptoms of asthma, from attacks of which he was always liable in unfavourable conditions of the weather), afterwards in the shipowner's office in Bristol. H. M. Jenkins came to London in March, 1859, having been appointed Assistant to Prof. Rupert Jones, in the Geological Society, Somerset House.

Here he won the good opinion of the officers and Council by his intelligence and aptitude for his duties, and on the removal of Prof. T. Rupert Jones, F.R.S., from the Geological Society to the Royal Military College, Sandhurst, Mr. Jenkins was appointed to succeed him in 1862 as Assistant Secretary. He was elected a Fellow of the Geological Society in 1863, and edited the Quarterly Journal with marked success from 1862 to 1868; at the end of the latter year he was chosen Secretary to the Royal Agricultural Society of England, a post which he has held for eighteen years with marked success, not only as Editor of the Society's Journal, but also as Secretary and Manager of its Annual Shows.

Mr. Jenkins's career, extending over twenty-seven years, has been one of steady upward progress, due to his indomitable energy and great capacity for mastering rapidly the details of all matters, whether scientific or commercial, which it was needful for him to understand and decide about judicially. His business shrewdness enabled him to save the Royal Agricultural Society hundreds of pounds annually, and his scientific ability as Editor has brought their Journal up to a standard of excellence which few Societies can equal and probably none surpass.

Mr. Jenkins was, in the early days of his career, for some time assistant editor to Mr. Samuelson, in conducting the Quarterly Journal of Science, to the pages of which he contributed many Reviews and Notices, also to the GEOLOGICAL MAGAZINE and the Quarterly Journal. We give the titles as under:—

"On the Tertiary Mollusca from Mount Séla, in the Island of Java." Quart. Journ. Geol. Soc. 1864, vol. xx. pp. 45–73, pl. vi.–vii.

"On the Occurrence of a Recent Species of *Trigonia* in Tertiary Deposits in Australia." GEOL. MAG. 1866, Vol. III. p. 201, Pl. X.

"Hypothetical Continents." Intellectual Observer, 1866, vol. x. pp. 88–97.

"Brackish Water Fossils in Crete." Quart. Journ. Science, 1864, vol. i. pp. 413–421 (Plate No. 3).

"Strata Identified by Organic Remains." Quart. Journ. Sci. 1865, vol. ii. pp. 622–630 (Plate No. 8).

"Amber; its Origin and History." Quart. Journ. Sci. 1868, vol. v. pp. 167–185 (with a Map and Plate).

"On *Palæocoryne*" (Joint paper with Prof. Duncan, F.R.S.), Phil. Trans. Roy. Soc. 1869.

The numerous writings of his later years have been directed to Agriculture in all its branches, and in the future his name will be best remembered by these; but his memory will be cherished by all who knew him, whether Geologists or Agriculturists.

*Ophiurella nereidea*, Wright.

Calcareous Grit, near Weymouth.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. IV.

No. III.—MARCH, 1887.

## ORIGINAL ARTICLES.

### I. -On a New *Ophiurella* from the Calciferous Grit, near Sandsfoot Castle, Weymouth, Dorset.[1]

By the late Dr. Thomas Wright, F.R.S., F.G.S.

(PLATE III.)

Genus Ophiurella, Agassiz, 1836.

DISK small, membranous, often indistinct, a character which separates this genus from *Ophiura*. Rays very long, slender, depressed, formed of circles of plates, four in each circle; the lateral plates are the largest, most prominent, and provided with long spines; the basal plates are small and spiniferous, and the dorsal smooth and without clothing. Mouth plates small and triangular. All the species known have been found in the Jurassic rocks.

*Ophiurella nereidea*, Wright, 1880. (Pl. III.)

*Description.*—Disk small, irregularly penta-lobed, each lobe consisting of a shield-like elevation formed by the radial plates, which are covered by a tegumentary membrane closely studded over with small granules; the interlobular integument is entirely absent, having apparently, if it ever existed, been destroyed in the process of fossilization.

The arms, or rays (five in number), are long, four times the length of the disk's diameter. They do not taper much between the radial plates and their termination, and consist of innumerable highly movable rings composed of:—1st a centro-dorsal plate, which, with its fellows, form a long, smooth, convex, continuous chain, flattened at the summit, and laid along the middle of the rays; 2nd, two rows of lateral plates which bend downwards, closely clasping the sides of the ray; each plate supporting a small tubercle, on which a stout thorn-like spine is articulated by a kind of ball and socket joint; 3rd, the basal or ventral plates which close the ray below are small and much concealed, they likewise carry short, stout spines. One of the spiniferous arms of the *Ophiurella*, as it lies on the slab of calcareous grit before me, resembles a marine worm, the *Nereis nuntia*, and hence the origin of the specific name I have ventured to give to this Brittle-star. The arms are very much bent and curled, so that this species may be said to have had highly moveable arms.

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[1] Extracted from the Dorset Natural History and Antiquarian Field Club, vol. iv. p. 56, printed at the "Journal" Offices, South Street, Sherborne.

*Dimensions.*—Diameter of the disk six-tenths of an inch; length of arm, two inches and six-tenths. This is less than in the living state, as none of the arms are preserved up to their terminations.

*Affinities and Differences.*—The fragmentary condition of the disk prevents any definite conclusions as to the true generic position of this form, but it agrees with *Ophiurella* closer than with any other. It has the small disk with the upper and under surfaces flattened, the lateral and ventral plates supporting spines, which are specially jointed to the lateral plates. In all these essential generic characters it agrees with *Ophiurella*. I know of no figured species from the Corallian rocks that resembles this Brittle-star. The only form that occurs to my mind is *Ophiurella bispinosa*, d'Orb., which has only been named, but was neither described nor figured by the author. Our species is so widely different from all the others, that there can be no confusion with them.

This Brittle-star was obtained by Professor Buckman, F.G.S., from the Calciferous Grit at Sandsfoot Castle, near Weymouth.

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## II.—ON TWO SPECIES OF PALÆOZOIC MADREPORARIA HITHERTO NOT RECOGNIZED AS BRITISH.

By ROBERT F. TOMES, ESQ.

THE present communication is the result of the examination of a considerable number of small Silurian Corals, from Wenlock and Colwall, made as long ago as 1883, and it was written with the intention of its being communicated to the Geological Society. I very much regret, however, that circumstances have arisen which render it extremely difficult, perhaps impossible, for me to place myself again in communication with that body. The paper appears therefore in the pages of the GEOLOGICAL MAGAZINE, a medium for publication which I hope from time to time to have recourse to.

Of the two species of Corals, an account of which I now lay before the readers of the GEOLOGICAL MAGAZINE, one represents an entirely new genus, which I designate *Hemiphyllum*, and the other is a species of *Cyathaxonia*.

### HEMIPHYLLUM, nov. gen.

*Cyathaxonia*, M'Coy?

The corallum is simple, small, conical, and curved. It has a porous structure, and is surrounded by a thin epitheca, which is more or less rudimentary at the calicular extremity. There is a large and spongy columella, but no septal fossette. The calice is circular and bounded outwardly by a ring of spongy tissue, formed by spongy septa united by porous endotheca, constituting a thick and spurious wall. At the inner margin of this ring each pair of septa coalesce to form a septum, which passes across the intervening space and unites with the columella. All the septa are irregularly perforate, the punctures appearing to be due rather to their porous nature than to any regularly arranged perforations. The loculi appear to be open from the bottom to the top of the corallum.

I place this peculiar form in the vicinity of *Cyathaxonia*, though only on account of the open loculi, and am somewhat doubtful as to its real affinities. There is no true wall, and when the epitheca is worn off, the edges of the porous septa are exposed. But the absence of a wall is compensated for by the ring of endotheca which takes its place and binds the septa together outwardly.

As it is quite possible that the species on which I here propose to form a new genus is no other than the one described by M'Coy under the name of *Cyathaxonia Siluriensis*,[1] I adopt for it the specific name given by him.

### HEMIPHYLLUM SILURIENSIS, M'Coy, sp.?

*Cyathaxonia Siluriensis*, M'Coy?

The corallum is small and cornute, the curvature being sometimes confined to the small extremity, but is more frequently uniform throughout its whole length.

The epitheca is thin, somewhat annulated, and it does not ever extend to the margin of the calice. When well developed, it has a well-defined upper margin, above which the calice projects; but when it is less complete, the upper margin is ill defined, and it does not always extend more than half-way up the corallum.

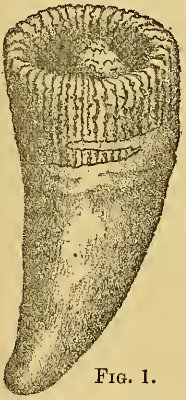

FIG. 1.

FIG. 2.

*Hemiphyllum Siluriensis*, M'Coy, sp.?
Magnified 2¼ times.

The calice is circular, shallow, and saucer-shaped, and when unworn the columella is nearly hidden by the septa which run into it. The outer ends of the septa project upwards, in the position usually occupied by the wall, and, with the abundant endotheca, form the margin of the calice. They are twenty-six in number, irregular in development, nearly equal in size throughout, and there is no distinction between the cycles. All of them pass inwards to the columella, the irregular papillæ of which blend with those of the septa, and the exact union of the columella and septa is obscured. The whole of the septa are perforate, but the perforations have no definite arrangement, and each septum divides into two near the

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[1] Ann. and Mag. Nat. Hist. 2nd series, vol. vi. p. 281, 1850.

outside of the corallum. Their denticulations bear but little resemblance to those of the *Astræidæ* and *Fungidæ*, and more nearly resemble undulations of the septal margin than actual denticulations, and they may be due to the want of continuous development incident on an open-work septum, rather than to the termination of vertical columns or ridges, as in so many of the *Astræidæ.*

When worn down, this coral assumes a different aspect. The calice is then distinctly tri-areal. There is the outer ring of spongy endotheca, an inner circle across which the septa pass, and a large central columellary space of spongy tissue.

The largest specimen I have seen has a height of one inch, and a calice of half that diameter.

It occurs in the Upper Silurian formation at Woolhope and Wenlock, but I have only met with a limited number of specimens from those localities.

By an error in transcribing M'Coy's description of *Cyathaxonia Siluriensis*, MM. Milne Edwards and Haime give it sixty or seventy septa instead of sixteen or seventeen,[1] and the error has been repeated in their general work on Corals.[2]

CYATHAXONIA DALMANI, MM. Edwards & Haime, Mon. Polyp. Foss. des Terr. Palæon. p. 322, pl. i. fig. 6.

In a Silurian quarry at the west foot of the hill at the back of the mansion at Old Colwall, Herefordshire, the residence of Mrs. Holland, I found, on the occasion of a visit there, a considerable number of small corals which could not be referred to any known English species, but which, on examination, proved to be identical with the *Cyathaxonia Dalmani* of MM. Milne Edwards and Haime.

The strata at the place mentioned are nearly vertical, and I was unable to ascertain the position of the corals in them, though, from the manner in which they were clustered in some of the nodular lumps of stone lying in the bottom of the quarry, I did not doubt that they were confined to one bed or zone. The quarry, so far as I can ascertain by reference to the map of the Geological Survey, is either in the Aymestry limestone, or the Ludlow bed.

One specimen only of another coral, in a very bad state and as yet undetermined, was found associated with the present species.

The figured specimen of *Cyathaxonia Dalmani* was obtained from the Upper Silurian of Gothland, and was preserved in the collection of M. Verneuil; and I have in my own collection examples from Gothland with which I have compared the Herefordshire specimens, and found them to be identical.

The figures accompanying this communication represent *Hemiphyllum Siluriensis*, magnified $2\frac{1}{4}$ times. Figure 2 shows a horizontal section a little below the calice.

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[1] Brit. Fos. Cor. pl. 5, p. 279.

[2] Hist. Nat. Coral. t. iii, p. 332.

## III.—NOTES ON SOME POST-LIASSIC SPECIES OF *ACRODUS*.

By A. SMITH WOODWARD, F.G.S., F.Z.S.,
of the British Museum (Natural History).

SO little is known of the extension through later Mesozoic deposits of Selachian teeth belonging to the familiar type of *Acrodus*, as represented in the Lias, that any additional evidence upon the subject is invested with considerable interest. It is impossible, of course, from these isolated relics, to determine whether the original Sharks were as closely allied as the resemblances in their dentition might at first lead one to suspect; in one case,[1] indeed, it has been proved that the complete fish differs much from the Liassic species; but the persistence of the dental type is at any rate of some significance, and it may therefore be acceptable to offer a few notes upon the undescribed Jurassic and Cretaceous Acrodonts preserved in the British Museum. These specimens furnish evidence of at least two new specific modifications, and they are also suggestive of novel points in regard to some of those already known.

### ACRODUS LEIODUS, Agassiz, MS.

1844. *A. leiodus*, L. Agassiz, "Rech. Poiss. Foss." vol. i. p. xxxiii (name only).
1871. *Acrodus*, J. Phillips, "Geol. of Oxford," p. 177, fig. 10.

In the recently acquired collections of Sir Philip Egerton and the Earl of Enniskillen, there are several teeth from Stonesfield bearing the name of *Acrodus leiodus* in Agassiz' own handwriting; and these may consequently be regarded as the types of the species intended to be so described in one of the projected supplements of the "Poissons Fossiles." The form, however, appears to have remained hitherto undefined, and the only allusion to it that I have succeeded in discovering occurs in Prof. Phillips' work quoted above.

The Egerton specimens (No. P. 2134) are very unsatisfactory—two being much broken, and the third somewhat waterworn—but two of those in the Enniskillen Collection (No. P. 2753) and others in the Museum are in a comparatively good state of preservation. The species is but a small one, as indicated by the annexed woodcut (Fig. 1), which is twice natural size, and the teeth vary considerably in shape, according to their original situation in the jaw; some are much elongated and relatively narrow, being referable to a posterior position, while others, evidently pertaining to the symphysial area, are notably short and broad. It is interesting to remark, also, that even the latter are destitute of any prominent rising of the coronal surface, and there are but slight traces of lateral points or cusps. All the less abraded examples show a very characteristic surface-ornament, consisting of large and rounded ridges, closely approximated, and disposed in the ordinary manner;


Fig. 1. Tooth of *Acrodus leiodus*, Ag. Twice natural size. Great Oolite, Minchinhampton. [Byne Coll., Brit. Mus.]

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[1] A. Wagner, "Monographie der fossilen Fische aus den lithographischen Schiefern Bayerns," Abh. k. bayer. Akad. d. Wiss. cl. ii.; vol. ix. pp. 300-304, pl. v. fig. 1.

and these seem to be most nearly paralleled in the smaller species, *A. minimus*, which occurs so abundantly in the Rhætic formation.

From those of *A. leiopleurus*, the present teeth are readily distinguished by the flatness of the grinding surface, and the rounded character of the ornamental rugæ. And there can be no doubt of their distinctness from *A. falcifer* of the Solenhofen Lithographic Stone, for Wagner's specimen of the last-named species has every appearance of being adult, and yet has teeth of much smaller size; while there is good evidence, also, that in the present Bathonian form the symphysial teeth were rounded and not acuminate.

*Formation and Locality.*—Great Oolite—Stonesfield, Minchinhampton; Forest Marble—Atford near Bath.

A. LEIOPLEURUS, Agassiz ("Rech. Poiss. Foss." vol. iii. p. 145, pl. 22, fig. 5).

This species is founded upon a single tooth in the Bristol Museum, supposed to have been derived from the Great Oolite; and its chief characteristics are the height of the crown and the angularity of the ornamental wrinkles upon its surface. A beautifully perfect tooth from the Great Oolite of Minchinhampton, preserved in the Byne Collection, appears to be referable to the same form, only differing in the extension of the ornament over the lateral prominences; and it seems not improbable that this slight divergence depends merely upon the abraded character of the original type specimen.

A. ELEGANS, Sauvage (Mém. Acad. Boulogne-sur-Mer, vol. ii. 1867, p. 54, pl. iii. fig. 9).

From the Great Oolite of Caen, Normandy; appears to be wrongly placed in the genus under consideration. The few specimens available for study leave little doubt that they belong to a species of *Strophodus*. It ought, however, to be added, that satisfactory evidence of the complete dentition of the latter genus has only been obtained since Dr. Sauvage's original description.

A. HIRUDO, Agassiz (" Rech. Poiss. Foss." vol. iii. p. 148, pl. 22, fig. 27).

The type specimen of this form is said to be preserved in Dr. Mantell's collection, but was not received among the fossils sent to the British Museum. A very characteristic tooth, however, from the Wealden of Telham Hill, near Battle, has recently been presented by John Edward Lee, Esq., F.G.S., and this (No. P. 4994) seems worthy of a passing note. The summit has been considerably abraded, so that the longitudinal wrinkle of the enamelled surface is represented rather as a faint groove; but numerous very fine corrugations are directed transversely outwards on either side, exactly as remarked in Agassiz' original description. The coronal surface has a remarkably unusual contour, being distinctly concave in the median portion, and rising into a slightly tumid prominence at either extremity.

A. LEVIS, sp. nov.

None of the Cretaceous teeth hitherto described under the name of *Acrodus* exhibit any very close resemblance to the typical forms from the Trias and Lias; and it is therefore of considerable interest to be able to record some most characteristic examples of this dental type from the Gault of Folkestone. The British Museum possesses about nine well-preserved specimens, obtained from the Gardner Collection, and it requires but a brief examination to recognize their distinctness from all previously described species. The teeth are of comparatively small size, and vary considerably in form according to their original situation in the jaw; examples that are evidently referable to the symphysial area are short, with much-raised crowns, and indications of lateral cusps (Fig. 2); while those from posterior positions (Fig. 3) are more elongated and have the coronal surface gently rounded and showing but little elevation. The superficial ornament consists of sharp wrinkles disposed in the ordinary manner, but relatively far apart, and never approaching a reticulate arrangement; and in most cases the rugæ do not extend far down upon the sides of the crown, so that there is a noticeable smoothness of the enamel, which suggests the appropriate specific name of *levis.*

FIG. 2.

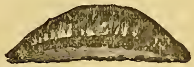

FIG. 3.

Figs. 2, 3. Anterior and posterior teeth of *Acrodus levis*, A. S. Woodw. Twice natural size. Gault, Folkestone. [Gardner Coll., Brit. Mus.]

*Formation and Locality.*—Gault—Folkestone.

A. TRANSVERSUS, Agassiz ("Rech. Poiss. Foss." vol. iii. p. 148, pl. 22, figs. 28, 29).
A. POLYDYCTIOS, Reuss ("Verstein. böhm. Kreideform." pt. ii. p. 97, pl. xxi. figs. 1–8).
A. CRETACEUS, Dixon ("Geol. and Foss. Sussex," 1st edit. p. 364, pl. xxx. fig. 13).

There can be no doubt that the species described under the above names are founded upon teeth of *Drepanephorus*. Agassiz himself admitted (*l.c.* p. 149) that the first of the three forms exhibited noteworthy deviations from the typical early Mesozoic species of *Acrodus*, and might be generically distinct; and later discoveries have now established this original surmise as a fact. All the teeth have the characteristic median ridge of those occupying the more posterior positions in *Drepanephorus*, and there is the same well-marked ornamentation—numerous fine rugæ descending on either side from the ridge and passing more or less abruptly into a complex and delicate network. To the first-named species, which was founded upon teeth from the Maestricht Beds, may probably be referred a well-preserved specimen obtained from the Chalk of Lewes by the late Dr. Mantell, and also one other small fragment from the same locality. The root is not displayed, so that it is impossible to determine whether there is the curious perforation noted by Egerton in the teeth of *D. canaliculatus*; nor is it possible, upon such fragmentary materials, to formulate any very definite specific diagnosis. The *A. polydyctios* of Reuss is evidently rather smaller, and may be distinct; but the figure of the tooth made known by Dixon as *A. cretaceus* does not suffice to distinguish it from Egerton's fossil already mentioned and I have not seen the type.

A. ILLINGWORTHI, Dixon ("Geol. and Foss. Sussex," 1st ed. p. 364, pl. xxx. figs. 11, 12, and pl. xxxii. fig. 9.)

From an examination of the detached teeth of this species, it is impossible to determine whether it is to be referred to the generic type under consideration, or ought rather to be placed with those Cretaceous teeth hitherto regarded as pertaining to *Hybodus*. The National Collection comprises a small group of about twelve naturally associated examples, but this does not afford any information as to the character of the complete dentition; and the discovery of further specimens must be awaited before it is possible to arrive at any definite conclusions. In form, the English fossils are remarkably similar to some minute teeth described by Reuss from the Chalk of Bohemia, under the name of *Hybodus polyptychus*.[1]

As already mentioned, comparatively satisfactory remains of at least one post-Liassic Selachian, with teeth of the *Acrodus*-type, have been described by Wagner (*loc. cit.*) from the Lithographic Stone (or Lower Kimmeridgian) of Solenhofen, under the name of *A. falcifer*. This species, however, differs so much from the typical forms of Liassic age, that it seems not unlikely that future discoveries may lead to its generic separation; the dentition, for example, is less uniform, the symphysial teeth being conical and pointed; the dorsal spines and shagreen are quite different, and there are no dermal "*Sphenonchi*" in the cephalic region; and there is considerable reason for suspecting that the vertebral column attains a much higher stage of development.

It seems also very probable that some of the species described above, upon mere dental evidence, may eventually prove to be equally distinct. As regards the Jurassic and Wealden forms, of course, it is quite possible that they were Sharks of the ordinary type as represented in the Lias; for both ribbed dorsal spines and dermal hooklets (*Sphenonchi*) are not unfrequently met with in the same deposits. But since none of these appendages can be distinguished from those of the true *Hybodus*, and since also there are numerous Hybodont teeth upon the same horizons, it is equally probable that they all pertain to the latter.

In Cretaceous formations, however, dorsal spines with a ribbed ornamentation are almost entirely wanting; Owen's *Hybodus complanatus*,[2] in fact, appears to be the only example hitherto described,

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[1] A. E. Reuss, "Verstein. böhm. Kreideform." pt. ii. p. 97, pl. xxi. figs. 9, 10.

[2] R. Owen, "Notes on Two Ichthyodorulites hitherto undescribed," GEOL. MAG. Vol. VI. 1869, p. 482. The small fragments in Dr. Mantell's Collection, said to have been obtained from the Chalk of Lewes, and described by Agassiz (*op. cit.* vol. iii. p. 44, pl. 10*b*, figs. 15, 16) as *Hybodus sulcatus*, are undoubtedly Wealden fossils: see S. J. Mackie, "The Geologist," vol. vi. p. 242.

and this is not of later date than the Neocomian; and, so far as is known, there are no traces of the curious hooked *Sphenonchi.* But a small smooth spine, originally described by Agassiz under the name of *Spinax major,*[1] is quite commonly discovered both in the Gault, Greensand, and Chalk; and its remarkable resemblance to the homologous appendage of the Solenhofen Acrodont is very suggestive of its true correlation, in part, with the new species of *Acrodus* recorded in the foregoing notes. This spine, of course, has already been proved to characterize the *Drepanephorus* of Egerton;[2] but it is not in the least unusual for the dorsal fins of distinct genera to be armed with dermal weapons of an essentially similar type. And it is interesting to add, in this connection, that *Acrodus levis* and *Drepanephorus canaliculatus* are almost certainly members of the same family of Cestraciontidæ, the last-named form having been originally referred in error to the Spinacidæ, as is shown by the asterospondylic structure of its vertebral centra.[3]

## IV.—The Faunas of the Ffynnon Beuno Caves, and of the Norfolk Forest Bed.

By Henry Hicks, M.D., F.R.S., F.G.S.

FROM Mr. Newton's letter in the February Number of the Geological Magazine, I am inclined to think that he has somewhat misunderstood my meaning where I referred to the fauna of the Norfolk Forest Bed in my paper in the December Number. Prof. Hughes had stated in his paper that the bones from the caverns "belong to the newer group of animals found elsewhere in undoubtedly Post-Glacial river deposits." As Mr. Newton admits "that most of these species have been found in the Pre-Glacial Forest Bed of Norfolk, and it is probable that others of them will yet be found," it is clear that I was correct in my contention that "a very large proportion of the animals occur in the Norfolk Forest Bed." My remarks, however, were not intended to claim the Forest Bed fauna as necessarily of the same age as the remains obtained from the caverns (though on careful analysis they are found to be much more closely allied than is usually supposed), but rather to point out that some highly important questions connected with the compulsory migration of animals in consequence of climatic changes are not taken sufficiently into consideration in these discussions, and also to show the fallacy of any such idea as that species suddenly jumped into existence to mark special stages in Geological history. Surely the species of Northern origin lived where the conditions were suitable for them long before this country was much affected by the gradually advancing glacial conditions, and only arrived here as the increasing severity of the climate compelled them to migrate further

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[1] L. Agassiz, "Rech. Poiss. Foss." vol. iii. p. 62, pl. 10*b*, figs. 8–14.

[2] Sir Philip Egerton, "Figures and Descriptions of British Organic Remains, Dec. xiii." (Mem. Geol. Surv. 1872), pl. ix.

[3] C. Hasse, "Paläontologische Streifzüge im British Museum," Neues Jahrb. 1883, pt. ii. p. 66.

south. We may, therefore, legitimately assume that ancestors of the Pleistocene animals of Northern origin (probably also Man) must have been in existence somewhere during the time the Pliocene deposits were accumulating in the south-east, for it is generally admitted that the cold crept slowly over this country from the north, and that there was much land with high mountain ranges in the north and north-west during Pliocene times. It is important to remember also that wherever Reindeer remains have been found, there also we find traces of Man.

Although Man probably reached this country from the east, it seems to me equally clear that he must also have arrived here with the Reindeer from some northern source during the advance of glacial conditions. A fauna therefore which would be Interglacial in the north would be Pre-Glacial for some of the areas further south. The Forest Bed Fauna is specially interesting in showing the southward extension of some northern mammalia such as the Glutton, Mammoth, and (according to Prof. Boyd Dawkins), the Musk Sheep, before glacial conditions had actually affected that area, and the absence from it of the Reindeer and Woolly Rhinoceros is only what might be expected, as most of the herbivorous animals would naturally keep near to the edge of the advancing ice and in the mountain valleys, until driven to the southern areas by the increased cold towards the climax of the Ice age. The apparent absence of the Lion is easily accounted for, since its remains, like those of the Hyæna, are chiefly found in caverns which were their dens, and where they died.[1] It must not be forgotten also that the Forest Bed contains the fauna of an eastern, not of a western, area, as the river on the banks of which the animals roamed flowed from the south-east. Moreover, the conditions in the north and north-west were such during Pliocene time as would not tempt the more southern forms to migrate there. If Pliocene deposits occurred in the north and north-west, it is strange that no traces of them are now anywhere to be seen, or that some of the remains should not be found re-deposited in the Drift. The Pliocene fauna throughout shows that the climate was during that period becoming gradually colder, and the Forest Bed fauna is a further indication of an important stage in the onward advance of the ice. Some lists recently published by Mr. Jukes-Browne[2] demonstrate this very forcibly. They show that of the Mammalia of the Pliocene, seventeen only are found in the Forest Bed, and of these no less than seven, namely, *Hippopotamus major*, *Rhinoceros megarhinus*, *Elephas antiquus*, *Cervus elaphus*, *Equus caballus*, *Machairodus latidens*, and *Castor europæus*, pass up into the Pleistocene. Of those which appeared for the first time in the Forest Bed, twenty-one ranged to newer beds, seven species of Deer and *Caprovis Savinii* being the only forms not known as yet in the Pleistocene. All the Mollusca of the Forest Bed pass up into the newer beds. If the

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[1] Mr. W. Davies mentions (Catalogue of Sir Antonio Brady's Collection, p. xxxiii) that "as we might expect from the known habits of the *Felidæ*, their remains are comparatively rare in all aqueous deposits, being more generally found in caves and rock fissures."

[2] Historical Geology, pp. 499 and 500.

Forest Bed is proved to be of Pre-Glacial age, because it is covered by Glacial deposits, then certainly we can claim the remains found in the Ffynnon Beuno Caves to be of Pre-Glacial age, since they also were completely covered over by undoubted glacial deposits, and the fact that the mammalian fauna of the Caverns would "lead one to assign to it a Pleistocene" age is certainly no proof against such a conclusion.

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## V.—ON THE BEDS CONTAINING THE GELINDEN FLORA.

By J. STARKIE GARDNER, F.L.S., F.G.S.

THE Gelinden Flora, described by Saporta and Marion (Mém. de l'Acad. de Belge, t. 37; and Révision de la Flore Heersienne de Gélinden, *ibid.*, t. 41), has assumed an immense importance owing to the fact that it alone, among Tertiary fossil floras whose age is definitely ascertained on stratigraphical and palæontological grounds, contains certain remarkable types of leaves which are common to it, to the inter-basaltic beds of Glenarm in Antrim, and to Atanekerdluk in Greenland. Two of these are long lanceolate leaves, with three or more parallel mid-ribs. The larger, called *Daphnogene*, is confined in Greenland to the so-called Miocene at Atanekerdluk and to the horizon from which the collections of McClintock, Whymper, Robert Brown, and Colomb were obtained; but the smaller, *McClintockia*, has been met with in the so-called Cretaceous as well. There is some variety in the latter, the number of mid-ribs varying, and the margin being either toothed or smooth. The *McClintockia* is also the more common in Antrim, being equally found at Ballintoy and Ballypalady. The venation is very peculiar, and appears to represent an early type still preserved in phyllodes, bracts, and sepals, but almost lost in true leaves, though a not dissimilar plan is to be found in a few herbaceous plants such as the Plantain, Peony, etc. The splendid specimens which I had the good fortune to find, after draining the disused mine at Glenarm, prove beyond doubt that they were true deciduous leaves, with long and distinctly articulated foot-stalks. The *McClintockia* was originally placed in the Proteaceæ by Heer, but subsequently removed to the Urticeæ, where both types undoubtedly belong. The *Daphnogene* in fact seems to almost still exist in the *Debugesia* of the Himalayas. The presence of these types in the Heersien alone, of all the innumerable stages of the Tertiary in Europe which have yielded fossil plants, shows so far that they are characteristic of one definite horizon only, and in the absence of any evidence to the contrary, it is to this horizon and no other that the floras of Antrim and Greenland containing these plants must be referred. If palæontological evidence of such nature is not to be accepted, when there is absolutely nothing to urge against it, the basis of geology would be sapped and common-sense rules ignored.

The Gelinden plants are preserved in a fine white chalky limestone. My friend, Mons. Th. Lefèvre, of Brussels, was instrumental in procuring me a fine series, now in the British Museum; but as I am personally unacquainted with the district, I have induced my friend Mr. G. F. Harris, F.G.S., to send the following notes upon it. The importance of a true appreciation of the evidence upon which the age of the plants is based is apparent, when it is considered that at the present moment the relative ages of the whole of the immense Tertiary formations of Ireland, Scotland, and Greenland rest almost solely upon it. This fact is brought into strong relief in my paper on the beds of Ardtun Head, Mull, read before the Geological Society on the 12th January, and further insistance upon it here is therefore unnecessary.

## ON THE GELINDEN BEDS, ETC.

By GEO. F. HARRIS, F.G.S.

Gelinden is a village about a mile and a half N.W. of Heers in Limbourg. The formation in which the flora occurs is called by the Belgian geologists Heersien supérieur; and the pit whence the great majority of the plants came from is very close to Overbroeck, about three-quarters of a mile due south of Gelinden.

On the opposite page is a geological map of the district, scale $\frac{1}{20000}$ (about $3\frac{1}{2}$ inches to the mile).

It will be observed that the section near Overbroeck is just off an outlier. The main mass, however, is close by, and the section in the "*Heersien*" is in fact in the valley of the Molen Beck, which cuts the outlier from the main mass. The *Landenien* beds thus thin out on the outlier, and their greatest thickness on it is probably not more than 3m. 40. I am nearly certain that no fossils have been found in the Lower Landenien beds on this outlier, but on the main mass, just a little N.W. of Gelinden, fossils occur in them, and the beds are thus easily identified. The base of the Landenien beds here is a more or less hard greenish sand.

The Heersien beds in the pit at Overbroeck are a pure whitish grey "marne," 10m.[1] thick, fossiliferous (especially towards the base). The base presents rather larger "bancs" than the other parts, but it is very much cracked up. The "bancs" towards the top are hard. The following fossils[2] have been found in the marne:—

*Cycloides incisus.*
*Osmeroides belgicus.*
*Smerdis Heersensis.*
*Lamna elegans*, sp ?
*Callorhynchus*, sp. ?
*Natica Deshayesiana*?

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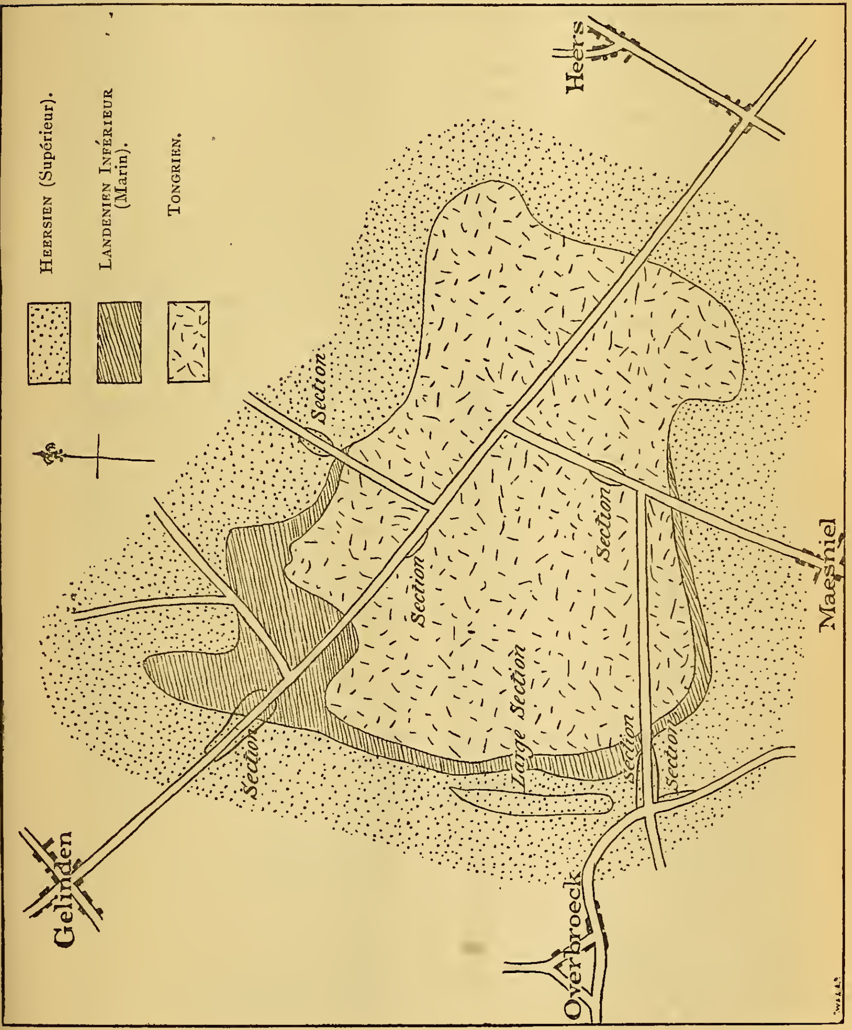
[1] The following analysis is by M. Laminne, of Tongres. Analyse de la marne de Gelinden, 100 parties de marne de Gelinden renferment:—

| | |
|---|---|
| Carb. de chaux mélangé d'un peu de carb. de magnésie | 71·290 |
| Phosphate de chaux | 0·141 |
| Sulfate de soude; sulfate de chaux; chlorure de sodium | 0·155 |
| Silice soluble | 0·170 |
| Sable, argile et oxyde de fer | 26·612 |
| Matière organique | 1·380 |
| Ammoniaque | traces |

(Extracted from "Explication de la feuille de Heers," by Rutot and Van den Broeck (1884), p. 125.) Marne of exactly similar appearance is found in many Belgian Eocene beds, even up to the Bruxellien. It usually occurs in bands more or less divided by sands (often false-bedded).

[2] Rutot and Van den Broeck, *op. cit.* p. 21.

*Chenopus* (*Aporrhais*) *dispar.*
*Teredo*, sp.?
*Panopœa triplicata.*
*Pholadomya cuneata.*
*Cytherea orbicularis.*
*Cytherea*, sp.?
*Cyprina Morrisii.*
——— *transversa.*
——— *acuminata.*
*Astarte inæquilatera* (*A. tenera*, syn.).
*Nucula Ryckholtiana.*
——— *lanceata*
——— *quadrangula.*
*Cucullæa crassatina* (*C. decussata*, syn.).
*Modiola Heersensis.*
——— *subcarinata.*
*Mytilus gelindenensis.*
*Ostrea inaspecta.*
*Spongiaire*, sp.?



Besides the above, 59 species of fossil plants have been found on the same horizon in this pit, described by de Saporta and Marion.

There is not the slightest doubt, therefore, that the flora is entombed in marine strata.

Everywhere, in the district under consideration, the Heersien beds rest unconformably on Maestrichtien.

Now, with regard to the position of the flora with reference to English beds.

The fauna of the Heersien Supérieur of Belgium is a very poor one, there being but few species, and they are all very badly preserved, with the exception of the fish teeth. There are only 23 species of Molluscs in them, unless others have been discovered within the last year. Of these at least eight are found in our Thanet beds. These are:—*Cyprina planata, Cucullæa decussata, Modiola elegans, Cyprina Morrisii, Astarte tenera, Cytherea orbicularis, Nucula Bowerbankii,* and *Pholadomya cuneata.* All these, with the exception of *N. Bowerbankii,* are very common in the Heersien (as far as that term "common" can apply), whilst it is a curious fact that the remaining species are *exceedingly rare.* In other words, Thanet fossils are the characteristic ones. If the Heersien Supérieur beds contained as many species as our Thanet, we should then be in a better position to get out a percentage; but as we have only, comparatively speaking, negative evidence to go upon, I think that the general facies should rule the day, and in this case this is decidedly a Thanet facies. I have no hesitation in making the beds which entomb the Gelinden flora, then, homotaxial with the lower part of our Thanet beds, and cannot see the slightest particle of evidence—as far as the fauna shows—for making them any older.

The Landenien beds overlie the Heersien. They are divided into two parts, an upper and a lower. The lower part—Landénien Inférieur—is marine; and contains in Belgium at least 105 species of fossils, many of which have not yet been described. The Landénien Inférieur are generally admitted to be the Belgian equivalents of our Thanet beds; but whilst thinking they in part represent them, I am inclined to believe that they in part also represent newer beds. There are only 12 species of Molluscs common to our Thanet beds. These are:—*Ficula Smithii* (?), *Scalaria Bowerbankii, Ostrea bellovacina, Modiola elegans, Cucullæa crassatina, Nucula Bowerbankii, Astarte inæquilatera* (*tenera*), *Cytherea orbicularis, Cyprina planata, Sanguinolaria Edvardsii, Corbula regulbiensis, Pholadomya Koninckii*; five of these are rare. There are 10 London Clay species in all:—

*Beloptera Levesquei.*
*Aturia zic-zac.*
*Ficula Smithi* (?).
*Ostrea bellovacina.*
*Pinna affinis.*
*Modiola elegans.*
*Nucula Bowerbankii.*
*Cyprina planata.*
*Corbula regulbiensis.*
*Panopæa intermedia.*

and nine are met with in the Oldhaven Sands:—

*Scalaria Bowerbankii.*
*Ostrea bellovacina.*
*Modiola elegans.*
*Astarte tenera.*
*Cytherea bellovacina.*
*Cytherea obicularis.*
*Sanguinolaria Edvardsii.*
*Corbula regulbiensis.*
*Panopæa intermedia.*

Not so much reliance, however, can be placed on the actual species as on the general facies in this case. The Landénien Inférieur beds contain 12 species of *Pleurotoma*, 1 *Voluta*, 6 *Natica*, 5 *Cerithium*, 2 *Turritella*, 2 *Solarium*, 2 *Arca*, 2 *Crassatella*, 1 *Nautilus*, 1 *Neæra*, etc., a fauna quite unlike that of the Thanet beds.

Wherever the Landénien Inférieur comes in contact with the underlying Heersien beds in the many sections I have seen, I have not noticed a true unconformability, though there is occasionally an overlap. The sand is sometimes coarse, otherwise the passage, from a stratigraphical point of view, is quite conformable. When the Landénien beds rest on the Calcaire Grossier de Mons, or on the Cretaceous beds, there is in the former case generally a pebble bed at the base, and in the latter green-coated flints, the same as we see in the London Basin. This bed of green-coated flints is present wherever the Tertiary beds, Heersien and Landénien, touch the Cretaceous. It is seen also in many parts of France occupying the same position.

With respect to the Landénien Supérieur beds of Belgium, they are generally regarded as the equivalents of our Woolwich and Reading beds. *The only places in Belgium* where molluscs from the Landénien Supérieur beds have been met with are in the artesian wells at Ostend and Ghent. There are only nine species of fossils in all. These are *Melania inquinata*, *Melanopsis buccinoides*, *Cerithium funatum*, *Ostrea bellovacina*, *O. tenera*, *Cyrena cuneiformis*, *C. antiqua*, *Mytilus*, sp., and *Cliona erodens*. The Landénien Supérieur beds are so deeply seated when fossiliferous, that it is with great difficulty that they can be identified when they crop out at the surface. The only fossils I have met with from them in an outcrop is a piece of silicified wood and tubes of Annelides. I may mention that the general character of much of the Landénien Supérieur beds in Belgium is such as to cause some geologists there to think it not only fluvio-marine or freshwater, but marine.

I regard the greater part of the Landénien Supérieur beds as being part of the Landénien Inférieur, for reasons I will not enter upon now.

## VI.—AN OUTLIER OF UPPER BAGSHOT SANDS ON LONDON CLAY.

By the Rev. A. IRVING, B.Sc., B.A., F.G.S.

THE chief object of this paper is to describe an unmapped outlier of Bagshot Sand, in which the pebble-bed, frequently met with at this level,[1] exhibits an extraordinary thickness and compactness. It is situated at Bearwood, on the estate of John Walter, Esq., who has kindly given me every facility for investigating it. The extent of the outlier may be said to coincide approximately with the space enclosed within the 250 foot contour-line of the Six-Inch Ordnance Survey Map. On the south side it extends a little way to the south of that line, in the form of several spurs forming low ridges, the principal of which is crossed, and partly cut through, by the main

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[1] See Proceedings of Geol. Assoc., vol. viii. pp. 149—151; Q.J.G.S., vol. xli. (Aug. 1885), p. 508; Proc. Geol. Assoc. vol. ix. pp. 219, 223, 224.

road from Arborfield Cross to Wokingham. The highest point on this outlier is on Birtle Heath, where it is capped with Quaternary Drift, containing an intermixture of rounded flint pebbles and subangular discoloured flints, and partaking therefore of the general character of the plateau gravels of this district. Close by Barkham Lodge (at the south-east corner of Bearwood Park) the altitude is marked on the Survey Map 280 above O.D. The well at Barkham Lodge is 40 feet deep; and as this well in all probability reaches the water-bearing line at the top of the London Clay, we may take this as representing very nearly the greatest thickness of the sands of this outlier, together with the capping of later Drift. Bearwood House is situated at an altitude of 240 feet, a little way off the mass of Bagshot Sands, and stands on a drift-gravel, consisting of pebbles and subangular fragments of flint embedded in a matrix of sand, of the same character as that which forms the mass of the outlier. I had a good opportunity during the summer of examining a section of this in a wide open trench across the yard of the house. The two feet of made earth at the top was well marked off from the gravelly sand below, which was seen resting at depths of from 4 to 6 feet upon an eroded surface of London Clay,[1] which could be identified with certainty, although it had lost its character as "blue-clay" by oxidation to a bright brown red. The large lake in Bearwood Park, about 50 feet lower than the house, lies in a hollow of the London Clay.

## THE PEBBLE-BED.

The best exposure of this *in situ* is in a "gravel-pit," about a quarter of a mile to the south-west of Barkham Lodge, just behind a small group of cottages, which stand in the angle of the roads. At the present time some hundreds of tons of flint pebbles, and nothing but flint pebbles, may be seen lying in heaps in this pit, the pebbles being of various sizes from that of a hazel-nut up to large pebbles measuring 6 × 4 × 2 inches. Nothing can exceed the smoothness and regularity of their contour. In the face of the quarry the pebble-bed is exposed in a horizontal band from 2 to 3 feet in thickness. The pebbles are closely huddled together, as closely as the Bunter pebbles are in the well-known quarries in Sutton Park, near Birmingham, which during the last meeting of the British Association I had the pleasure of examining in company with Mr. Harrison. They are enclosed in a greenish sandy matrix, precisely like that in which the pebbles are embedded at some points in the cutting north of Wellington College Station, about four miles distant from this section. The boundary-line between the pebble-bed and the bed of Bagshot Sand which comes immediately above it is as sharp and well defined as anything can possibly be. The latter bed is a strong loamy sand, very ferruginous and rather coarse in grain; so loamy that on weathering it flakes off on the face of the section, and its outline becomes somewhat rounded. The beds

[1] Proved depth 256 feet. See Mem. Geol. Survey, vol. iv. p. 423. Compare my paper in GEOL. MAG. for September, 1886.

exposed in the pit pass northward under the hill-slope, which is occupied by a ploughed field. On the southern side of the quarry a bed *beneath* the pebble-bed is exposed; and the lithological resemblance between this and the bed exposed beneath the pebble-bed[1] in the railway-cutting at Wellington College Station is very striking. I subjoin a diagram of the section as it is exposed in the gravel-pit, of which a description has just been given. The full thickness of the pebble-bed and the nature of the subjacent bed on the north side were proved by an excavation which Mr. Walter was good enough to have made for me.

I am aware that several very competent geologists, whose opportunities for detailed observation of the stratigraphy of the Bagshot Series have been but limited, are very sceptical as to the existence of veritable Bagshot pebble-beds, since in many instances, these beds have been examined at the present surface, where, in arresting further denudation, they have often got somewhat reconstructed and mixed up with a few discoloured subangular fragments of flint (which belong to the later Quaternary Drift, and are easily recognizable); but I am quite sure that such scepticism would be removed by an inspection of this Barkham pit. The pit was re-opened only last winter, after having been disused for years, and getting quite overgrown with weeds and brambles. The pebble-bed crops out in great force in the gardens of the adjoining cottages, and in the lane which runs along the south side of them.

The bed of pebbles exposed in the gravel-pit just described runs through beneath the road which leads up the west side of the field in which it is situated towards the southern boundary of Bearwood Park, and is seen again in the wood which covers the slope of Coomb Hill behind Barkham Vicarage, where it forms a rude terrace, numerous flint pebbles appearing in the sides of the ditch, and even here and there among the forest-litter. In this direction it has been proved recently by a trial shaft sunk in the nose of the hill at a spot about 260 feet above O.D. In this hole some 6 feet of buff-yellow loamy sand is at present exposed in a fresh section, which no unprejudiced observer who knows the stratigraphy of the Bagshots of this district could, I think, hesitate to refer to the Upper Bagshot. On following the 250 foot contour-line through the wood, the frequency of the occurrence of pebbles shows the extension of the deposit in that direction. There is no exposure that I have been able to find in Bearwood Park, as the same contour-line is followed towards Bearwood Lake; and as the line is followed towards the house, everything is covered up with ornamental shrubberies and gardens. The model gravel-walks through these are, however, little else than artificially reconstructed "pebble-beds."

At rather less than half a mile to the south-east of the house, an excavation for a reservoir was made a few years ago. I saw it when just dug, in company with my former pupil, Mr. Norman Walter, and was fairly puzzled at the time, from the extraordinary resemblance of the sands exposed to those in our railway-cutting at

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[1] Bed No. 4 of my section, Q.J.G.S. April, 1885.

Wellington College Station. The depth of the pit is 9 feet, and all round the sloping sides the pebble-bed comes out in a most unmistakable manner below a surface capping of Drift about 2 feet thick. The pebble-bed itself is from 1 to 2 feet in thickness; its altitude is, within a few feet, that of the bed in Barkham Pit; the pebbles are embedded in sand, and not so compactly aggregated as they are in the Barkham gravel-pit; but there is no mistaking the character of the bed.

If we return to the Barkham Pit, and follow the 250 feet contour-line eastwards and northwards, we can trace the outcrop by the exposure of the pebbles at the surface. Where the hill-slope is rather steep, they have been carried down the slope a few feet by the wash of heavy rains and the action of melting winter-snows. I traced a broad band of them across a turnip-field in the spring of 1886, on a rather steep slope near Sandy Bottom. Many of the pebbles were of large size (3 and 4 inches in length), and so thickly strewn were they across the field that it was impossible to step between them. As the contour-line is followed northwards (on the east side of the Bagshot Outlier), we come across the pebbles again in ditches and in the spinny to the north-west of the Scotch Farm; and they appear to crop out again at the northern extremity of the outlier, outside the churchyard, which is just on the 250 feet contour-line.

There are not many sections of the sands above the pebble-bed, but a small one occurs in the wood on the northern side of Birtle Heath, where I made a clearance of the steep slope in several places with a spade, and satisfied myself as to the Upper Bagshot character of the sands. A more extensive section is exposed in the sand-pit, to the east of Sandy Bottom, some 20 feet or so above the pebble-bed. On one side of this pit there is a very fresh exposure of sands evenly stratified; but as these are followed round the pit, the stratification disappears suddenly, as if it terminated against an ancient sand-dune. The character of the higher bed in this pit bears a striking resemblance to one on the Wellington College Estate, in the Upper Bagshot, not many feet below the 300 feet contour-line.[1] Crossing over to the west side of Sandy Bottom (in reality a small valley of erosion with much sand-wash from the adjoining hills at the bottom), the Upper Sands are again seen in the road-cutting, above the level of the pebble-bed, and they can be seen along the same road as it skirts the south side of Bearwood Park. On descending the hill into the valley of the Loddon, we come again rather suddenly upon the London Clay of the usual dull bluish-grey colour, as I saw it last summer exposed in a fresh road-side excavation, with pebbles of flint dispersed through it. Lithologically, I am unable to recognize in the loamy bed which occurs in this outlier above the pebble-bed anything but the equivalent of the loamy (sometimes even clayey) bed with which I am very familiar, as it occurs at about the same altitude and above the pebble-bed, in the country about Wellington College, and in other parts of the interior of the main mass of the

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[1] I am not sure that they are not in reality, in both cases, parts of a later drift.

Bagshot Sands, where the strongest possible evidence (that of proved superposition) leaves no room for doubt as to its occupying a low horizon in the Upper Bagshot.

The longest of the three spurs mentioned above as projecting to the south of the mass of the outlier terminates in a hill about 240 feet above O.D., just to the east of Manor Farm, and rather more than a quarter of a mile to the north of Barkham Church. This hill is of London Clay uncovered by drift on its slopes, and capped by a mass of pebbles and sand of the same nature as that in the Barkham pit. The pebbles were dug here in quantity for some time for road material. The pit is now ploughed over, but the enormous number of well-rounded pebbles seen in the ploughed surface at the top of the hill bears testimony to the nature of this hill-cap, though, not having seen the pit open, I am unable to say whether the cap contained the pebble-bed *in situ*, or consisted of a mass of re-constructed materials.

There are some very ancient gravel-pits about half a mile nearly south-west of the Scotch Farm, where the nature of the drift which caps the outlier can be studied; and in the open field close by there is an open gravel-pit on the crest of the hill, remarkable for the number of Sarsen-stones which occur in the sandy gravel, and for the huge size of some of them; but of the Sarsens I hope to have something to say in a future communication, in addition to what I have already written.[1]

One or two remarks are suggested by this Bagshot outlier at Bearwood.

1. The pebble-bed occurring here so remarkably well developed (as has been shown above) in such a way as to leave no possible room for doubt of its Bagshot age, *at the same altitude* as the pebble-bed at the base of the Upper Bagshot in the more central parts of the Bagshot area, we can hardly avoid assigning it to the same horizon. Though there is no fossil-evidence to bring forward in support of this view, it must be borne in mind that it is only from a few sections in the Upper Bagshot that fossils have been recorded, and such as have been found are nothing more than mere ferruginous casts. There is no dip to the south or east in this pebble-bed.

2. If, on the strength of the pretty strong physical evidence cited above, we are led to assign the outlier at Bearwood to the horizon to which it is assigned in this paper (and I see no valid argument against so doing), then we have here a clear case of Upper Bagshot Sands resting directly upon the London Clay; a phenomenon which can only be explained by the former overlap of the Upper members of the series.[2]

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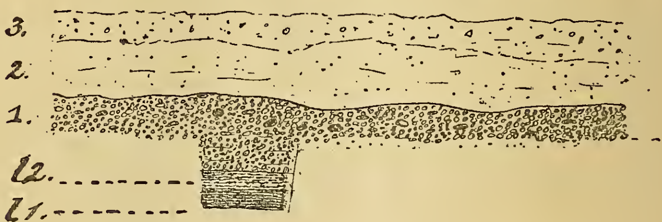
[1] See Proc. Geol. Assoc. vol. viii. pp. 153–160.

[2] A very similar case of a massive pebble-bed *at the base of the Bracklesham Series*, and resting upon London Clay, has been recently mentioned in a letter to the author by Mr Whitaker, as occurring in the Hampshire Basin. No authenticated instance of a bed of pebbles in undoubted Lower Bagshot Sands has yet been recorded in this western part of the London Basin. while those in Essex may for very good reasons be assigned to a higher horizon. (See Whitaker, Geol. of London, p. 52.)

3. There is a remarkable coincidence in the altitudes of the Bagshot Pebble-bed at Bearwood and of the Pebble-bed at Easthampstead Church and at Bracknell with a similar relation of the pebbles to the sands;[1] and I regard the beds of all these three localities as occupying the same horizon and consisting of detritus from older strata accumulated along the northern London Clay shore of the tidal estuary, which covered over the earlier delta-deposits of the Middle and Lower Bagshot, in which the old sand-dunes were for the most part levelled down, while the Upper Bagshot Sands accumulated as we now find them.

SECTION (EAST AND WEST) IN BARKHAM GRAVEL-PIT, BEARWOOD, BERKS.
[Massive bed of flint pebbles underlying Bagshot Sands.]



| | feet. |
|---|---|
| 3. Reconstructed material of bed 2 with a few pebbles and flints as in the ordinary angular Drift ... ... ... ... ... ... ... ... ... ... | 1 |
| 2. Strong ferruginous loamy sand without very pronounced bedding (Bagshot Sand) ... ... ... ... ... ... ... ... ... ... ... ... | 2 |
| 1. Bed of well-rolled flints, completely rounded, densely packed in a grey-green sand in the upper portion, in a brown loamy sand below. Thickness proved in the excavation ... ... ... ... ... ... ... | 5 |
| *l* 2. Light-grey clay, slightly laminated ... ... ... ... ... ... ... ... | 1 |
| *l* 1. Puce-coloured clay extremely tenacious and plastic ... ... ... ... ... | 1 |
| | —10 |

The clay *l* 2 appears to be a decolorized portion of *l* 1, somewhat reconstructed. It is difficult to say if this is original London clay. Both these clays can be matched exactly by well-defined clay-beds in the Wick Hill Section (Finchampstead), only three miles distant, which are high up in the Middle Bagshot; also by a clay (at Woodhay) of the Middle Division (Bristow, Mem. Geol. Survey, vol. iv. p. 330), for specimens of which I am indebted to F. J. Bennett, Esq., F.G.S.

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## VII.—SUPPLEMENTARY NOTE ON *EUPHOBERIA FEROX*, SALTER.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.
British Museum (Natural History).

WHEN I noticed this species in the January Number of the GEOLOGICAL MAGAZINE (pp. 1–10, Plate I.), I had not prepared a figure of the original specimen from the Hope Collection at Oxford, which had been kindly lent me by Prof. J. O. Westwood for that purpose.

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[1] See Q. J. G. S. August, 1885, and Proc. Geol. Assoc. vol. ix. p. 223. Since the statements here referred to have been published, they have been called in question by the authors of a paper in the Quarterly Journal. The authors of that paper, from insufficiency of observation, have misunderstood the Easthampstead section, and have mistaken a mass of Quaternary drift at the surface for the pebble-bed which I described as occurring at a horizon some 20 feet lower!

Having since obtained a careful drawing, I think it may be desirable to place the earlier figure of this specimen beside the later figure, in order to show how Mr. Scudder was misled by the former, and that in fact (as may be seen by comparing the woodcut Fig. 2 below, with the drawings of other examples given on Plate I.) there can be no reason for separating this specimen from its congeners, with which it agrees in every particular.

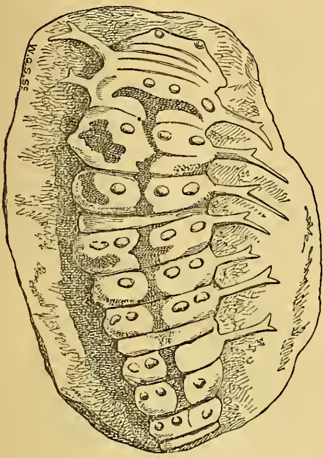

Fig. 1.

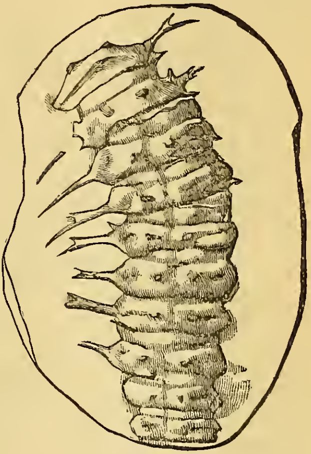

Fig. 2.

*Euphoberia ferox*, Salter, Coal-measures, Coalbrook-dale ("Hope Collection").

Fig. 1.—Rough copy of original figure in "Brodie's Fossil Insects" (1845, pl. i. fig. 11).

Fig. 2.—The same specimen re-drawn to show that there are only two pairs of spines to each segment.

The lateral spines are bifid, there are two submedian spines, broken off as usual; the supposed third pair of spines on each somite, one on either side above the pair of lateral branched spines, are (as already pointed out on p. 2 *op. cit.*) only *depressions* in the tergum near the base of these lateral spines. This led to the error of attributing the Oxford specimen to the genus *Acantherpestes*, to which it certainly does not belong.

## NOTICES OF MEMOIRS.

### I.—On the Classification of the Caroniferous Limestone Series; Northumbrian Type. By Hugh Miller, F.R.S.E., F.G.S.[1]

It is now twenty years since the late George Tate, of Alnwick, published a completed classification for the Carboniferous Limestone Series of North Northumberland. For more than half that period it has been set aside as of merely local value. It will be the endeavour of this paper to restore it to its true place.

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[1] Read before British Association, Birmingham, in Section C (Geology).

Tate's classification may be summarized as in the following table:—

### Carboniferous Limestone Series of North Northumberland: Tate's Classification, 1856-1868.

[References:—G. Tate, History of Berwickshire, Naturalists' Club, 1856, p. 219; *Ibid.* vol. v. 1866-7, pp. 283, 357; Hist. of Alnwick, 1866, p. 444; Tyneside Transactions, vol. ii. 1868, p. 6.]

*Upper or Calcareous group:—From the base of the Millstone Grit to the Dun Limestone—"the lowest limestone of any value."* Good workable limestones, interstratified among alternations of sandstone, shale, and coal; large numbers of marine organisms connected with the calcareous strata. Thickness, about 1700 feet.

*Lower or Carbonaceous group:—From the base of the Dun Limestone to the top of the Tuedian group.* Marked by the number, thickness, and quality of its coal-seams; limestones thin and generally impure; marine organisms in fewer numbers. Thickness, 900 feet.

*Tuedian Groups:—Beds intermediate between the Productal and Encrinital limestones and the Upper Old Red Sandstone.* Distinguished by coloured shales, by thin, argillaceous and cherty or magnesian limestone, and by the rarity of of Encrinites and Brachiopoda; some Stigmarian layers, but no beds of coal. Thickness, about 1000 feet. In one of his papers Tate distinguishes an upper group of "Tuedian grits."

[*Upper Old Red Sandstone.* Local conglomerates, "more connected with the Carboniferous than with the Devonian." No *Stigmaria.*]

The southern part of Northumberland Tate seems to have visited only very occasionally; but from his small map of the county, in which he uses three colours for his three divisions throughout (Tyneside Transactions, vol. ii.), and from his treatise upon the geology of the Roman Wall (Bruce's Roman Wall, 4th edition), it is evident that his careful eye detected nothing to conflict with his classification. Mr. Tate died in 1873.

In 1875, Tate's classification of the upper divisions of the series was set aside by Professor Lebour in favour of an arrangement more "natural and convenient." Professor Lebour abolished the distinction between the *Calcareous* and *Carbonaceous* groups, and threw them together—along with some of the Tuedian grits—into a single large series, to which he applied the term *Bernician.* It is based on the assumption that Tate's two divisions either do not exist in nature or do not persist throughout the county.

### Carboniferous Limestone Series in Northumberland: Lebour's Classification, 1875-1886.

[References:—G. A. Lebour, "On the Larger Divisions of the Carboniferous Rocks in Northumberland," Trans. N. of England Min. Inst. 1876; "On the terms Bernician and Tuedian," Geol. Mag. 1877, p. 19; "Outlines of the Geology of Northumberland," Newcastle, 1878; "Sketch of the Geology of Northumberland," Geologists' Association, 1886.]

| | |
|---|---|
| *Bernician* . . . . . | A large group—which "cannot be divided in any natural manner"—of limestones, grits and sandstones, shales, and coals; lower limit, "a variable one," not keeping to any one horizon; thickness, in North Northumberland, 2600 feet (after Tate); in Mid Northumberland, a maximum of "at least 8000 feet"; in South Northumberland, 2500 feet (after Westgarth Foster). |
| *Tuedian* . . . . . | As in Tate's classification, but without definition at its upper limit. |
| *Basement Conglomerates* | Local. |

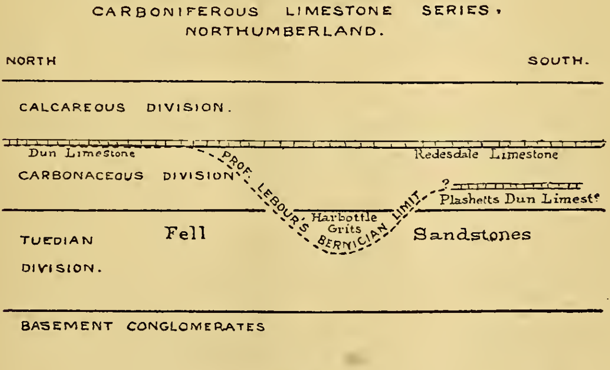
It has never been contended, the author believes, that Tate's prior classification is not applicable to North Northumberland. It is now, as the result of the labours of the Geological Survey shows, found to be equally applicable to South Northumberland, and to the whole of what deserves to be distinguished as the *Northumbrian Type* of the Carboniferous Limestone series, in contrast with the Yorkshire type and Scottish type. It is amplified in some not very important details, as set forth in the following table :—

CARBONIFEROUS LIMESTONE SERIES—NORTHUMBRIAN TYPE (Northumberland, East Cumberland, and Liddisdale).

[Reference :—H. Miller, Article "Northumberland," Encyclopædia Britannica, 9th edition.]

| | | Feet |
|---|---|---|
| Upper Limestone Series. | *Felltop or Upper Calcareous Division :—From the Millstone Grit to the zone of the Great Limestone.* Sandstones and shales; one or more beds of marine limestone, including the Felltop Limestone ; some coals . . . . | 350—1200 |
| | *Calcareous Division :—From the Great Limestone to the bottom of the Dun or Redesdale Limestone.* Many beds of good marine limestone ; sandstones and shales ; coals | 1300—2500 |
| Lower Limestone Series. | *Carbonaceous Division (Scremerston Beds of North Northumberland) :—From the Dun or Redesdale Limestone to Tate's "Tuedian Grits."* Strata prevalently carbonaceous ; limestones chiefly thin, many of them containing vegetable matter ; coals . . . . . . . . | 800—2500 |
| | *Tuedian Division or Tweed Beds :—Upper Tuedian or Fell Sandstone Group, the "Tuedian Grits" of Tate :—From the Carbonaceous Group to the Cement-Limestones.* Great belt of massive grits (Tweedmouth, Chillingham, the Simonside and Harbottle Hills, the Peel and Bewcastle Fells). Shales greenish and reddish as well as carbonaceous-grey ; coals rare, thin, or absent . . | 500—1600 |
| | *Lower Tuedian or Cement-Limestone Group :—From the base of the Grits downwards.* Cement-stone bands passing (Rothbury, Bewcastle) into limestones; coals very rare; generally some coloration of the shales and sandstones . . . . . . . . . . . . . . . . . . | 530—1500 |
| | *Basement Conglomerates (Upper Old Red Sandstone)*; local . | 0— 500 |

The relation borne to the lines of this extended classification by Prof. Lebour's Bernician limit, so far as he has hesitatingly defined it by horizons,[1] is shown in the following diagram :—



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[1] "To the north of Berwick, the lowest accepted Bernician limestone is the Dun limestone, well known throughout the northern part of Northumberland, but only with great reserve to be correlated with a bed of the same name in the Upper North Tyne district (the Plashetts Dun Limestone of the diagram). This is the limestone

Tate's admirable classification presents us with well-defined types, generally recognizable almost at a glance by the practised eye, and bounded by lines as good probably as from the complications of the structure (faults, obscurities, etc.) could be expected. His names, if not high-sounding, are at least sufficiently expressive.

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## II.—THE CARBONIFEROUS LIMESTONE OF NORTH FLINTSHIRE. By G. H. MORTON, F.G.S.

(Abstract of Paper read before the British Association, Birmingham, September, 1886.)

IN the year 1870 I described before the Association the subdivisions into which the Carboniferous Limestone of North Wales is naturally divided by clear lithological characters, and in 1877 more fully described the subdivisions of the formation as they occur in the Eglwyseg ridge, near Llangollen. Since then the whole of Flintshire has been examined, and the original classification found to extend to the sea-coast at the north of the county. Although the subdivisions are not piled up, one over the other, in a precipitous outcrop, the succession is as clearly shown between Prestatyn and Meliden as at Llanymynech and Llangollen, and the uniform character of each subdivision along the intervening 44 miles of country is remarkable.

The following four subdivisions of the Carboniferous Limestone are all well exposed in a fine mural section 3¼ miles in length, from Castell Prestatyn on the north to the end of Moel Hiraddug on the south, and occur in the following descending order:—

Upper Black Limestone—a black, fine-grained, thin-bedded limestone, containing very few fossils, but including *Posidonomya Becheri* and the remains of many plants. Thickness, 200 feet.

Upper Grey Limestone—a dark grey, thin-bedded limestone, with thin seams of interstratified shale, containing numerous fossils, including *Productus giganteus* and Corals. Thickness, 500 feet.

Middle White Limestone—a white or light grey, thick-bedded limestone, containing very few fossils. Thickness, 600 feet.

Lower Brown Limestone—a brown or dark grey, irregularly-bedded limestone, containing few fossils, but with interstratified shales at the base of the subdivision, which contain the remains of Plants. Thickness, 400 feet.

The total thickness of these four subdivisions, forming the Carboniferous Limestone of the North of Flintshire, is 1700 feet, which is much greater than anywhere else in North Wales.

Although the line of the section is nearly N. and S., the average dip of the strata is about 14° to the E.N.E. at Coed-yr-Esgob, N.W. at

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which crops out for some miles along the coast at Lamberton . . . But in the Upper Coquet district (Mid-Northumberland), where the Tuedians are extremely well developed, no such limestone can (could) be traced, and the Harbottle Grits are so thoroughly Bernician in facies, and so well divided stratigraphically from the Tuedians, that *there* the base of this great sandstone series forms quite the most convenient boundary-line. Now there is little doubt that the horizon of the Lamberton or Dun Limestone is *above* the Harbottle Grits, so that the merely expedient and artificial character of the boundaries thus arrived at is shown at once. The truth is that no line should be drawn at all except as the merest matter of convenience."—Lebour, Outlines of the Geology of Northumberland, p. 44. In the diagram it is of course a matter of convenience that this confessedly artificial limit should be represented by a dotted line.

Bryniau, and N.E.N. at Moel Hiraddug, so that it is greater than it appears to be in the section. The highest subdivision, the Upper Black Limestone, occurs at the north end, and the Upper Grey Limestone crops out from under it, and extends to Nant-yr-ogof, where there is a considerable fault, which brings up the top of the Lower Brown and the base of the Middle White Limestone. From the fault the Middle White extends three-quarters of a mile, when the Lower Brown Limestone crops out, continues some distance, and forms the conspicuous hill, Moel Hiraddug, on the top of which the lower beds of the Middle White Limestone are again exposed.

Along the west and parallel with the section there are two great faults, known as the Prestatyn fault and the Vale of Clwyd fault, and on the western side of the former a bare limestone hill, Graig-fawr, rises to an elevation of 500 feet, and presents a grand exposure of the Middle White Limestone, which is 600 feet in thickness. Numerous fossils occur at the north end of Graig-fawr, and a greater number has been obtained there than from the Middle White Limestone anywhere else.

On the west of the Carboniferous Limestone shown along the line of section several faults, including the two already referred to, have thrown down the limestone beneath the level of the sea, and the Lower Coal-measures have been proved to occur at Meliden and Dyserth, beneath a deep covering of drift. In one of the recent "Memoirs of the Geological Survey," by Mr. A. Strahan, M.A., F.G.S., a full description of the Geology—*Explanation of Quarter-sheet* 79 *N. W.*—will be found, with all the details of the drift and underlying strata.

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### III.—A Sketch of the History of the Rivers and Denudation of West Kent, etc. By F. C. J. Spurrell, F.G.S. 8vo. Greenwich, 1886. [Reprinted from the Report of the West Kent Natural History Society, 1886.]

THE author commences with some remarks on the "plane of marine denudation" which was produced over the Wealden area before the present features were carved out by subaërial forces. He observes that nowhere over the Wealden rocks is there to be found any deposit belonging to that old marine age; but it is quite possible that the Pliocene deposits of Lenham, etc., may be relics of the period. He then refers to the denudation by rain and rivers, and the breaching of the Chalk Downs, and states that "On the crest of the Downs there may be found in some places relics of the rocks from the Weald, Gault Clay, Chert, Greensand, Sand and Limestone, etc., lying on the Chalk, not in the condition of river gravel, but of patches of the old beach." The gravel of Shooter's Hill is, in his opinion, largely composed of the wreck of Bagshot Beds, and there are many similar outliers of pebbly gravel. These beds occur, as a rule, at a higher level than the Thames Valley gravels, and they may be distinguished from them by the absence of the erratic pebbles and fossils of northern origin (derived from Glacial Drifts), that occur in the newer deposits. These Thames Valley gravels, in Mr. Spurrell's opinion, lie below the 200 feet contour-line, the highest elevation being at Wimbledon, 190 feet.

Referring to the Flint Implements found at different levels over the whole district, he observes that he is unable to draw a sharp line of demarcation between Palæolithic and Neolithic forms.

Turning his attention to the subject of superficial deposits, he devotes the second part of his paper to the Warp and Trail, described by Joshua Trimmer, and the Rev. O. Fisher (see GEOL. MAG. 1867, p. 193); and this subject is illustrated with a number of sections showing the superficial disturbances affecting the Trail. To the folds he applies the name "Underplight," reserving the name Trail for the material filling the troughs and hollows. He believes that the folds or Underplight "may have resulted from the heavy pressure of a superincumbent mass of snow on a soil in a condition capable of yielding, and frequently repeated." No doubt many instances of Trail may in this way have been disturbed, for the Trail after all is generally but the relic of a more extensive gravelly accumulation which has been for the most part denuded. Surface disturbances of similar character are produced in strata over which the Chalky Boulder Clay has been accumulated, and are referable to the agent (probably land-ice) which formed it. Mr. J. G. Goodchild also has drawn attention to many instances of surface disturbance in Kent (to whose paper, by-the-bye, no allusion is made by Mr. Spurrell), and he has suggested that they were probably produced in Glacial times (Proc. Geol. Assoc. vol. ix. p. 151).

## REVIEWS.

### I.—MIKROSKOPISCHE PHYSIOGRAPHIE DER MASSIGEN GESTEINE. Von H. ROSENBUSCH. 1 Abtheilung. Zweite gänzlich umgearbeitete Auflage. (Stuttgart, 1886.) [Pp. 416.]

MICROSCOPIC PHYSIOGRAPHY OF THE MASSIVE ROCKS. By H. ROSENBUSCH. Part I. Second edition, completely revised.

THE appearance of a second edition of Professor Rosenbusch's well-known treatise on the microscopical study of the igneous rocks will be hailed with satisfaction by all workers in petrology. The present instalment is the first part only: the remaining portion, with the plates for the whole work, is to be expected next Easter.

On the publication of a new edition of a standard work, the reader naturally wishes to note what alterations and additions have been made to the former text; but the present edition is so completely re-written as to be practically a new work, and important differences of principle, as well as method, render futile any detailed comparison with the original. The chief features of the author's new treatment of the subject are the prominence given to structure and geological mode of occurrence, the subordination to them of purely mineralogical characters as a criterion of classification, and the abandonment, to a great extent, of geological age, or assumed age, as an essential character of igneous rocks. It is true that the division into older (Pre-Tertiary) and newer (Post-Cretaceous) groups is retained among the volcanic rocks: but the only reasons assigned for this artificial classification are those depending on the history of the science, and the practical difficulty of referring the older rocks definitely to a volcanic origin, owing to the "ephemeral" nature of volcanic formations and the easy removal of the tuffs by denuding agencies (pp. 6 and 346). These reasons will perhaps not appear conclusive to most English geologists.

At the outset the author divides igneous rocks, according to their mode of occurrence, into plutonic (*Tiefengesteine*), volcanic (*Ergussgesteine*), and a group of intermediate nature occurring characteristically in the form of dykes (*Ganggesteine*). The volcanic class includes the tuffs as well as the lavas.

The structure of igneous rocks is dealt with on the lines indicated in the author's valuable paper in the *Neues Jahrbuch* (1882, vol. ii. p. 1), in which he divides the rock-forming minerals into four groups, and lays down the important law that in granular igneous rocks of the normal type the minerals have consolidated in a definite order, that of "decreasing basicity." The term *granular* is restricted to those holocrystalline rocks in which each constituent mineral is entirely of one generation, thus indicating a steady change of chemical and physical conditions throughout the process of consolidation. This is opposed to the *porphyritic* structure, where some of the minerals recur in a second generation, giving evidence of two distinct periods in the formation of the rock. The form of an individual mineral in a rock may either be due to its own mode of crystallization (*idiomorphic*), or dependent on causes other than the molecular forces proper to the mineral (*allotriomorphic*). The normal plutonic rocks are characterized by a structure in which idiomorphic constituents occur only in small proportion (*hypidiomorphic*): this is contrasted with the *panidiomorphic* structure of a certain type of dyke-rocks, in which nearly all the component minerals exhibit more or less crystalline forms.

The plutonic rocks are divided by the author, according to their mineralogical constitution, into eight families. Here the chief new features noticeable are the division of the felspars into alkali-felspars, and lime-soda-felspars, superseding to some extent the old distinction of orthoclase and plagioclase, and the introduction of a family of plagioclase-nepheline-rocks (styled *Theralites*) to balance the elæolite-syenites. The diabases are placed in the plutonic class, though with an admission of their intermediate nature (p. 173). The headline "The Tuffs of the Diabase-rocks" under the class "*Tiefengesteine*" certainly has an anomalous appearance.

As in the old edition, each family is fully treated under several heads—mineralogical composition, classification, structure, and the phenomena of metamorphism produced or suffered by the rocks. There is much new matter, especially with reference to the local variations (*Faciesbildungen*) of rock-masses, the effects of contact and mechanical metamorphism, and the secondary alterations of rock-forming minerals. The bibliographical lists are much enlarged, and the matter throughout is brought well up to date.

The author next treats of the dyke-rocks, among which are found mineralogical representatives of four of the above eight families—the granites, syenites, elæolite-syenites, and diorites. They exhibit three types of structure: the *granitic*, met with only in the most acidic rocks (Aplite, which is thus removed from the granites); the *granite-porphyritic*, divided mineralogically into granite-porphyry, syenite-porphyry, elæolite-syenite-porphyry, and diorite-porphyrite; and the *lamprophyric*, including syenitic and dioritic families only. The lamprophyres, as that name is used by the author, are either panidiomorphic-granular or holocrystalline-porphyritic in structure. The syenitic lamprophyres comprise Minette and Vosgesite, the latter name being given to those members which contain hornblende or augite in place of biotite; similarly the dioritic family divides into Kersantite and Camptonite.

The characteristic structure of the volcanic rocks is the *porphyritic*, which is classified under various types according to the nature of the ground-mass. The palæo-volcanic rocks are ranged under five families: quartz-porphyries, quartzless-porphyries, porphyrites, augite-porphyrites and melaphyres, and picrite-porphyrites; of which only the first is treated in the part of the work already issued. The discussion of the essential nature of the ground-mass in the quartz-porphyries and the section devoted to the classification and structure of these rocks have been rendered fuller, but little is said on the subject of secondary devitrification. The artificiality of the separation of palæo- and neo-volcanic rocks is sometimes apparent, as for instance in the description of the Arran pitchstones on p. 407.

Professor Rosenbusch's treatise seems to be a real step towards a true natural classification of rocks, and perhaps we may even be sanguine enough to hope that it will afford a basis for a uniform system of nomenclature in petrological writings. A. H.

## II.—M. Dollo's Notes on the Dinosaurian Fauna of Bernissart.

(*Continued from p.* 87.)

The hind limbs next claim attention. Having insisted on the avian form of the femur, and its divergence from birds in being relatively longer as compared with the tibia, M. Dollo goes on to argue that, whereas the femur is horizontal in birds, its length implies a more inclined or mammalian position in these Dinosaurs. We are unable to appreciate the force of the argument, which might have some weight if the animal were an ordinary quadruped. But, in the first place, the Kangaroo, an animal not entirely beyond comparison in its proportions, carries the femur at rest in a nearly horizontal position; and, secondly, by giving the femur this highly inclined position, M. Dollo raises the extremity of the ischium and the chevron bones of the caudal vertebræ off the ground to a level with the distal extremity of the tibia. Now, when the skeleton of such an animal as *Iguanodon Bernissartensis* is examined, the tail, unlike the tail of a Kangaroo, is seen to have consisted of dense muscular substance like the tail of a Crocodile, of enormous weight, extending from the extremities of the chevron bones to the extremities of the neural spines. Just as the lifting of this weight from the ground would be a purposeless expenditure of strength when the animal was at rest, so I think the analogy of the Crocodile, which is not quite incomparable in caudal structure, may be appealed to in evidence that the tail was carried in a lower position than M. Dollo gives it. To bring this result about we must flex the limb more at the knee, so as to make the femur more nearly horizontal, and incline the tibia further forward, which would give a more easy, and I think more natural position, than the expectant attitude into which the animals are at present hoisted. The bones of the posterior extremity are well described. Evidence is given that the outer distal condyle of the femur articulates with the cnemial crest of the tibia, and that the fibula, which is shorter than the tibia, has its distal extremity brought in front of the tibia, in the way indicated by Marsh in the *Archæopteryx,* so as to articulate with a proximal facet of the calcaneum, a portion of which is applied to the tibia. The author does not clearly distinguish in his description between the two types referred to *Iguanodon*; but since he states that the two bones of the proximal series of the tarsus articulate with each other, the description may well refer to *I. Bernissartensis,* in which we know, from other evidence, that this condition obtains. The distal tarsal row, not hitherto described in *Iguanodon,* is said to consist of three bones. A thin bone articulates proximally with the astragalus, and distally with the first and second metatarsals; a second bone, rather stouter, lies between the astragalus and the third metatarsal; and the third, of intermediate size, rests on the fourth metatarsal, and articulates with the calcaneum. This distal row is noticed as being quite as avian in general character as the proximal row. The author describes the metatarsus, which has long been well known in *Iguanodon Mantelli.* He points out that the second to fourth metatarsals are the three usually developed in birds, and that the bones are placed with regard to each other as in birds, so that the middle metatarsal is slightly displaced forward distally, and backward proximally. The number of phalanges corresponds with the number in lacertilians and birds, being 3-4-5.

Finally, M. Dollo adopts the dictum of Huxley that if the structures between the ilium and the digits of a young fowl are supposed to augment to the bulk of a Dinosaur, and then to be ossified and fossilized, there would be no characters to separate the corresponding parts from those of these gigantic reptiles. There is no doubt much truth in this generalization, which we should be disposed to accept in principle so far as *Iguanodon* is concerned. If it were worth while for M. Dollo to pursue his line of argument concerning the avian characteristics of the Dinosaurian pelvis and hind limb, practically to the exclusion of all other resemblances, the comparisons must derive their importance from being steps in a chain of proof, either that Dinosaurs have acquired their avian characteristics in consequence of the muscular development and functions of the posterior extremities being avian, in types like *Iguanodon,* or else that these genera, in which avian characters culminate, are ancestors of birds. M. Dollo has already elected to dismiss for the present both of these questions, but the subject is one which must eventually be faced, and I venture to urge that the functional development of avian characters is the safest basis of interpretation; first, because functional conditions are the primary directing cause of structural variations; and, secondly, because the modifications of structure in any Dinosaur which would be necessary to convert it into a bird, are not less considerable than would be required to convert a Crocodile into a Dinosaur. If Dinosaurs and Birds are supposed to descend from an ancient common stock, then the functional evolution of some avian characters in certain families of Dinosaurs becomes more intelligible. M. Dollo's chief inference, however, from the avian resemblances is, that the *Iguanodon* also must consequently be inferred to have been a biped. He quotes Sir Richard Owen to show that the mere difference in size between the fore and hind limbs would not establish this conclusion, since the difference, as marked in the Crocodile and in *Iguana*, is relatively almost the same as in *Iguanodon Mantelli.* The proof of the biped condition is made to rest upon the greatly reduced size of the anterior extremities, the difference in number of digits on the anterior and posterior limbs (both of which characters are common to the Crocodile); and, thirdly, divergences of structure which show a different physiological use for these members. Here a good deal is assumed. The presence in *Iguanodon* of a powerful offensive spine on the inner anterior digit, which has no parallel in the hind limb, is surely a doubtful argument that the animal was a biped. The argument would have been much stronger if the author had been content to show that the weight of the tail would necessitate the trunk being thrown into a forward position, so that the body could only have been carried when balanced on the pelvic axis. The author goes on to contest Sir Richard Owen's arguments against the upright position, in the course of which he states that the neck is relatively long, containing ten or twelve vertebræ, while in the dorso-lumbar region there are sixteen or eighteen. The opisthocœlous articulation of the centrum, and the nature of the zygapophyses give great mobility to the neck; and, although the number of vertebræ in the sacrum is smaller than that in birds, yet this number may be apparently reduced, since the number of sacral vertebræ in *Archæopteryx* is probably fewer than in *Iguanodon Bernissartensis.* M. Dollo remarks that the position of the occipital condyle is interesting as having an intermediate position between the horizontal arrangement of quadruped reptiles and the condition in birds, in which the head is carried at right angles to the neck. The foot-prints which have been attributed to *Iguanodon Mantelli* are discussed, with the result that the author finds evidence of no other known Wealden Dinosaur which could have produced these tridactyle impressions, while the bones of the three digits are superimposed successfully on the natural cast; and hence it follows that the animal walked as a biped, without leaving any impression of its tail upon the shore. The author agrees with Sir Richard Owen that the resemblance of the tail to that of a Crocodile, and the development of the lateral trochanter to the femur, may be taken as evidence of aquatic habits for these Dinosaurs, which are supposed to have frequented marshes, and to have been, like Crocodiles, more frequently in water than on land. And on this view the bipedal position is regarded as a protective adaptive modification, by which the animal was enabled to discover carnivorous enemies and encounter them with advantage.

At this point M. Dollo diverges into an interesting note on the presence of the third trochanter in birds, and on its function. Describing the femur of the Crocodile and bird, it is stated that the femur of *Iguanodon* is constructed upon the avian plan, and this view is supported by a dissection of the Wild Duck, in which, as in the Bernicle Goose, and Swan, a faint indication of the lateral Dinosaurian trochanter is found. The author shows that the distal portion of this ridge in birds gives attachment to a small caudo-femoral muscle (which, however, was large in some Dinosaurs, such as *Orthomerus Dolloi*), and to a large proximal ischio-femoral muscle. Accordingly, the trochanter which occupies the middle of the inner side of the shaft in a Dinosaur is attributed to these muscles. It is probable that this explanation may be substantially correct; only the tail of a Dinosaur is so essentially the tail of a Crocodilian, that we must suppose its muscular structure to have resembled that of the Crocodile's tail, in which the transverse division of the caudal muscular masses is as well marked as in other cold-blooded Vertebrata. I would especially urge that, even if this homology of the lateral trochanter is beyond question, it does not in itself quite establish the view that the *Iguanodon* femur is built on the bird type, or used under conditions like those of a bird's femur.

In common with many other naturalists, M. Dollo prefers to name the lateral trochanter the fourth trochanter, reserving the name third trochanter for the process usually so named in mammals.

The fourth note is devoted to the skull and axial skeleton. Commencing with the mandible, it is shown that the coronoid process occupies an unusually backward position, and that the teeth extend behind it, as far as the middle of the temporal fosse. In addition to the dentary, coronoid, and articular bones, which are seen on both sides of the jaw, the angular, surangular, and splenial bones are visible only on the inner side. Anteriorly, in front of the dentary bone, forming a horse-shoe-shaped extremity to the jaw, is a bone which the author names pre-symphysial, and which Mr. Hulke has named pre-dentary. It is convex externally, concave internally, and its upper border, relatively thin, rises into bony processes like denticles. This ossification appears to characterize the group of Dinosaurs allied to *Iguanodon*, and probably gave a cutting surface to the front of the jaw, comparable to that seen in Chelonians. The author would compare it to a representative of the two pieces which unite the rami of the mandible of anourous Batrachians, which Professor Albrecht terms inferior intermaxillaries; and as these elements carry teeth in *Amphignathodon Guentheri*, the author believes that a like toothed condition is developed in *Hypsilophodon*. Detailed descriptions follow of the other elements of the jaw, from which it appears that the coronoid process is formed by the dentary, coronoid, and articular bones. As a whole, the lower jaw perhaps has most correspondence with *Hatteria.*

The skull in *Iguanodon Bernissartensis* is 65 centimetres long, 25 centimetres wide, and including the mandible, 35 centimetres high. The head is described as having a transversely compressed lacertilian aspect, with the external narines divided, sub-terminal and lateral; with the orbits lateral, of moderate size, without sclerotic ossifications; the temporal fossa are limited by superior and inferior arcades. The cerebral cavity is completely ossified. Teeth are limited to the maxillary bone. The description treats of the roof of the skull, and its cavities. I cannot give here all the details conveyed in the description and figures; but there are two pre-maxillaries, extending between the nares and forming their anterior and inferior borders. The alveolar margin is edentulous, and no doubt had a horny covering opposed to that of the predentary bone below. It closely resembles the premaxilliary of *Hypsilophodon*, except that the bones in *Hypsilophodon* carry teeth. The maxillary bone is large, uniting anteriorly with the premaxillary, superiorly with the nasal, with a bone termed supra-orbital, as well as with the lachrymal and prefrontal, while posteriorly it unites with the jugal. On the palate it connects with the external pterygoid, and apparently with the palatine. It carries 25 teeth in use. Its resemblances are with the maxillary of *Hatteria* and *Iguana.* It contains towards the lachrymal, a prelachrymal vacuity. The nasal bones are long and well developed, forming the roof of the skull between the orbits and nares. The frontal bones have a great transverse expansion, and are large and flat. They margin the orbit above, and on their lateral border are two bones termed supra-orbital. There is no trace of a median suture to the frontals such as characterizes *Iguanodon Prestwichi.* The prefrontals each carry a supra-orbital, so that they are hidden laterally. The lachrymal is connected with the prefrontal, maxillary, and jugal. The jugal is attached to a special process of the maxillary, which is given off some distance in advance of the termination of the alveolar border. This bone unites with the lachrymal, postfrontal, qudrato-jugal, and maxillary. It is stated that there .is a quadrato-jugal, which unites with the quadrate, but in the figure (plate ix. fig. 1) there is no suture to separate the parts of the bone which are lettered respectively jugal and quadrato-jugal. Up to the spring of 1879 I supposed that the quadrato-jugal had no separate existence in Dinosaurs, and so wrote of it; but I learned better in the autumn of 1879, when, by the courtesy of M. de Pauw, I was enabled to draw the details of the parts of the Bernissart skeletons which were then developed. The post-frontal bone has the usual connections with the parietal, frontal, squamosal, and jugal. It divides the orbit from the lateral temporal fosse, and borders the anterior margin of the supra-temporal fosse. The squamosal bone is connected with the post-frontal, the parietal, supra-occipital, parotic, and quadrate bone. These bones, like the parietals, find considerable resemblance in the living *Hatteria*. They are undivided, and have a somewhat prominent median crest. The form of the brain case appears to correspond with that already described by Mr. Hulke. The quadrate bone is remarkably long and strong, covered proximally by the squamosal bone, like a hat; it sends a process inward to articulate with the pterygoid. Many of the bones of the palate, notably the vomer and palatine, are extremely thin long bones. The pterygoids are thrown back towards the occiput. They are in contact with the ectopterygoids, below the temporal fossa, and closely resemble the pterygoids of *Hatteria*. Regarding the *Hatteria* as a Lizard, the author agrees with Huxley and Hulke that the palate was lacertilian rather than crocodilian. But *Hatteria* is I submit no more a Lizard than a Crocodile. The vertebral column in *Iguanodon Bernissartensis* comprises 85 vertebræ, of which 10 are cervical, 18 dorso-lumbar, 6 sacral, and 51 caudal. In the neck the vertebræ are opisthocœlous, in the back and loins flat at both ends, in the sacrum anchylosed, and in the tail slightly amphicœlous. In the neck all the vertebræ except the atlas carry ribs; one vertebra in succession to the dorsal series is counted as lumbar, having no ribs.

The fifth note states that in *Iguanodon Mantelli* 65 vertebræ are at present known. They comprise 10 cervical, 16 dorsal, 2 lumbar, 5 sacral, while in the tail only 32 vertebræ are preserved. All the cervical vertebræ except the atlas carry ribs. The atlas has the usual reptilian condition. The author then enters into a discussion of the bones named by Marsh post-occipital,[1] identifying them with the pro-atlas of Albrecht.

The author then goes on to show that the form of the skull depends upon the development of the muscles which work the lower jaw. And states that in *Sauropsida* the temporal and masseter muscles are often united. When the temporal is predominant, there is a strong sagittal crest, the coronoid process of the mandible is well developed, the supra-temporal fossæ are large openings; while the pterygoids are thin, parallel to the plane of the skull, and the quadrate process of the pterygoid is not ossified. When the internal pterygoid muscles have a predominant development, there is neither sagittal crest to the skull nor coronoid process to the mandible; the supra-temporal fossa are closed, the pterygoid bones are thick plates, perpendicular to the median plane of the skull; while there is a mandibular fontanelle. The former type is Lacertilian, the latter is Crocodilian. In *Iguanodon* the muscular arrangements were in the main Lacertilian, while in *Ceratosaurus* they were more Crocodilian. Many herbivorous Dinosaurs, however, used in mastication muscles, which are only developed among mammals in the Carnivora; and the *Teleosauria* show in the sagittal crest, large temporal fossa and narrow pterygoids, evidence that the temporal muscles were large and the pterygoid muscles small, or in other words the animals had the reverse development of these muscles to that seen in Crocodilia. In

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[1] These bones had long been known in fishes, and were described in the Carp by Mr. Robertson of the Oxford University Museum, and by many other writers.

this matter of the muscles *Iguanodon* and its allies are termed by M. Dollo slightly modified types, while *Ceratosaurus* and *Diplodocus* are more specialized; and just as Professor van Beneden has shown that since Miocene times the form of the skull in *Mystacocete* has undergone a specialization by shortening, so *Diplodocus* presents a similar specialization as compared with *Iguanodon.* Thus, by muscular modification, the primitive terminal narine comes to occupy a more backward position. It would take more space than is here available to discuss these interesting speculations.

On the prelachrymal vacuity M. Dollo observes that, it is small in Dinosaurs which have the pterygoid muscles feeble, and large when they are greatly developed. The pterygoid muscles are inserted in birds on the anterior border of the pre-lachrymal fossa, so that it seems possible that the size of the vacuity may depend upon the volume of the muscle which passes through it.

These papers are but a small fraction of the mass of valuable memoirs which the author has published. Any one who studies them carefully will be impressed by the originality and power of the writer. His method is his own. The memoirs that we have noticed are a landmark in the history of the group to which they relate, greatly adding to our knowledge, and applying the methods of comparative anatomy for the elucidation of Dinosaurian structures in new ways. We trust that the time is not distant when the author may be enabled to issue detailed monographs, like those in which Van Beneden has so well described the Mammalia of the Antwerp Crag; for the development of exact knowledge of all Dinosaurians cannot but be influenced by the data for comparison which such monographs would afford. When this work is done, we may anticipate that stringent comparisons of form and measurement of bones will be made, and that the same canons of determination will be extended to fossils as have already given to the comparative anatomy and zoology of living animals many of the attributes of an exact science.

H. G. SEELEY.

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III.—GÉOLOGIE DE JERSEY. PAR LE P. CH. NOURY, S.J. Pp. 173, with coloured map. Price 5*s.* (Paris, Librairie F. Savy; Jersey, Librairie Le Feuvre.)

THIS book is modestly described as intended principally for residents and visitors, but it contains matter that may be useful and interesting to any geologist.

After a notice of previous writers and some general remarks, the author commences with a "Brief Description of the Rocks." He describes the nature and distribution of the many varieties of eruptive rocks, classifying them as granitic, granitoid, porphyry, diabase dykes, mica-trap dykes, and diorite dykes. The granitic rocks are subdivided as granite proper, forming the N.W., S.W., and much of the S.E. corner of the island, and granulite such as that of the Mont-Mado quarries. "Granitoid" rocks include syenite and diorite, the latter occurring in considerable mass on the S.E. shore. Along with the porphyry are described the remarkable pyromerides (perlitic felstones?), which in one locality named present immense spherules attaining diameters of as much as a foot. "Spherolithes" nearly as large are mentioned as occurring in one of the diabase dykes, but the description points to these being spheroidal weathering. The localities of mica-trap dykes are carefully enumerated.

The sedimentary rocks are said to be chlorite-schist (the first notice of its occurrence in Jersey); felspathic schist or grit, including by far the largest part; metamorphic schist; and conglomerate. The metamorphic schist is divided into "spilites" and "porphyres argileux," the distinction made between these is not very clear. The author seems to regard both as altered forms of the felspathic schists, but alludes to the possibility of the "spilites" being eruptive. The metamorphism he thinks mainly due to the eruption of the porphyries; he does not seem to have considered the idea that they may be ashes belonging to those eruptions. The remarkable conglomerate of the N.E. corner is very fully described.

Next comes a chapter on "Contours and Relief of the Island," in which its physical geology is treated with admirable completeness. The caves and clefts, the giants-kettles, pits, and natural tunnels, are enumerated and explained almost individually: similarly with the inlets, cliffs, and bays. Specially interesting are his descriptions of the Pinacle and the Creux de Vis or Trou du diable. The origin of nearly every valley is discussed, and many valuable remarks are made on the causes which guided and shaped the channels.

In the chapter on the Past of Jersey the author assumes the hypothesis of an original granitic crust on which afterwards the gneisses were deposited in an intensely heated ocean. Sedimentation in a more normal sea laid down the Jersey rocks which he calls schists, and to which he assigns a Cambrian age. (The term schist is not very appropriate to these rocks.) Nothing shows, he says, whether the true granites are prior to them or not; the other eruptive rocks are certainly later, and range from Cambrian or Silurian to Triassic; evidence is to be found in other regions. No sedimentary rock exists between the Cambrians above named and the conglomerate; to this he attributes a Permian age, and he gives good reasons for regarding it as due to sea-wave, not torrent action. A section on Quaternary and modern geology contains a very able discussion of past oscillations of land and sea. After a careful sifting of the evidence, he concludes that since the Roman occupation only subsidence has happened: and that probably Jersey was still joined to Normandy as late as the sixth century. The discussion of this question contains many interesting remarks on dunes and their growth, submerged forests and their mode of origin and destruction, the formation of raised beaches, and other important points in littoral geology. He adduces reasons for thinking that some at least of the "raised beaches" of the Channel Islands are not due to changes of level.

A vein of humour appears here and there: as in the relation of a stonemason's belief that building-stones can be corroded by the moon's rays.

The book is a valuable monograph: the topographical indications are especially full and excellent. It is well printed and furnished with a good coloured map and some sketch-plans. Only a resident could have produced such a work. Jersey is to be congratulated on possessing one both able and willing. E. HILL.

## REPORTS AND PROCEEDINGS.

### I.—IMPERIAL GEOLOGICAL INSTITUTE, VIENNA.

September 30th, 1886.—On *Cretaceous Crustacea* of Mount Lebanon, by Herr Dames.

*Ranina cretacea*, sp. n., near the Eocene form *R. marestiana*; *Penæus septem-spinatus*, sp. n.; *Penæus Libanensis*, Brocchi; *Ibacus præcursor*, n. sp. (a post-abdomen); *Pseudastacus Hakelensis*, O. Fraas, very frequent, generic position not yet clearly ascertained, as also of *Pseudastacus minor*, O. Fraas. *Sculda Syriaca*, sp. n.; *Sculda* is the representative of a peculiar family, the oldest known type of *Stomatopoda*. *Sculda lævis*, Schloth. (=*Squilla Lewisi*, Woodw.), is the type of another family and genus—*Pseudosculda*, Dames. *Pseudosculdidæ* are known to exist in the Upper Cretaceous. *Sculdidæ* in the Upper Cretaceous and Upper Jurassic; and genuine *Squillidae* (*Squilla cretacea*, Schloth.) begin in the Upper Cretaceous, and continue upward to the present time.

*Larvæ of crustaceans*—*Pseuderichthus cretaceus* and *Protozoëa Hilgendorfi*, sp. n., are very frequent near Sahel Alma. *Limulus Syriacus*, Woodw., *Loriculina Noetlingi*, Dames, are found at Hakel. The beds of both localities, Sahel Alma and Hakel, although possessing a quite different Ichthyological and Crustacean fauna, appear to be coeval; and, considering the presence of Jurassic and early Tertiary forms, may possibly be of Upper Cretaceous age. The fauna of Hakel, notwithstanding the difference of age, offers striking comparisons with the fauna of the Bavarian Lithographic flagstones. It includes a few Post-Cretaceous types, such as *Ibacus præcursor* and *Ranina cretacea*.

### II.—GEOLOGICAL SOCIETY OF LONDON.

(1).—January 26, 1887.—Professor J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

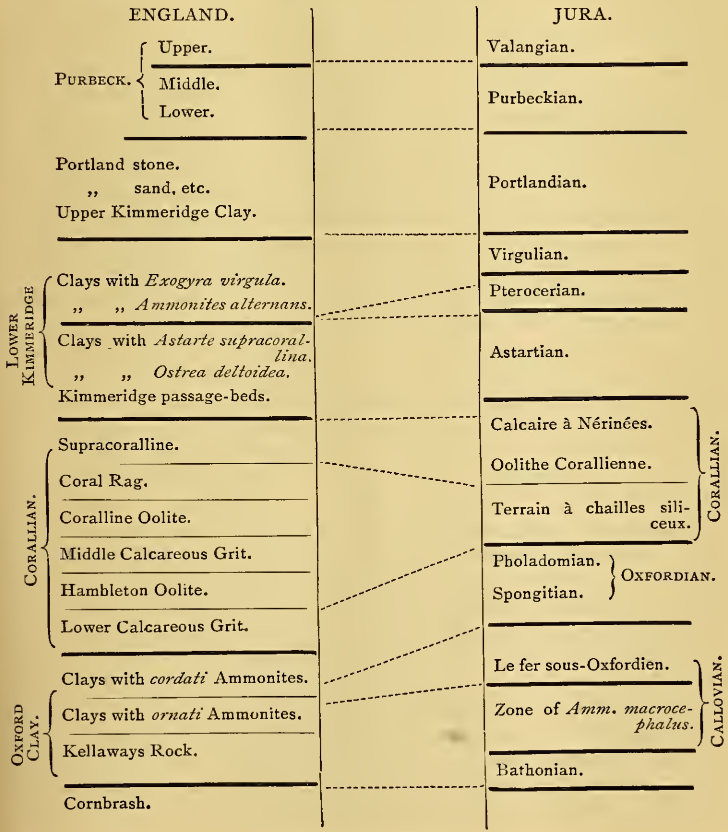
1. "On the Correlation of the Upper Jurassic Rocks of the Jura with those of England." By Thomas Roberts, Esq., M.A., F.G.S.

The author described at length his observations on the rocks of the Jurassic system, from the Callovian to the Purbeckian inclusive, first in the Canton of Berne, and then in the more southerly Cantons of Neuchâtel and Vaud. The sections in the former differed materially from those in the latter: the following stages were observed:—

| NORTH DISTRICT. | SOUTH DISTRICT. |
|---|---|
| Purbeckian. | Purbeckian. |
| Portlandian. | Portlandian. |
| Virgulian. | ? |

| | North District. | South District. | |
|---|---|---|---|
| | Pterocerian. | Pterocerian. | |
| | Astartian. | Astartian. | |
| Corallian. | Calcaire à Nérinéés. | ——— | |
| | Oolithe Corallienne. | ——— | |
| | Terrain à chailles siliceux. | Corallian. | |
| Oxfordian. | Terrain à chailles marno-calcaire. | Pholadomian. | Oxfordian. |
| | Calcaire à Scyphies inférieur. | Spongitian. | |
| Callovian. | Le fer sous-Oxfordien. | Supérieur. | Callovian. |
| | Zone of *Amm. macrocephalus*. | Inférieur. | |
| Bathonian. | Dalle nacrée, etc. | Dalle nacrée. | |

Some of the lithological and palæontological differences between these rocks and the English Oolites were noticed, and the views of Oppel, Marcou, Waagen, Blake, and Renevier, as to the relations of the beds in the two countries, were commented upon. The author then proceeded to compare the fossils of the Swiss Jurassic beds with those of their English representatives, stage by stage, and finally suggested the following correlation:—



2. "The Physical History of the Bagshot Beds of the London Basin." By the Rev. A. Irving, B.Sc., F.G.S.

The author, in reviewing the position taken up by him, attempted to estimate the value of such palæontological evidence as exists, and insists on the importance of the *physical* evidence in the first place. He gave reasons for considering the evidence of pebbles, pipe-clay, derived materials, ferruginous concretions, percentages of carbon (ranging in the more carboniferous strata up to nearly 2½°/₀) taken together with the evidence of carbon in combination, as adduced in former papers, *freshwater Diatoms* (now perhaps recorded for the first time in the Middle and Lower Bagshot), and the microscopic structure of the sands and clays, as furnishing such a cumulative proof of the fluviatile and delta origin of the majority of the Middle and Lower Bagshot Beds, as can hardly be gainsaid; while he regarded the wide distribution of the Sarsens, taken along with the absence of such evidence as is quoted above, as indicating, along with the fauna, a much greater former area for the Upper Bagshot than for the strata below them.

He referred to the evidence furnished by the Walton section (Q.J. G. S. May, 1886), the Brookwood deep well (Geol. Mag. August, 1886), the contemporaneous denudation of the London Clay (Geol. Mag. September, 1886) as affording further support to the view which he has advocated; gave six new sections on the northern side of the area, showing (1) the attenuation of the Lower Bagshots beneath the Middle Bagshot clays, (2) the greater development of clays towards the margin at the expense of the sands, (3) contemporaneous transverse erosion of the London Clay, (4) cases of overlap, (5) the occurrence of massive pebble-beds at nearly the same altitude along the northern flank underlying (as at Easthampstead and Bearwood) Upper Bagshot sands, and resting either immediately upon, or in near proximity to, the London Clay; and added an account of his observations on the flank of St. Anne's Hill, Chertsey, which he takes to be nothing more than an ancient river-valley escarpment. subsequently eroded by rain-water, the hollows thus formed having been subsequently filled up and covered over by pebbles and other débris of the beds in the higher part of the hill, these assuming the character of ordinary talus material. The consideration of the southern margin of the Bagshot district is reserved for a future paper.

The author considered that his main position, resting as it does upon physical evidence, remains untouched by the attempt of later writers to disprove it; while the disproof breaks down even on its own lines (the stratigraphical), the paper in which this disproof is insisted upon being characterized by (1) an incomplete grasp of the problem on the part of its authors, (2) equivocal data, (3) omission of important evidence, (4) inconsistencies, (5) erroneous statements.

The author (while correcting some errors of stratigraphical detail, which appeared in his former paper, from insufficiency of data) maintained that (though occasional intercalated beds with marine fossils may be met with, as is commonly the case in a series of delta- and lagoon-deposits) the view he has put forward is, in the main, established; and he proposed the following classification of the Bagshot Beds of the London Basin:—

| Old Reading. | New Reading. |
|---|---|
| 1. Upper Bagshot Sands | = 1. Marine-estuarine Series. |
| 2. Middle Bagshot Sands and Clays | = 2. Freshwater Series. |
| 3. Lower Bagshot Sands | |

(2).—February 9, 1887.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "Evidence of Glacial Action in the Carboniferous and Hawkesbury Series, New South Wales." By T. W. Edgworth David, Esq., F.G.S.

After giving a tabular statement of the sequence of rocks connected with the coal-bearing beds in New South Wales, the author passed in review the notices by previous observers of glacial action in the Carboniferous beds of that country, terminating with the discovery by Mr. R. D. Oldham of polished and striated boulders in fossiliferous marine beds of Carboniferous age at Branxton. The author had since found another extensive deposit of similar beds at Grass-tree near Musclebrook, 28 miles N.W. of Branxton, and described the section there exposed in a railway-cutting. A fine calcareous sandy shale, reddish to greenish-brown in colour, was crowded with round and subangular fragments of rock, from pebbles no larger than marbles up to a third of a ton in weight. The surfaces of these fragments were in many cases ground and scattered. The parent-rock of some of the boulders was 30 miles distant.

The evidence of ice-action in the Triassic Hawkesbury series was also described. This evidence was twofold, and consisted of the disrupted angular fragments of shale first observed by Mr. Wilkinson, and of contemporaneously contorted current-bedding, of which no account had previously been published. The contortions were represented on a diagram, and attributed to a lateral thrust such as would be produced by the grounding of floating-ice.

The discovery by Mr. Wilkinson of polished and striated boulders in some gold-bearing conglomerates, believed to be of Siluro-Devonian age, was also noticed.

2. "The Terraces of Rotomahana, New Zealand." By Josiah Martin, Esq., F.G.S.

The author, after deploring the recent calamity, proceeded to describe the *White Terrace.* Its origin, the Terata Geyser, was situated in a crater-like escarpment near the centre of a conical hill of steaming and partially decomposed felspathic tuff on the south-east side of the warm lake, Rotomahana. The Terrace was divided into:—

1. The Upper Terrace, with its long horizontal lines of cups, steaming and overflowing with hot water.

2. The Middle Terrace, with its massive steps and shaggy fringes, without basins or receptacles for the overflow.

3. The Lower Plateau, a series of shallow basins and wide, level platforms.

The great cauldron and the action of the Geyser were described in much detail. The following analysis of the water was given in *grains per gallon* :—

| | |
|---|---|
| Silica, free and combined with soda | 50 |
| Sodium and potassium chlorides | 60 |
| Alkalies, chiefly soda. | 30 |
| Sodium sulphate, etc. | 10 |
| Total | 150 |

The amount of rock-material withdrawn in solution would amount to about 10 tons per day; observations lead to the conclusion that 10 per cent. of the silica would be deposited on the surface covered by the overflow—equivalent to about 120 tons per annum. Then followed the description of the three divisions previously defined, including such local features as the *Giant Buttress*, the *Boar's Head*, and the *Broken Basin*—the latter a circular pool 12 feet in diameter and 30 inches deep—the only warm-water basin on the White Terrace of sufficient depth to be used as a bath. The central portion of the Middle Terrace was distinguished by a series of massive, rugged, and rippled perpendicular steps, many of which exceeded six feet in height, and were variously ornamented. The margin of the lower plateau was somewhat undefined towards the lake.

The author observed that the comparative study of local phenomena must precede any attempt to explain the origin of the Terraces. The phenomena of mud-volcanoes exhibited at the plateau of Rotokanapanapa afford to the geologist valuable indications of the probable appearance of the Te-Tarata cauldron in the earlier stages of its activity. These phenomena he described, and arrived at the conclusion that the initial activity of Te-Tarata was of a similar nature, and that the successive periods which mark the history of the formation of the White Terrace correspond with the increasing activity of its source. Given a crater-lake of seething mud, as activity increased, the outer wall of the crater would occasionally be broken down, and mud-streams would be liberated. Such periodical overflows he regarded as having built up the curious and complex terraced series. This hypothesis he applied in detail, and concluded that deposition and removal combined to produce the great variety of forms which existed. Thermal activity within the cauldron having at length removed the softened rock, the deposition of siliceous incrustation commenced.

Lastly he gave a short description of the Pink Terrace, and remarked that by the catastrophe of June 10th the waters of the lakes Rotomakirisi and Rotomahana were drawn into the new fissure at the base of Tarawera, whilst the Terraces were blown away.

3. "The Eruption of Mount Tarawera." By Capt. F. W. Hutton, F.G.S.

The paper commenced with a description of the country in which the eruption took place. From Tongariro to White Island, in the Bay of Plenty, a distance of 130 miles, there extends a belt, 20 or 30 miles wide, abounding in solfataras, geysers, hot springs, etc., and composed of volcanic rocks, chiefly rhyolite, with some augite-andesite. About the middle of this belt lie the mountain and lake of Tarawera, and two or three miles further south Lake Rotomahana, the spot where the famous Pink and White Terraces existed. Before the recent eruption there were no craters on Mount Tarawera, the form of which was a ridge, apparently due to denudation.

Shortly after midnight on the 10th of June a series of tremendous explosions took place from various parts of the Tarawera ridge, and columns of steam were thrown up with quantities of red-hot stones. The whole mountain appeared as if on fire. A column of steam was then sent up from near Okaro far to the west, and, finally, a great explosion took place in Lake Rotomahana, and steam rushed forth to a height exceeding that of the columns from Tarawera. These eruptions from the plain were not accompanied by any red-hot stones; the ejecta were of much lower temperature. The principal eruption, accompanied by violent earthquakes and loud noises of various kinds, was over by 5·30 A.M., and the mountain craters ceased to be active within twenty-four hours, but steam with some stones and mud continued to issue from the Rotomahana and Okero craters for several days, and steam has ever since been emitted from Rotomahana.

The results of the eruption in the form of fissures on Mount Tarawera, the change of Rotomahana from a lake to a crater of larger dimensions, with precipitous walls, the formation of a new lake between this crater and Tarawera, and the formation of a number of small craters about Okaro, were then briefly noticed. The materials ejected were composed of augite-andesite, and rhyolites, both compact and vesicular. The mineral structure and distribution over the surrounding country of various forms of pumice, scoria, and ash were described, and it was shown that there was a difference in the substances ejected from the mountain craters of Tarawera and those from the craters in the plain at Rotomahana and Okaro, the former comprising pumice and scoria, which were not thrown out from the latter, and but little steam issuing from the higher craters. when compared with the enormous volumes emitted from the lower vents. The cause of the eruption was ascribed to the reheating of old lava-streams saturated with water. This reheating was apparently not due to crushing; for, had it been so, the preceding earthquakes would have been more violent, but probably to molten rock coming up from below and heating the rocks near the surface. The eruptions from Rotomahana and Okaro were purely hydrothermal.

## CORRESPONDENCE

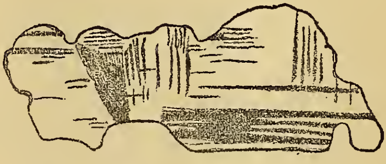
### THE LIZARD SERPENTINES.

Sir,—As Prof. Bonney has called in question my statement that felspar occurs in the Rill serpentine, I should like to mention the grounds on which that statement was based. Of course there is always a certain amount of inference involved in the identification of minerals under the microscope. One recognizes a number of characters, and then one forms the opinion that those characters indicate the presence of a certain mineral.

Now I find in all sections of the Rill serpentine that I have examined irregular grains of a colourless mineral having the refractive index of felspar, so far as one can judge of this by the relief of the section and the character of its surface. This mineral always polarizes in the neutral tints of the first order in sections in which olivine and augite would give as a rule chromatic polarization. It frequently shows, moreover, a fine lamellar twinning, and sometimes two sets of parallel lamellæ may be seen intersecting each other at a high angle. It has been rendered turbid in places by granular decomposition products. Now I know of no mineral except felspar which possesses all these characters. Professor Bonney vaguely suggests that it is augite or diallage. I am, of course, aware that augite does show multiple twinning; but I cannot possibly regard this mineral as augite. In one case in which the extinction of the two sets of twin lamellæ were approximately symmetrical with reference to the trace of the face of composition, the combined angle was 53°. Now, if the crystal were augite, twinned according to the ordinary law, such a section could not possibly be cut approximately at right angles to an optic axis;[1] and, therefore, in slides of the thickness used, could not possibly polarize in the neutral tints of the first order, as it actually does.

Another very important point is the existence of two sets of lamellæ intersecting at a high angle. This is perfectly easy to understand on the assumption that the mineral is felspar; but, so far as I know, inexplicable on the assumption that it is augite.

To sum up. As the mineral possesses the refractive power of felspar, the double-refraction of felspar, the twinning of felspar, and the mode of alteration of felspar, so far as we are able to judge of these characters under the microscope, I adhere most firmly to my original statement.



Section of felspar in the Rill serpentine, showing cross-twinning; Nicols crossed. Magnified 80 diameters.

In my remarks on the Rauenthal serpentine I have simply followed Weigand, and I must leave him to take care of himself, as, no doubt, he is well able to do. I may remark, however, that the main point of Weigand's paper, so far as it relates to the Rauenthal rock, is to prove that serpentine has been largely produced by the alteration of hornblende, and that the serpentine so formed can be distinguished from that produced by the alteration of olivine. The slides of specimens purchased from Sturtz amply

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[1] On referring to Fouqué and Lévy (Min. Micrographique, p. 355), it will be seen that the section in question, if of augite, would be out of the zone 100 : 010 and would make an angle of about 35° with the ortho-pinacoid.

confirm Weigand so far as this is concerned. It must be remembered that Weigand's paper appeared in 1875, at a time when the notion that all serpentines were altered olivine-rocks was becoming very general in consequence of the researches of Sandberger and Tschermak, published some eight or nine years previously.

I may take this opportunity of referring to Col. McMahon's paper in the same number of the GEOLOGICAL MAGAZINE. I have no new facts of any importance to add on the subject referred to, and I do not think that any useful purpose would be served by my attempting to remove the objections raised by Col. McMahon. I cannot explain why foliation has been developed in some cases and not in others. The apparently capricious manner in which foliation comes in is equally striking in the Scourie Dyke and in the Lizard gabbros. If I am right in one case, I am right in the other; and if I am wrong in one case, I am wrong in the other. I believe with Col. McMahon that foliation may be produced in connexion with the intrusion of plutonic rocks; but I cannot explain the foliation of the Lizard gabbros in this way.

Col. McMahon quotes Prof. Bonney as saying that the serpentine is "free from all signs of disturbance." This is true of the serpentine locally, as it is of the gabbro; but it is not true generally. There are the same signs of disturbance in the serpentine as there are in the gabbro. I have a polished slab of serpentine from Porthalla, which shows precisely the same structural features as the figured slab of augen-gabbro from Karakclews. Abundant signs of pressure metamorphism occur also in the serpentine near Mullion Cove.

J. J. H. TEALL.

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## BORING AT BLETCHLEY.

SIR,—The London and North-Western Railway Company have for some time been carrying out a trial-boring for water; and if they have not found what they were in search of, they have made a discovery which is interesting to geologists in reference to the underground structure of the central and eastern parts of England. I have not yet the full details before me; but, from the information furnished by Mr. C. Bowen Cooke, it would appear that the boring-rods, after penetrating the Jurassic Clays (called by my informant the "Oxford Clay"), struck on a very hard rock, of which three small specimens were sent to me for identification. On examining them I had no difficulty in giving a reply. The specimens appear to consist of finely-crystalline quartz-felsite, with some green mica, and evidently form a portion of the old Pre-Triassic ridge, which, as all underground borings combine to prove, underlies the Mesozoic formations of this part of England.

I hope ere long to have a complete series of the cores brought up from the boring, and to be able to give fuller details.

GEOL SURVEY OF IRELAND,
14, HUME STREET, DUBLIN.

EDWARD HULL.

## THE PEA GRIT OF CLEEVE HILL.

Sir,—I thank Mr. Witchell for his courteous correction of my figures in the thickness of the Pea-grit, and underlying Ferruginous Oolite in the Cleeve Hill Section, which I quoted in my letter in the Geological Magazine for November last. The error occurred in the numbers of the beds being inserted as feet, and the three figures were transferred to the inch column. Mr. Witchell remarks that "the correct reading confirms my statement, except as regards the lowest 5 feet." Exactly, but the exception makes all the difference; if there are only 5 feet of Oolite under the Pea-grit beds at Cleeve Hill, then Dr. Wright could not make the thickness more, and as I understand Mr. Witchell, in his paper in the Quarterly Journal of the Geological Society, he maintains that the basement beds were overlooked by Dr. Wright. Mr. Witchell in his paper says, "The beds next above the Cephalopoda-bed are usually brown sandy limestones in two or three beds, varying in thickness from 5 feet at Cleeve Hill."[1]

Now I think it would have been fairer to Dr. Wright if Mr. Witchell had given a reference to Dr. Wright's Cleeve Hill section where that fact was first mentioned. Doubtless in the Stroud area the basement beds assume a greater importance than Dr. Wright recognized, but of course he had to be guided by the available exposures of the strata in his day.

I do not think I need argue the matter further, as Mr. Witchell seems to me to admit my contention, viz. that the late Dr. Wright in his sections of Cleeve Hill and Leckhampton showed that there were Oolitic beds below the Pea-grit proper. Edward Wethered.

## THE COLLINGHAM OR SCARLE BORING.

Sir,—The alternative figures, given by me, as Reporter to the British Association Underground Water Committee, on the authority of Mr. W. H. Dalton, are correctly copied from a lithographed copy of a report by him to the Gainsborough Board of Health, "On the Water Supply obtained from Underground Sources at Gainsborough," handed to me by the Board on the 24th of October, 1884, and now before me.

On the 1st of November, of that year, I recommended the Board to sink an artesian boring at Gainsborough to a depth of 750 feet: this proposal was adopted, and I have to-day learnt by telegraph that the contractors, Messrs. Timmins, of Runcorn, have penetrated the Keuper Marls, and reached the Sandstone at a depth of 725 feet from the surface. C. E. De Rance.

54, West Parade, Rhyl.

## FOLKESTONE GAULT.

Sir,—Mr. John Griffiths, of Folkestone, the well-known collector of Gault fossils, is without resources and is permanently disabled by rheumatism brought on by exposure in his daily labours, which have

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[1] Q. J. G. S. vol. xlii. p. 267.

not only enriched the Museums of Europe and the United States, but have formed the groundwork of the investigations into the *zones* and *fossils* of the Gault made by myself, and fellow-workers—the Rev. Professor Wiltshire before my own endeavours, and those of Mr. F. G. H. Price, F.G.S., and Mr. Starkie Gardner, F.G.S., since. Mr. F. G. H. Price, of Messrs. Child's Bank, Temple Bar, W.C., has kindly undertaken to receive subscriptions for the "Griffiths Fund."

H.M. GEOLOGICAL SURVEY. C. E. DE RANCE, F.G.S.

## OBITUARY.

### CALEB EVANS, F.G.S., MEMB. GEOL. ASSOC.

BORN JULY, 1831; DIED SEPT. 16, 1886.

THE subject of our present Memoir was a resident of Hampstead. He was educated at University College School, and so early as in 1846 he entered a solicitor's office, and was appointed Clerk in the Chancery Pay-Office in 1852, where he served for 30 years, but retired on account of ill-health in 1882.

He commenced to study geology about the year 1855, and attended lectures by Prof. Owen and Dr. Melville. He made no actual collection of specimens until 1858, but from that time until his health gave way, he took advantage of his annual official vacations to visit the various localities of geological interest, especially those of the South-East of England. In 1859 he became a member of the Geologists' Association, and in 1867 he was elected a Fellow of the Geological Society of London. The beds to which he chiefly directed his attention were those of the English Tertiaries and the Chalk, and in addition to a large collection from the Isle of Wight and Hampshire beds, he obtained numerous London Clay fossils by watching the excavations in various parts of the Metropolis, and more especially from the main-drainage works in the South of London, which yielded numerous fossils of the Woolwich and Reading Series, from strata then exposed for the first time, and which have never been accessible since in this particular area.

Mr. Evans was author of eleven papers, eight of which appeared in the Proceedings of the Geologists' Association, the most important being that "On the Geology of the Neighbourhood of Portsmouth and Ryde." But the paper by which he will be best known was that read before the Geologists' Association in January, 1870, entitled, "On some Sections of Chalk between Croydon and Oxtead," which was separately published. It was the first attempt made in this country to subdivide the Chalk into zones according to their fossil contents, and to correlate these zones with those in other parts of England and on the Continent.

Mr. Evans constructed several geological relief-maps or models, based on his own observations; one of the neighbourhood of Hampstead and Highgate; one of the Thames Valley in the neighbourhood of London; one of Hastings, one of Sidmouth, and one of England

and Wales. Although Mr. Caleb Evans only attained the age of 55 years, he has left behind him a very excellent record of geological work achieved by a private individual in the leisure hours of a busy life.

## JOHN ARTHUR PHILLIPS, F.R.S., V.P.G.S., F.C.S., M.I.C.E., ETC.

Born November, 1822; Died 5 January, 1887.

The new year has deprived us not only of an excellent chemist, mineralogist, and geologist, but of a dear and valued friend. Born at Polgooth, near St. Austell, where several of his family had been connected with that important tin-mine, young Phillips inherited a love of mining and metallurgy which he retained unabated to the end of his useful and valuable life. His school-days were passed at St. Austell, but he does not appear to have developed a love for science until near his 20th year, when the subject of electro-metallurgy attracted John Arthur Phillips' attention, and he exhibited some specimens of electro-deposited copper on lace, for which he received the first prize from the Royal Cornwall Polytechnic Society in 1842 at Falmouth.

This led to a series of investigations into the formation of mineral lodes. But the want of more accurate scientific training led him to Paris in 1844, where he entered as a student at the École des Mines. Here he passed through the regular course of study, and showed such proficiency that he obtained the appointment of engineer to one of the large French Collieries, which he held for some years. On his return to England, he was engaged by Sir Henry de la Beche and Dr. Lyon Playfair to carry out experiments at Putney for the Admiralty, on the various qualities of coal suited for the steamships of the Royal Navy. Lead-smelting and desilvering works next occupied his attention. Thence he went to California on an inspection of the gold-producing regions, and to report upon the machinery and methods in use in separating the precious metal at gold-mines and works. On his return to England, he lectured before the Society of Arts, on May 14th, 1862, on "Gold-Mining," giving the result of his own experience and observations in America. Mr. Phillips published his "Manual of Metallurgy" in 1852, a second edition in 1854, and a third in 1858. At the time of his death he was engaged upon a fourth edition assisted by Mr. Bauerman, which we understand will be almost immediately published. Mr. Phillips was also the author of a work on "The Mining and Metallurgy of Gold and Silver," which appeared in 1867. In 1884 he published his "Treatise on Ore-deposits," giving all the varied natural phenomena connected with the occurrence of metalliferous deposits.

For the last sixteen years Mr. Phillips has mainly directed his attention to the study of petrography, and his paper in the Quarterly Journal of the Geological Society, "On Concretionary Patches and Fragments of Rocks found in Granite," and others of a kindred nature, are of the greatest value to petrologists.

His communications were not however confined to the Geological

Society, but were made also to the Chemical and the Royal Societies, and some were published in the Philosophical Magazine. He was elected a Fellow of the Geological Society of London in 1872, and of the Royal Society in 1881, and at the time of his death was a Vice-President of the former Society. He was also a F.C.S., a M.I.C.E., and an "Ancien Elève de l'École des Mines."

Those who were personally acquainted with Mr. Phillips, while they lament the loss to science which his sudden death has inflicted, mourn still more the extinction of a life of singular simplicity, earnestness, and kindliness. He was a large-hearted and open-handed man, fond of taking every chance that came in his way of doing a good deed and helping every one to whom his help could be of service.

## CHARLES FRANÇOIS FONTANNES.

Of the losses by death sustained by Geological Science in the year 1886, none has been greater than that of M. Fontannes. Men of riper age, and of wider reputation, we may have lost; but when we consider the value and the amount of the work performed by M. Fontannes before reaching his 48th year, it will be evident that the gap left by his death will not be easily filled. Especially will this be the case with the "International Geological Congress," which is to hold its next meeting in England in 1888.

There are several Secretaries to the Congress at each meeting, but the bulk of the work falls on one or two. At Bologna, in 1881, M. Fontannes divided the work with M. Delaire; but in 1885, at Berlin, M. Fontannes took it almost entirely upon himself. The "procés verbal" of a foreign scientific meeting is very different from the "minutes" of an English meeting; it is really a full abstract of the entire discussion, and the prompt preparation of this is no small test of a man's powers.

M. Fontannes' earliest work was a notice of the Museum of Lyons, 1873. This was followed in 1874 by a Note on the Infra-Lias of Narcel, and by notes taken at Athens. In 1876 he published, with M. Dumontier, "Description des Ammonites de la zone à *Ammonites tenuilobatus* de Crussol et de quelques autres fossiles Jurassiques nouveaux ou peu connus" (*Mem. l'Acad. Lyon*). In 1879 this was followed up by a work on the same subject by Fontannes himself, Dumontier having died meanwhile. In the Introduction to the later work Fontannes pays a warm tribute to his late master, attributing to his encouragement and influence his own love for geology. These books made known a new Jurassic Fauna for the South-east of France.

The most important works by Fontannes were "Les Invertébres du Bassin du Sud-est de la France—Les Mollusques Pliocènes de la Vallée du Rhône et du Roussillon," of which two volumes appeared (1879-82); and "Etudes stratigraphiques et paléontologiques pour servir à l'histoire de la Période Tertiaire dans le bassin du Rhône" (*Ann. Soc. Agric. Lyon*) ; of this eight parts appeared :—

i. Le Vallon de la Fuly et les Sables à Buccins des Environs d'Heyrieu (Isère) 1875.
ii. Les Terrains tertiaires supérieurs du Haut Comtat-Venaissin (Bollène. St. Paul-Trois Châteaux. Visan) 1876.
iii. Le Bassin de Visan (Vaucluse) 1878.
iv. Les Terrains néogène du Plateau de Cucuron (Cadinet-Cabrières-d'Aigues), 1878.
v. Description de quelques espèces nouvelles ou peu connues, 1879.
vi. Le Bassin de Crest (Drôme), 1880.
vii. La Région Delphino-Provençale, 1881.
viii. Le Groupe d'Aix dans Le Dauphiné, La Provence et le Bas-Languedoc, 1885.

An active worker in the field and a careful student in the museum and library, M. Fontannes united in himself the two important requisites for studying problems of this nature. He explored the later Tertiaries of the South of France and the neighbouring regions, wherever known, and traced them into districts where they were not previously known to exist.

Besides the important works here alluded to, M. Fontannes published numerous papers on the same or on kindred subjects, chiefly in the *Bull. Soc. Géol. de France* and *Ann. Soc. Agric. Lyon.* But he also wrote on the Miocenes of Portugal (*Ann. Sci. Géol.* 1884) ; on the Constitution of the Subsoil of the Chalk and of the Plain of Avignon (*Bull. Soc. Géol. France*, 1884) ; on Borings in the Isère, Drôme, and Vaucluse (*Ann. Soc. Agric. Lyon*, 1883). His minor and miscellaneous papers amount to about forty in number.

M. Fontannes was an Officer of Public Instruction, and of the Geological Survey of France; Chevalier of the Order of St. Maurice and Lazare, and a recipient of other Orders conferred by Foreign Governments. In recognition of his important researches, the Academy of Sciences awarded him, in 1883, the Grand Prize of the Physical Sciences.

W. TOPLEY.

## THE EARL OF ENNISKILLEN, D.C.L., LL.D., F.R.S., F.G.S., M.R.I.A.

BORN 25 JANUARY, 1807; DIED, 12 NOVEMBER, 1886.

BY the death of William Willoughby Cole, third Earl of Enniskillen, geological science has lost one of its most earnest supporters. Educated at Eton, and afterwards at Christchurch, Oxford, he became attached to Sir Philip de Malpas Grey-Egerton, Bart., and having studied geology with him under the Rev. W. Conybeare and Dr. Buckland, they spent their long vacation with the former at Lyme Regis, where they made the acquaintance of the well-known Mary Anning, and commenced to collect Lias fossils. Afterwards, by advice of Dr. Buckland, they visited Franconia, and explored the caverns of Küloch, Rabenstein, Scharzfeld and Gailenreuth, and returned laden with spoils of Hyæna, Bear, Lion, Rhinoceros and other cave-animals. Encouraged by Prof. Agassiz, they took up the study of fossil Fishes, with which their names will ever remain associated. It seems only appropriate that the collections made by these two eminent palichthyologists, whose life-long friendship was cemented by a common interest, should now rest side by side in the Geological Gallery of the British Museum (Natural History).

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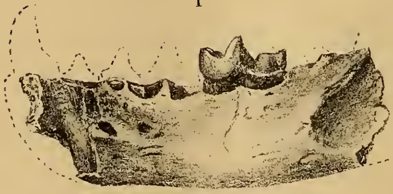

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West, Newman & Co. imp.

1. 2, Otter. 3-5, Eagle Owl. 6. 7, Shoveller Duck.
8, Cormorant.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. IV.

No. IV.—APRIL, 1887.

# ORIGINAL ARTICLES.

## I.—NOTE ON SOME RECENT ADDITIONS TO THE VERTEBRATE FAUNA OF THE NORFOLK "PRE-GLACIAL FOREST-BED."

By E. T. NEWTON, F.G.S., F.Z.S.

(PLATE IV.)

SINCE the publication of my last notes on the Vertebrata of the Norfolk "Forest-Bed" in this MAGAZINE,[1] several new forms have been identified,[2] and we are now under obligation to Mr. W. Barker and Mr. A. Savin, whose diligent search in these beds has brought to light four species not hitherto recorded; three of them are bones of Birds, and therefore especially interesting, as so few remains of this class have been determined from British Pre-Glacial deposits. I have to thank Prof. Stewart and Dr. Garson for the facilities they have afforded me on this, as on other occasions, when comparing specimens in the Hunterian Museum of the Royal College of Surgeons; and for similar assistance at the British Museum I am indebted to Mr. R. Bowdler Sharpe and Mr. Oldfield Thomas.

### LUTRA VULGARIS (Otter). (Pl. IV. Figs. 1, 2.)

A left ramus of a lower jaw has been found by Mr. A. Savin in the "Forest-Bed" exposed on the shore at East Runton, near Cromer, which enables us to add the above-named species to the Pre-Glacial fauna of the East of England. This specimen has the extreme front and hinder part broken away; but the alveolar margin is complete from the socket for the canine to that of the hindermost molar, leaving no doubt therefore as to the number of cheek-teeth, namely, five, three premolars and two molars. The large sectorial tooth (pm. 1) is well preserved, and agrees in all particulars with the same tooth in the common Otter. The two anterior outer cusps of this tooth are sharp and show slight facets due to contact with the upper sectorial tooth; while the inner cusp is not so high as the median outer cusp. The hinder part of the tooth is low with the upper surface concave; and a distinct cingulum extends along the lower part of the outer surface of the crown. The rest of the teeth are absent; but the number, position, and size of the alveoli agree exactly with

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[1] GEOL. MAG. Dec. II. Vol. X. p. 433.

[2] *Vide* Quart. Journ. Geol. Soc. vol. xxxix. p. 575; vol. xli. p. 243; and vol. xlii. p. 316.

those of the Otter; in fact, in every particular, the agreement is so close there can be no question as to their specific identity.

MEASUREMENTS.

| | | |
|---|---|---|
| Length of alveolar border for cheek-teeth | 34·5 | millimètres. |
| Depth of ramus under sectorial tooth | 13·5 | ,, |
| Length of sectorial tooth | 12·0 | ,, |
| Width of sectorial tooth | 6·5 | ,, |

### BUBO MAXIMUS (Eagle Owl). (Pl. IV. Figs. 3–5.)

The second specimen, also found by Mr. A. Savin in the "Forest-Bed" at East Runton, is a right tarso-metatarsus of a large Owl. This bone is perfect from the lower extremity upwards to the ridge for the attachment of the anterior tibial muscles, but the parts above this are wanting. The most marked characters of this bone are the deeply grooved hinder surface bordered by sharp ridges, and the backward extension of the distal articular surfaces for the second and fourth digits. The last-named peculiarity is such that when the bone is viewed from its lower extremity as in Fig. 5, it is seen to form rather more than a semicircle. The front and sides of this bone are much flattened, giving a square appearance to the shaft. At the lower part, in front, between and a little above the articulations for the third and fourth digits, is the perforation for the tendon of the adductor muscle of the fourth digit; and immediately above this a second, smaller foramen. Towards the lower part of the hinder and inner surfaces, there is a flattened space for the attachment of the fourth metatarsal.

The only Birds, so far as I am aware, with a tarso-metatarsus of this form, are the Owls, and some of these agree very closely with this "Forest-Bed" specimen, the species which comes nearest to it being *Bubo maximus*.

There is a marked difference between the tarso-metatarsi of different examples of this species; thus in the *Bubo maximus* in the College of Surgeons (No. 1602) this bone is not quite so long as our fossil, but is more robust, the upper part being wider and the shaft thicker. The example figured by Milne Edwards,[1] is not quite so stout, and therefore comes nearer to our fossil. A third specimen, in the College of Surgeons (No. 1602 A), is much more slender than the other two; it is as nearly as possible the same length as the fossil, but is even more slender. Possibly these differences may be due to sex, for the male and female of this species differ in size; but, be that as it may, this "Forest-Bed" fossil bone is within the extremes of variation of the tarso-metatarsi of *Bubo maximus*. The front of the fossil is flatter than in either of the recent examples examined; but as this is due to the sharp muscular ridge on the outer edge, possibly age may have much to do with it. Length of bone from distal end to tibial crest, 55 mm. Greatest width of distal end, 22 mm. Width of shaft in middle, 7·5 mm.

### SPATULA CLYPEATA (Shoveller Duck). (Pl. IV. Figs. 6, 7.)

A small but perfect left coracoid of a bird, found by Mr. W.

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[1] Oiseaux fossiles, pl. 189, f. 1.

Barker in the Freshwater portion of the "Forest-Bed Series" at West Runton, is referred to the above species. A comparison of this specimen with the series of avian coracoids in the College of Surgeons leaves no doubt as to its nearest affinity being with the Anatidæ and especially with the Ducks; whilst its close agreement in size, form, structure, and muscular markings with the coracoid of the Shoveller Duck leaves one no option but to refer it to that species. The greatest length of the specimen is 44 mm., and the widest part, at the sternal articulation, is 17 mm.

PHALACROCORAX CARBO (Cormorant). (Pl. IV. Fig, 8.)

The last specimen which I have to notice was likewise found by Mr. W. Barker in the Freshwater-bed at West Runton. This is the upper part of a bird's coracoid with a markedly flattened inner surface, agreeing in this, as in other particulars, with the somewhat peculiar coracoid of the Cormorant. When comparing this specimen with recent forms, nothing could be found so nearly approaching it as the common Cormorant, and no doubt was felt as to its belonging to the same species. Some allied forms, such as the Shag and other Cormorants, were somewhat like, but *P. carbo* was certainly nearest and one might say identically the same. The Gannet, which is nearly related to the Cormorant, has a different form of coracoid.

Although other avian remains have been found in the "Forest-Bed," some evidently belonging to species differing from those which have been determined, it has not been possible to identify them. All the "Forest-Bed" birds at present known are *Bubo maximus, Phalacrocorax carbo, Anser* sp., *Anas* sp., and *Spatula clypeata.*

### EXPLANATION OF PLATE IV.

FIG. 1. *Lutra vulgaris*, left ramus, outer surface. "Forest-Bed," East Runton.
,, 2. Same specimen seen from above.
,, 3. *Bubo maximus*, right tarso-metatarsus, front view. "Forest-Bed," East Runton.
,, 4. Same specimen, back view.
,, 5. Same specimen, end view of distal extremity.
,, 6. *Spatula clypeata*, left coracoid, outer surface. "Forest-Bed," West Runton.
,, 7. Same specimen, inner surface.
,, 8. *Phalacrocorax carbo*, upper end of right coracoid, outer surface. "Forest-Bed," West Runton.

All the figures natural size.

## II.—INTER-GLACIAL LAND-SURFACES IN ENGLAND AND WALES.

By A. J. JUKES-BROWNE, B.A., F.G.S.

THE exploration of the caves in the Vale of Clwyd, and the conclusions announced by Dr. Hicks at the last meeting of the British Association, have naturally aroused much interest; for if the facts are rightly interpreted by Dr. Hicks, and the deposits which are banked up against the north-western end of the cave are really of Glacial age, then it is clear that the contents of the cave date from a time anterior to the great submergence during which those deposits were formed. The occurrence of a worked flint-flake in the cave-earth makes this conclusion of the greatest importance, and revives the question of Man's first arrival in Britain, carrying this back to Inter-Glacial, though not necessarily to Pre-Glacial times.

Dr. Hicks's inferences are, however, disputed by Prof. Hughes, whose objections may be summed up as consisting of two assertions —(1) that the deposits concealing the north-west mouth of the cave are not true Boulder-clays, but consist of rainwash and re-sorted Drift; (2) that if they did belong to what he calls the Clwydian Drift, they would still be Post-Glacial, and not Glacial.

Upon the first point it would appear that the majority of those who saw the excavation are against Prof. Hughes, and as fresh openings are to be made next June, we may hope that geologists who are acquainted with the Glacial beds of Cheshire and Lancashire will visit the place, and give us an authoritative opinion. In the mean time I may draw attention to the regularly stratified succession of sands and Boulder-clays in Dr. Hicks's section (see GEOLOGICAL MAGAZINE, December, 1886, p. 569); this is not the kind of structure which rainwash deposits usually exhibit.

Prof. Hughes's second objection is simply an unwarranted assumption; his only grounds for the statement that the so-called Clwydian Drift is Post-Glacial appear to be that it is of marine origin, and was formed during "the submergence which followed the extreme glaciation." Prof. Hughes may choose to assume that Post-Glacial time commenced with this submergence; but this is not the view which is usually held, and students of Pleistocene geology will naturally call upon him to define what he means by the terms Glacial and Post-Glacial. The latest authorities are agreed in correlating the Boulder-clays and gravels of the Vale of Clwyd with the similar deposits which spread over such large areas in Cheshire and Lancashire, and he must be a bold man who would exclude these from the category of Glacial deposits.

It is true that the late Mr. S. V. Wood, Jun., made a similar assumption with regard to the Drifts of Lincolnshire, speaking of a major and a minor glaciation, and referring the product of the latter (Hessle Beds) to the Post-Glacial era, because they contained *Cyrena fluminalis*, and were in his opinion contemporaneous with certain river-gravels which are usually called Post-Glacial. I have elsewhere shown, however, that the Hessle beds are so intimately associated with the underlying Purple clay that they cannot possibly be dissociated from it; and that as both were evidently formed under glacial conditions, it would be both confusing and illogical to call any part of the series *Post-Glacial.*

The fact is, as Prof. Boyd Dawkins has pointed out, the so-called Glacial period was only an episode in Pleistocene time; the length of this episode was necessarily different in different parallels of latitude, and consequently the term Post-Glacial can only have a local significance. Deposits which are evidently the products of ice-action must be called Glacial, and Post-Glacial deposits could not be formed at any given place until glacial conditions had ceased; hence it is probable that the Post-Glacial deposits of southern England are of earlier date than those of northern England, while in France the term Post-Glacial ceases to have any value at all.

In discussing questions of relative age, therefore, it would be much better to use the terms Older and Newer Pleistocene instead of Glacial and Post-Glacial, the true test of age being the constitution of the Mammalian fauna, and not the cessation of glacial conditions. I can see no reason why the newer Pleistocene fauna should not have occupied our southern and midland counties before the formation of the later glacial deposits of Cheshire and North Wales, provided only there was a time when a land-surface existed that was sufficiently free from snow and ice to permit of their immigration. If this were the case, Man was probably a contemporary immigrant; but this would not make him Pre-Glacial: consequently it is needless to compare the fauna of the Welsh caves with that of the Pre-Glacial Forest Bed.

The question then is, do the facts, so far as we know them, afford any evidence in favour of the supposition that there was a land-surface free of ice anterior to the submergence during which the later glacial deposits were formed? I think this question may certainly be answered in the affirmative; it is indeed a remarkable coincidence that three separate inquirers, each studying a separate district lying between the same parallels of latitude, should have independently arrived at conclusions which favour the above supposition. These three districts are (1) Lincolnshire, (2) South Derby and Nottingham, (3) North Wales.

One of the most striking points in the Pleistocene Geology of Lincolnshire is the contrast and distinction between the two great groups of glacial deposits; on this point I agree with the late Searles Wood, Jun., that the facts indicate the lapse of a very considerable interval between the formation of the older and newer deposits. Whether the older Boulder-clay was formed on land or beneath the sea is of course an open question, though I incline to the latter opinion; but it certainly seems to have been exposed to extensive erosion before the deposition of the newer red and brown clays. The facts favour the idea that a land-surface existed which was free of ice, but exposed to the action of rain and running streams, and that the district remained above water long enough for a distinct valley-system to be produced. Submergence then took place, the ice-laden waves of the North Sea attacked the coast-line and cut it back for many miles, forming a plane of erosion which terminated in a line of cliffs. More rapid submergence ensued, the cliffs and the wolds sank beneath the sea, and the valleys were filled up with gravels and Boulder-clays, which bear evidence of their marine origin in the shells which are found in them up to heights of 200 feet.[1] Here, therefore, we seem to have fairly good evidence of an inter-glacial land-surface.

Again, the Pleistocene deposits of South Nottingham and Derby have recently been described by Mr. R. M. Deeley, who divides the series into Older, Middle and Upper, assigning the East Anglian Chalky Boulder-clay to the Middle stage; from his description

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[1] See Quart. Journ. Geol. Soc. vol. xli. p. 130, and "The Geology of East Lincolnshire," Mem. Geol. Survey, 1887, p. 91.

of the succeeding Newer Pleistocene epoch I quote the following:—"The evidence furnished by the deposits of the two previous epochs favours the assumption that, up to the close of Middle Pleistocene times, the area under consideration was uninterruptedly submerged to a greater or less extent . . . The deposits of the Newer Pleistocene epoch now to be considered indicate the first signs of subaerial erosion, and the consequent formation of river-gravel. . . . During this stage the rivers cut down their valleys through the older Boulder-clays and sands to within about twenty feet of their present depths, and left their gravels stranded as terraces at various heights above their present courses. Upon these *inter-glacial gravels*, or upon the older rocks, there frequently rests a Boulder-clay sometimes reaching a considerable thickness."[1] This later Boulder-clay would appear to be contemporaneous with the marine clays of Staffordshire and Cheshire on the one hand and of Lincolnshire on the other, though this point cannot be taken as proved.

Lastly, with regard to the Pleistocene succession in North Wales, we have the concurrent testimony of Mr. Mellard Reade, Mr. A. Strahan, and Dr. Hicks. Mr. Strahan sums up as follows:[2]—"While, however, there is a general agreement as to the marine origin of the sand, gravel and associated Boulder-Clays, there is an equally wide-spread opinion that the tough and very strong basement-clay seen at Colwyn Bay, Bryn Elwy, Llanefydd and other places in North Wales is the product of an ice-sheet." The distinction between the older and newer Boulder-clays seems therefore to be as marked in North Wales as it is in Lincolnshire; and if Dr. Hicks's views with regard to the relation of the caves to the newer glacial deposits are confirmed, the Pleistocene record in North Wales may be read thus:—

(1) Intense glacial conditions; Wales buried in ice, but the relative level of land and sea not yet known.

(2) Retreat of the ice, exposal of land-surface, and occupation of the district by Man and the newer Pleistocene Animals.

(3) Extensive submergence, during which the later (marine) Glacial beds were deposited.

(4) Elevation and re-occupation of the country by man and animals.

All recent observations tend to show the high probability of there having been a free land-surface over the greater part of England in the midst of what is usually called the Glacial period. During this Inter-Glacial period valleys were excavated, caves were formed, and a long process of subaerial detrition went on; the caves being occupied by Hyænas, while the plains were inhabited by an assemblage of animals very little different from that which again occupied the country after the second Glacial episode had passed away.

At present this is little more than a theory, but it will be interesting to see how far future investigations will confirm what I have suggested, and some geologists may perhaps be stimulated to search for further evidence bearing upon the question.

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[1] Quart. Journ. Geol. Soc. vol. xlii. p. 466.

[2] Q. J. G. S. vol. xlii. p. 386.

## III.—The Work of Ice-Sheets.

By J. E. Marr, M.A., F.G.S.,
Fellow of St. John's Coll. Camb., University Lecturer in Geology.

THE occupation of Britain by Ice-sheets in Pleistocene times has been established by the researches of Sir A. Ramsay, Dr. J. Geikie, Messrs. Peach and Horne, Tiddeman, Goodchild, and others. At the time that these inquirers made their observations, the very complex nature of the phenomena of the Greenland ice-sheet was hardly recognized, and many difficulties arose, upon which considerable light is thrown by a knowledge of the work of a modern ice-sheet. Under these circumstances it may be well to apply the information gained in recent years, and published by the Commission for Directing the Geological and Geographical Exploration of Greenland[1] to the clearing up of some of these difficulties.

A few remarks upon the nature of this continental ice, extracted from the "Meddelelser," may not be out of place.

The Greenland ice-sheet is stated to extend probably over an area about three hundred and fifty times that of all the glaciers of the Alps taken together, and it may be readily understood that the phenomena presented by such a mass are very different from those of the small glaciers so generally known. The difficulties of exploration of this great continental ice-sheet are very great, and the arduous undertakings of the Danish explorers must command universal admiration.

Owing to the cold polar current which bathes the eastern coast of Greenland, an almost impenetrable mass of ice blocks the shores between latitudes 60° and 69° N., and consequently our knowledge of that portion of the country is slight. On the western coast, however, a more favourable set of conditions exists, and the exploration of the ice-sheet has been undertaken from this side. The southern part of the country, around Cape Farewell, is occupied by gigantic glaciers, in the depressions between rugged mountains reaching a height of about 7000 feet, the summits of which, according to the observations of Herr Sylow, appear never to have been covered by moving ice; but north of the latitude of Julianehaab the ice-sheet is encountered, and the numerous fjords which indent the coast to the north of this are frequently barred at their inner terminations by great ice-cliffs which form the ends of huge glaciers projecting like tongues of ice from the ice-sheet of the interior into the valleys of the coast-region.

The confinement of the ice to the valleys in this region appears to be due to the elevation of the mountains surrounding the littoral. The country rises rapidly from the fringe of islets surrounding the coast, which have a maximum height of under one thousand feet, to heights of from 2000 to 4000 feet upon the peninsulas between the fjords. After this it falls towards the interior of the fjords, and again rises rapidly inland, so that one meets with summits of 3000 to 5000 feet and more, further inland; but as the ice itself rises in the interior, these heights become more and more buried in ice,

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[1] "Meddelelser om Grönland," parts i.—vi. Copenhagen, 1879—1883.

their summits standing up from the surrounding ice as islets of rock known as "Nunatakker," until finally nothing is seen but a gently sloping plain of ice extending into the interior. The "Nunatakker" of Jensen, situated at a distance of over forty English miles from the edge of the ice-sheet, have a height of over 5000 feet above the sea. The ice to the east of them is elevated to a height of 5000 feet, whilst to the west it is considerably lower, as it becomes heaped up against the eastern side of the barrier like running water against a projecting rock. For a considerable distance to the west the ice is nearly horizontal, and afterwards it slopes downwards at a very small angle, having at first an average of 0° 49′ and afterwards at greater angles, which do not exceed 2° 14′.

The effects produced upon the movements of the ice by these partially buried barriers are most remarkable, and remind one strongly of the phenomena described by Messrs. Tiddeman and Goodchild in the area of and around the Pennine Chain.

If we examine the map of the directions of movement of the ice in Phillips's Geology of Yorkshire, third edition, part i. p. 9, and read it in the light of recent discovery, we are at once struck with the similarity of the conditions to those now presented by Jensen's and Dalager's "Nunatakker," as described in part i. of the "Meddelelser." This map may be taken to represent roughly the emergence of the Pennine "Nunatakker" above the ice about the period of maximum glaciation. The whole of the low tract to the west of the Pennines was occupied by the great masses of ice which, as shown by Messrs. Tiddeman and Goodchild,[1] came from the Lake District hills and from those of the south of Scotland. This ice passed over the Pennines at Stainmoor, and by the low watershed separating the valleys of the Ribble and Aire further to the south. The Scotch ice and apparently some of the Lake District ice passed over the low land between the northern extremity of the Pennine Chain and the Cheviot Hills, and it is generally recognized that this ice spread out far and wide over the Yorkshire plains.

This ice is considered by Mr. Goodchild not to have risen much above the 2400 feet contour-line in the Dale district examined by him, and judging from his map, the highest marks of glaciation occur here, where the ice would be heaped up against the Pennine Chain. In the district to the south described by Mr. Tiddeman, the marks of glaciation occur up to a height of 1400 feet on Bowland Knotts. The distance from Baugh Fell, where the highest marks are found in Mr. Goodchild's district, to Bowland Knotts, is over twenty miles, giving a fall of not more than 1 in 110 for the surface of the ice-sheet.

In the case of the Greenland "Nunatakker," we find that the greater part of the ice passes round the buried ridge of rock, describing a nearly complete circle, but that the upper portion flows over the depressions which separate the different "Nunatakker," and moves over the main mass of ice on the lee-side of the obstructing ridge, usually at right angles to the course of that ice, and that

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[1] Q. J. G. S. vol. xxviii. p. 471, and vol. xxxi. p. 55.

the line of junction between the two is marked by a horse-shoe-shaped *moraine profonde*, which has been dragged up the more inland side of the rocky ridge over the passes, and becomes exposed as a terminal moraine at the extremity of the tongue of ice which has flowed over these passes. That this is true *moraine profonde* is indicated by the rounded and polished condition of all the stones composing it, showing that they have been brought from a distance, and not fallen from the Nunatakker to form superior moraines.[1]

The conflicting currents assumed by Sir A. Ramsay and others from an examination of the phenomena presented by the glaciation of Britain are here actually seen. Just as the great mass of ice presses against the "Nunatakker" of Jensen and Dalager, and is borne round it, whilst a thin superficial portion is carried over the passes between the "Nunatakker," bearing with it some of the *moraine profonde* of the ice-sheet, so the lower part of the Lake District ice appears according to Mr. Goodchild to have ridden northwards into the Eden Valley, as shown by the distribution of erratics along the western side of the Pennines to the north of Stainmoor, and the northerly pointing scratches near Crosby Ravensworth, whilst the upper portion flowed at right angles to this over Stainmoor, bearing with it part of the *moraine profonde* of the ice-sheet, including blocks of Shap granite.

Again, the "Nunatakker," by causing the deflection of the ice, allow of the formation of a hollow on the lee-side, whilst the main streams of ice which have been carried on either side of each "Nunatak" unite some way below the obstruction. This is shown in the case of "Nunatak" *i* of Jensen's group, where a lake occurs with ice-cliffs towering to a height of 600–800 feet above it, but especially by the small "Nunatak" *e* situated to the east of Dalager's "Nunatakker." In this case, the *moraine profonde* appears at the surface above the "Nunatak," and flows in a crescentic form around it, the horns of the crescent nearly uniting at the extremity of the hollow, which is filled with water forming a small lake on the lee-side of the "Nunatak."[2] The tendency of this must be to produce a "driftless" area on the lee-side of the obstruction, up to the point where the two streams of ice re-unite. Such a driftless area is described by Mr. Dakyns[3] as occurring on the east side of the Pennine chain, to the south of the Aire basin, except where the chain is broken by the Wye and Calder valleys.

Similar driftless areas[4] seem to be indicated by the lines on Prof. Phillips' map, as occurring on the east side of the Chain between its northern extremity and Stainmoor, and between the latter pass and the pass between the Ribble and Aire valleys. The curves of the distribution of drift in this map remind us strongly of the curves taken by the ice in rounding the Greenland "Nunatakker."

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[1] *Cf.* Meddelelser, part i. plate v. figs. B′, B″, C′, C″, and C‴.

[2] Meddlelser, part i. plate v. figs. D′, D″.

[3] Q. J. G. S. vol xxviii. p. 383.

[4] *i.e.* not occupied by Scotch and Lake District drift.

To complete the parallel, the ice seems to have spread out at its extremity in a fan-like form on the low ground of East Yorkshire, just as does the Greenland ice to the S.W. of Dalager's "Nunatakker" on similar low ground, forming the great Frederikshaab glacier.

The moraine-like mound mentioned by Mr. Tiddeman as occurring on the east flank of Ingleborough, running parallel with the curving set of scratches, which according to him appear to have been caused by the ice rounding Simon's Fell, may be the relic of a crescentic moraine formed at the end of a small tongue of ice passing over the depression between Ingleborough and Simon's Fell, and sliding over the main mass of ice below in the same way as the tongues of ice slide over the main masses on the lee-side of the ridges which form Jensen's and Dalager's "Nunatakker." This mound, in any case, merits careful examination.

Another point illustrated by the Greenland ice-masses is the formation of contorted sands and clays associated with boulder-clay. Such deposits are usually referred to the action of the sea, or of running water, and it does not seem to be generally recognized that similar deposits are actually being formed in the ice itself.

In part iv. of the "Meddelelser," plate iii., bands of stratified sand and clay are seen interstratified with the ice at the extremity of a glacier which descends towards the fjord of Umanak, and these bands are not only overfolded, but also faulted along lines of crevasses in the ice. Similar bands are seen in plate iv. fig. 3, at the end of the glacier of Tuapagsuit, and above them, at one part, is a mass of moraine formed of gravel and large stones with their asperities worn off. If these masses of ice melted, they would leave contorted beds of sand and clay, with small faults, associated with morainic matter. May not some of the remarkable stratified deposits figured by Mr. Goodchild have been produced in a somewhat similar way?

The very conspicuous manner in which the Greenland valleys are stopped up by ice is also worthy of notice in connexion with the glacial theory of the origin of the Parallel Roads of Glenroy. The Jacobshavn glacier stops up both ends of a valley running parallel with its course, converting it into a lake which is separated from the glacier throughout the greater part of its length by a "Nunatak." The lower end of another valley considerably to the south of this is stopped by the ice-sheet, and the valley converted into a lake (Tasersiak), which is drained by a river running over the col at the head of the valley into the Strömfjord, just as in the case of the Märjelen See, only the Greenland lake is much larger than this. A similar lake drains into the N. Isortok fjord, and another into that of Alangordlia. Two similar lakes are formed to the east of Sermilik fjord, and several small ones to the east of Björnesund. North of the Frederikshaab glacier is a valley running north and south, the mouth of which is stopped by the Frederikshaab glacier, whilst a tongue of ice flows through a col situated half-way up the valley and bars the valley, one part of the tongue of ice flowing a small distance to the north, and another to the south, thus causing the conversion of the valley into two lakes. On the east of the Frederikshaab glacier is the lake Tasersuak, bounded on the north by the "Nunatak" Kangarsuk, and stopped at its lower end by the Frederikshaab glacier, and having a tongue of the ice-sheet entering into it at the upper end.

The erosive power of an ice-sheet is well seen by a glance at the observations made upon the rivers which flow into the fjords of Nagsugtok and Isortok, and which have their origin at the ends of the tongues of ice which occupy the valleys continuous with these fjords.[1] The river from the first contained only 200—225 grammes of mud per cubic metre of water in the month of July, whilst the second in the month of June enclosed 9129 to 9744 grammes. This is compared with the amount carried by the Aar where it emerges from the glacier; it there contains only 142 grammes. The great difference presented by the rivers which fall into the two fjords is attributed to the fact that the ice moves with much greater speed towards the fjord of Isortok than towards that of Nagsugtok. It is calculated that the quantity of fine mud carried into the former of these fjords amounts to 4062 million kilogrammes per day. This mud is deposited in the interior of the fjord, which is filled up to such an extent in its upper portion that even flat boats cannot pass up it. What a powerful machine for the formation of the fine clay of "till" is here!

At the time when the Pennine Chain was nearly buried by the great ice-sheet from the west and north-west, the parts which stood out above the ice may still have possessed a meagre flora, for plants are found upon Jensen's Nunatakker which, as already stated, are situated about forty English miles from the edge of the ice, and have an elevation of over 5000 feet. Amongst these plants are *Draba alpina* and *Potentilla nivea*. Herr Kornerup has collected altogether 54 species of plants from various "Nunatakker."

Observations have been taken by members of the various expeditions as to the former extension of the ice, with the result that it is found to have stretched much further seaward in the period of great glaciation, but at the same time its height does not appear to have risen very much above the present level, for the summits of many mountains along the littoral show no traces of former glaciation. This seems to indicate that the thickness of the ice depends rather on the elevation of the country than on the intensity of the cold.

I have written the above slight sketch in hopes of calling attention to the importance of the results obtained by the Danish explorers in Greenland, to those who wish to elucidate fully the history of the ice-sheets of our own country.

## IV.—THE CAMBRIAN ROCKS OF NORTH AMERICA.

By HENRY HICKS, M.D., F.R.S., F.G.S., etc.

CONSIDERABLE attention has been given of late years to the faunas of the rocks in North America considered to be the equivalents of the rocks usually classed as Cambrian in this country,

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[1] Meddelelser, part ii.

and the facts which have been obtained are particularly interesting to British geologists. Two recent communications by Mr. C. D. Walcott, Palæontologist to the U. S. Geological Survey, are especially deserving of study in reference to the classification of these rocks,[1] and many facts of importance bearing on the same question are also given in papers by Mr. G. F. Matthew, of St. John's, N.B.[2]

That the classification found most suitable by the majority of those who have, during recent years, studied these rocks in Great Britain should now have been adopted by such experienced geologists in America, is very strong evidence of its wide applicability, and is a fact which should, I think, have influence on those who still hesitate in adopting it as the best means of bridging over the insuperable difficulties connected with the classifications of the rival schools of Sedgwick and Murchison.

In his introductory observations Mr. Walcott says,[3] "In using the name Cambrian in this paper for the series of strata characterized by the First or Primordial fauna of Barrande, I do not forget the claims of the name 'Upper Taconic,' which Dr. E. Emmons proposed for the strata now placed under the Middle Cambrian or Georgia Formation," and, "The term Cambrian is used from the belief that in so doing I approve of the view of those writers who hold that each of the distinguished authors, respectively, of the names Silurian and Cambrian will be fairly recognized, and geologic nomenclature advanced by the use of the names Cambrian and Silurian for the divisions of strata characterized by the first and third faunas as defined by Barrande. . . . . Of the presence of a well-defined geologic system beneath the strata characterized by the second fauna of Barrande or the Trenton fauna (including the Chazy and most of the Calciferous) of North America, on the North American continent, there is no question. The geologic sections given in this paper show it to have a total thickness of over 18,000 feet, and that its middle division has a known fauna of 43 genera, represented by 107 species. We also know that the Lower Cambrian or Paradoxides fauna has 32 genera and 76 species; that the Upper Cambrian or Potsdam fauna includes 52 genera and 212 species; that of the 393 species now known from Cambrian rocks but very few pass up into the Calciferous horizon of the Lower Silurian (Ordovician); and that the faunas of the two systems are so distinct in their general facies, and also in detail, that they are quite as readily separated as the Silurian and the Devonian or the Devonian and the Carboniferous. There is no doubt that in certain areas the faunas of the Cambrian and the Lower Silurian (Ordovician) systems are intermingled; but the same is more or less true of all the great divisions of the entire geologic series from above the great Archæan break to the Quaternary."

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[1] "Classification of the Cambrian System of North America," Amer. Journal of Science, vol. xxxii. and "Bulletin of the United States Geolog. Survey, No. 30," 1886.

[2] "Illustrations of the Fauna of St. John's Group," Trans. Royal Soc. Canada, 1885, and "On the Cambrian Faunas of Cape Breton and Newfoundland," Canadian Record of Science, Oct. 1886.

[3] Bulletin U.S. Geolog. Survey, No. 30, 1886.

Dr. Sterry Hunt has strongly advocated[1] the adoption of the term Ordovician (first proposed by Prof. Lapworth and now used by many authors in this country) for the American second division (Lower Silurian), and it is highly advisable that it should be adopted by American authors, as it would then be possible to know exactly to which portion of the Lower Palæozoic rocks the author referred. The tripartite division of the Lower Palæozoic rocks of Great Britain under the names Cambrian, Ordovician, and Silurian, seems at present the only means of avoiding confusion, and it is highly satisfactory, therefore, to find that some American authors are prepared to accept these terms to designate the primary divisions of the American Lower Palæozoic rocks.[2]

On the other hand, it is advisable that groups and series should still have local names, and the names should be those of places where the beds were first examined, or are well exposed. The following table expresses Mr. Walcott's views on the classification of the various groups that go to make up the Cambrian system of North America.

Classification of North American Cambrian Rocks.

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| UPPER CAMBRIAN. | Lower Calciferous. | Lower portion of the Calciferous Formation of New York and Canada.<br>Lower Magnesian of Wisconsin, Missouri, etc. |
| | Potsdam.<br>Knox.<br>Tonto. | Potsdam of New York, Canada, Wisconsin, Texas, Wyoming; Montana and Nevada; Tonto of Arizona; Knox Shales of Tennessee, Georgia, and Albama. The Alabama section may extend down into the Middle Cambrian. |
| MIDDLE CAMBRIAN. | Georgia.<br>L'anse au Loup.<br>Prospect. | Georgia Formation of Vermont, Canada, & New York.<br>Limestones of L'anse au Loup, Labrador.<br>Lower part of Cambrian section of Eureka and Highland Range, Nevada.<br>Upper portion of Wasatch Cambrian section, Utah. |
| LOWER CAMBRIAN. | St. John.<br>Braintree.<br>Newfoundland.<br>Wasatch.<br>Tennessee? | Paradoxides beds of Braintree, Mass., St. John, New Brunswick.<br>St. John's area of Newfoundland. Lower portion of Wasatch section, Utah.<br>The Ocoee conglomerate and slates of East Tennessee are somewhat doubtfully included. |

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[1] Trans. Roy. Soc. Canada, 1883, and "Mineral Physiology," etc. 1886, p. 528.

[2] In a former paper (Geol. Mag. Aug. 1885) I ventured to suggest that the term "Cambrian," instead of being confined to the lowest rocks, might fairly be extended as a main term to indicate the whole of the Lower Palæozoic rocks, and that the name "Georgian" (from St. George's Channel, on the borders of which the lower rocks are best exposed) would be a suitable term for the lowest rocks. I have since found that the Middle Cambrian rocks of Franklin County, Vermont, America, had previously been designated the "Georgia Group"; therefore it is evident that the adoption for a much larger division of the term "Georgian" would only lead to confusion. It is better, therefore, to confine the term "Cambrian" as in the present paper to the rocks underlying the "Ordovician."

In Bulletin No. 30, Mr. Walcott treats mainly of the fauna of the Middle Cambrian rocks and figures and descriptions of a large number of new genera and species are given. In Great Britain the fauna of these rocks is comparatively a poor one, and none of the typical American forms have as yet been discovered in them.

The American Middle Cambrian fauna is said to combine[1] "the characters of the Lower Cambrian and Upper Cambrian faunas and yet is distinct from each of them. . . . The conditions that developed the Middle Cambrian fauna appear to have been largely peculiar to the American continent. During the deposition of the St. John's series of the Lower Cambrian, or the Paradoxides strata, we learn from the European and eastern American sections, that the fauna was essentially of the same type over the entire basin (Atlantic), and, from evidence known to date, that the fauna did not extend west of a line passing north-east through Eastern Massachusetts to New Brunswick and Newfoundland. . . . From the data we now have, I think that during the existence of the greater portion of the Lower Cambrian (Paradoxides) fauna, a barrier existed that prevented its extension westward of the line mentioned; that towards the close of the time of the Paradoxides fauna that barrier was removed to the north-east, in the vicinity of Newfoundland, and the descendants from the Paradoxides fauna entered the westward seas and spread to the eastern and western basins and formed the Middle Cambrian fauna. What route was taken by the Middle Cambrian fauna after passing to the western side of the outer barrier is not yet traced, but I think from the indications we now have of a continental area, during Lower and Middle Cambrian time, in the central portion of the continent, that the fauna passed to the south around the southern end of the then existing land, and thence north along the west shore. In the Atlantic basin, the Paradoxides fauna persisted to a greater or less extent and mingled with the types of the Upper Cambrian fauna, as in the Upper Lingula Flags of Wales."

As Mr. Walcott is personally acquainted with the strata from which the fossils have been obtained, and has studied in the field most of the sections referred to, the conclusions at which he has arrived are important and highly deserving of very thoughtful consideration.

## V.—The Appearance and Development of Dicotyledons in Time.

By J. Starkie Gardner, F.G.S., F.L.S.

It has been acknowledged by botanists that the methods generally pursued in determining fossil dicotyledonous plants have been scarcely such as were likely to lead to trustworthy results. Their study has, or should have, two practical aims. The one, that geologists may be able to determine the ages of strata, when they only contain fossil plants, with as much certainty as if they contained the remains of animals. The other, that botanists may be able to trace the evolution of the existing genera of plants from the palæontological record under conditions no less favourable than those at the disposal of the zoologist.

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[1] American Journal of Science, vol. xxxii. p. 181.

Each new discovery should fall into a definite place, fill in some gap, and serve as a new point of departure.

That this is not the case when new fossil floras are described is but too apparent. When we sum up and examine the whole of the knowledge we possess of the ancestral forms of existing Dicotyledons, we find we are in a state of almost complete ignorance regarding them. We merely know that in certain formations, which we believe, from their included marine fauna, to be of Cretaceous age, perfectly developed leaves of Dicotyledons abound ; but we do not know with any certainty how far we are justified in assigning them to existing genera, nor in what way they are linked to these. We know absolutely nothing of the successive steps by which even the leading existing families have been developed. We know nothing concerning the evolution of the Leguminosæ, the Proteaceæ, the Cupuliferæ. We see nothing beyond a more or less vague recognition of the fact that plants with simpler flowers should have preceded those with flowers of more compound character. We assume from the absence of Dicotyledons in older Cretaceous rocks that they must have been relatively somewhat rapidly developed; but the where, how, and whence, are still sealed books.

In the first place, we must inquire whether we can be absolutely certain that the ages of the Cretaceous beds which contain them are correctly known. Our first impression would be that the age of the Aix-la-Chapelle series is established on the most unequivocal evidence, for the beds with plants are intercalated between strata which belong lithologically and at first sight palæontologically to our Upper Greensand and Chalk, yet nevertheless the similarity may be completely misleading; and when we compare the faunas together critically, we shall realize that those of the Aachenian series are relatively considerably the younger. In an area of prolonged and gradual subsidence, as Europe undoubtedly was throughout the Upper Cretaceous period, the deep sea, or ancient gulf of the Atlantic, as represented by the Chalk, would gradually encroach further and further in every direction as the levels were lowered. At certain depths blue mud resembling that known as the Gault, and green mud and sands, similar to our Upper Greensand, would now be forming. These require a less depth and are more littoral than the deeper sea deposits corresponding with our Chalk, and in every area where chalk exists are seen to underlie it. During the Cretaceous subsidence, whereever oceanic waters penetrated, one or other or both of these qualities of mud must have preceded the deposition of true Chalk. Nothing could be more erroneous and more liable to beget confusion than to speak of all the blue mud as of one age, the green mud and green sand of another, the calcareous mud with chloritic grains as another, and the finer calcareous ooze as another. Their relative ages must be judged by the faunas they contain, and the greater or less resemblance of the organisms composing these to the existing types now found in the same qualities of sediment. There is no reason to suppose that the Cretaceous subsidence extended over Europe synchronously ; it is at all events perfectly obvious that so long as Chalk was being formed over any part of its area, the formation of those qualities of sea-bed called in their upheaved state Gault and Greensand must also have been forming synchronously over the lesser depths nearer land.

There is no physical reason whatever why the Aachenian, Danish, Irish, Scotch, or even Devonshire basins or gulfs, should not have begun to form contemporaneously with the deposition of the newest White Chalk in Kent and Sussex, or even with the much newer chalks that have since been denuded without leaving a trace. Stratigraphy, or rather petrology, is entirely at fault in this question, while palæontology tends to show that subsidence travelled outwards from the South-East of England and the North-East of France, and that the farther we recede from this centre, the younger will be the relative ages of the Cretaceous series, and the nearer the approach in them to what is recognized as a Tertiary fauna. Cretaceous forms would still be present in the newest of them, for it cannot be supposed that the extinction of these was sudden, or that they must necessarily be absent from a Cretaceous quality of sea-bed, even though its deposition was continued into Eocene times, for much of the life characteristic of the Cretaceous period is even now living in the deeper seas. It would on the other hand be very surprising to find Cretaceous forms in our Eocene muds, as these were formed under wholly different conditions which precluded the possibility of the existence of any faunas approaching in character those of the Chalk. The Aix-la-Chapelle flora, therefore, though overlaid by Greensand and Chalk with some Cretaceous types, is not necessarily as old as it appears to be stratigraphically. In countries so distant as America, we might have had Cretaceous formations in progress *pari passu* with the formation of our Eocene. The presence of some extinct or supposed extinct types is no certain proof of antiquity, for we only know them to be extinct now, but do not know when they became extinct, because we do not at present recognize the possibility of any deep-sea, or, in other words, deposits of Cretaceous aspect, being of Tertiary age. A great number of Cretaceous genera have been discovered to be not yet extinct; why then should we suppose that all those that are extinct disappeared simultaneously with the recession of a Cretaceous-depositing sea from our area, instead of the more rational hypothesis that they disappeared gradually, dropping out now one, now another, at any time between that period and the present day. If these considerations were not lost sight of, we should not find the presence of an Ammonite, Belemnite, or Inoceramus in a deep-sea deposit of America or New Zealand, held as proof conclusive that this is as old as our Cretaceous series, for they may merely be survivals of archaic types, which once swarmed in every condition of sediment, but which gradually took refuge in deeper water, to become extinct, no one can know when until our record of deep-sea deposits be more complete or better understood.

It is thus obvious that the supposed sudden appearance of a number of highly developed and almost perfectly distinct dicotyledonous floras during the Cretaceous period, at so many distinct parts of the world, may be illusory. The first appearance of Dicotyledons remains, however, in any case remarkably sudden, and we are still left with very little clue as to how and by what progressive steps they originated.

The flora of Aachen is, I believe, the most extensive European Cretaceous flora known. Very little concerning it has been published, and neither it nor any other Cretaceous flora with Dicotyledons is adequately represented in any Museum in Great Britain. I had fortunately, however, an opportunity of going carefully through Dr. Debey's collection, and of visiting the quarries whence it had been obtained and even finding a few specimens. Its great antiquity is obvious, despite the presence of dicotyledonous leaves, for the Coniferæ depart very widely from existing species, or even from those of the Eocene, and among the Ferns there seem to be representatives of two singularly archaic genera, *Matonia* and *Thyrsopteris*, which do not occur in any Tertiary formation in Europe. I did not see, and am not aware of any good grounds for the supposed identifications of the Dicotyledons with living genera, such as Oak, Beech, Fig, Willow, Poplar, Bog-myrtle, nor with any genera of the Proteaceæ and Myrtaceæ. The leaves are of considerable variety of form and size, lobed, serrate and simple. There are many other localities in Europe from which similar Cretaceous floras have been obtained, but I am not so well acquainted with them.

A more ancient flora is that of Kome in Greenland, from which a single though apparently perfectly developed dicotyledonous leaf has been obtained, and referred, upon no ground whatever, except a fancied resemblance in the form of the leaf, to *Populus*.

The newer Cretaceous rocks of Greenland are said to contain species of a large number of existing genera; but these appear, with trifling exceptions, to be all determined upon the greater or less resemblance of the fossil leaves to some of the forms of leaf met with in such genera. The ages of the deposits are apparently very uncertain, and no specimens have yet found their way to our museums.

Another extensive and supposed Cretaceous flora from Vancouver's Island has frequently been referred to; but no specimens, so far as I know, exist in England.

A yet more extensive flora is that from the Dakota group at the base of the American Cretaceous series. The leaves are mostly lobed, resembling those of *Platanus*, *Sassafras*, and *Liquidambar*, but seemingly no fruits have yet been identified. A remarkable fact about this flora is, that while utterly disconnected from any other supposed Cretaceous flora in Europe, it bears a resemblance to the English Lower Eocene flora.

Cretaceous rocks containing Dicotyledons are also met with in New Zealand, but as yet little appears known about their floras.

It is quite apparent that the whole subject is still involved in the utmost obscurity, and that our actual definite knowledge of Cretaceous Dicotyledons practically amounts to very little. A man would indeed be bold who ventured to pronounce upon the precise age of any Cretaceous rock only from the character of the dicotyledonous plants found in it. They require, before this can be done, and deserve, the most profound study.

We have next the supposed Pre-Eocene or Pal-Eocene floras, the chief of which are from the calcareous tuffs of Sézanne and the limestone of Gelinden. Large collections from both these localities have been in my possession, and are now in the British Museum. The stratigraphical evidence as to the age of the former is inconclusive, and the flora, rich in flowers as well as leaves, is unlike any other. The Gelinden flora is mainly composed of small and simple leaves, and is equally unlike any other, though its age seems to rest on a surer basis. It does not appear so far that the age of any Pre-Eocene or very old Eocene deposit could yet be recognized with certainty through its Dicotyledons.

We next come to the true Eocene deposits, and in the first place I am able to correct the erroneous assumption that no flora in our latitude comprising such modern and temperate-looking genera as *Platanus*, *Salix* and *Alnus* can be Eocene. At Reading, underneath the true London Clay with its typical marine fauna and the Reading series, leaves and fruits abound of *Platanus* as completely differentiated as existing species. With these are leaves and fruits of at least two leguminous trees, a large-leaved tree with melon-shaped fruits of the size of a walnut, and others forming a completely distinct and homogeneous flora, easily identifiable, and of perfectly defined age. It strongly resembles the Dakota flora of America, but does not seem known elsewhere in Europe. At Newhaven and at Coldam Common near Winchester, we have some Reading plants mixed with others belonging to the somewhat higher and also perfectly characterized horizon of Bromley, Lewisham, Croydon and Dulwich. *Platanus* here mingles with many new forms of leaf, for the most part strongly serrate, forming another group of plants quite unknown out of England. We now reach the well-known flora of Sheppey, led up to by the Herne Bay flora with *Alnus Richardsoni*. The Sheppey flora is extremely instructive, although it is so utterly distinct from any other that it is of little value for purposes of comparison. Such vast numbers of fruits have been collected from it that we may safely consider ourselves in possession of all the chief types, yet, singular to say, though the presence of trees with such easily recognizable fruits as Quercus, Fagus, Corylus, Castanea, Juglans, and some Proteaceous genera has been insisted upon in all the preceding dicotyledonous floras, not a single fruit even remotely resembling those of any one of these genera has been found among them. I do not yet realize the full significance of the fact, but so far most of the early dicotyledonous seeds seem to be clustered in fruit spikes as in *Alnus* and *Platanus* and the *Urticeæ*, and few seem of the nature of single-seeded nuts; nor up to this horizon is there any indication of winged-seeds such as the Maple, Ash and Elm. The oldest leguminous pods seem those from Reading. Next in age, and possibly even to some extent contemporaneous with the London Clay, is the flora of Alum Bay, also met with in France in the Grès du Soissonais. It is specially characterized by leaves of

*Myrica*, large-lobed leaves referred to *Acer*, and large simple leaves referred to *Ficus* and others, together with leaves of an immense Fan Palm. None of the determinations seem well grounded except *Myrica*, but there are several leguminous fruits, and the flora, as a whole, is easily and immediately recognizable, and would suffice to define the age of any beds in which it occurred.

Following in order is the Bournemouth flora, of great variety and extensively collected. It is very unlike any of the preceding, and were its age not absolutely known beyond the faintest possibility of doubt, it would have been referred to the Miocene, though actually older than the Bracklesham beds. It greatly resembles the Eocene floras from the South of France and of the Lignitic Series of America. Its affinity to the Oligocene floras of the rest of Europe appears so great that it is doubtful whether any distinct line can be drawn between them, but a little higher at Hordle, some of the Older Eocene Reading types seem to mingle with it.

All these Eocene floras are in beautiful preservation, and their stratigraphical position is definitely ascertained. A careful study of them will be repaid by much valuable information regarding the order of appearance of the genera of Dicotyledons, and would enable us to at once recognize the ages of any Eocene floras of adjoining countries. We should be able to argue from the known to the unknown, instead of the reverse as heretofore practised, and to construct for the first time a definite chronological sequence with which other floras might be contrasted and compared. The series can only be paralleled by the fossil floras of South-Eastern France, so beautifully described by Saporta.

In utilizing them for comparison with the fossil floras of other countries, the differences of latitude and longitude must be taken into account. Nor have we any right to suppose that all the plants preserved from an immense number of localities grew at the same elevation above the sea, while they may also have lived on very different stations, and under relatively dry or moist climates. Any of these influences, singly or combined, might profoundly modify floras, which, though perfectly contemporaneous, would then present very different compositions and aspects. Such considerations are so very obvious, that it would seem almost unnecessary to insist on them, yet we find in examining works on the Miocene floras that they have not been regarded. Floras from Spitzbergen in the North to Australia in the South have been classed as Miocene from a very slender fancied resemblance to those of Switzerland, and great series of strata have been assigned without sufficient reason to that age, not only in Central Europe, but in such distant lands as Greece, Madeira, Borneo and Sumatra, Sachalin and Alaska, and in fact wherever other evidence of age was absent. The resemblance of some of these floras to those of Switzerland is in many cases very shadowy and quite insufficient to justify any conclusion as to their age; but it is more than doubtful whether many of the supposed Lower Miocene Floras of Switzerland classed as Aquitanian are not themselves as old as the Eocene, and others, as the Mayencian, Oligocene. Enough has, however, been said to show that no scientific value can attach in a general way to these determinations, and it will suffice to select the Greenland floras as an example, and to investigate the evidence upon which their supposed Miocene age was originally established. This was stated in 1868 to rest on an assured basis, when of 70 described species, 20 were alleged to occur in Miocene beds of Central Europe.

Of these two are Ferns, and appear respectively allied to *Osmunda regalis* and *Pteris aquilina*. They are ancient and northern forms which do not appear in any profusion to the south until Miocene times, though the *Osmunda* occurs in the old Eocene of Gelinden. Of Coniferæ two are referred to *Sequoia*; the first is erroneously united to *S. Couttsiæ* of Bovey, and the second, *S. Langsdorfii*, is a form known in the Cretaceous, and to which every fragment of distichous Coniferous foliage from the Tertiaries, that could not be placed in the third form, *Taxodium dubium*, has been at one time or another referred. The latter genus is found in the Middle Eocene of England. The sixth plant is merely a rush-like fragment referred to *Phragmites*. Of the thirteen Dicotyledons, ten are the most ordinary and widespread forms of leaf, such as occur in every flora, and of the three that are at all distinctive forms, two, the *Platanus* and *Populus Zaddachi*, are characteristic of the Lower Eocene of Reading, and the third has only been found elsewhere in the Oligocene of Armissan. The age of the Greenland formations can hardly be considered settled on such evidence as this, even were the determinations trustworthy, which is far from the case. Of course enormous quantities of plant remains have been described from Arctic formations since then, but they do not help to justify their reference to the Miocene, and the significant fact remains, that the most distinctive species belong to the Eocene floras of Reading and of Gelinden.

But supposing the identity of the floras were satisfactorily established, should this suffice to establish contemporaneous growth? Could floras of forest trees so closely related to existing species have grown at so recent a geological period synchronously with 24° of latitude intervening? This, it must be remembered, is the distance between Lombardy and Iceland, or Florida and Newfoundland. There is no reason why Eocene floras should be unrepresented round the Pole, and all the Eocene formations existing there be unfossiliferous. A series of sedimentary rocks destitute of fossils, and sometimes a thousand feet thick, is said to occur between the uppermost Cretaceous and lowest supposed Miocene, representing probably the temperate Lower Eocene period, when forests of leafy trees could no more have grown within the Arctic Circle than they would at the present day. As the temperature increased towards the Middle Eocene period, the temperate floras of the Lower Eocene would have migrated north, and we accordingly find, not fancied resemblances, but identity established by the presence of such peculiar and typical species as the Reading *Populus Zaddachi*, *P. Richardsoni*, *Platanus*, and the Gelinden *McClintockia* and *Cocculus Kanii*.

The Middle Eocene temperature was moreover exactly that required, according to Heer, to admit of the growth of the Greenland floras, for it was above 70° Fahr. in the South of England, lat. 50°, and 50° Fahr. in Greenland, lat. 70°, the distance, difference in temperature, and difference between the floras being as nearly as possible equivalent to that existing between Madeira and England at the present day.

When we reflect that the first dicotyledonous floras of any extent to be described were from the Miocenes of Italy and of Germany, we are no longer surprised at the immense relative importance that that formation assumed in the eyes of subsequent workers. It is small wonder that Heer was led by comparisons with these and with the well-known Miocene formation of Oeningen, to class all the dicotyledonous floras of Switzerland as Miocene. As each is in turn farther and farther removed in age from the horizon of Oeningen, it is seen to contain a decreasing proportion of true Miocene types. Thus, of the floras belonging to the Aquitanian stage, only six out of 34 species at Ralligen, 27 out of 193 species at Monod, and seven out of 47 at Paudèze, are common to Oeningen. Yet each in turn, as it came to be incorporated in the Miocene, has furnished fresh standards for comparison, each addition approaching more nearly to Eocene types, and departing more widely from those of the Miocene. By including the Swiss Aquitanian and Mayencian in the Miocene, and then in comparing Eocene and Oligocene floras of other countries with them, the latter would be shown to possess Miocene characters, for there can be little doubt that the Aquitanian floras are really Eocene, and the Mayencian are truly Oligocene. We thus get at the root of the matter, and though I could not induce the lamented Prof. Heer to understand the grounds of my contention, I have no doubt that had he lived to investigate our magnificent and typical series of English floras, he must have modified his views. The process of assimilating floras with the Miocene became a habit with him, and was always justified by percentages. He persistently ignored Eocene floras, and it was only the stratigraphical and overwhelming palæontological evidence as to the position of the Dakota and other floras of America that led him to admit the Cretaceous age of the older dicotyledonous floras.

It was Heer's privilege to describe the floras of Greenland, and he called them Miocene. Had it fallen to Saporta's lot, he would possibly have assigned to them a Lower Eocene age, on account of the considerable number common to Gelinden, including the typical *M'Clintockia*, which had not then been found in any other formation. A student of our Reading flora would have assigned them to that age. The Greenland flora has in its turn served to identify the Mull and the Antrim floras as Miocene, and must have absorbed the Gelinden flora and the American floras, had stratigraphical evidence not intervened and made this impossible. Not the least remarkable fact about these determinations is, that wherever the stratigraphical evidence is *nil*, as at Antrim, Mull, and Bovey, the floras are Miocene; but where there is stratigraphical evidence, we hear of few Miocene floras to the west of Switzerland.

Before quitting the subject, it is well to revert to the danger of determining the ages of fossil floras in remote parts of the world by comparing and estimating the percentages common to those of Europe. Not only have we to keep in mind the similarity that dicotyledonous leaves belonging to different genera bear to each other, a likeness increased by the process of fossilization where the matrices are similar, but the fragmentary condition of the specimens usually brought from distant countries. In the first five volumes of the Arctic flora hardly a perfect dicotyledonous leaf is illustrated, and it is most rare to find them collected with so important a character as the petiole complete. In addition to this, were we to take an armful of fallen leaves at random from each country, such as Siberia, Japan, Sumatra, Australia, New Zealand, Madeira, Scotland, France, Greece and the United States, and compare them together after the manner of palæontologists, is it likely that we should find grounds for supposing that they all belonged to floras growing synchronously? The fallacy of such reasoning is even more apparent when we realize that a considerable percentage of the species of even Eocene floras, including such unmistakable forms as *Osmunda Javanica*, are now living on the East Coast of Asia, for a comparison by percentages would make the existing and the Eocene floras contemporaneous. In like manner we have living Asiatic species at Mull and Antrim, living Australian species at Bournemouth and Sheppey. These must have migrated to or from their present habitats, and might be found imbedded anywhere along the routes they have passed over, and if so found might be of any age between the Eocene and the present day.

We are too accustomed to treat these floras as complete exponents of the vegetation of the past. They are, however, but mere fragmentary indications of what existed. The flora of Gelinden consists of, for instance, some 60 species, but only contains three Ferns and one Conifer. Can we suppose that Ferns and Coniferæ were not at least as richly represented then as now? And if we were well acquainted with the bulk of them, how entirely erroneous our inductions from the few we do know might appear. Bournemouth is a case in point, for on the right of the old river delta, of which the present cliffs are a section, the flora is completely different in character to that met with on the left. The latter is a flora of leafy trees, and had it alone been accessible, the climate might have been inferred to have been too temperate for the growth of Palms, for none are found in it. Thus an utterly different view of the character of the plant world of the Eocene period during the Middle Bagshot would be deduced by a student of the flora of the right bank, from that fairly deducible by a student of the left bank. But, extraordinary to tell, within a few hundred yards of the latter, still another completely different flora is found, in which occur Fan Palms in place of Feather Palms, *Araucaria Cunninghami*, *Eucalypti*, *Aroïds*, and a whole host of tropical Ferns. Even now, after years of collecting, new and astonishing plants are continually coming to light, such as *Hewardia regia*, a South American type of Fern, and

*Stenocarpus*, a purely Australian genus, as if to impress the danger of prematurely drawing inferences. Not deep below we have another completely different tropical flora on the Alum Bay horizon, with scarcely a type of plant in common to the horizon above; and again, separated in this district by only a few hundred feet, we might find the characteristic flora of the Reading beds with an utterly distinct assemblage, indicative of a temperate climate. In face of such amazing facts it is only possible to smile at the glib way in which temperatures and comparisons for every little handful of fossil plants are set out, and the physical features of the country which bore them reconstructed.

These remarks are not intended to discredit those who have laboriously worked at the task of deciphering fossil floras. They are simply meant to warn those who have to make use of the facts arrived at, that the conclusions and the inductions drawn from them are not based upon foundations as assured as those of other branches of geology and palæontology. They may or may not prove to be wholly or partially correct, but what we had best do for the present is to abstain from theorizing, and to devote ourselves to the work of deciphering, more especially those floras whose ages are definitely stratigraphically known, and by friendly intercourse and repeated comparisons of actual specimens, to ascertain beyond all dispute that a species means one and the same plant to each individual worker.

If at the same time it could be agreed that new species should not be founded on fragments so obscure and imperfect that no good specific characters can be obtained from them; that references to genera founded only on resemblance of foliage should be distinguished by a special termination; and that fossil plants found to be still existing should bear the name of the living plants; the science would rapidly command that consideration and respect to which its vast importance so well entitles it.

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## VI.—NOTES ON THE EROSIVE POWER OF GLACIERS, AS SEEN IN NORWAY.

By Professor J. W. SPENCER, M.A., Ph.D., F.G.S.

1. DURING last summer it was my good fortune to visit the three largest snowfields in Norway, namely, Folgefond, at the head of Hardangerfjord, in Southern Norway, whose area is 108 square miles; the Jostedalsfond, two degrees to the northward, and beyond Sognefjord, whose area is 580 square miles, and the largest snowfield in Europe; and the Svartisen, of nearly equal area, extending from just inside the Arctic Circle for 44 miles to the northward. All of these snowfields send down glaciers to within from 50 to 1200 feet of the sea. These snowfields are not basins like those in the Alps, but are mantles covering the tops of the plateaux from 3000 to 5000 feet or more above the tide, from which great *cañons* suddenly descend to the sea, and extend themselves as fjords from 1000 to even 4000 feet in depth.

2. Many of the Norwegian glaciers are rapidly advancing. In their progress they do not conform to the surfaces over which they are passing, but are apt to arch over from rock to rock and point to point, especially as they are descending the icefalls. Thus are produced great caverns into which the explorer can often wind his way for long distances.

3. Beneath the glaciers of Fondal, Tunsbergdal, and Buardal, in the northern, north central, and south central snowfields of Norway, as well as under other glaciers, I observed many stones enclosed in ice, resting upon the rocks, to whose surfaces—sometimes flat and sometimes sloping steeply—they adhered by friction, and by the pressure of the superincumbent weight. Although held in the ice on four sides, with a force pushing downward, the viscosity of the ice, or the resistance of its molecules in disengaging themselves from each other in order to flow, was less than that of the friction between the loose stones and the rock, consequently the ice flowed around and over the stones, leaving long grooves upon the under surfaces of the glaciers. (The use here of the word 'viscosity' is in the sense of ice moving like a viscous body, irrespective of the cause.) The first observation made was at Fondalbræ, where an angular stone, whose section was 10 by 18 inches, rested upon the sloping face of smooth rock. For 20 feet below the stone, the under surface of the glacier was grooved by the moulding of the ice about the obstacle. This distance showed the advance of the glacier after the stone had come in contact with the rock, for it had evidently been completely buried at the lower end of the groove, before the ice had begun to flow about it. As the ice between the stone and the rock gradually disappears, the embedded stone does not suddenly cease to move but drags, until enough of its surface rests upon the rock to allow of friction between the two granitoid surfaces to overcome the viscosity of the ice, when the latter flows around the obstacle. Elsewhere an example of this action was seen. The knife edge of a wedge-shaped piece of gneiss was protruding beneath the ice and resting upon the rock. The front end of this stone had moved beyond the subjacent surface, whilst the posterior end was still upon it. Yet the sharpness of the edge had scarcely been blunted.

4. Abundant examples were found showing that the flowing of the ice about loose obstacles was quite the rule. Both large and small (even an inch in length), angular and rounded masses lying either upon the rock, or upon morainic matter, were sufficient to channel the bottom of an advancing glacier.

5. No blocks of rock were seen in the act of being torn loose from the floor or sides of the valley, and certainly there were no loose or solid masses being picked up by the advancing glacier.

6. At Tunsbergdalbræ, whose lower end is 1600 feet above the sea, a modification of the above-described phenomenon was seen. A roughly rounded boulder of 30 inches diameter was enclosed in the convex side of the glacier, which rose above it from 30 to 50 feet in height. It was resting upon a surface, sloping at 45°, and was held in place by the ice itself. As the surface of the stone, bearing upon

the rock, was small compared with that held in the ice, it should have been dragged along. But it was being rolled, as shown by the moulding of its form in the glacier, which was advancing faster than the stone was rolling down the steep slope. The pressure upon this stone could not have been merely that of the superincumbent ice, but a powerful component of the energy of a glacier descending 1500—2000 feet, as if the ice were moving more or less as a fluid. The energy upon our boulder was sufficient to crush it into one large and two smaller masses, together with stone dust. When seen these fragments had hardly begun to part company.

7. The abrasion of the solid rock by the fall of stones, and detached masses of ice and stones was illustrated at the locality just named. The two guides and myself succeeded in detaching a large boulder of about five tons weight, adjacent to the edge of the glacier. It went rolling and sliding down a hundred feet or more, tearing away great blocks of ice, which held a considerable amount of *débris*, and in its wake the rock was more or less crushed and scratched.

8. A further example of the ability of the ice to flow like a plastic body was shown in a cavern 400 feet higher than the end of the glacier, where the temperature was 4° C., whilst that outside was 13° C. Upon the *débris* of the floor rested a rounded boulder whose longer diameter was 30 inches. It could have been rolled over by one man. A tongue of ice, in size more than a cubic yard, was hanging from the roof, and pressing against the stone. In place of pushing the stone along or flowing around it, the lower layer of ice above the tongue had yielded, and was bent backward at right angles, as easily and gracefully as if it had been a thin sheet of lead, in place of one of ice a foot thick.

9. According to the experiments of Pfaff,[1] the temperature of ice has a great deal to do with its flow about obstacles. Below freezing-point, the movement is scarcely more than appreciable, whilst above that point, but not below, it may reach 28 inches a day or more. The conditions arising from the temperature beneath a glacier are more or less favourable to the movement of the ice, as the lower surfaces are never entirely below freezing-point, even in winter. Prof. S. A. Sexe found that the water flowing from a Folgefond glacier,[2] in February, 1861, had a temperature of 1° R., whilst that of the air was 7° R.

10. The movement or flow of the ice about detached stones has been observed by Prof. Sexe beneath the Buarbræ, and by Prof. J. W. Niles[3] beneath the Aletsch glacier. Prof. Sexe illustrates the sliding of the ice over a loose stone, which was wedged beneath the glacier by a projection of the rock. My observations were upon masses not held up by wedges, but upon surfaces often sloping downward. Although Prof. Niles did not record observations showing that there was definite movement of the stone, yet he concluded that

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[1] Nature, Aug. 19th, 1875.

[2] "Om Sneebræen Folgefon," af S. A. Sexe.

[3] Am. Jour. Sc., Nov. 1878.

there was a differential movement of the ice and the block. Whatever differential movement there is beyond that referred to, it must be very inconsiderable even upon the inclined surfaces, and upon the horizontal plains it must be indefinitely small, as here even the movement of the ice is reduced to almost zero, as shown by the measurements of Prof. Tyndall,[1] upon the Morteracht, where the velocity of the surface, some distance from its end, was 14 inches, whilst that of the tongue of the glacier, as it reached the plain, was only two inches a day.

11. The most favourable condition for holding stones in ice as graving tools is low temperature, which impedes its progress, but this condition beneath the glacier does not generally exist. At higher temperatures the velocity of the glacier is not great enough to overcome its plastic movement and to drag along the detached blocks. However, when the whole mass of ice is charged with sand and stones, there is no doubt that polishing and some scratching are effected : but when there are only occasional fragments in the bottom of the ice, as is commonly the case, the erosion from the sliding ceases, as soon as the resistance due to friction between the stones and the rock equals that due to viscosity, which observation shows to be soon reached. Consequently we should not expect to find great troughs or grooves scooped out by the actual glacier. These I have not seen about the existing glaciers of Norway, which are not dependent upon atmospheric and aqueous erosion and the texture of the rock, although their surface may have been subsequently polished. Generally speaking, as shown in the valley behind the Fondal Gaard, where the glacier is nearly free from sand, and contains comparatively few stones, as well as at many other places, the surfaces of the subjacent crystalline rocks, although of the form of *roches moutonnées,* with angles mostly removed, are not smooth, but are as rough and as much weather-worn as similar rocks in warmer countries where no glaciers have been. Upon these surfaces it is often difficult to discover any scratches, even where present, for they are often so faint as to be only rendered apparent by moistening the rock. Even the faces of the hummocks are commonly unpolished. In other places, particularly at Tunsbergdalbræ, which contains much sand along the margin, the rocks are highly polished and but little scratched. One is everywhere surprised to find beneath the glaciers the paucity of glaciated stones, and in many terminal moraines they are scarcely if at all to be found.

12. The insufficiency of glaciers to act as great erosive agents is further shown at Fondal, where a mass of ice, 30 to 40 feet thick, abuts against a somewhat steep ridge of rock, 10 feet or less in height. In place of a stone-shod glacier sliding up and over the barrier, the lower part of the ice appears stationary (or else is moving around the barrier), whilst the upper strata bend and flow over the lower layers of ice.

13. When the barrier to the advance of a glacier is met with, whether composed of hard rock, or of morainic matter, the ice,

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[1] Tyndall's "Forms of Water."

provided it be sufficiently high, flows over upon itself, yet when the sheet is no higher than the barrier, the lateral thrust may push it up somewhat. The best example of the consequences of such a condition is to be seen at Svartisen glacier, at the head of Holandsfjord, which descends to within 50 feet of the sea, where it ends in a morainic lake of considerable size, the northern side of which is filled with ice. The water of the lake rises, in part, to the level of the ice, or over it, where the waves of the lake are depositing sand upon its surface. Part of the ice is not less than 25 feet thick, and most of it is probably double that thickness. Some of the strata of the ice are pushed up and rest at 5° from the horizontal. But the interesting observations are at the end of the glacier, where it impinges against the morainic barrier. Being unable to advance, the lateral pressure has forced up an anticlinal ridge, or rather dome, in the ice, to a height of 15 feet, along whose axis there has been a fracture and fault. Upon this uplifted dome rests the undisturbed sand stratified perfectly conformable to the surface which was formerly just below the level of the lake. As the ice about the line of fracture melts, the sand falls over and leaves a sand cone, of which there were examples, one at the end of the lake, and two in the centre, but the *nuclei* of the mounds were of solid ice. By this lifting process, pockets of loose clayey sand were thrown on top of the morainic matter, producing thus the appearance of having been ploughed up by the glacier, to even several yards beyond its termination.

14. Nowhere is there apparently more ploughing action, and yet little or none to be seen, than at the Buarbræ, which is advancing rapidly against a high lateral moraine. There is a large ridge of stone upon a thin snout of the glacier, just as if the ice were pushing under the boulders or earth, which, however, it is not doing. The glacier has a steep convex margin, from 20 to 40 feet high, with many blocks and boulders upon it. These become detached, and rolling down upon the lower tongues of ice, leave a deep trough between the ridges thus produced and the side of the glacier, and delay the melting of the layer of ice beneath, which is too thin to do any undermining of the moraine.

15. An excellent illustration of a glacier advancing, without any ploughing action, over a moraine, and at the same time levelling it into a sort of ground moraine, was seen at the Suphellebræ. Here the glacier was moving up the slight elevation or moraine produced by the early summer retreat of the glacier, although advancing again in July. The lower surfaces of the ice tongues were furrowed by the loose stones of the soft incoherent water-soaked moraine, into which one's foot would sink when stepping upon it. The moraine was being levelled by the constant dripping of the water from the whole under surfaces of the advancing glacier.

16. This glacier of Suphelle is the most remarkable of its kind, being a *glacier rémanié.* From the Jöstedalsfond, which, near the head of Fjærlandfjord, is 3000 to 4000 feet high, the clear bluish ice and the consolidated snow fall over a precipice of dark rocks for

about 1000 feet, and at about 1500 to 2000 feet above the sea re-form into a glacier extending down into and nearly across the valley of Fjærland, for a distance of somewhat less than a mile, to a level of only 175 feet above the sea. The glacier is much crevassed and covered and filled with *débris*. In fact, it is the most dirt-laden glacier known—not excepting the Aar glacier in the Alps. These materials are wholly derived from the side of the mountain, and brought down by frosts, and more largely by the fall of ice as it dashes from one frost-cracked rock to another. One of these great ice avalanches I witnessed from the other side of the valley—fully a mile distant. Thousands of tons must have fallen at this time, but as the ice fell from rock to rock, it was converted into what, seen from the distance, appeared to be white dust.

17. There are no considerable streams from the upper glacier, but from the melting ice, below the fall, the volume of water laden with mud is large. As this glacier is not ploughing up but levelling down the inequalities of its bed of loose materials, we cannot suppose that the mud comes from any other than the dirt upon and within the ice, and that obtained by the dripping water as it levels the terminal moraine. This is only one of the examples everywhere to be seen showing the erroneous estimate of glacier-erosion, when based upon the amount of mud carried down by the streams flowing from the glaciers, for the *débris* is brought upon their surfaces by other than grinding action, and, as far as observation goes, it is not derived from beneath them, at least, to any great extent.

18. Although I have seen some of the sharp angles of the rocks at 2000—3000 feet above the sea, along the sides of the valleys, more or less rounded, yet the inequalities of the faces have not been generally removed by erosion of any kind. At numerous places in Norway as well as in other countries, hummocks of rocks rise above or out of the glaciers, as the ice flows around them at lower levels—these channels having been deepened not by glaciers but by subglacial streams.

19. Nowhere are the *roches moutonnées* so abundant as on the coast of Norway. In their more perfect form, they are not extensively developed along the coast more than 250 feet above the sea. At higher altitudes they are best seen about glacier-falls, farther up the valleys. But since the Pleistocene days, the coast has been raised several hundred feet, at least. The form of the hummocks is precisely like what may be seen in South-Eastern Missouri, and other states south of the line of northern drift, or like those described in Ceylon, Brazil, and other tropical countries, to which only are added the scratches. The forms of the hummocks must be principally attributed to the atmospheric erosion of the crystalline rocks, where the *débris* has been swept away by currents or by ice. We see them more frequently swept clean upon the coast of either cold or warm countries than in the interior, where the currents are only those from rain or local glaciers, for even the sweeping beneath the glaciers is principally effected by dripping waters or streams. Prof. Kjerulf, of the University of Christiania, than whom there is no better

authority, regards the production of hummocks and their glaciation up to a height of 600 feet upon the coast of Norway as the result of floating-ice.[1]

20. The absence of transported boulders and striations upon the surface of many parts of the high plateaux of Norway is doubtless, in part, attributable to the capacity of ice to flow over loose obstacles, and the frequent want of higher ridges to furnish material by their *débris* falling upon the ice, which might afterwards work through the mass.

21. The faith in glaciers as great erosive agents has been so severely shaken, that most geologists who personally study those still existing do not attribute to them much greater power than that of removing soft materials, or are even sceptical of this power—as, for instance, Prof. Penck of the University of Vienna, who has been misquoted as having proved their great potency.[2] To this scepticism, it seems to me that these notes must contribute, especially when applied to the hypothetical excavation or modification of great lake-basins, and the transportation of northern materials in the Boulder-clay over the broad plains of America, as there were no mountains of adequate height with peaks and screes to supply the detritus sufficient to furnish the surface of the glaciers with all the boreal material of the drift, which now covers half a continent.

UNIVERSITY OF MISSOURI, Feb. 1887.

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## VII.—ON *HEMIPHYLLUM SILURIENSE*, TOMES.

By H. ALLEYNE NICHOLSON, M.D., D.Sc.,
Regius Professor of Natural History in the University of Aberdeen.

IN the last Number of the GEOLOGICAL MAGAZINE there is published a paper by Mr. Robert F. Tomes dealing with two Corals from the Silurian rocks of Britain. For the reception of one of these Corals Mr. Tomes proposes to form a new genus under the name of *Hemiphyllum*. The single species of this proposed genus he identifies, somewhat doubtfully, with the form described by M'Coy (Ann. Nat. Hist. ser. 2, vol. vi. p. 281, 1850) under the title of *Cyathaxonia siluriensis*; and he therefore describes it as *Hemiphyllum siluriense*, M'Coy, sp., with a note of interrogation.

I wish, however, to point out, in the first place, that the description and figures given by Mr. Tomes of this Coral render it perfectly certain that he has had to deal with a species of the genus *Calostylis*, Lindstr., founded long ago, and rightly referred to a position among the *Eupsammidæ*, by Dr. Gustav Lindström (Öfversigt af Kongl. Vetenskaps-Akad. Förhandl. 1868, and Kongl. Svenska Vetenskaps-Akad. Handl. Bd. ix. 1870). The proposed genus *Hemiphyllum*, Tomes, cannot, therefore, be sustained, and the name must simply

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[1] Discourse before Meeting of Scandinavian Naturalists, Copenhagen, 1873.

[2] GEOLOGICAL MAGAZINE, April, 1883.

be added to the long list of synonyms which already afflict the students of Palæozoic Corals.

In the second place, with regard to the *specific* determination of Mr. Tomes's Coral, it may at once be unhesitatingly stated that it has no relation of any kind to the form which M'Coy described as *Cyathaxonia siluriensis*. Of all the troublesome little cup-corals of the Silurian and Devonian rocks, I do not know one so clearly marked off and so easily recognized by its general aspect and characters as this rare form, and I am at a loss to imagine what should have led Mr. Tomes to suppose that he had to deal with examples of this species. That *Cyathaxonia siluriensis*, M'Coy, is not a species of *Cyathaxonia*, Mich., but that it is truly referable to the genus *Lindstrœmia* has been formerly pointed out by Mr. R. Etheridge, jun., and myself (Mon. Sil. Foss. Girvan, p. 82, 1880). Our determination was based simply upon a macroscopic examination of the species; but I have since then examined the species by means of thin sections, and have completely confirmed our reference of it to *Lindstrœmia*. I shall take an early opportunity of publishing a description and figures of its internal structure.

The *Hemiphyllum siluriense* of Mr. Tomes is not, however, referable to any recorded species of the genus *Calostylis*, Lindst. So far as I am aware, only two species of *Calostylis* have been previously described, both of these being from the Silurian rocks. One of these is *C. denticulata*, Kjerulf, fully described and figured by Lindström, first under the name of *C. cribraria*, and subsequently under the above title (*loc. cit.* supra). The second species was described, from British specimens, by Mr. R. Etheridge, jun., and myself (Mon. Sil. Foss. Girvan, p. 65, pl. v. figs. 2—2*c*, 1880), under the name of *C. Lindströmi*. Neither of these species agrees in its characters with the form which Mr. Tomes has had under examination. This I am the better able to affirm as I have not only fully examined the two recorded species of *Calostylis*, but I am well acquainted with the species here in question. My friend, Dr. George J. Hinde, in fact, presented me with specimens of this form, from the Wenlock Shales of Buildwas, some years ago, since which time they have lain in my cabinet with the MS. name of *Calostylis breviuscula* appended to them; but I have never found time to publish a description of the species.

Lastly, with regard to the Corals to which Mr. Tomes refers under the name of *Cyathaxonia Dalmani*, E. and H., I may point out that Dr. Lindström long ago recognized that the Coral so named did not belong to the genus *Cyathaxonia* at all. The correctness of this view was demonstrated by Mr. R. Etheridge, jun., and myself (Mon. Sil. Foss. Girvan, p. 84, fig. 4), who showed that *C. Dalmani*, E. & H., belonged properly to the genus *Lindstrœmia*, Nich. and Eth. jun., a determination which has been since accepted by Dr. Lindström himself (List of the Fossils of the Upper Sil. Form. of Gotland, p. 19, 1885).

## NOTICES OF MEMOIRS.

### L'Excursion de la Société géologique en Bretagne. Par M. De Lapparent. Revue Scientifique, 8 Janvier, 1887.

THIS is an article upon the excursion already described in the February Number of this Magazine. It gives a general view of the geological features of the Armorican peninsula, the igneous and metamorphic rocks occurring there, and certain questions hitherto controverted on which evidence regarded as conclusive was produced. Among these were the age of certain granites, the causes of the metamorphism in certain localities, and the nature of the passage from Cambrian strata to Silurian. As to this last, the sections in the Bay of Douarnenez and the succession seen at Gourin are said to present concurrent indications that in this district the transition is conformable and continuous.

Upon the Archæan question the author expresses decided opinions. To think that the crystalline schists can be excised from the chronological succession, and to regard them as capable of being produced out of any strata, whatsoever their age, is, he says, "an extension of the idea of metamorphism which is altogether a misuse of it." "The facts observed in Brittany seem fatal to this view." E. H.

## REVIEWS.

### Geological and Natural History Survey of Canada. Annual Report (New Series), Vol. I. Accompanied by an Atlas of Maps. Royal 8vo. pp. ix. and 798. With Geological Maps, Plans, Plates, and Woodcuts. (Montreal, 1886.)

THE present volume ushers in a new series, and although entitled Report for 1885, it includes work done in previous years, and in the early part of 1886. It begins with the customary "Summary Report" ("A." pp. 1A—108A [1]) by the Director, Dr. A. R. C. Selwyn, F.R.S., F.G.S. This contains an excellent résumé of the operations of the Geological Staff in the field, and of the work carried on at head-quarters (Ottawa) in the museum, laboratory, and library.

The succeeding reports fully sustain the deservedly high reputation so long enjoyed by the Canadian Survey. Many important contributions to the history of the geology and resources of the country are contained in them; showing how work has been prosecuted "over portions of every province and territory in the Dominion, from Nova Scotia to the west coast of Vancouver Island."

Among the varied duties that now fall to the lot of the Dominion geologists are included the collection of specimens illustrative of the Zoology, Botany and Ethnology of the tracts explored, in addition to their Geology and Lithology.

Messrs. Whiteaves and Ami undertake the palæontological and zoological work, with the occasional assistance of eminent English

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[1] The Reports being also published separately, each is distinguished by a letter or letters in the pagination.

and American "specialists." Professor Macoun (Botanist to the Survey) reports upon the plants collected, while Sir J. W. Dawson frequently lends his valuable assistance in the department of palæobotany. Messrs. Hoffmann and Adams carry on the work of the chemical laboratory. The staff now numbers 50, viz. 34 "professional," and 16 "ordinary" members.

Much attention is naturally bestowed upon the mining industries of the country. In 1885 a survey was commenced by Mr. Bowman and assistants of the gold-mining region of Cariboo in the interior of British Columbia. This district, comprising an area of 50 by 75 miles, has yielded in the past twenty-five years about thirty million dollars of gold by placer mining. The various mining centres in the Eastern Townships (Province of Quebec, east of the St. Lawrence) were visited by Messrs. R. W. Ells and N. I. Giroux. The minerals obtained are gold, silver, iron, copper, and asbestos. In the last of these a flourishing trade is carried on. The copper deposits are also extensively worked. Most of these minerals find a market in the neighbouring States.

Leaving the Summary Report, of which we have given but a very brief sketch, let us now turn to the reports of the field corps, which make up the bulk of the volume.

Report B. (pp. 7B—167B), by Dr. George M. Dawson, "is intended as a preliminary geological and general account of that portion of the Rocky Mountain range included between the 49th parallel on the south and the upper waters of the Red Deer River (about lat. 51° 30′) to the north. The Rocky Mountain range proper, in this region, is definitely limited to the south-west by the great Columbia-Kootanie Valley, which separates it from the Selkirk and Purcell ranges, while to the north-east the edge of the Palæozoic rocks may be regarded as its boundary. The width of the range thus naturally outlined is about fifty miles. The length of the range here treated of in a north-west and south-east bearing is about 200 miles, while the approximate total area covered by this report and the accompanying map is about ten thousand square miles." The map spoken of is geologically coloured, and is on a scale of five miles to one inch. It contains marginal notes and sections.

Beginning with an account of former geological and geographical explorations of the region, amongst which the most important were those of Captain Palliser, Dr. Hector, and Mr. Bauerman, the author proceeds to describe its orographic features. He explains that the so-called Rocky Mountains are divisible into four great systems, which are from east to west as follows:—"(1) The Rocky Mountains proper; (2) Mountains which may be classed together as the Gold Ranges; (3) The system of Coast Ranges sometimes improperly regarded as a continuation of the Cascade Mountains of Oregon and Washington Territory; (4) A mountain system which in its submerged parts constitutes Vancouver and Queen Charlotte Islands."

Taking up the geology of the district surveyed by Dr. Dawson, we find that the Cambrian is the basal formation, and consists of "quartzites, and quartzitic shales passing into argillites, and occasionally including limestone or more or less calcareous or dolomitic materials and conglomerates. Sheets of contemporaneous trap also occur, probably at several horizons."

An instructive section of the Cambrian formation, with a thickness of about 3000 feet, was met with near Waterton Lake, and in the eastern part of the South Kootanie Pass. But between the latter and the Flat-head River these beds were calculated to have a minimum thickness of 11,000 feet, and this "included neither the summit nor the base of the series."

The similarity both as respects their lithological characters, and the general absence of life, of the Cambrian of this part of the Rocky Mountains, to that of the Wasatch Mountains in Utah, and to the same rocks of the Chuar and Grand Cañon Groups of the Colorado Cañon in Arizona, is pointed out by the author. Mr. C. D. Walcott (Amer. Journ. Sci. vol. xxvi. p. 437) has suggested that the absence of the Lower Cambrian Fauna in the western part of the Continent of North America may be due to a land barrier having existed at that time between the eastern and western portions of the continental area. But Dr. Dawson remarks that "the body of water in which the lower portion of the rocks here described were deposited was a basin separated from the ocean, and, occasionally, if not continuously, in the condition of a saturated brine, and this may in itself explain the absence of life of any kind, at least in this particular region."

Between the Cambrian series and the "Devono-Carboniferous" rocks which succeed, and rest unconformably upon them, there is an interval which is in part at least filled up in the north-western portion of the area by a mass of beds of "Silurian and possibly also of Cambro-Silurian [Ordovician] age."

The "Devono-Carboniferous" series attains an estimated thickness of from one thousand to four thousand feet and "forms many of the most prominent ranges and mountain masses." This great limestone series is overlaid unconformably by rocks which are upon stratigraphical, in the absence of palæontological, evidence deemed to be of Triassic age, and are here "probably the northern limit of a great Triassic mediterranean sea, which extended far to the southward in the western part of the present continental area."

The Cretaceous rocks are next in ascending order, and belong to the lower division of that group, here named by Dr. Dawson the "Kootanie Series," though showing, according to Sir J. W. Dawson, who examined the plants, consisting of Ferns, Cycads, and Conifers (with one exception the only fossils collected), affinities with the Jurassic of the Amur country of Siberia, and of the Lower Cretaceous of Greenland, as these floras have been described by Heer."

The sandstones, shales, and conglomerates composing the Kootanie Group are estimated to be about 9000 feet in thickness.

Important Coal-bearing rocks occur in this series, and their distribution is depicted upon a coloured geological map of part of the "Cascade Coal Basin." The coal is an anthracite of excellent quality, and its proximity to the Canadian Pacific Railway line will cause it to be soon turned to account.

The chief development of the Coal-bearing rocks is in the valley of the Cascade River, a tributary of the Bow, where the Cretaceous rocks form a "long, narrow, synclinal fold, which, owing to the immense pressure from the south-westward, has been bodily overturned in the opposite direction; the mountain range on the south-west side being composed of an anticlinal of the limestone series, similarly compressed and folded over on the Cretaceous rocks."

Volcanic beds (ashes and agglomerates) occur at an horizon not far above the summit of the Kootanie Group, which would make them of the age of the Dakota period. Their maximum thickness is estimated at 2200 feet.

In a "provisional general section" of the Cretaceous beds of the mountains of the area explored, their thickness is put down at 13,350 feet, making with that of the Foot-hills and Plains (7490 feet) a maximum thickness for the Cretaceous of the region of 20,840 feet.

Upon the subject of economic minerals Dr. Dawson informs us that the recognized gold-mining district is "Wild Horse Creek," "but nearly all the streams flowing into the Columbia-Kootanie valley contain more or less alluvial gold, which should be sought in those parts of the district which are based on the slaty zones of the Cambrian."

The author was much struck with the grandeur and beauty of the scenery of the mountains, and the excellent engravings with which the report is illustrated enable the reader to realize in some degree the physical features of this magnificent tract of country.

Mr. R. G. McConnell's Report (pp. 5c—78c) treats of the geology and resources of the Cypress Hills, Wood Mountains, and adjacent territory, embracing part of the district of Assiniboia, and covering an area of about 31,000 square miles. It is accompanied by a geological and topographical map of the district, together with photographic and other illustrations.

The most interesting result of Mr. McConnell's researches from a geological point of view was the discovery of thick deposits of conglomerates of Miocene age, covering Laramie beds, which have by this means escaped destruction. The Miocene rests unconformably on the Laramie, as a rule; but in some places it overlaps and comes in contact with the Fox Hill beds beneath.

The Miocene beds are characterized by the great quantity of water-worn pebbles in them, derived from the quartzite formations of the Rocky Mountains. These beds cover an area of nearly 14,000 square miles, capping the more elevated parts of the plateaux from the west end of the Cypress Hills to the east end of Swift Current Creek plateau, a distance of 140 miles.

Numerous invertebrate fossils were collected in the Cretaceous beds, and remains of Reptilia (*Testudinata*) and Mammalia (*Bunotheria* and *Perissodactyla*) in the conglomerates. The Vertebrates furnish the subject of a separate report by Prof. E. D. Cope (Appendix i. pp. 79c—85c).

Mr. Andrew C. Lawson's report (pp. 5cc—151cc) is "On the Geology of the 'Lake of the Woods' Region, with special reference to the Keewatin (Huronian?) belt of the Archæan Rocks."

The beds examined consist of a belt of schistose rocks which runs through the granitoid gneiss across the northern parts of the Lake of the Woods, and has been hitherto regarded as of Huronian age. Mr. Lawson, however, considers these rocks to be older than Sir W. E. Logan's typical Huronian. His reasons for coming to this conclusion are based mainly upon the lithological characters of the rocks. Thus he finds (1) that Logan's typical Huronian is essentially a quartzitic series, whereas in the Lake of the Woods series quartzites form a very small proportion of the rocks. (2) Logan's series is characterized by bedded limestones, but there are none of these in the Lake of the Woods series. Further, the basal conglomerate of Logan's Huronian on Lake Temiscamang is described as holding pebbles and boulders, of the subjacent gneiss, from which they appear to be derived. Mr. Lawson holds that the Lake of the Woods rocks are not basal conglomerates, but "agglomerates" of volcanic origin, the fragments in them being frequently sharply angular.

Taking these and other facts into consideration, Mr. Lawson is of opinion that it is best to regard the Lake of the Woods rocks, at least provisionally, as a distinct series, for which he proposes the name of "Keewatin"[1] series, and adds that they "may be taken as representative of an important division of the Archæan, extensively developed in parts of the great Laurentian area."

Mr. A. P. Low's report (pp. 5D—55D) consists of geological and meteorological observations in the region of Lake Mistassini.[2] It was found by this explorer that with the exception of the comparatively small areas of Huronian and Cambrian rocks, in the vicinity of Lake Mistassini, the Laurentian gneisses and associated rocks occupied the whole country from the Gulf of St. Lawrence to James' Bay, along the route taken by the expedition.

Appendices I., II. (pp. 34D—44D) of the report contain lists of birds and of plants collected at Lake Mistassini, and along the banks of the Rupert River.

Dr. Robert Bell's report (pp. 5DD—27DD) contains brief observations on Geology, Zoology, and Botany, made in his capacity as Geologist and Naturalist on board H.M.S. "Alert," on the Second Expedition to Hudson's Strait and Bay, sent out by the Government of Canada in 1885.

The opportunities for gathering information were necessarily limited, and advantage had to be taken of stoppages for the landing of supplies, etc., to make a few rapid notes. The report embodies the results of the geological investigations of previous years, dating from 1870.

Hudson's Bay, which has an area equal to about half that of the Mediterranean Sea, occupies the centre of a wide depression in the great Laurentian area. The Laurentian system of rocks prevails

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[1] The Indian name for the North-West, or the North-West wind, applied to the district within which the rocks occur.

[2] Formed from two Algonquin words signifying "big-stone," and so called because of the large boulders of gneiss that strew the west shore of the lake.

everywhere in this region; but Palæozoic strata occur in many of the islands in Hudson's Bay, and probably extend over much of its bed. Rocks of volcanic origin were observed in the north-western part of the Bay.

The report by Mr. R. W. Ells (pp. 5E—71E) gives an account of the geological formations in South-Eastern New Brunswick, and in Cumberland and Colchester counties of the adjoining province of Nova Scotia.

The prevailing rocks of this area are the Pre-Cambrian or Huronian (?), the Carboniferous and Permo-Carboniferous. The Pre-Cambrian rocks are typified in the "Cobequid Series," which underlie unconformably the iron-ore belts flanking the Cobequid mountain range on the south. The Carboniferous system is represented by the three divisions, Upper, Middle, and Lower, and an elaborate description of each of these is contained in the report. The Spring Hill area was especially examined for the purpose of determining the extension of the thick coal-seams. The famous South Joggins Coal-measures, made historical through the labours of Logan[1] and Dawson,[2] are briefly described by Mr. Ells.

The report concludes with a reference to the economic minerals of the region surveyed. These include Coal (by far the most important), Iron, Copper, Gypsum, etc.

A coloured geological map on a scale of four miles to one inch accompanies the report.

Professor L. W. Bailey contributes a report (pp. 5G—30G) upon portions of Northern and Western New Brunswick. This also is illustrated by a geological coloured map, in which the orographic features of the region are delineated. It is upon the same scale as that of Mr. Ells.

The following geological systems are embraced in the region examined:—

Carboniferous.
Devonian (?).
Silurian.
Cambro-Silurian (Ordovician).
Pre-Cambrian.
Crystalline rocks, including granite.

The Carboniferous is of limited extent, and consists of the Millstone Grit, and the lower or marine beds of the system.

Much of the region is too densely wooded to admit of the examination of the underlying rocks, and their boundaries are therefore difficult to define with accuracy. Eruptive rocks in the form of dykes and intercalated masses are met with in many parts of the Silurian area, notably in the gorge above the Falls of the Aroostook river, close to the boundary-line of the State of Maine. Connected with these igneous and trappean overflows are innumerable faults, and the Silurian rocks are everywhere twisted and folded.

To the south of these rocks portions of the country are occupied by metamorphosed strata, penetrated by great masses of intrusive granite, supposed to be of Cambro-Silurian age, while other strata, apparently connected with these last, furnish in their fossil contents satisfactory evidence for referring them to that horizon.

[1] Report, 1845.

[2] Acadian Geology, 1868.

The Pre-Cambrians consist typically of crystalline felsites, mostly obscurely stratified; and hard fine-grained syenites. Intrusive masses of igneous rocks also occur in the Pre-Cambrian area.

Mr. R. Chalmers furnishes a preliminary report (pp. 5 GG—58 GG) on the Surface Geology of New Brunswick, in which he describes the superficial deposits as consisting of "Alluviums, or Recent Deposits," and "Stratified Sands, Gravels and Clays." The topographical features of the Province, agricultural character, forests, etc., are also particularized, and a table of glacial striæ and a list of Post-Tertiary fossils are added.

Report K (pp. 5K—15K) by Mr. Eugène Coste, Mining Engineer, contains valuable observations on "Mining Laws and Mining in Canada," in which the writer attributes the failure of so many mining schemes in the Province of Ontario and Quebec and in the north-west territory to the defective state of the laws governing such undertakings.

Speculators are allowed to "purchase very cheaply large tracts of 'mineral lands,' which they are not compelled to work, and which they hold against the interest of the mining industry and of the country, awaiting fabulous prices for them, and so preventing *bona fide* working companies from developing them."

To remedy this deplorable state of things, Mr. Coste proposes that national mining property should be submitted to an administration similar to that which is in force in France, Prussia, Austria, and other European countries. He formulates a series of "principles which should be followed in determining the conditions under which mining rights should be acquired and maintained." These relate to the leasing of mining property, the prevention of monopoly of mining rights on too large an area of land; penalties for insufficient working of mining property; regulations concerning the purchase of a sufficient extent of land for the surface requirements of the mine, and finally, the due inspection of mines by government officers.

The concluding report (pp. 1M—29M), by Mr. G. Christian Hoffmann, assisted by Mr. Frank D. Adams, contains a record of assays and analyses carried out in the Laboratory of the Survey, attention having been devoted chiefly to such minerals as promised to be of economic value.

A general Index to the volume completes this large and valuable accession to our knowledge of the physical geography, geology and material resources of Canada. ARTHUR H. FOORD.

# REPORTS AND PROCEEDINGS.

## I.—THE GEOLOGICAL SOCIETY OF LONDON.

1.—ANNUAL GENERAL MEETING, February 18, 1887.—Prof. J. W. Judd, F.R.S., President, in the Chair.

The Secretary read the Reports of the Council and of the Library and Museum Committee for the year 1886. The Council stated that they had to congratulate the Fellows upon a continuation of the improvement in the state of the Society's affairs, to which they had the satisfaction of calling attention last year, although they regretted that they could not announce any increase in the total number of Fellows. The number elected during the year was 41, and the total accession was 46; while the losses by death, resignation, etc., amounted to 48, making an actual decrease of 2 in the number of Fellows. Nevertheless the number of contributing Fellows was increased by 2. The Balance-sheet showed an excess of Income over Expenditure during the year of £390 5*s.* 9*d.* The Council's Report further announced the awards of the various Medals and of the proceeds of the Donation Funds in the gift of the Society.

In presenting the Wollaston Gold Medal to Mr. J. W. Hulke, F.R.S., the President addressed him as follows:—

Mr. Hulke,—It is a very pleasant duty which I am called upon to perform in presenting you with the Wollaston Medal, as a recognition of your great services to the study of Vertebrate Palæontology. A member of that honoured profession which has given to Geology—and especially to the biological side of our science—so many diligent and accurate students, you have succeeded, in spite of the labours and anxieties incident to a very active career, devoted to the alleviation of human suffering and the training of others for the same duties, in finding time for very valuable researches among those wonderful forms of Reptilian life which characterize the Mesozoic period. Your hardly-earned vacations have been spent in the search of fossil bones among the mud-flats of Dorsetshire and the sandy cliffs of the Isle of Wight; and in this way you have acquired an exceptional amount of knowledge concerning the exact geological horizons and the mode of occurrence of the fossils you have so admirably described. As by successive discoveries you have been able to add new details to your restoration of the bony framework of *Iguanodon*, you must have experienced a joy akin to that of Creation! But though you are best known to the world by those osteological researches, those who, like myself, have had the happiness of being associated with you in the work of this Society, have discovered how wide is the knowledge, how catholic the sympathy, and how keen the interest with which you follow all the manifold developments of our Science.

Mr. HULKE, in reply, said:—Mr. President,—I cannot find words adequately to express how highly I value the distinction which the Council has this day, by your hands, conferred upon me. The pleasure I experience in receiving it is in no small degree increased by the words of approbation which have fallen from your own lips. The Wollaston Medal is so truly great a prize, and the work I have done to merit it has appeared to me so little in comparison with that accomplished by the long roll of illustrious men on whom in past time it has been bestowed, that I have fancied that (as occurred to Sir Philip Egerton on a similar occasion) in awarding it to myself the Council may also have desired to mark the recognition of the labours of those who, whilst not devoting the chief part of their time and energy to the culture of that branch of Natural Science for the advancement of which our Society exists, yet endeavour in their leisure hours to do what in them lies to add to our common stock of knowledge. To you, Sir, to the Council, and to the Fellows, I tender my warmest thanks.

The President then presented the Balance of the Proceeds of the Wollaston Donation Fund to Mr. Benjamin N. Peach, F.G.S., and addressed him as follows:—

Mr. Peach,—In addition to your services to science as an officer of the Geological Survey of Scotland—and how important those services have been every geologist in recent years has had an opportunity of judging—you have, in conjunction with your colleague and friend, Mr. Horne, devoted your holidays to arduous labour in studying the geology of the Orkneys and Shetlands. Both the glacial and the volcanic phenomena of those islands have been admirably elucidated by your joint researches. But besides your work in the field you have devoted much attention to palæontological investigations; and your discoveries concerning the nature of the Carboniferous Arachnids and their allies have justly excited very great interest. To aid you in the prosecution of such studies the Proceeds of the Wollaston Donation Fund have been awarded to you, and I feel sure that one circumstance in connexion with this Fund will make the award specially welcome to you. In the roll of names of those who have in previous years received this distinction, will be found one, honoured alike by you and by us, that of your lamented father, Mr. Charles Peach.

Mr. PEACH, in reply, said :—Mr. President,—I desire to record my cordial thanks for the honour now conferred upon me. The pleasure derived from the pursuit of the researches indicated by you has more than compensated for my labour. It is, however, an additional gratification to me to know that my investigations have been deemed worthy of recognition by the Council of this Society.

The President next presented the Murchison Medal to the Rev. P. B. Brodie, M.A., F.G.S., and addressed him as follows :—

Mr. Brodie,—Never probably has an award of this Society been made to one who can look back upon so long a record of faithful services to Geology as yourself. It is now 54 years ago since you became a Member of this Society, at a time when the Founder of the Medal which has now been awarded to you occupied the Presidential Chair. At the date of your election the 'Principles of Geology' had but just appeared, while Sedgwick and Murchison had not even commenced their researches among the Palæozoic rocks of Western Britain. A pupil of the great Cambridge professor and infected with his enthusiasm, you soon began to contribute to various scientific journals, our own among the number, and in 1845 your valuable 'History of Fossil Insects'—the first treatise of the kind published in any language—made its appearance. A dweller in the provinces, you have shown how the advancement of our Science may best be promoted under those conditions; and in the field-clubs and local societies which have done so much for the study of geology in the West of England, where your home lay, you have long been a prominent and very active worker. Your published papers on a variety of subjects amount to more than 50, and only last year we were glad to welcome a fresh contribution from your pen, and to hear your clear exposition of it, as you stood before us with eye undimmed and with natural force unabated. The Council of this Society have adjudged you to be a worthy recipient of the Medal founded by their President of 1833.

Mr. BRODIE, in reply, said :—Mr. President,—I receive, Sir, this mark of the approbation of the Council with very great pleasure and grateful thanks; and it was more gratifying because it took me quite by surprise. After searching the rocks for more than half a century, and having been a Fellow of this Society for 53 years, it might be expected that I should have done more to enlarge our knowledge of geology; but of course my time was not entirely at my own disposal in this respect, and I could therefore only study Natural Science in the closet and the field during hours of leisure. As a proof that I have not been altogether idle, I have made during that time a large collection of fossils, numbering twenty-three thousand specimens, numbered and arranged, more or less illustrating every formation in the British Isles. But of course a mere collection of fossils, though having a certain value, is of little worth without an accurate knowledge of the rocks and their organic contents.

The award of the Murchison Medal is especially agreeable to me because I have had many pleasant and instructive days in the field with that distinguished geologist; but I do not forget that at Cambridge I was a pupil of the illustrious Sedgwick, to whom I owe a lasting debt of gratitude for the kind help and encouragement which that great and good professor was ever ready to give to any student anxious to learn. In after years, I can with pardonable pride speak of him as my friend. When I made some of my earlier discoveries of fossil insects and other organisms in the Wealden Purbecks in the Vale of Wardour, I received a letter from him in which he said, "you have made a good hit, go on and prosper," and this medal shows that I have so far done so. It is now more than half a century since I was admitted a Fellow of this Society, just before I went to college, and I know that some hesitation, and very properly, was felt whether I should take up geology to any good or useful purpose. But my kind proposer Mr. Clift, the able Curator of the College of Surgeons, to whom I was well known, and where I often went as a student, would not give me up; and this proof of the Society's favour just received shows that he was not altogether mistaken.

In my younger days, when I resided in London, I was a regular attendant at the meetings of this Society, then held in Somerset House, where I was a humble but (I hope) not inattentive listener to the papers read and the discussions which followed, and I recall with pleasure the many intellectual combats between the geological giants of those days. I regret that distance from London and the higher duties of my profession prevent my attending our meetings so often as I could wish; but though now a septuagenarian, I am thankful to say that I can still hammer the rocks, and that my zeal and love for the noble science we all love so well has not abated; but I fear I shall not be able to do much more to elucidate their history, though, if younger, this Medal would encourage me to make still further efforts; and my chief regret is that, for reasons stated, I have not been able to do more to deserve the honour which the Society has kindly conferred upon me. I can only hope that the Society will pardon me for saying so much about myself.

### In handing the Balance of the Proceeds of the Murchison Geological Fund to Dr. Henry Woodward, F.R.S., for transmission to Mr. Robert Kidston, F.G.S., the President said :—

Dr. Woodward,—The balance of the Murchison Fund has been awarded by the Council of the Geological Society to Mr. Kidston, to aid him in his important investigations among the fossil plants of the Palæozoic period. Mr. Kidston's great knowledge of the extensive literature and the complicated synonymy of these forms is borne witness to by the valuable catalogue which he has prepared under your superintendence, and which was issued only a few months ago by the Trustees of the British Museum; a large number of remarkable memoirs have also shown his capacity for dealing with this difficult and intricate subject. In seeking to extend our knowledge of the earliest forms of plant-life, Mr. Kidston seems determined to leave no museum unvisited and no stone unturned, if perchance it should be found to exhibit any traces of an ancient vegetation. I will ask you to convey to Mr. Kidston, with this award, the hope of the Council that it may be of some assistance to him in enabling him to prosecute his researches.

Dr. Woodward, in reply, said :—Mr. President,—It is with much pleasure that I am permitted to act as Mr. Kidston's representative here this day, and to receive for him, at your hands, the award of the Murchison Donation Fund. I am sure Mr. Kidston would, had it been possible, have been present in person to receive the award. He writes as follows :—"I desire to express my thanks to the President and Council of the Geological Society for the honour they have conferred upon me in acknowledging my labours in Fossil Botany, an honour which I beg to assure them I fully appreciate; it is one which will act as a stimulus in my future investigations in Vegetable Palæontology. My aim has always been most carefully to work out our Palæozoic flora, and in this spirit I hope to continue my labours, trusting that the results may be of use to others."

### The President then handed the Lyell Medal to Prof. T. G. Bonney, D.Sc., F.R.S., for transmission to Mr. Samuel Allport, F.G.S., and addressed him as follows :—

Prof. Bonney,—It is to me an especially gratifying circumstance that it falls to my lot to deliver into your hands for transmission to Mr. Allport the Lyell Medal for the present year. Mr. Allport commenced the microscopical study of rocks at a time when the workers in that department of science were comparatively few, and when the road he had to travel was encumbered with difficulties and stumbling-blocks which have now been, to a large extent, removed by the labours of many earnest and patient workers. It was at that time my good fortune to know him, and to have frequent opportunities of admiring the perseverance and energy with which he carried on his researches. You have yourself from this chair paid a warm and well-merited tribute to the generosity with which, at that time, he was always ready to assist his fellow-workers. The establishment of one very important principle will always be associated with Mr. Allport's labours, namely, that the apparent differences between the igneous rocks of widely different geological periods are, to a great extent, due to the changes which the constituent minerals of the older rock-masses have undergone since their original formation. His classic papers on the Archæan rhyolites of Shropshire and the Carboniferous dolerites of various parts of this country furnish the clearest evidence of the truth of this principle, and in several thoughtful and logical essays he has very ably enforced it. On a great variety of other questions connected with Petrology his researches have added largely to our knowledge; and the fine collection of rock-sections now in the National Museum, which were made by his own hands, bear striking testimony to his industry and skill.

Prof. BONNEY, in reply, expressed his regret that Mr. Allport was unable to be present to receive this Medal from the hands of the President, but said that he found some consolation in the fact that he had thus an opportunity of most heartily endorsing what had been said by the President as to the great value of Mr. Allport's own work, and of the kind assistance which he was always so ready to afford to his fellow-labourers in the field of Petrology. Prof. Bonney added that he should best thank the Society by reading to them a letter received from Mr. Allport, in which that gentleman wrote as follows:—"I much regret to inform you that I shall be unable to attend the Anniversary Meeting of the Geological Society in consequence of the very unsatisfactory state of my health. I venture, therefore, to request that you will kindly express to the Council my very grateful sense of the honour they have conferred upon me by the award of the Lyell Medal. It is, I assure you, most gratifying to me that the name of Sir Charles Lyell should be associated with this award; for I have not only ever regarded his character and scientific method with the greatest admiration, but it is undoubtedly to the study of his works that I am chiefly indebted for what little knowledge I possess of the principles of geological science."

### The President next presented the Balance of the Proceeds of the Lyell Geological Fund to the Rev. O. Fisher, M.A., F.G.S., and said:

Mr. Fisher,—The Council of the Geological Society has awarded to you the balance of the Lyell Fund, in recognition of your great and long-continued services to our science. Nearly forty years ago you commenced your well-known stratigraphical investigations among the Newer Jurassics of Dorsetshire and the Older Tertiaries of the Isle of Wight, your attention being subsequently directed to the Pliocene and Post-Tertiary beds of East Anglia. At a very early period in your career a predilection for the great problems of Physical Geology began to manifest itself; and for dealing with such problems your mathematical training gave you obvious advantages. In these researches, however, which have been recorded in a number of separate memoirs, worthily crowned by the publication six years ago of your "Physics of the Earth's Crust," you have always maintained a just estimate of the proper sphere and necessary limitations of the mathematical method of treatment as applied to such problems. Speaking of the processes you have chosen to employ, you truly remark in the preface to your well-known work, "When it is recollected that, for the most part, we can assign only very hypothetical values to our symbols, it would be affectation to seek close results, which would, after all, have no greater value than those which claim to be only distant approximations." In you we rejoice to see that the geologist has not been altogether lost in the mathematician, and that you have always kept in mind in your researches the weakness no less than the strength of the mathematical method.

Mr. FISHER, in reply, said:—Mr. President,—It is no small gratification to me that the Society, through its Council, has expressed approbation of what I have done in the favourite study of a long life. I commenced geologizing almost before I can remember, when my uncle, the Rev. George Cookson, taught me to collect fossils in the cliffs of my native village of Osmington. My work in the field is now finished, and I geologize in my arm-chair out of my inner consciousness, but still, I hope, to some purpose. It appears to be rather these later attempts to unravel some of the physical riddles of our science (although my earlier observations in the field have not been forgotten) which have been thus handsomely recognized; and, indeed, for my own part I think what I have done in applying mathematical methods to these geological problems has been my most useful labour. Nevertheless I feel assured that my earlier work in the field has been of much service to me; for no one can pretend to grapple usefully with the great problems of geology who has not personally studied the actual phenomena. It is in this respect that the greatest physicists of the day fail to give us the decided assistance which they might do had they a more accurate knowledge of the questions to be solved.

We pass on the torch from hand to hand. Some of the ideas which I have tried to work out were suggested by conversations with honoured friends long gone to rest—Sedgwick, Hopkins, Miller, Phillips, and others. May I hope that when some one now young, in this assembly, receives a similar recognition of a similar life's work, he may think of me as an intermediate link connecting him with those earlier workers?—a link which, whatever may be its intrinsic defects, and however inferior the metal, you have seen fit to gild with the balance out of the munificent legacy of the great Lyell.

In presenting the Bigsby Gold Medal to Prof. Charles Lapworth, LL.D., F.G.S., the President said:—

Professor Lapworth,—The late Dr. Bigsby established a Medal to be awarded to one "not too old for further work, and not too young to have done much." That you admirably comply with the latter qualification every geologist knows; but that your age could possibly fall below the limit prescribed by the founder of this Medal, any one not personally acquainted with you might be pardoned for doubting. In studying the difficult, but, to geologists, very important group of the Graptolites, in utilizing your knowledge of those remarkable fossils for unravelling the stratigraphical problems presented by the contorted beds of the Scottish Borderland, and in applying the valuable experience thus acquired to the far more difficult examples of involved stratigraphy found in the county of Sutherland, you have exhibited a happy blending of those powers of patient observation and of bold generalization which are equally necessary for the man of science. Those who know you best will feel the least doubt concerning those "favours to come" in the shape of further work, the "lively sense" of which constitutes the staple of our gratitude to you to-day.

Prof. LAPWORTH, in reply, said:—Mr. President,—I am deeply sensible of the distinction which the Council of the Geological Society has conferred upon me in awarding me the Bigsby Medal; and I am grateful, indeed, for the generous words in which you have referred to my geological work. If anything could add to the gratification with which I accept this award, it is that I receive it from the hands of one who, since the reading of my first paper before this Society, has been a staunch friend and a sympathetic adviser. I am afraid that the Members of this Society are a little inclined to rate my geological labours somewhat higher than they deserve, and I regard this Medal less as a reward for what I have done in the past than as a stimulus and encouragement for the future. The pursuit of original research has always appeared to me to be the highest and most pleasurable of enjoyments—and none the less pleasurable, as it has for years been associated in my mind with the unfailing interest, sympathy, and friendship accorded me by the Members of this Society. My leisure and means for work of this kind are, however, but small; but I am sure that there is no need for me to assure the Society that such leisure and powers as I possess in the future will be wholly given to the service of that science to which we are all devoted.

The President then read his Anniversary Address, in which he gave obituary notices of the following Fellows of the Society who have died since the last anniversary:—The Earl of Enniskillen, Sir Charles Bunbury, Mr. George Busk, Mr. John Arthur Phillips, Mr. Henry Michael Jenkins, Dr. Harvey B. Holl, Mr. Caleb Evans, the Rev. Willlam Downes, Dr. Frederick Guthrie, and Mr. Arthur Grote. Also of the late Foreign Member, Dr. Hermann Abich, and of the deceased Foreign Correspondents, Professor Guiscardi and M. Cornet. In the Address proper, the President, after congratulating the Society on its present condition and prospects, and referring to some of the more notable incidents in the history of Geological Science during the past year, proceeded to discuss the past and present relations between Mineralogy and the Biological Sciences. After insisting that the supposed distinction between living and non-living matter was not a fundamental one, he maintained that minerals resemble animals in possessing definite organization, and in going through regular cycles of change. He further pointed out that, in the course of its development, Mineralogy was now exactly following in the same lines which had been already taken by Zoology and Botany. He expressed his conviction that Geology and Mineralogy were powerful for mutual help, and that the latter science, now passing from the classificatory stage, had a great future before it.

The Ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year:—*President*:—Prof. J. W. Judd, F.R.S. *Vice-Presidents*: H. Bauerman, Esq.; Prof. T. G. Bonney, D.Sc., F.R.S.; A. Geikie, LL.D., F.R.S.; Henry Woodward, LL.D., F.R.S. *Secretaries*: W. T. Blanford, LL.D., F.R.S., and W. H. Hudleston, Esq., M.A., F.R.S. *Foreign Secretary*: Warington W. Smyth, Esq., M.A., F.R.S. *Treasurer*: Prof. T. Wiltshire, M.A., F.L.S. *Council*: H. Bauerman, Esq.; W. T. Blanford, LL.D., F.R.S.; Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; A. Champernowne, Esq., M.A.; Thomas Davies, Esq.; Prof. P. M. Duncan, M.B., F.R.S.; A. Geikie, LL.D., F.R.S.; Henry Hicks, M.D., F.R.S; Rev. Edwin Hill, M.A.; W. H. Hudleston, Esq., M.A., F.R.S.; J. W. Hulke, Esq., F.R.S.; Prof. T. M'Kenny Hughes, M.A.; Prof. T. Rupert Jones, F.R.S.; Prof. J. W Judd, F.R.S.; R. Lydekker, Esq., B.A.; J. E. Marr, Esq., M.A.; E. T. Newton, Esq.; Prof. H. G. Seeley, F.R.S.; Warington W. Smyth, Esq., M.A., F.R.S.; J. J. H. Teall, Esq., M.A.; Prof. T. Wiltshire, M.A., F.L.S.; Rev. H. H. Winwood, M.A.; Henry Woodward, LL.D., F.R.S.

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2.—February 23, 1887.—Prof. J. W. Judd, F.R.S., President, in the Chair. The following communications were read:—

1. "On the Origin of Dry Chalk Valleys and of Coombe Rock." By Clement Reid, Esq., F.G.S.

Whilst engaged in examining the Pleistocene deposits of Sussex, for the Geological Survey, the author observed that the Coombe Rock differs from anything commonly seen in the strongly glaciated districts of the Yorkshire and Lincolnshire Wolds. As in these localities, the seaward slope of the South Downs is broken by the line of a partially buried sea-cliff before passing under the low-lying drift areas. Subsequent to the formation of this sea-cliff a mass of angular flint and chalk detritus spread out from the Downs over the low lands, being seldom found far up the valleys. This is the Coombe Rock, which passes further on into a worthless mixture of angular flint and loam, and at a still greater distance into almost clean brick-earth. It is not of glacial origin, neither is it marine, nor is it a gravel formed by ordinary fluviatile action. A study of the contours of the Downs may give us, the author thinks, a key to the mode of formation.

The rolling outline of the Downs and the steep-sided dry valleys point to conditions which have passed away. However much rain may fall, the upper parts of these valleys are always dry, and no running water can be found where the incline of the bottom of the valley exceeds the slope of the plane of saturation—never more than 60 feet per mile. Three explanations have been offered:—

1. Former submergence and rise in level of the plane of saturation.

2. Former higher level of the plane of saturation before the valleys were cut down to their present depth.

3. Increase in the rainfall.

None of these theories is sufficient to account for the origin of Coombes and the transport of Coombe Rock. There is no evidence of submergence whilst the Coombes were being eroded; on the contrary, the descent of the Coombes to the sea-level near Rottingdean and elsewhere, is suggestive of a slight elevation. The deep trenching of the Downs by valleys, and the consequent lowering of the plane of saturation, is applicable to many of the slightly inclined Coombes, but the whole structure of the country shows that the outlet for the water must have been as clear then as now. Since the dry chalk valleys play no part in the present superficial drainage, it would make but little difference in the plane of saturation if they were filled up again. If springs had formerly existed in the higher valleys, their gradual failure would have left evidence in the shape of gravel deposits and terraces. Moreover, as an objection, both to the first and second theories, it is urged that if valleys had been cut back by springs, some of them should fall to the north, where most of the springs occur, whereas the Coombes open to the south. Lastly he finds no traces of the "hypothetical Pluvial period."

In suggesting an origin for the dry valleys and Coombe Rock, he considers that the fauna and flora, both at Fisherton and Bovey Tracey, point to a great degree of cold, from 20° to 30° lower than what now prevails in the South of England. The ground would thus be frozen to the depth of several hundred feet, and the drainage system of the chalk entirely modified. There would be no underground circulation. The summer rains would immediately run off any steep slope, often in violent torrents. These would tear up the layer of rubble already loosened by the frost, carrying down masses of unthawed chalk too rapidly for solvents to have much effect. No Coombe Rock is found in valleys that have a greater slope than 100 feet per mile. There is no need of excessive rainfall; it might have been a dry period corresponding to that of the Löss.

If the time had not been short, all soft rocks in the South of England would have been planed down to one gently undulating surface like the plains of Russia and Siberia. Such Tundra-conditions may have occurred more than once.

2. "Probable Amount of former Glaciation of Norway, as demonstrated by the Present Condition of Rocks upon and near the Western Coast." By W. F. Stanley, Esq., F.G.S.

The observations on which this paper are based were made in June last, during a voyage along the west coast of Norway. Inland conditions were also noted in the Hardanger and Sogne Fjords, and a few trips up some of the valleys enabled these inland observations to be further extended. The author limited his work in searching for outline evidence of ice-action. The aspect of the coast for hundreds of miles consecutively has a uniform character of jagged and pointed rocks nearly to the sea-level. At the mouths of the fjords the rocks are more rounded, particularly at heights less than 100 ft.

Within the Arctic Circle the Swartisen glacier reaches nearly to the sea, and here the rocks are more rounded.

He exhibited sketches showing the characteristic forms of the rocks, and concluded from a study of these that ice had never prevailed along the entire western coast of Norway, neither had inland ice of any considerable thickness flowed over this coast in sufficient volume to wear off the points of the sharply-fractured granite. Even the rocks below 100 feet are not more worn than is sometimes the case in tropical climates. The "shark's teeth" of the Lofotens have not been planed down, nor is there any vestige of the great ice-sheet of our text-books within the Arctic Circle. Even in the fjords there is no evidence of ice-action until we arrive at the head, where it is very evident. There can be no better demonstration of the extent of former glaciation than in the Romsdal valley, where the line of the worn base extends as high up the rock as 600 feet. He also instanced the principal glaciers of the Folge Fjord, now about 7 miles from the open water of the fjord, though formerly within 1½ mile. The angular character of the low rocky island in front of Odde shows that it cannot have advanced further.

The author concluded that at no period within geologically recent, say Tertiary times, has ice extended much further than at present. Seeing that the morainic matter now in the valleys has been derived from the hills, there must formerly have been a greater extent of land above the snow-line, and this would cause a former extension of glaciers without resort to any extraneous theory or change of climate. The Great Ice Age has left no trace on the Norwegian littoral.

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## II.—Imperial Geological Institute, Vienna.

September 30, 1886. — "On new Neogene Isopoda," by N. Andrussow.

*Cymodocea Sarmatica*, Andr., from the dark-tinted Lower Sarmatian Clays of Kertch (Crimea), where it is associated with *Mactra Podolica*, Eichw., *Cardium obsoletum*, Eichw., *C. papyraceum*, Sinzoa, *C. Fittoni*, D'Orb., *C. Barboli*, R. Hörn., and several new species, *Modiola navicula*, Dub., *Tapes Vitaliana*, D'Orb., *Buccinum Verneuilii*, D'Orb., *B. substriatulum*, Sinz., *Trochus*, several species, *Polyzoa*, *Foraminifera*, *Vertebræ* of *Fishes*, and impressions of leaves, is remarkable, as being the first known undoubted fossil representative of the marine *Sphæromida*. All hitherto known fossil *Sphæromidæ* are *freshwater* forms, or belong actually to other families or even orders, such as the Inferior-Oolite species *Sphæroma Catullii*, Zigno. As early as 1868, Prof. Eichwald described *Sphæroma exsors*, from the Sarmatian Beds of Kijchenew (Bessarabia). *Palæga Anconitana*, Andr., from the "Schlier" of Ancon, is a counterpart of *P. Gastaldii*, Sism., from the Miocenes of Turin. Besides the above-mentioned two species, the other known *Palægæ* are *P. scrobiculata* from Karing (Tyrol), the Eocene *P. Catullii*, Zigno, sp., two Cretaceous species, and possibly the Cretaceous *Cymatoga Jazikowi*, Eichw., from Simbirsk on the Volga. *Ægites Kunthi*, Amm., is an Upper Jurassic representative of the family *Ægida*.

## III.—ZOOLOGICAL SOCIETY OF LONDON.

December 7th, 1886.—Prof. W. H. Flower, LL.D., F.R.S., President, in the chair.—The following communication was read :—

"On the Anatomy and Systematic Position of the Liassic Selachian, *Squaloraja polyspondyla*, Agass." By A. Smith Woodward, F.G.S.

After a brief notice of previous researches, the author attempted an almost complete description of the skeletal parts of *Squaloraja*, as revealed by a fine series of fossils in the British Museum. He confirmed Davies' determination of the absence of the cephalic spine in certain individuals (presumably females), and added further evidence of its prehensile character, suggesting, also, that the various detached examples afforded indications of one or more new species. The cartilages of the skull were, as far as possible, described in detail, and special attention directed to the palatine region, which appeared remarkably similar to that of the Myxinoids: there is a long forwardly-directed process on either side, evidently representing a pre-palatine element, and if the conclusions suggested by the present genus can be substantiated by an examination of other forms, the Selachian antorbital cartilage must fall under the denomination of post-palatine. A well-marked hyomandibular was noted, resembling that of typical Rays; and each ramus of the jaw was shown to be provided with a single dental plate, exhibiting the ordinary Selachian mode of growth, and having the grinding surface rendered more efficient by a series of longitudinal rugæ; to the latter there probably correspond some slight sutures, which allow of the shedding of the outer edge at intervals during growth. The pectoral fin shows but two basal cartilages, the preaxial being only about one-fourth the size of the postaxial; and the pectoral girdle is of the Ray-type. The pelvic girdle is remarkable for the enormous size of the prepubic process, and there appear to have been no sutures in the basal cartilage of the pelvic fin, which passes, in the male, directly into the large clasper of either side. The author concluded with some general remarks on the affinities of the genus, and proposed to institute the new family of Squaloraiidæ, which may be placed near the Pristiophoridæ and Rhinobatidæ, and is conveniently defined as follows:—Body scarcely depressed, elongate. Head produced into a long flat rostrum, without lateral teeth. Males with a prehensile spine on the upper part of the snout. Dentition sharply divided at the symphysis. Pectoral fins with small propterygium, free.

## CORRESPONDENCE.

### GLACIATED AND FACETTED BOULDERS IN THE PUNJAB.

SIR,—The statement of the case of the glaciated (?) rock-fragments of the Punjab has been thus far all from one side. As the "arch-heretic" who ventured to suggest that the four "Indian geologists," who took part in the discussion of the subject at Birmingham, had overlooked some important physical agencies, when they asserted that no agency other than moving-ice could produce the effects observed, perhaps I may venture to ask for space for a few lines. I wish to point out that there appears to be considerable confusion of thought on this matter.

The rock-fragments are described now as "pebbles," now as "boulders," which are surely representatives of very different sets of mechanical forces. The term "pebble" is certainly a misnomer if applied to the two specimens which were exhibited at Birmingham. I saw and handled them both. The felsitic block had portions of its original surface somewhat smoothed, the sharper lines of its fracture somewhat rounded off in a fashion suggestive of the way in which the more flinty sarsens of this district acquire a certain degree of polish. The striated "facets" on this block are certainly difficult of explanation by reference to glacial agencies: they seemed to me very different from the ice-striations of blocks, of which I have had rather extensive observation in Alpine regions; nor can the necessary retention of the block in a fixed position in resistance to great and long-continued pressure be reconciled with the known physical properties of ice (see Q. J. G. S. February, 1883, pp. 62 *et seq.*).

The other block exhibited was more of a basaltic character, and was no doubt a slightly water-worn fragment of a basaltic column, as Prof. Carvill Lewis pointed out in the discussion at Birmingham. I do not recollect that this block was striated.

The question as to how the blocks came into their present position is entirely distinct from that of the agencies by which their present surface-character was given to them; and we have *no right to assume that these agencies acted upon them simultaneously.* On the contrary, Mr. Oldham's description[1] of the beds in which they occur affords, I think, convincing evidence to show that these facets and striations were produced by some agency or other *prior* to their deposition in the beds in which they now occur. This disposes at once of that writer's objection to the landslip theory (miscalled "soil-cap movement"), which I urged as the most likely explanation of the phenomena. In the discussion I referred to the objections of so excellent a physical geologist as Prof. Heim[2] of Zürich, to which I have on a previous occasion drawn attention in the pages of this MAGAZINE (Decade II. Vol. X. pp. 160 *et seq.*), where it was also pointed out that the polishing and striations of the surfaces of fragments of rock by the slow grinding movement, which often goes on for years, was worthy of some consideration from their resemblance to some of the effects of glacial action. As I fail to see that this explanation has been met as yet by any insuperable objection, it will not be from mere obstinacy if I still adhere to it as upon the whole the most probable.

Mr. Oldham remarks on the origin of the name "Olive Group," and then a few lines further on says there is not "any sign of carbonaceous matter in the bed." Has chemical analysis decided this? A. IRVING.

WELLINGTON COLLEGE, BERKS,
*January 8th*, 1887.

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[1] *Vide* GEOL. MAG. January, 1887, p. 32.

[2] "Ueber Bergstürse."

## THE BAGSHOT SANDS.

SIR,—Mr. Irving commences an article in the GEOLOGICAL MAGAZINE for March (p. 111) with the following statement: "The chief object of this paper is to describe an unmapped outlier of Bagshot Sand." I have no desire here to raise the question of the age of the beds he has described in that article, especially as that subject was fully discussed on a paper read by Mr. Irving before the Geological Society in January last. But I wish to point out that, unless I have greatly misunderstood Mr. Irving's account of the geographical position of the outlier which he describes, the Bagshot Sand in question is neither *unmapped* nor does it form an *outlier*. In the Survey Map the Lower Bagshot Beds are represented as extending from the main mass westwards, between Barkham and Bearwood Park, including part of the latter, and sending off spurs to the southward, one of which "is crossed by the main road from Arborfield Cross to Wokingham," exactly as described by Mr. Irving. The only difference appears to be that Mr. Irving gives the beds a rather greater northerly extension than the Map. Moreover, the beds are not only mapped, they are also described. In the "Memoirs of the Geological Survey," vol. iv. page 314, we find the following:—"About three-quarters of a mile N.N.W. of Barkham, near Wokingham, there is light-brown fine micaceous glauconiferous sand, with thin layers of pipe-clay towards the top, about 12 feet thick, over a pebble-bed in whitish micaceous sand." This may possibly have been a description of the "Barkham Pit" described by Mr. Irving on p. 112. It agrees well enough in position, and the pit is said (p. 113) to have been "re-opened only last winter, after having been disused for years." It is true we find no mention of these beds in the list of outliers given in the memoir (*loc. cit.* p. 316); but, as I have stated above, the Survey considers that the sands are connected with the main mass.

It would seem, therefore, that in the alleged new outlier of Bagshot Sands, with which he has lately been puzzling those who are interested in Bagshot geology, Mr. Irving has only discovered an old friend.

R. S. HERRIES.

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## PALÆONTOGRAPHICAL SOCIETY.

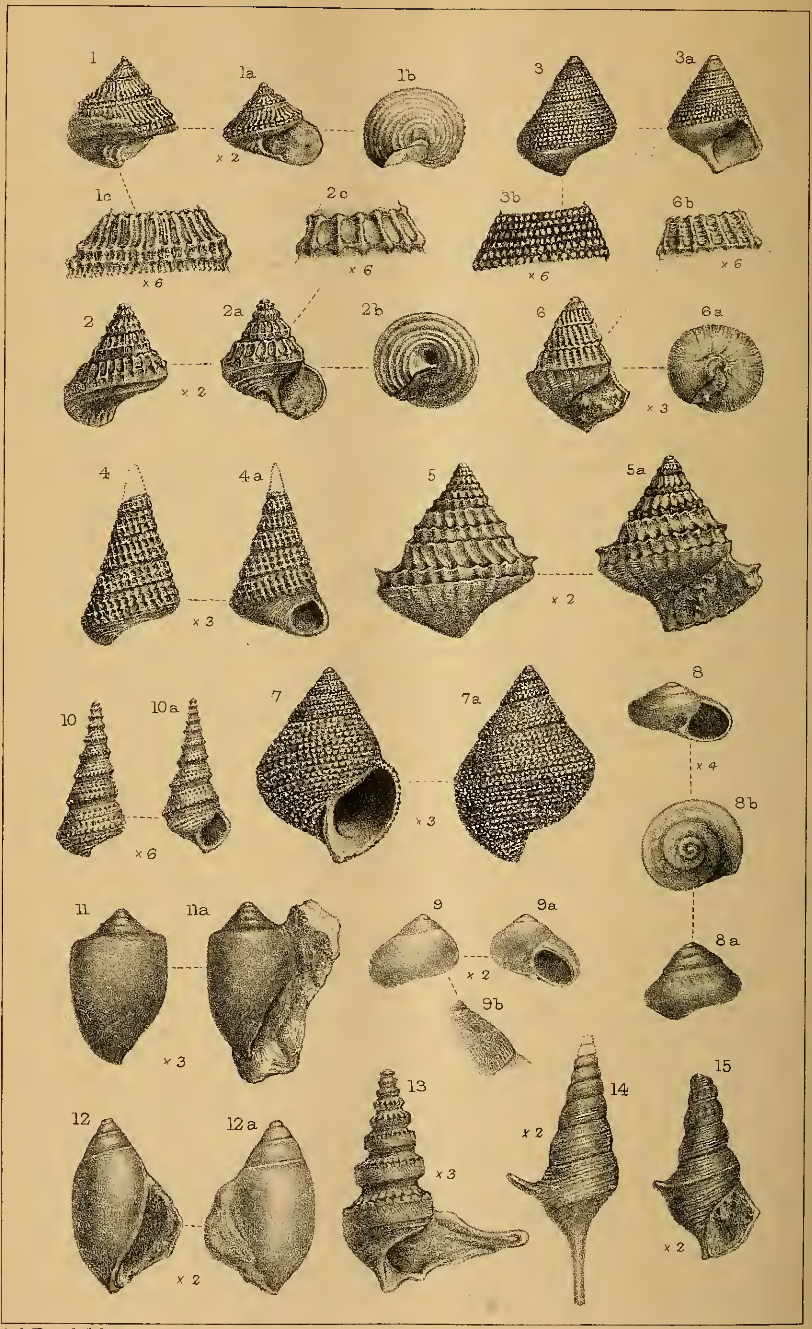
SIR,—The volume for the year 1886, price one guinea, containing: (1) Stigmaria ficoides, by Prof. W. C. Williamson, with 15 plates; (2) Fossil Sponges, Part I. by Dr. G. J. Hinde, with 8 plates; (3) Jurassic Gasteropoda, Part I. No. 1, by Mr. W. H. Hudleston; (4) Inferior Oolite Ammonites, Part I. by Mr. G. S. Buckman, with 6 plates; (5) Pleistocene Mammalia, Part VI. by Prof. W. Boyd Dawkins, with 7 plates, is now with the binder, and will be issued to the Members toward the close of the present month,

The volume for 1887, of which nearly all the plates are ready, will be placed in the printer's hands at once, and will be distributed before the end of the year.

The new Monographs, on the Fossil Sponges, the Stromatoporoids, the Jurassic Gasteropoda, and the Inferior Oolite Ammonites, will require many plates for their illustration, and will be very costly. It would be a considerable aid to the Society if Members would mention these Monographs to those of their friends who are interested in such subjects, and if they would try to bring in new Subscribers.

25, GRANVILLE PARK, LEWISHAM,
LONDON, 7*th March*, 1887.

THOS. WILTSHIRE,
Secretary.



A. S. Foord del. et lith. West Newman & Co. imp.

New British Liassic Gasteropoda.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. IV.

No. V.—MAY, 1887.

## ORIGINAL ARTICLES.

### I.—British Liassic Gasteropoda.

By E. Wilson, F.G.S.; Curator of the Bristol Museum.

(PLATE V.)

#### Introduction.

THE Gasteropoda, next to the Lamellibranchiate Mollusca, are the most varied class of organisms found in the Lias. The general elegance of their forms, and the frequent beauty of their ornamentation, make these fossils extremely attractive objects; whilst their limited vertical range gives them a by no means inconsiderable stratigraphical importance. Notwithstanding these inducements to their study, the Gasteropoda of the Lias have not received, in this country, anything like the amount of attention which has been given to the other leading classes of organisms derived from that formation. On the Continent, on the other hand, considerable progress had been made in the investigation of this interesting group of fossil mollusca more than thirty years ago. The elaborate Memoirs of Münster (in Goldfuss's "Petrefacta Germaniæ"), D'Orbigny (in the "Paléontologie Française"), Deslongchamps the elder, Dunker and Terquem, Chapuis and Dewalque, furnish the basis of our knowledge of the Gasteropoda of the Lias, whilst in later years Messrs. Eudes Deslongchamps, Stoliczka and Piette, Jules Martin and Dumortier, have each and all contributed a large amount of very valuable information in this department of Palæontology. The above difference, to our disadvantage, is perhaps to be explained, in part at any rate, by the more localized distribution of Gasteropodous Mollusca in the English Lias, by their prevailing small size, and the comparative rarity of the more conspicuous forms, such as the Pleurotomariæ, and finally, by their generally more highly mineralized condition, and the consequent greater difficulty there is, in this country, in extracting these fossils in anything like perfect condition.[1] During recent years, however, an increasing amount of attention has been given to the palæontology of the English Lias. In this work a number of earnest students are now actively engaged, chiefly in the Midlands, a district which had previously been greatly neglected, and one of

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[1] In the Lias of Luxembourg and Hettange, several Gasteropods have been found, which are not only perfect in form, but even retain the original colours and markings of the shells. (See Terquem, "Paléontologie de Hettange," Mem. Soc. Geol. France, 2nd ser. vol. v. pp. 219–343, pl. xii.–xxvi.)

the results of their labours has been to materially add to our knowledge of the Gasteropoda of the Lias formation.

The following summarized account will serve to illustrate the progress which has been made in this branch of Palæontology in recent times. In the Catalogue of British Fossils (2nd edition), published by the late John Morris in the year 1854, only six species of Gasteropoda are quoted from the Lias formation, viz. *Pleurotomaria Anglica*, *Pl. compressa*, *Pl. expansa*, *Trochus imbricatus*, *Turbo undulatus*, and *Dentalium giganteum*. In 1872, twenty-three species had been obtained from the Lias of Yorkshire, but in 1876 this number was, through the labours of Messrs. Tate and Blake, increased to 89 (see "Yorkshire Lias," p. 331). Mr. E. C. H. Day in 1863 obtained 40 species of Gasteropoda from the Middle Lias of Dorsetshire, many of which were new to this country, and appear to be confined to that district (Q.J.G.S. vol. xix. p. 278, and vol. xxxiii. p. 167). One of the most indefatigable students of the palæontology of the Lias at this period was the late C. Moore, who chiefly worked in the Somersetshire and S. Wales areas. The fruits of the labours of that very capable geologist are to be seen in the splendid "Moore Collection" of Lias fossils in the Bath Museum. This collection, which is, I believe, richer in Lias Gasteropoda than any other in England, contains 180 named British species, including no less than 90 type forms, many of which are unique both in their interest and rarity.[1] In 1871 Prof. Ralph Tate, in his "Census of the Marine Invertebrate Fauna of the Lias," enumerated 269 species representing 32 genera of British, as compared with 650 species representing 43 genera of Continental Liassic Gasteropoda (Geol. Mag. Vol. VIII. 1871, p. 4). Mr. R. Etheridge, F.R.S., in his Presidential Address to the Geological Society in 1882, "On the Analysis and Distribution of the British Jurassic Fossils," quotes 388 species, which are classed by him under 51 genera, from the Lias of Great Britain. Of this large number only six[2] species are stated to pass up into the Inferior Oolite, viz. *Actæonina pulla*, *Amberleya capitanea*, *Cerithium papillosum*, *Natica adducta*, *Onustus pyramidatus*, and *Pleurotomaria princeps*, one of which (*A. capitanea*) survived into the Forest Marble (Q.J.G.S. vol. xxxviii. p. 165). In reference to the foregoing account I would observe, without in any way questioning the general accuracy of the figures given by my esteemed friend Mr. Etheridge, or the validity of the conclusions founded thereon, that the number both of the species and of the genera appear rather too high for what they respectively represent. It was admitted, for instance, that the 136 Middle Lias names represented only 118 true species, and this, apart from any similar deduction for duplicated nomenclature in the

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[1] See Quart. Journ. Geol. Soc. vol. xxiii. p. 449, pl. 14–16; Proc. Somerset Arch. and Nat. Hist. Soc. vol. xiii. p. 119, pl. 4–6. It is unfortunate that these types should have been so indifferently delineated. Moore's sketchy figures give but a poor idea of the beauty of these fossils, and, in several instances, are so inaccurate as to be positively misleading as to their form. Students of this group should therefore beware of too readily trusting to identifications founded solely on comparisons of their specimens with these figures.

[2] This number is certainly capable of increase.

other two divisions of the Lias, would reduce his gross total to 370. Then again we find some of the genera repeated under different names: '*Amberleya*,' '*Eucyclus*,' and '*Tectaria*,' for example, are cited as three instead of as one only, and similarly the synonymous *Actæonina* and *Orthostoma* are apparently counted as two.

I have recently drawn up lists of the British Liassic Gasteropoda which, exclusive of those now described, comprise 425 species, distributed provisionally under 51 genera. In these lists care has been taken to avoid the reduplication of names, but it is probable that a small number of the species have been counted twice under different synonyms. These last, however, will, I believe, be more than balanced by the various new forms now awaiting description. The number of genera on the other hand is almost certainly too great. The 425 species are very unequally distributed among the genera. The dominant Liassic genera are *Trochus*, *Turbo*, *Cerithium*, and *Pleurotomaria*. Taking with the last the sub-group *Cryptænia*, each of these genera would comprise about 50 species, or together nearly a moiety of the whole number. Next comes *Chemnitzia* with some 30 species, and then *Amberleya* (=*Eucyclus*) *ctæonina* (= *Orthostoma*), *Turritella*, and *Patella*, with from 10 to 16 each. The following genera are represented by an average of 6 species each: *Actæon* (= *Tornatella*), *Alaria*, *Dentalium*, *Discohelix*, *Eulima* (= *Niso*), *Littorina*, *Natica*, *Neritopsis*, *Phasianella*, *Pitonillus* (= *Rotella*), *Solarium*, *Straparolus* and *Trochotoma*; whereas *Cylindrites*, *Cryptaulax*, *Delphinula?*, *Euomphalus?*, *Kilvertia* (=*Exelissa*), *Monodonta*, *Nerita*, *Neritina*, *Onustus*, *Purpurina*, *Rimula* and *Rissoa* are represented by 1 to 3 species each only. The remaining genera, which are mostly founded on extremely few forms, and in some cases on single and imperfect or on minute and immature specimens, cannot be considered to be satisfactorily established at present. These are *Chiton*, *Conus*, *Fusus*, *Nerinæa*, *Pterocera*, and *Pyrula*, one if not both of Moore's genera *Pleuratella* and *Pterocheilos*, and the following terrestrial and freshwater types:—*Ampullaria*, *Helix*, *Hydrobia*, *Melania*, *Planorbis*, *Proserpina*, *Valvata*, and *Vertigo*. Some of the foregoing are pretty sure to break down as Liassic genera under closer scrutiny and the acquisition of more satisfactory material. Indeed, it is very questionable whether any one of the first six of the above genera can be maintained; and, before accepting any *land* or *freshwater* form, as coming from a formation so essentially marine as the Lias, we must require in each case the most clear and convincing evidence. The net result of a future revision will probably be to reduce the number of generic types given above, whereas the species are probably capable of an appreciable and immediate increase.

The enumeration of 425 species of British Liassic Gasteropoda in 1886 as compared with the trivial number of six only in 1854, is a striking illustration of the progress which has been made in Palæontology in this country during the last thirty years.

Without further preface, I proceed to the main object of the present communication, which is to describe thirteen species of Gasteropoda. These are mostly new to science, and all are new to the British Lias.

For a full moiety of the material on which the following species are founded I am indebted to Mr. W. D. Crick, of Northampton, who has very generously placed a number of interesting specimens at my disposal for the above purpose, and has also furnished me with much valuable information as to their precise geological position. I am under a considerable obligation to the Rev. H. H. Winwood, M.A., F.G.S., for the facilities he has kindly given me for examining the specimens in the Bath Museum, to Mr. H. E. Quilter, of Leicester, for assistance with specimens from that county, and to Mr. T. Beesley, F.C.S., of Banbury, and Mr. B. Thompson, F.G.S., of Northampton, for useful information on the general subject.

*Note.*—In the following descriptions, the "sutural angle" is the greater angle which the suture makes with the side of the spire; and the "length of the last whorl" is measured axially, and posteriorly when practicable, from the anterior extremity of the aperture to the last preceding suture.

## DESCRIPTION OF NEW SPECIES.

### TROCHUS DALBIENSIS, spec. nov. Pl. V. Figs. 1, 1*a*, 1*b*, 1*c*.

*Description.*—Shell conical, as broad as high; imperforate; spiral angle concave, apex acute; whorls 7, slightly concave, separated by deep sutures, last whorl very large relatively, squarely angulated at the periphery. The ornamentation of this very pretty little shell is as follows:—Numerous slender radial costæ commence close to the posterior suture in a row of fine granulations, apparently formed at the junctions of the costæ with a fine encircling thread, and are continued forwards rather obliquely across two rows of larger rounded tubercles, similarly occurring at the decussations of the costæ with fine encircling threads; these two granulated lines occupy the anterior third of the whorls, and the anterior one of the two, which is the most prominent, gives a distinct angulation thereto; from each of the tubercles of this anterior row two fine threads pass downwards obliquely across the deep sutural groove, and terminate in a finely-granulated encircling thread close to the anterior suture. Base of shell almost flat, very slightly convex, with 12 or more very finely-crenulated concentric threads, which are closer together towards the centre and circumference, and wider apart in the intermediate area. Aperture trapezoidal, transverse and oblique. Outer lip boldly arched, inner lip almost straight and effuse over the columellar border.

*Dimensions.* — Length, 8 millimètres; diameter, 8 mm.; length of last whorl, 5 mm.; spiral angle, 70°; sutural angle, 128°.

*Affinities.*—This species is somewhat closely related to *Tr. Thetis*, Mün. (Goldfuss, Petr. Germ. pl. 179, figs. 10*a*, *b*: and Plate V. Figs. 2*a*, *b*, *c*). It differs therefrom by its finer ornamentation, the *double* row of anterior tubercles, the fine granules over the suture, and the more numerous concentric striæ on the base, also by its greater spiral angle, larger number of whorls, and more acuminate apex. Judging by the specimens of this latter species found at Dalby associated with the foregoing form, Münster's figure (*loc. cit.*) errs in showing unduly straight costæ, want of tubercles on the keel, a roundly-furrowed instead of a sharply-ribbed base, and an apparent and large umbilicus.

*Note.—Trochus Thetis* seems to be a difficult form to delineate. It has several times been re-figured, but never drawn with perfect accuracy. The figures I give (Pl. V. Figs. 2, *2a*, *b*, *c*) are an advance on most of the previous figures, but the appearance of an umbilicus is fallacious.

*Geological Position and Locality.*—Lower Lias, zone of *Am. oxynotus*, Railway-tunnel, Old Dalby, Leicestershire.

TROCHUS CRICKI, spec. nov. Pl. V. Figs. 3, *3a*, *3b*.

*Description.*—Shell conical, imperforate; spiral angle regular, very slightly concave, apex acute; whorls 5–6, quite flat; sutures linear, only slightly inclined; last whorl obtusely angulated at the circumference; base almost flat, very slightly convex; columella prominent, massive and vertical; outer lip imperfect, but the aperture when complete appears to have been rhomboidal and only a little wider than high. The whorls are covered with close-set spirals of small rounded tubercles, the spiral lines and the individual tubercles being respectively closer together than their interspaces; on the penultimate whorl there are 5–6 spirals; the tubercles of the most anterior row of these are a little the largest, and give a slight tabulation to the whorls, the row next behind are nearly equally large, then there is a very fine row, and behind these two rather coarser rows; on the last whorl 4 rows of coarser tubercles occupy the angular border, posterior to which are 4 rows of finer tubercles; on the base immediately within the 4 coarse granular lines are 3 finer lines, of which the outer one only is granular; the rest of the base is smooth.

*Dimensions.*—Length, 5 millimètres; diameter, 4 mm.; length of last whorl, 3·25 mm.; spiral angle, 65°; sutural angle, 130°.

*Affinities.*—This small shell appears to have rather close affinities with certain small Oolitic Trochi having granulated spires and smooth bases, such as *Tr. monilitectus*, Phil., and its allies *Tr. Scarburgensis*, Hudl., and *Tr. strigosus*, Lyc., figured and described by Mr. W. H. Hudleston, M.A., F.R.S., in his "Palæontology of the Yorkshire Oolites" (GEOL. MAG. Dec. III. Vol. II. 1885, p. 121, *et seq.*). It does not, however, appear to be absolutely identical with any of these.

*Obs.*—I name this fossil after Mr. W. D. Crick, of Northampton, whose valuable work on the palæontology of the Lias of that district has already been acknowledged.

*Geological Position and Locality.*—Middle Lias, zone of *Am. margaritatus*, Daventry, Northamptonshire.

TROCHUS SAGENATUS, spec. nov. Pl. V. Figs. 4, *4a*.

*Description.*—Shell conical, turrited, imperforate; spiral angle regular; whorls 8 probably (the apex being lost in my sole specimen), a little concave and slightly imbricating. Each whorl bears 3 equidistant encircling raised lines one a little in advance of the posterior suture, the second a little in front of the middle of the whorl, and the third forming a slight keel directly overhanging the deeply cut but very narrow suture; these are crossed by numerous slender, slightly oblique, radial costæ, forming with the spiral lines a neat meshwork, having little nodules at the decussations; the radial costæ are more slender and more closely set on the last whorl. Base almost flat, bearing numerous fine encircling threads with nearly equal interspaces; the radial costæ are continued over the angular border of the last whorl, to which they give a fine crenation, and then rapidly die away. Aperture depressed, lunate and oblique, outer lip somewhat thickened, columella inconspicuous.

*Dimensions.*—Length (restored), 6·75 millimètres; diameter, 4 mm.; spiral angle, 35°; sutural angle, 110°.

*Affinities.*—This form appears to be related to *Trochus Holwellensis*, Moore, a fossil derived from the Liassic deposit contained in fissures of the Mountain Limestone near Frome (Q.J.G.S. vol. xxiii. p. 554, pl. 17, figs. 1, 2). The types of this species should be in the Bath Museum, but they are unfortunately missing. Comparison of our specimen with Moore's figure, however, shows that whilst the two fossils agree in general form and ornamentation, *Tr. Holwellensis* had a more elongated spire, the whorls of which, instead of imbricating each other, were separated by wide and deep sutures, and bore fewer and coarser radial costæ, making prominent "bosses" on the margin of the last whorl. Moore's type appears also to have had a small umbilicus. These points of difference seem quite sufficient to distinguish the two forms specifically.

*Geological Position and Locality.*—Upper Lias (transition-bed to Middle Lias), L. and N. W. Railway, Watford, Northamptonshire.

### TROCHUS NORTHAMPTONENSIS, spec. nov. Pl. V. Figs. 5, *5a*.

*Description.*—Shell conical, imperforate; apex acute; spiral angle, regular or slightly convex; whorls 7, concave; a prominent and acute crenulated ridge or carina encircles the anterior portion of the whorls, and a similar but much less prominent ridge encircles the whorls close to the posterior suture; between these there is a concave area occupying two-thirds of the width of the whorl; from the anterior carina the surface of the whorl falls vertically to the anterior suture, this portion occupying about a third of its width; the last whorl is tricarinated, having two anterior crenulated carinæ, the posterior of which is the more prominent; broad undulating costæ run somewhat obliquely from the spinose points of the posterior to those of the anterior carina, beyond which they are continued vertically to the anterior suture, and on the last whorl, after connecting the spinose points of the two anterior carinæ, are continued in more or less prominent serpentine ridges from the circumference to the centre of the base. A few faint encircling lines are discernible in the concave portions of the whorls. The whole shell is covered with fine close-set radiating flexuous lines, which pass over the costæ and their interspaces, the carinæ and the base. The base is only slightly convex, but prominent in the centre, and marked with numerous concentric lines, which are either equally distinct and spaced from circumference to centre, or are much more distinct and more widely spaced towards the circumference, in addition to the radial serpentine lines and ridges above mentioned. Aperture transverse, outer lip thin, with an irregular outline; inner lip concave, with a broad expansion over the massive, axial and somewhat obliquely produced columella.

*Dimensions.*—Height, 10·75 millimètres; diameter, 9 mm.; length of the last whorl, 6·75 mm.; spiral angle, 60°; sutural angle, 125°.

*Note.*—Figs. 5 and *5a*, being drawn from a laterally compressed specimen, show a rather greater breadth and spiral angle, and a more transversely elongated aperture than this form really possesses.

*Affinities.*—In its general form and ornamentation this shell appears almost identical with one (viz. fig. 6) of the figures of D'Orbigny's *Turbo subduplicatus* (Pal. Fr. Terr. Jur. vol. ii. p. 339, pl. 329, figs. 1–6), a species which, according to that authority, is synonymous with *Trochus duplicatus*, Sow., *Turbo duplicatus*, Goldfuss, *Turbo plicatus*, Goldfuss, and *Turbo Palinurus*, D'Orb. We are, however, confronted with the fact that the Northamptonshire fossil is certainly not a *Turbo*, but a *Trochus.*

The aperture of the particular form (*l.c.* pl. 329, fig. 6) which is so like our specimens is not shown, but the author defines its character in this very variable species of his as "round, with a broad thickening over the columella." The question arises, was the aperture of this particular shell (*l.c.* pl. 329, fig. 6) hidden or imperfectly shown, and has D'Orbigny mistaken its genus in consequence, or has he and Goldfuss also (Petr. Germ. vol. iii. p. 95, pl. 179, fig. 2) misinterpreted the character of this portion of these shells generally, and thus of the genus, from having had to deal with imperfectly-preserved specimens?[1] The description and figure of *Trochus duplicatus*, Sow., which give the aperture as quadrangular (Min. Conch. vol. iii. p. 181, t. 181, fig. 5), indicate that Sowerby's type was a genuine *Trochus.* The species *Trochus duplicatus*, Sow., is therefore good, and must stand. If Goldfuss and D'Orbigny were correct in their respective *specific* identifications of *Turbo duplicatus*, and *Turbo subduplicatus*, with Sowerby's type, they have both erred in their *generic* appellation. However this may be, I consider the Northampton fossil distinct from all these, with the probable exception of the particular shell figured by D'Orbigny as *Turbo subduplicatus* (*l.c.* pl. 329, fig. 6), which—relying upon the vertically truncated whorls and spinose and widely-channelled double-keel—I consider distinct from the other forms figured by that author (*l.c.* pl. 329, figs. 1–5).

*Geological Position and Locality.*—Upper Lias, zone of *Am. communis*, New Railway, Weedon and Dodford, near Daventry, Northamptonshire.

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[1] The matter is complicated by D'Orbigny describing a typical *Trochus duplicatus*, Sow., in another part of the Pal. Franc. (Terr. Jur. Gast. ii. p. 275, pl. 313, figs. 5–8) under that name.

### TROCHUS NIORTENSIS, D'Orb. Pl. V. Figs. 6, 6*a*, 6*b*.

1850. D'Orb. Pal. Franc. Ter. Jur. vol. ii. Gast. p. 282, pl. 315, figs. 5—8.

I recently obtained a little shell from the Marlstone Rock-bed of Downcliff, near Bridport, Dorset, which in all essential respects agrees with *Tr. Niortensis*, described by D'Orbigny as having been derived from the étage bajocien (Inferior Oolite) of Niort (Deux Sèvres).

*Description.*—The following is a translation of that author's description:—"Shell conical, much longer than broad, imperforate. Spire formed of a regular angle, composed of whorls very much hollowed out, striated longitudinally, and marked in the lower portion with oblique costæ tuberculated *below* (*i.e.* posteriorly). The last whorl is convex, striated concentrically above and angular over the sides. Aperture a little depressed and angular. Spiral angle, 49°. Length, 10 mm.; breadth, 8 mm." (D'Orbigny, Pal. Fr. *l.c.* p. 282).

*Affinities.*—My specimen has a less elevated spire than D'Orbigny's type, being only a little higher than broad, 6 : 5, with a decidedly greater spiral angle, viz. 60°; the three apical whorls and the spiral angle are a little convex; the costæ, too, are more strongly nodulated at their *anterior* ends and prominent on the upturned keel; the base shows radial as well as encircling striæ; and the aperture is more squarely angulated than in D'Orbigny's figure. These differences are of detail rather than of essence, and not more than might reasonably be expected between individuals of the same species derived from such widely-separated horizons as the Middle Lias and the Inferior Oolite. D'Orbigny speaks of the aperture of his *Tr. Niortensis* as "angular," and in this the description is probably more correct than the delineation, which, like that of too many of the figures in the Paléontologie Française, appears to have received an artistic rounding off or restoration not strictly true to nature.

*Obs.*—The occurrence of this fossil in the English Lias is of special interest from its being one of those that range into the Oolite.

*Geological Position and Locality.*—Middle Lias, Conglomeratic Marlstone, zone of *Am. spinatus*, Down Cliff, near Bridport, Dorset.

### AMBERLEYA CALLIPYGE, spec. nov. Pl. V. Figs. 7, 7*a*.

*Description.*—Shell turbinate, thin, imperforate; spiral angle regular; whorls 6–7, only slightly convex, the greatest diameter of the whorl is attained a little behind the anterior suture, whence it falls rapidly thereto, thus giving a slight tabulation; sutures narrow, but clearly defined; last whorl relatively large, long and inflated; base very convex; aperture broadly ovate; outer lip thin, with its inner margin very finely crenated; inner lip slender, extending somewhat over the columella, vertical, but arching forwards towards its angular junction with the outer lip at the anterior margin, which at this point is patulous and a little effuse. The ornamentation of this handsome shell is elaborate, the whole surface being covered with close-set spirals of small rounded tubercles. On the first 4–5 whorls these granular tubercles are much finer than on the last 2. The third whorl bears only 4 of these spirals. The penultimate whorl bears 7 granular spirals; of these the sixth from the posterior suture lies on and determines a faint angle, and the seventh is close to the anterior suture; these two rows consist of rather coarser tubercles, and speaking generally the granules get smaller towards the posterior suture; the spirals are separated by about their own breadth from one another, and the individual beads of a spiral from a little less up to rather more than their own width. On the last whorl very finely granulated lines are seen setting in between the rows of coarser granules; there are eight or nine of each series counting from the periphery, whilst the base shows a like number of the coarser spirals (which are more closely set and somewhat finer than those posterior to the periphery), with indications of fine alternating spiral lines.

*Dimensions.*—Length, 8 millimètres; diameter, 5·75 mm.; length of last whorl, 5·75 mm.; spiral angle, 68°; sutural angle, 125°.

*Geological Position and Locality.*—Middle Lias, zone of *Am. margaritatus*, Daventry, Northamptonshire.

Monodonta (Turbo) humilis, spec. nov. Pl. V. Figs. 8, 8*a*, 8*b*.

*Description.*—Shell small, smooth, spire greatly depressed; whorls 4, flattened and embracing, with linear sutures and scarcely exsert (Fig. 8), but occasionally the whorls are a little convex, the sutures distinct, and the spire slightly raised (Fig. 8*a*). A shallow sulcus encircles the whorls posteriorly; this depressed area is most apparent on the last whorl, and occasionally becomes so marked as to hollow out its whole upper surface, and give an angulated instead of the prevailing obtusely rounded border to the shell; the columella is very short and twisted, it terminates by uniting with a prominent bluntly triangular tooth, which originates at the edge of the inner lip in advance of and reflected over the minute umbilicus. Aperture transversely ovate, rather small and not quite continuous, directed obliquely forwards, and having its outer border slightly constricted by the sulcus. Base almost flat, very slightly convex, more or less wrinkled towards the centre. Under a lens the shell shows numerous close-set lines of growth.

*Dimensions.*—Height, 2·50 millimètres. Diameter 3 mm.

*Geological Position and Locality.*—Lower Lias, zone of *Am. oxynotus*, common in the Tunnel waste heaps, Old Dalby, Leicestershire.

Monodonta (Turbo) Lindecolina, spec. nov. Pl. V. Figs. 9, 9*a*, 9*b*.

*Description.*—Shell small, thick, transversely ovate; imperforate; spire scarcely exsert, and apex obtuse; whorls 5–6, convex, embracing with scarcely visible linear sutures, the last whorl inflated; a shallow sulcus bounds the posterior suture; base slightly convex; the umbilical region, which appears to be covered by a thin shelly callus, is encircled by a more or less prominent semicircular ridge which runs nearly from the posterior to the anterior inner margin of the aperture; aperture almost exactly circular, oblique, the last whorl slightly disjoined from the penultimate posteriorly at the aperture; columella very short, and twisted horizontally, terminating in a prominent bluntly-pointed tooth, in front of which is a narrow groove. The shell is smooth and shining, but under a strong lens its whole surface up to the basal ridge above referred to is seen to be covered with numerous fine encircling striæ, and still finer curved radial striæ.

*Dimensions.* — Height, 4 millimètres; diameters, 5 mm. and 5·75 mm.

*Geological Position and Locality.*—Upper Lias, zone of *Am. serpentinus*, Lincoln.

### EXPLANATION OF PLATE V.

Fig. 1, a, b, c. *Trochus Dalbiensis*, sp.n.—Lower Lias, zone of *Am. oxynotus*, Old Dalby. Back and front views and base enlarged twice, penultimate whorl enlarged six times.

,, 2, a, b, c. *Trochus Thetis*, Mün.—Lower Lias, zone of *Am. oxynotus*, Old Dalby. Back and front views and base enlarged twice, penultimate whorl enlarged six times.

,, 3, a, b. *Trochus Cricki*, sp.n. — Middle Lias, zone of *Am. margaritatus*, Daventry. Back and front views enlarged three times, penultimate whorl enlarged six times.

,, 4, a. *Trochus sagenatus*, sp. n.—Upper Lias, Watford. Back and front views. enlarged three times.

,, 5, a. *Trochus Northamptonensis*, sp. n.—Upper Lias, zone of *Am. communis*, Weedon. Back and front views enlarged twice.

,, 6, a, b. *Trochus Niortensis*, d'Orb.—Middle Lias, zone of *Am. spinatus*, Down Cliff. Front and basal views enlarged three times, penultimate whorl enlarged six times.

,, 7, a. *Amberleya Callipyge*. sp. n.—Middle Lias, zone of *Am. margaritatus*, Daventry. Front and back views enlarged three times.

,, 8, a, b. *Monodonta humilis*, sp. n.—Lower Lias, zone of *Am. oxynotus*, Old Dalby. Front, back, and apical views enlarged four times.

,, 9, a, b. *Monodonta Lindecolina*, sp. n.—Upper Lias. zone of *Am. serpentinus*, Lincoln. Back and front views enlarged twice, portion of penultimate whorl enlarged six times.

,, 10, a. *Cerithium trigemmatum*. sp n.—Lower Lias. zone of *Am. oxynotus*, Old Dalby. Back and front views enlarged six times.

,, 11, a. *Actæonina ferrea*, sp. n.—Middle Lias. zone of *Am. spinatus*, Tilton. Back and front views enlarged three times.

,, 12, a. *Cylindrites æqualis*, sp. n.—Middle Lias. zone of *Am. spinatus*, Tilton. Front and back views enlarged twice.

,, 13. *Alaria Hudlestoni*, sp. n.—Lower Lias, zone of *Am. Bucklandi*, Bitton. Front view enlarged three times.

,, 14. *Alaria semicostulata*? Piet et Eug. Desl.—Upper Lias, zone of *Am. serpentinus*, Dodford. Back view enlarged twice.

,, 15. ,, ,, ?—Upper Lias, Chipping Warden. Front view enlarged twice.

(*To be continued.*)

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## II.—The Water-Supply of East Kent, in Connection with Natural Springs and Deep Wells.

(Being the substance of a Paper read before the East Kent Natural History Society.)

By George Dowker, F.G.S.

THE numerous demands made upon our underground water-supply, both for sewage and sanitary as well as brewing purposes, render the subject of my paper a matter of deep and serious importance.

I shall set forth in the first place the rise and course of the rivers, and in the next place the wells, especially the deep ones in the Chalk area; and I propose to show the connection between the height of the springs and the rainfall of the district.

Although I have chosen for the title of this paper "The Water-supply of East Kent," I must premise that the area to which I shall confine my remarks is chiefly East Kent as represented by a line from West Hythe to Whitstable and eastwards, and generally to that part of Kent included in the new one-inch maps, numbered Sheets 273, 274, 289, 290, 305, 306, which combined will form a very good map of reference to my paper.

The well-sections are many of them unpublished, but my remarks will chiefly be directed to their water-level rather than their geological features.

The section I have constructed from West Hythe to the north of Canterbury will show the general dip of the beds of the whole area, and define approximately the thickness of the underlying beds: I say approximately, for the beds below the Chalk vary in relative thickness, and between the Gault and the Wealden beds we may expect to find (after the facts revealed in the deep well-section at Dover Convict Prison, where the Lower Greensand is only represented by 31 feet of clayey sand) no certainty as to thickness or character.[1]

The bed called Upper Greensand between the Gault and Chalk Marl is barely represented in East Kent, and the base of the Chalk Marl, which (in all the sections I have met with) has been so squeezed and contorted that no definite thickness could be assigned to it, and some 50 feet of the Lower Chalk resting on the Gault is an alternation of sand and clay which for the most part retains water. It is from this bed, probably the upper part of it, that we find the springs thrown out all along the southern edges of the escarpment of the Chalk. For the details of these beds Mr. Hilton Price's paper on the beds between the Gault and the Upper Chalk may be consulted.[2]

The rivers of this district are the Stour, the Little Stour, and the Dour.

The Stour has two branches, which both take their rise from numerous springs which issue from the Chalk escarpment of the Weald, mostly between the Chalk and Chalk Marl, or the latter and the Gault. The southern source of the Stour is close to Postling Church, where a strong spring rises at about the elevation of 330 feet above Ordnance Datum. Thence it flows in a north-westerly direction receiving various tributaries; strong springs at Horton Park, Stouting, and Brabourne, the strongest springs in each case rising at the level of 300 and 350 feet. The water is highly charged with carbonate of lime, and travertine (calcareous tufa) is deposited. Thence, flowing westward by Ashford, it is joined by another branch, rising near Lenham Church and Westwell, and so flowing in an opposite direction to Ashford. Here the united streams cut through the Chalk escarpment, and flow as one river between Wye, Godmersham, Chilham,

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[1] See Quart. Journ. Geol. Soc. vol. xlii. p. 36.

[2] Quart. Journ. Geol. Soc. vol. xxxiii. pp. 431.

Chartham, and Canterbury. Here the river is fed by several strong springs issuing from beneath the drift gravel and clay beds of the Stour and lateral valleys. At Canterbury, and thence towards the Isle of Thanet, there are many springs, which rise in the alluvium of the valley on either side, in the form of circular deep conical pits, which are locally called "Nicker-pits"—a name of Saxon or perhaps Celtic derivation. As the water from these pits is highly calcareous, it probably is likewise derived from the Chalk, or flows between the Chalk and Lower Tertiary beds. Such springs occur at Chartham and at Canterbury, where one goes by the name of the Silver Hole, and is situated near White Hall. It was proposed by Mr. Pilbrow, the engineer, to utilize this spring for the water-supply of Canterbury. Again, at West Bere, on either side of the river, like springs are met with.

The Little Stour, which in the upper part of its course constitutes the *Nailbourne*, takes its rise at a very short distance from the source of the Great Stour, at Postling Church, is derived from the same range of hills, and has its first spring at Etching Hill, which is about one mile south of Postling Church; thence it flows through the Elham Valley, by Lyminge, Elham, Barham, Bishopsbourne, and Beaksbourne, where it forms a *permanent* stream, flowing thence to Wingham, through Littlebourne, Ickham and Wickham. At Wingham it is joined by a branch stream fed by strong springs ("Nicker-pits") at Danbridge, and by another stream running along the Tertiary escarpment by Ash towards Woodnesborough; at the latter place there are large "swallow-holes" which absorb the water from the surface and convey it some distance underground. Passing Wingham these streams unite their waters in the Little Stour, which flows parallel with the Great Stour, till their waters finally unite at Stourmouth; from which place the Stour (formerly the Wantsum) flows in a very circuitous course round to Sandwich, where it bends upon itself and flows out to sea at Pegwell Bay.

The Dour, the next river, has two heads, one a little above Ewell, at a place called "Little Waters," and another southward towards Alkham, which rises at an elevation of about 300 ft. O. D. The Alkham Valley receives the drainage of the higher hills, running as a "Nailbourne," these two streams unite at River, and thence, as the Dour, flow out to sea through Dover Harbour. The waters of the Dour are highly calcareous, and deposit travertine. Large quantities of this substance have been found in the Dour Valley, which formerly appears to have received a much larger quantity of water.

To the north of Canterbury in the Tertiary area of the district the chief stream is one which rises, in the Blean Woods near Dunkirk, at an elevation of about 200 ft. O.D., and flows in a north-easterly direction to Chislet, where it flows through a valley called the Nethergong, and thence out to sea northwards by Reculver.

A similar small stream, rising near the same place as the last, flows northward out to sea at Swalecliffe, and a third stream issues from the Blean Woods, and flows into Whitstable Bay by the Graveney marshes.

Over the Tertiary area from Deal to Sandwich are several strong springs, which are partly used in the Delf, an artificial water-course, constructed to supply the town of Sandwich with water. One of these rises at Northbourne, receiving there the drainage of the Chalk valleys which run from west to east: this Northbourne stream empties into the Stour near Sandwich Haven. At Eastry another similar spring occurs, flowing in a like direction, and receiving in the same way the underground drainage from the Chalk valley running towards Dover.

In the Isle of Thanet there are no streams of any importance; but one occurs at "Great" and "Little" Brooks End, and runs north-west into the sea near St. Nicholas, while another small brook is found eastward of Minster, emptying into Pegwell Bay; springs issue near the "Sportsman," and from the Thanet beds of Pegwell Bay cliff, in these instances apparently from the Tertiary beds.

Between West Hythe and Folkestone, south of the Chalk hills, are several springs. I would particularize those at Sandling Park and Saltwood, taking their rise from the *Lower Greensand strata*, and flowing out to the sea at Hythe. Similar smaller streams are met with at Newington and Cheriton, while another occurs at Lymne.

By the seaboard from Folkestone to Deal many springs are tapped by the sea-cliffs. Among these I would mention a strong spring at Lydden Spout, which issues from the Chalk Marl, about 15 feet from the base of the cliff, which is about 400 ft. in height. The bed from which this water issues is No. V. bed in Mr. Price's section, 48 feet above the Gault.[1] At St. Margaret's Bay are some very strong fresh-water springs below high-water mark.

The way in which the Chalk strata absorbs, retains, and gives out the rainfall is strikingly illustrated in the wells and "Nailbournes" of the Chalk, to which I wish here to draw attention. Details of the Petham Nailbourne are to be found in the Proceedings of this Society for 1880.[2] I have before mentioned the source of the Lesser Stour as taking the character of a Nailbourne from Etching Hill to Beaksbourne. After a wet season the springs rise, as is apparent by the increase of water in the wells; those situated on the highest level being the first to show it, then successively the springs rise in the wells lower down the valley, till they overflow, or discharge their waters as a periodical stream; this stream runs down the course of the before-mentioned valley till it joins the permanent stream at Beaksbourne. After excessive wet seasons the stream comes from the highest level, but at other times lower down. It is evident, however, that the water is flowing as an underground stream long before and and after it appears at the surface. In proof of which I would mention the following facts. After a very wet season the stream flows all the way down the valley from Etching Hill Pond; at other times it flows only above ground from Lyminge Pond; while at dry seasons it flows above the ground only low down the valley at Beaksbourne. After some wet winters the

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[1] Q.J.G.S. vol. xxxiii. p. 431.

[2] See Mr. Hammond's paper, E. K. Nat. History Society, 1880.

Nailbourne may run for two years in succession; on other occasions it may not appear for two, three, or four successive years.

Matthew Bell, Esq., writes to me to the effect that in dry seasons his ponds became dry when the Nailbourne was not running, and being convinced that all the time at Bourne Park the water was finding its way down below ground, he caused a trench three feet wide to be sunk across the valley, through the underground stratum of gravel (which he then ascertained to be about 12 to 15 feet in thickness), into the Chalk below, and then filled this trench with stiff puddle, forming an underground dam. The water, as he expected, immediately began to rise, and the sheet of water opposite his house has never been dry since. A reference to the section which I have prepared to illustrate this paper will perhaps explain the action of this Nailbourne better than a mere verbal description. It will be seen that the beds dip at a considerable angle from south to north; at the former the impervious beds of Chalk Marl and Gault Clay cause the water to gravitate in the porous Chalk strata from south towards the north. The water from the Chalk is derived in the first instance from the rain falling on its surface. This takes a considerable time to find its way down to the *impervious* bed; and, after doing so, to spread laterally through the surrounding strata. It is evident that when the Chalk is *saturated with water*, the water-level is correspondingly raised. It happens that it is some time after the abnormal rainfall, before it affects the water-level of the wells, and consequently before the lower strata become saturated with water. When this is the case, the water finds its way out at the surface, and runs down the valley. It may at first sight appear strange that springs should break out at Postling and Horton, as the beds dip in the contrary direction to the flow; but if you consider that the impervious beds of clay there come to the surface, and the rainfall takes a long time to expand laterally through the Chalk, you will understand that it will here find vent where there is the least resistance.

An examination of the section will show also that the water-level by no means corresponds with the height above the sea-level (a very prevalent error). It will be seen that the water-level in the wells at Acrise, Horton, Elmsted, and Wootton, stands at a level some two hundred feet or more above those at Canterbury. These well-sections are placed to scale at their respective heights, and the water-level of the wells is shown by a shaded line. Most of these wells are dug in the Chalk, not bored, and many of them have been deepened in dry seasons, so that in this case the well depths represent pretty nearly the ordinary water-level in dry seasons; for it is impossible to get these wells sunk to any considerable depth below the point of saturation or water-level in the Chalk. For instance, Mr. Collett, of Elmsted Rectory, who has dug a well 277 feet deep, states: "The springs rise and fall here in a wonderful way; they are usually highest in May, and fall till January, when they begin to rise again. In 1884, Jan. 13, the well was dry, next day it rose 14 feet; the water varies in height from 13 to 63 feet." Mr. Metcalfe, of Upper

Hardres Rectory, writes, "This well was formerly 300 feet deep, but failed in the dry seasons of '56 and '58, when it was deepened 60 feet. The water-level lowers in autumn from 20 to 30 feet."

The Chalk area is by far the largest in this district, and, exclusive of the Isle of Thanet, equals about 296 square miles. While the area of the Tertiary beds is about 158 square miles.

The rainfall of the district is subject to considerable variation, and more statistics on this head are needed. At Sheldwich the average rainfall for three years 1883 to 1885 equalled 25·99 in. At Canterbury for 1884 it was equal to 20·83 in. At Ramsgate for three years from 1883 to 1885 = 21·81 in. While at Horton Park I have for 1883 above 30·00 in. It must be remembered that the last three years were exceptionally dry ones.

One inch of rainfall represents about 100 tons of water to the acre. A portion of this is lost by evaporation, and some passes away underground to sea; the remaining portion constitutes our available supply in rivers and wells.

A consideration as to the permeability of different beds, and their capacity for retaining water, will form an important element in our calculation. We may consider the Chalk area as the most important, not only as the chief water reservoir, but as constituting by far the largest portion of the district, and it will be found that it is throughout its extent extremely permeable when not saturated with water, down to a short distance from the Gault. The large supplies of water required for the Canterbury Waterworks, the Chartham Asylum, the Canterbury Breweries, the wells for drinking water at Ramsgate, Margate, and Dover, are all derived from this formation. In the case of the deep boring for the Convict Prison at Dover, made during this year, when strata were pierced to the depth of over 900 feet (penetrating both Gault and Lower Greensand), the water-supply was chiefly, if not entirely, derived from the upper three hundred feet, all in the Chalk. The time taken by the water to reach the line of saturation in this Chalk area appears to be about three or four months, and the height of the springs varies in proportion to the rainfall.

The Chalk area is in some places capped by impermeable beds of clay, as at Swingfield Minnis, but the clays and gravels over the Chalk are for the most part permeable. North of Canterbury, over the Tertiary area, the permeable beds are the sandy portions of the Old Haven, Woolwich, and Thanet beds; the lower parts of the latter, however, are impermeable. Above these the London Clay and the clay and gravel beds of the Blean district are impermeable.

A narrow tract of land below the escarpment of the Chalk Downs, stretching from Folkestone to Wye, is composed of impervious Gault and pervious beds of the Lower Greensand. In many of the wells, after piercing the Gault, the water flows up to, or over the surface. In this area the water from the Sandgate beds of the Lower Greensand is bad, being largely impregnated with iron. I have very few data relating to the wells of this district, which is, however, of little importance in the general survey of the water supply.

Mr. W. Whitaker, B.A.Lond., Assoc. Inst. C.E., F.G.S., of H.M. Geological Survey, has kindly placed at my disposal some well-sections not before published, chiefly that of the Herne Bay Waterworks at Ford and the Whitstable Waterworks, which are in the Tertiary area north of Canterbury. But it is not certain from these data whether the water is derived from the Thanet Beds or the Chalk. In the case of Whitstable, at a height of 48 feet above Ordnance Datum, the well, 400 feet deep, pierced the London Clay at 69 feet, the Tertiaries at 240 ft., and penetrated the Chalk 160 feet. The water-level is stated to be 35 feet down, and the yield 220 thousand gallons daily. And in the case of Ford, reaching a total depth of 260 feet, piercing the Lower Tertiaries at 110 feet, and penetrating the Chalk 50 feet—the water-level standing 26 feet down. From which facts it seems that the Chalk in both cases was the source of the supply.

The well-sections in the Isle of Thanet, which have (with the exception of one at Mr. Cobb's Brewery, Margate) been sunk but little below the sea-level, have only yielded water at about that level. In the case of Mr. Cobb's well, which reached a depth of 317 feet, no spring was met with. Artesian wells at Minster at a low level, piercing the Thanet Bed to some 20 feet or so into the Chalk, yielded water springs flowing to the surface.

The permeability of the Chalk in Kent was shown some years ago by an old member of our Society, Mr. Bland, of Sittingbourne, in some tables which he published showing how one well was influenced by another, and how they all fluctuated with the rainfall of the seasons. Mr. Prestwich has in his memoirs[1] made use of it, and I am indebted to the Rev. C. J. Wimberley, of Sibertswold Vicarage, for a copy of this interesting paper. His conclusions with respect to the permeability of the Chalk have been corroborated in all the observations I have made, and the truth cannot be too often repeated to those who are engaged or interested in sanitary matters. It must be of the first importance to consider this in relation to the sewage and health of towns. Sewage matter will contaminate a large area of Chalk, if precautions are not taken.

The section I have made would show how regularly the lower beds dip towards Canterbury; but if I had continued the section to Whitstable nearly in the same line, it would be apparent that the Gault must rise, or there would be an enormous thickness of Chalk to be accounted for had the Gault continued at the same dip. It is assumed that the bore at the Chartham Asylum touched the Gault. Mr. Whitaker places the bottom of the bore at that horizon. From the specimens I have seen at the Canterbury Waterworks, I doubt if they quite reached the Gault. There seems also to be a slight synclinal of the Thanet beds in the valley of the Stour east of Canterbury—the Isle of Thanet being on an anticlinal.

It would seem as if the Lower Greensand in this neighbourhood cannot be reckoned upon as a source of water-supply, firstly, because

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[1] "The Water-bearing Strata of the Country round London," and "Manual of Geology."

the water is not good, and secondly, because there is no high land of this formation to receive the rainfall, nor is it certain that it would be met with in any thickness east of Dover.[1]

The slight anticlinal ridge of the Thanet Chalk has yielded water for the present supply of Ramsgate, Margate, and Broadstairs; but in dry seasons the supply has not equalled the demand, and supplementary wells have been sunk; these, however, all derive their supply from the exceedingly porous beds of the Upper Chalk, the wells not reaching much below the sea-level, about which point the line of saturation of the Chalk is there reached. From the fact that one of these, the Southwood Waterworks near Ramsgate, became brackish from the influx of sea-water, the engineers of these waterworks appear to have been afraid to sink deeper in the Chalk. It is proverbially foolish to prophesy unless you know; but I would venture to suggest that the future water-supply of Thanet must be sought for in a well reaching down nearly to the Gault. For though there is every appearance that the whole depth of the Chalk strata of Kent are to be found here (the Thanet beds reposing on the higher beds at Margate, St. Peter's, and Broadstairs), yet there should be no difficulty in piercing the Chalk, and I should expect an unlimited supply of good water would be found in the Lower Chalk. Should such be the case, there would be no danger of its being contaminated with sea-water, if a site were chosen not too near the sea, or directly in a line of fault. If the stratum pierced was in a state of saturation, there would be no reason to fear that sea-water would replace the fresh.

One great advantage of the water derived from deep Chalk strata is its great purity, the only drawback being its exceeding hardness, from the presence of bicarbonate of lime; this may, however, be got rid of by adopting the admirable method employed at Canterbury, of passing lime water in certain proportions into the fresh pumped water, which, uniting with the excess of acid in the bicarbonate of lime in solution, precipitates it as an impalpable powder, and at the same time killing all organic impurities and precipitating them with the lime.

It now only remains for me to explain the supplementary section and well notes which have been placed at my disposal. Mr. Bland's paper, already alluded to, is entitled, "Measurements of the Altitudes of the Hills and Valleys and the Depths of Wells through a Part of Kent, undertaken for the purpose of ascertaining the Height of the Springs above the Sea-level," and referring chiefly to the Chalk in and around Sittingbourne in the years 1827 and 1828, with the rainfall and state of the weather from 1819 to 1829. Privately printed at Sittingbourne. For the loan of this interesting paper I am indebted to the Rev. C. J. Wimberley, Sibertswold Vicarage.

Notes on the Petham Nailbourne from 1772 to 1869. Communicated by Mr. James Reid, of Canterbury. "The Nailbourne came into Shamford Street, Feb. 22, 1772, and continued to run through the street till June 16, 1772. It came into the street again, March 7, 1774, and continued running till June 28, 1774. It came into

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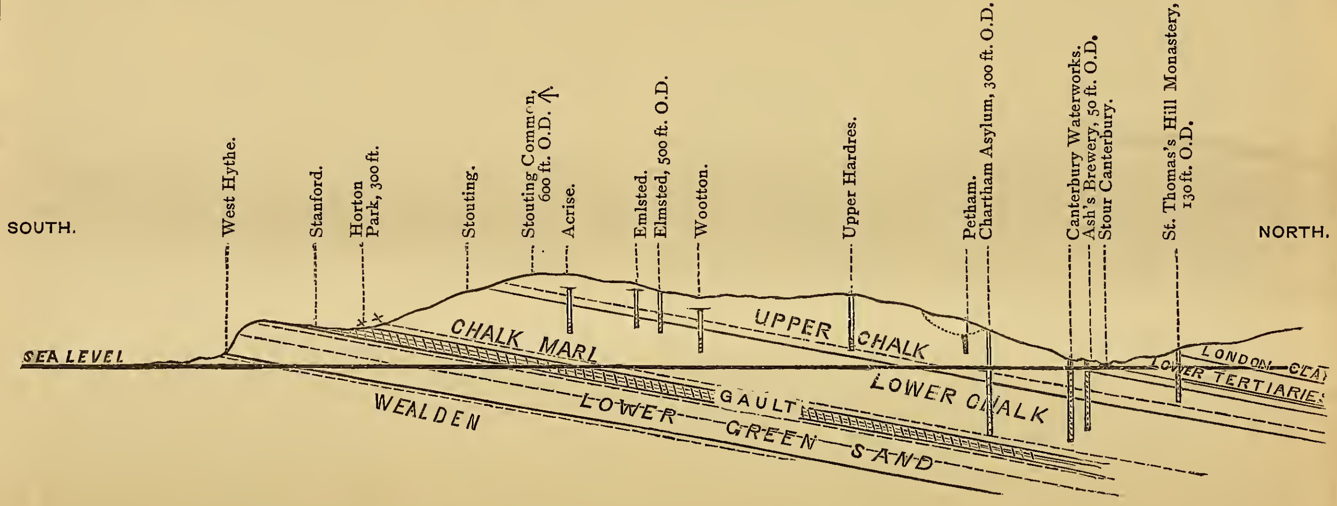
[1] See section in Mr. Whitaker's paper, Quart. Journ. Geol. Soc. vol. xlii. p. 36.

To illustrate Mr. Dowker's paper on the Water-supply of East Kent, in connection with Natural Springs and Deep Wells.

SECTION FROM WEST HYTHE TO CANTERBURY, ABOUT 17 MILES. GENERAL DIRECTION, SOUTH TO NORTH.



* Springs issue from this level south.
The wells, bottoms and tops are to scale above and below Ordnance Datum level.
The stations are nearly on the line of section except Acrise.

Horizontal Scale three miles to one inch. Vertical Scale 1200 feet to one inch.

George Dowker, F.G.S., del.

## APPENDIX.—WELL-SECTIONS.

| SITUATION. | AUTHORITY. | Surface Height above O.D. | DEPTH. | Water Level from Surface. | REMARKS. |
|---|---|---|---|---|---|
| | | FEET. | FEET. | FEET. | |
| Whitstable Waterworks | W. Whitaker | 43½ | 400 | 35 | Tertiaries to 240 ft. Chalk, 160 ft. Bored. |
| Ford, Hoath | W. Whitaker | 50 | 260 | 26 | Tertiaries, 110. Chalk, 50. Bored. |
| Canterbury Monastery | W. Whitaker | 120 ? | 310 | 105 | Tertiaries, 208. Chalk, 102. Bored. |
| Canterbury Waterworks | J. C. Homersham, C.E. | 47 | 509 | 19 | In Chalk, Greenish Chalk, 26½ ft. Yielding 900,000 gallons per diem. Bored. |
| Canterbury Dane John | Kentish Gazette, 1886 | 50 ? | 400 | 18 ? | To Chalk, 24 feet. Yielding 2500 gallons per hour. Bored. |
| Chartham Asylum | W. Whitaker | 300 | 740 | 230 | Chalk 734 ft. Gault 5 ft. Bored. |
| Upper Hardres | Rev. F. Metcalfe | 400 | 360 | 300 | Water lowest in Autumn 20 to 30 feet. Dug. |
| Hardres School | Ditto | 429 | 200 | Dry at times. | The former deepened 60 feet in 1856. Dug. |
| Elmsted Vicarage | Rev. G. A. Collett | 500 | 243 | 180 | Varies much. Dug. |
| Elmsted | Rev. G. A. Collett | 514 | 277 | — | |
| Sibertswold | | 400 | 300 | 288 | Water generally 12 feet deep. Dug. |
| Wootton Rectory | J. P. Hambrook | 420 | 333 | 290 | Stands at — varies greatly. Dug. |
| Wootton Denton | Rev. J. Wimberley | — | — | — | Varies from 13 to 63 feet. Dug. |
| Acrise Place | W. A. Mackinnon | 500 | 240 | — | Varies but never fails. Dug. |
| Stouting Rectory | Rev. Upton | 350 ? | 12 | — | Highest in January, lowest in October. Dug. |
| Monks Horton | J. Kirkpatrick, F.G.S. | 386 | — | — | Surface springs at 300 feet, O. D. Dug. |
| Dane Farm, Petham | Ditto | 300 | 260 | 240 | Depth of water 20 ft. Dug. |
| Dover Convict Prison | W. Whitaker | 280 | 916 | 315 | Water yielding 18,000 gals. per diem. Bored. |
| Margate | G. Dowker | — | 374 | — | No spring of water met with. Bored. |
| Ramsgate Waterworks | J. T. Hillier | 118 | 150 | 10 ? | Yields 900,000 gallons per diem. Dug. |
| Ramsgate Hersen J. | J. H. Hillier | 100 | 80 | — | Brackish, influenced by the tide. |
| Stourmouth | G. Dowker | 20 | 159 | 11 | To Chalk 138 feet. |
| Sandwich | W. Whitaker. | 15 | 62 | 20 | |
| Canterbury Clergy Orphan Asylum | G. Dowker | 140 | 145 | 120 | All in Tertiaries. Bored. |

the street again Jan. 12, 1775, and again Feb. 26, 1776. This Nailbourne ariseth at Dean, in the parish of Elmsted, and at Duck Pit in the parish of Waltham. This by Thos. Page." From other data this Nailbourne ran in Jan. 1860, Feb. 1861, 1864, to June, 1865, and slightly in 1866, 1869, and Jan. 1873.

Notes on a Well at Elmsted Vicarage. Communicated by Rev. G. A. Collett. "This well was sunk in the Vicarage garden in 1884, at an elevation of 500 feet O.D. Water was first reached at 180 feet. Waiting for this to lower, the well was continued to 243 feet, where a good head of water was met with. The strata met with were firstly, 11 feet of diluvial matter, stones, clays, etc., called locally 'clay pillars.' All below this, Chalk without flints, with joints few and far between, the Chalk so hard that it had to be blasted with gunpowder, no need to 'steen.' We sent up at 58 feet some palatal teeth of fish, and lower down fragments of *Inocerami*. Below 220 feet the Chalk was more jointed and easier worked. The springs rise and fall here in a very wonderful way, they are usually highest in May and fall till January, when they begin to rise again. In December, 1884, I ran my well dry, but kept sounding it in January, 1885, expecting water. On the 13th it was dry, next morning I found fourteen feet of water, which soon increased to 40."

In the tabulated list of wells appended, I have given the height above O.D., the depth of well, and the water-level (where this information is given), but in most cases, especially in bored wells, the latter is not very conclusive. For other particulars of well-sections I must refer my readers to the Memoirs of the Geological Survey, vol. iv. pt. 1, by Mr. W. Whitaker, B.A., F.G.S., and the Quarterly Journal of the Geological Society, vol. xlii. p. 26. I have confined my observations chiefly to the water supply.

I am indebted to those gentlemen whose names appear in the Appendix of Well-sections (p. 211) for much valuable information.

## III.—THE GNEISSOSE-GRANITE OF THE HIMALAYAS.

By Colonel C. A. McMahon, F.G.S.

### *Introduction.*

THE cause, or causes, which result in the foliation of igneous rocks is a subject which at present occupies the attention of many geologists, and seems likely, in the near future, to lead to some discussion. In view of this, a short account of the foliated granite of the Himalayas may be of interest. It may be as well, however, to preface my remarks by saying that I believe that foliation may be produced in several distinct ways, and the explanation which I offer of the mode in which the foliation of the Himalayan granite has been brought about is only intended to apply to the case of that granite.

In the following pages I propose to give a brief summary only of some of the more important results worked out in detail in a series of papers published in the Records of the Geological Survey of India; and to add thereto a brief consideration of the question whether the foliation of the gneissose-granite of the Himalayas was, or was not, produced by pressure-metamorphism, a point not touched on in my published papers.

As the Himalayas cover a large area, I shall limit my remarks almost exclusively to the rocks in the neighbourhood of Dalhousie, a sanitarium in the mountains nearly due east from Lahore, the capital of the Panjab. Want of space obliges me, however, to make my observations on the stratigraphy extremely brief. Any one requiring more detailed information will be able to find it in the volumes of the Records of the Geological Survey of India.

In the neighbourhood of Dalhousie the gneissose-granite appears in two bands striking in a north-westerly direction. The inner band at Dalhousie itself is six miles and a half in thickness; further to the south-east the thickness increases to eleven miles, and this broad belt extends for some hundreds of miles in a south-easterly direction. In its north-westerly extension from Dalhousie the band suddenly contracts to a width of two hundred and fifty yards: but twenty-one miles further on it expands again as abruptly as it contracted.

This outcrop is in contact along both margins with Silurian rocks; those along its eastern margin being older, and those along its western margin younger Silurians. The interpretation which I have put on this section is that the granite has risen through the axis of a flexure that resulted in an overfold fault.[1]

The outer band of gneissose-granite, roughly speaking, runs a course parallel to the western margin of the inner band, being divided from it by a broad belt of Silurian beds. To the south of Dalhousie it dies out altogether. Its general width is between four hundred and five hundred feet; but to the north-west of Dalhousie it widens out to several thousands of feet in thickness. Along its eastern margin it is in contact with Lower Silurian, or Cambrian, mica-schists (no fossils have ever been found in them, so their precise age cannot be determined); and along its western margin with limestone and slaty beds of Carboniferous age. The latter are not greatly altered rocks; the limestones are never more than sub-crystalline; and though the slaty rocks have often a thin micaceous glaze, they are sometimes shaly in appearance; and are frequently so highly charged with carbonaceous material, and so coal-black in colour, that they have from time to time, in various parts of the Himalayas, raised fallacious hopes of finding coal in the minds of non-geologists.

The strike of the Silurian and Carboniferous beds conforms to that of the granite, following all its curves. The beds in contact usually dip into the granite; but occasionally dip away from it.

### *The Gneissose-Granite.*

The gneissose-granite is almost always decidedly porphyritic, though it occasionally passes into a fine-grained non-porphyritic rock. The matrix is usually a granite of moderately large grains (it is

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[1] A geological map of the Dalhousie area and diagrammatic sections explaining it will be found at page 110, vol. xviii. Records Geol. Survey of India.

never coarse-grained), but occasionally it becomes so extremely fine-grained that the rock assumes, to the unaided eye, the appearance of a felspar porphyry. In the perfectly granitic varieties the porphyritic crystals of felspar, which sometimes attain a length of from three to three and a half inches, orient in all directions, and present sharply rectangular forms. From the porphyritic-granitic and non-porphyritic-granitic varieties the rock passes by gradual transitions into a more or less foliated granite. The passage from one variety to the other is often apparently capricious; but even in the most perfect granitic masses a tendency towards foliation may generally be observed at its edges.

Speaking generally, the granite of the inner outcrop is foliated along both margins; and the foliation becomes intense where the band contracts, on the north side of the river Rávi, to a width of two hundred and fifty feet. At this point it passes, on its western margin, into what, from its macroscopic aspect, would be called a mica-schist.

The outer band of gneissose-granite is intensely foliated. It does not indeed pass into a mica-schist; but it not unfrequently looks, viewed macroscopically, as if it had been flattened under a steam roller.

Joints are abundant; and they frequently simulate bedding; but true bedding is not to be seen.

The granite is composed of orthoclase, plagioclase, microcline, quartz, biotite, and muscovite. In some localities biotite predominates—in others muscovite. Magnetite, garnets, and apatite are sometimes present; whilst schorl is rarely absent from the granitic varieties. The presence of ilmenite may also be inferred from the occasional existence of leucoxene.

### *Mircoscopic characters of the Gneissose-Granite.*

Under the microscope the granite yields abundant evidence of strain, pressure, and shear or traction. The twinning planes of the triclinic felspars are sometimes bent; felspars are frequently cracked, fractured, and occasionally the pieces are pushed over like books on a shelf; whilst crumpled micas may be seen which have been completely bent and one end folded over on the other like a sheet of note-paper preparatory to being placed in an envelope.

A prominent characteristic of every variety of the Dalhousie gneissose-granite, even the most granitic, is the presence of what I have called in my papers by the short term of crypto-crystalline mica. It is mostly a form of muscovite, though the imperfectly crystallized material of biotite is occasionally present in ropy masses. This crypto-crystalline mica varies from a pale-buff to a pale-grey colour, and it has a superficial resemblance to the base of some felsites and rhyolites. In its typical form, though its double refraction is strong, no definite crystals of mica can be made out; and the leaflets, under polarized light, melt into each other and exhibit no definite shape. This crypto-crystalline mica passes into a micro-crystalline condition, in which the leaflets, though of extreme microscopic size, have a distinct individuality of their own. Both varieties will, in the following remarks, be referred to under the term crypto-crystalline mica.

This crypto-crystalline mica is present in all varieties of the Dalhousie granite. It is to be seen in every thin slice under the microscope; and in the foliated specimens it traverses them in strings; sometimes extremely attenuated; at other times widening out into comparatively broad lake-like expanses. It does not run in straight lines, but flows in curves like those of rivers on a map; now approaching each other; now diverging widely; bending sharply at one turn, and making a wide sweep at another. It frequently leads up to, or embraces in its streams, large crystals of muscovite, quartz grains, and other minerals; and it occasionally traverses large felspars. I shall have to allude to this crypto-crystalline mica further on.

Another striking characteristic of all varieties of the Dalhousie granite is what I have termed in my papers fish-roe quartz; that is to say, quartz in grains of microscopic size clustered together in a way to suggest the roe of a fish. This polysynthetic or fish-roe quartz behaves very much as the crypto-crystalline mica behaves; that is to say, in the foliated specimens it flows about in streams round the larger minerals; fills the interstices between larger grains of quartz; and stops the fractures in felspars. I shall have to allude to this further on.

The most important questions which arise in connection with the rock above described are: Is it an igneous eruptive rock? and if so, was the foliation produced prior, or subsequent, to its final consolidation? I propose to consider each point separately.

### *Evidence of the eruptive origin of the Gneissose-Granite.*

In the first place it seems necessary to meet the objection of those who may be disposed to hold the view that it is an ancient, possibly Pre-cambrian rock, which suffered erosion before Silurian times. It would be impossible to discuss this position in detail in a brief article that only proposes to give the results of the author's investigations; but I may say that I carefully considered this point in the field at a time when I had formed no theories about the Dalhousie rock in my own mind, and that I could not discover any evidence to support it. Two considerations seem to offer serious obstacles to the acceptance of this theory. In the first place, erosion which reduced the gneissose-granite from a thickness of eleven miles to that of two hundred and fifty feet would hardly have left a long stretch of this slight thickness without having cut through it altogether; secondly, if this crystalline rock represents an ancient and eroded land-surface, the granite to the north of the Ravi, where its thickness is only two hundred and fifty feet, ought to be a fair sample of the granite two or three miles to the south of the Ravi, where its thickness is six miles and a half; but, on the contrary, the former is a much more intensely foliated rock than any portion of the latter. The thin band of granite north of the Ravi has evidently been subjected to much more intense squeezing than the massive portion, and field observations favour the conclusion that the intensity of the foliation and the narrowness of the outcrop are directly connected with each other.

Without pausing to discuss this question further, I pass on to state briefly the evidence which the rock presents of eruptive origin.

*Stratigraphical evidence.*—First, the granite has produced a certain amount of contact metamorphism on the rocks touching it. The slates exhibit a marked increase in induration and they pass more or less into a crystalloid condition as they approach the granite. Schorl, garnets, dark mica, muscovite, and magnetite have been formed in the slates by contact action; foliation has sometimes resulted from that action—at other times "spotted schists" have been formed.

Secondly, tongues and intrusive veins have been sent from the granite into the adjoining rocks: in other places the granite appears in sheets between the beds of the sedimentary rocks at some distance from the junction of the latter with the main mass of the granite; and in some cases these sheets, or dykes, have cut through the beds and passed from one horizon to another.

Thirdly, the main mass of the granite appears at different geological horizons.

Fourthly, the granite contains veins similar to those caused by shrinkage on cooling in granites of admittedly eruptive origin.

Fifthly, it contains fragments of slates and schists imbedded in it. A striking photograph, or rather a print produced by the heliogravure process from a photograph, of a schist enclosed in the main mass of the granite, half a mile from its contact with the slates, will be found at p. 175, Records Geological Survey of India, vol. xvii. (with a paper thereon); which, in conjunction with the evidence afforded by the microscope, completely sets at rest any doubts that might have existed, previous to the discovery of this specimen, as to whether or not these inclusions are true fragments of foreign rocks caught up in the granite.

*Microscopic evidence.*—The evidence afforded by the study of numerous thin slices under the microscope confirms the conclusion arrived at by the stratigraphical evidence, and indicates the eruptive origin of the gneissose-granite. I select the following instances for enumeration:—

First, the presence of microliths containing contraction cavities precisely similar to those in microliths to be seen in undoubted eruptive rocks. As an illustration I would point to fig. 11 of the plate at page 158, Records G.S.I. vol. xvi., which gives the sketch of a microlith seen in one of the Aden lavas, but which serves equally well as an illustration of some of those seen in the gneissose-granites; *vide* Records G.S.I. vol. xvii. p. 60.

Secondly, cracks in microliths formed by contraction on cooling. In some cases the fractured portions have been floated to a little distance from each other. Fig. 5 of the plate at p. 72, Records G.S.I.

vol. xvii. affords a striking illustration of a microlith thus ruptured. Cracks of the character alluded to do not in any case extend from the microlith into the matrix.

Thirdly, opacite embracing and riding on the backs of previously formed microliths. As illustrations I would point to the right-hand figure of fig. 6, plate ii. p. 144, vol. xvi., compared with fig. 13 of plate at p. 158, vol. xvi. Records G.S.I. The former is a representation of a microlith in a Himalayan gneissose-granite, and the latter of one in an Aden lava. The last-mentioned illustration could be exactly matched by numerous illustrations from the gneissose-granites.

Fourthly, stone cavities,[1] in which mineral matter has been deposited on cooling. Compare fig. 18, plate, p. 72, vol. xvii. (a Dalhousie specimen) with figs. 4 to 10, inclusive, plate, p. 158, vol. xvi. Records G.S.I., Aden lava specimens. The presence of clusters of minute microliths sticking to and fringing the *outside* of the Dalhousie stone cavity shows conclusively that this is not a case of schillerization.

Fifthly, stone cavities in which either crystals have been deposited on cooling, or in which mineral matter has caught up and enclosed previously formed crystals. Illustrations, figs. 1, 6, and, possibly, the upper portion of fig. 18, plate, p. 72, vol. xvii. Records G.S.I.

These instances, which are selected by way of sample of the kind of evidence applicable, indicate I think that the gneissose-granite at one period of its history was in a condition of what may be termed —roughly speaking—igneous fusion. That water was, however, to a considerable extent mixed up with the constituents of the rock when it was in a plastic state, and that its condition may be more correctly described as one of igneo-aqueous fusion, is made plain by the examination of thin slices under the microscope. Liquid cavities abound in the quartz of the granite; whilst, it is important to observe, they are entirely absent from the slates in contact with it. The heat produced by contact with the granite appears to have been sufficient to drive the water out of the quartz of the slates and of the siliceous rocks brought within its influence. An interesting illustration of this was afforded by an examination of the crystals of schorl found in the slates in contact with the granite. When these crystals were first formed, they appear to have contained inclusions of air, gas, or liquid; but as the heat increased, and the included matter expanded under its influence, the included gas, or liquid, was forced out to the surface of these crystals and driven off. An interesting illustration of this will be found at fig. 7, pl. ii. p. 144, vol. xvi. Records G.S.I.

### *Cause of the foliation of the Gneissose-Granite.*

A realization of the eruptive character of the rock described in the above pages removes many difficulties from the way of the Himalayan geologist. "Despite the wonders performed by flexure of strata in mountain regions," wrote Mr. Medlicott, the Director of the Geological Survey of India, in his Annual Report for 1883, "the

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[1] This is an awkward term; but, as it was introduced by Sorby, I retain it: microscopists know what it means.

structural features presented by this rock in certain cases were impossible of satisfactory explanation on the supposition of its being a really stratified gneiss." But if the eruptive origin of the gneissose-granite be admitted, the further question arises whether the foliation observed in it was produced prior, or posterior, to the consolidation of the rock. In considering this question, I leave out of sight altogether evidence of fluxion structure as being really irrelevant to the question at issue, though I think it material to state that the rock does show very decided evidence of fluxion. Without laying any stress on this fact, however, I think the following considerations prove that the foliation was not produced by pressure acting on the rock after its consolidation.

First, the granite is not always foliated at its contact with the rocks into which it has been intruded; on the contrary, though still porphyritic, it is not unfrequently decidedly granitic along its margin. This fact presents no difficulty to the acceptance of the hypothesis advocated below, but I think it offers an insuperable barrier to the acceptance of the view that the foliation was produced by pressure. Simple pressure will not do: that would not explain the crumpled micas and the very decided evidence of flow or fluxion. Pressure resulting in shear, motion, the development of heat and concomitant chemical and mineralogical action, might possibly account for the fluxion structure; but if shear and motion were established on the grand scale required after the consolidation of the rock, the granitic portions along the margins could not possibly have escaped the effects of this action.

Secondly, the apparently capricious passage from a granitic to a foliated structure in the main mass of the granite is another serious impediment in the way of the acceptance of the theory of dry pressure.[1]

Thirdly, the conjunction of the outer band of gneissose-granite at Dalhousie with the Carboniferous series presents another almost insuperable difficulty. The outer band is the most intensely foliated of all the Dalhousie granite. Parts of it look as if it had been rolled under a gigantic steam roller. Unquestionably it has been subjected to very great pressure, and to either traction, or shearing; and yet this rock is chock and block with little altered black Carboniferous rocks. He who would apply the dry-pressure theory to explain the intense foliation of the outer band of granite, would have to invent a new set of conditions out of his inner consciousness and bring some other rock into position next the granite before he applied the squeeze.

Fourthly, the condition of the long tent-peg-like splinter of schist included in the granite, alluded to above, shows conclusively that the granite at the point where the inclusion was found was not subjected to extreme pressure of the character under consideration after its consolidation. Had it been, the splinter of schist would

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[1] I use this expression as a short term to indicate pressure applied *after* the consolidation of a rock, though, of course, I am aware that pressure so applied may produce heat and even fusion.

have been flattened to a wafer. A mere glance at the plate, a photograph reproduced by the heliogravure process, will show this at once.

Fifthly, neither the crypto-crystalline mica, nor the fish-roe quartz, described *ante*, can possibly have been produced by the grinding down of the mica and the quartz in the consolidated rock, or by any analogous process; for, besides the crypto-crystalline mica, and the fish-roe quartz, we have very numerous *large* crystals of muscovite, biotite, and quartz. The muscovite and biotite are large and beautiful specimens of these minerals, and they orient in all directions and at every angle up to a right angle to the strings of crypto-crystalline mica. Mechanical action potent enough to have reduced mica to the pulpy condition of the crypto-crystalline mica would not have left the larger micas untouched. Similarly, the fish-roe quartz not only fills cracks in felspars, and forms a sort of setting to quartz grains, but it meanders about in the interior of large quartz grains, and terminates abruptly inside them, in a way that does not suggest to the observer that he is looking at cracks stopped with micro-crystalline quartz, but rather that the crystallization of the quartz was brought to a comparatively rapid termination towards its close.

Indeed, properly considered, I think the crypto-crystalline mica, and the fish-roe quartz, furnish a clue to the riddle. I may mention in passing that I have observed in a felsite patches of material closely resembling the crypto-crystalline mica mixed up with the quartz and the ordinary felsitic base; but I desire more particularly to refer to a series of rocks which occur in the peninsula of India about eighty-five miles nearly due west of Delhi. We have there a very interesting group ranging from felsites, quartz-porphyries, and granite-porphyries to almost true granites. The felsites appear to be true lavas; and the others, though merging gradually into rocks of plutonic character, are probably more or less directly connected with them. These rocks never show any trace of foliation, or give any indication of crushing. But what is important to note is, that the gradual genesis, so to speak, of the fish-roe quartz may be observed in these rocks. The quartz gradually becomes more and more developed in the felsitic base; it begins to crystallize out in grains of microscopic size, and the grains increase in number, until at last the whole base, or ground-mass, of the granite-porphyries partakes closely of the characters of the fish-roe quartz of the Dalhousie granite. The true explanation of the foliation of the latter rock I believe to be briefly as follows:—The rock had partially consolidated before it was moved into place: large porphyritic crystals of felspar, and numerous micas and quartz grains had formed; it was very much in the condition of a felspar-porphyry, or a granite-porphyry; when, in the course of the earth-movements that were contorting, crumpling, and folding the strata of the Himalayas, this imperfectly consolidated granite-porphyry was forced through the faults that had been formed along the axes of over thrust-folds; the semi-plastic mass was subjected to enormous pressure; the mica was crumpled; the crystals of felspar were cracked and ruptured; and so much of the micaceous siliceous materials as remained unconsolidated were forced into the rents made in the already formed minerals. The final consolidation took place under conditions of continued strain; but before it was actually accomplished minor and subsidiary eruptions took place which forced new supplies of the granitic material into fissures formed in the previously injected rock, and this fresh material consolidated under conditions somewhat different from those of the first eruptions.

I think this view meets all the difficulties of the case, and that the intelligent reader will with its aid be able to harmonize all the facts stated above without detailed exposition on my part.

## IV.—ON THE GEOLOGICAL HISTORY OF THE CORNISH SERPENTINOUS ROCKS.

By J. H. COLLINS, F.G.S.

(*Continued from* GEOL. MAG. Decade III. Vol. III. 1886, p. 366.)

### III. ROCKS EXHIBITING BUT A MODERATE AMOUNT OF SERPENTINOUS CHANGE.

*Botallack Mine.*—The dark hornblendic slates of the sea-border of the parish of St. Just are known to many geological tourists. They have been well described by the late Mr. J. A. Phillips,[1] who regards them as consisting of altered killas; and the justice of this conclusion will not I think be questioned by any who have studied the rocks *in situ*; traces of an original lamellar structure are visible even in hand-specimens. Phillips (*op. cit.* p. 322) gives the following analyses of the rock, *a* being from near the surface, and *b* from a depth of 130 fathoms, or far below the sea-level; while *c* is the analysis of a typical Cornish killas (from Polgooth Mine, 100 fathoms from surface):—

| | | *a.* | | *b.* | | *c.* |
|---|---|---|---|---|---|---|
| Water | hygros. ·39<br>comb. 2·74 | 3·13 | 4·12<br>6·97 | 11·09 | 2 00<br>1·26 | 3·26 |
| Silica | | 40·22 | | 32·98 | | 50·92 |
| Phosphoric acid | | ·66 | | trace | | — |
| Titanic acid | | ·15 | | trace | | trace |
| Alumina | | 24·01 | | 16·73 | | 20·79 |
| Ferrous oxide | | 11·27 | | 13·71 | | 4·92 |
| Ferric oxide | | 4·21 | | 7·03 | | 13·41 |
| Lime | | 4·11 | | 4·90 | | 1·62 |
| Magnesia | | 6·52 | | 11·52 | | — |
| Potash | | 1·67 | | ·72 | | ·93 |
| Soda | | 3·57 | | ·63 | | 4·03 |
| | | 99·52 | | 99·31 | | 99·93 |
| Sp. Gr. | | 2·95 | | 2·82 | | 2·73 |

Evidently *a* and *b* are in a highly-altered condition; but assuming that they were originally of similar composition, approximating to *c*, it would seem that the deeper-seated rock has been much more altered than the other in the direction of serpentine; it is also softer, lighter, and more serpentinous in aspect. The following is its appearance under the microscope, as stated by Mr. Phillips or as

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[1] Quart Journ. Geol. Society, 1875, vol. xxxi. pp. 319-343.

observed by myself. The base is green and transparent; it includes many minute acicular or fibrous crystals of hornblende or asbestos crossing each other in all directions, some in bundles with parallel axes, as if from the partial destruction of a cleavable crystal. In some instances the hornblendic bundles are replaced by a greenish mineral which is possibly chlorite, and there is always present more or less crystalline magnetite. Mr. Phillips says, "It is worthy of notice that while the slates of Botallack are highly magnesian, the sea-water which percolates through them into the workings of the mine has lost three-fourths of its magnesium. Similar effects appear to be produced at Huel Seton, where the amount of magnesia in the rock bounding the great cross-course, which is traversed by the modified sea-water constituting the well-known 'lithia spring,' is twice as large as it is in the normal killas of the locality. The magnesium of the sea-water has in this case almost entirely disappeared."[1]

*Terras, St. Stephens.*—This is a band of dark and fine-grained rock used locally for roadstone, which is not marked on the 1-inch Geological Map. It is very tough, and often platy in character, owing to an incipient pseudo-cleavage which I take to be an indication of an original bedding now almost obliterated. It has all the appearance of a compact hornblende schist. Thin veins of an asbestiform mineral are often seen in the joints, and occasionally the fibres of this mineral are so interlaced as to result in a kind of "rock-leather" or "rock-felt" sometimes as much as half an inch in thickness. Some of the joints, however, are lined with thin films of serpentine, and in such cases the rock itself exhibits serpentinous change to a depth of an inch or more, so as to be almost indistinguishable from the Botallack rock above referred to. In thin sections, and under a moderate magnifying power, it is seen to be made up of a transparent greenish serpentinous base full of matted crystals of hornblende. The original laminar character of the rock is indicated by many crystals of magnetite and minute patches of viridite. Occasionally, too, fibres of asbestos are visible, and, rarely, minute prisms of apatite.

I made a partial analysis of this rock in 1872, with results as follows :—

| | |
|---|---|
| Loss on ignition | ·92 |
| Silica | 45·20 |
| Alumina | 19·80 |
| Magnetite | 5·01 |
| Ferrous oxide | 7·35 |
| Lime | 8·00 |
| Magnesia | 6·20 |
| Not determined | 7·52 |
| | 100·00 |

A very similar rock, probably an extension of the same bed, was opened up some years since at Terras Mine, and described by Mr. J. A. Phillips as a greenstone (Q.J.G.S. vol. xxxii. p. 175).

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[1] *Loc. cit.* See also "On the Composition and Origin of the Waters of a Salt-spring in Huel Seton Mine," Phil. Mag. July, 1873.

At this locality I obtained in 1872 a number of interesting crystals of pharmacosiderite, scorodite, and olivenite, which were noticed in the Mineralogical Magazine, vol. i. pp. 16 and 17. I regard this rock as a slightly serpentinized and otherwise much altered hornblende schist.

*St. Cleer Downs.*—On these downs there are several broad bands of hornblendic rock, mostly lying in the line of strike of the associated slates, and graduating in places into them. The chief mass extends about one mile from east to west, and nearly half a mile from north to south, dipping to the south-south-west. It is usually more or less decomposed, and in a quarry now filled up near the church, asbestos in fine silky fibres was obtained by Canon Rogers in 1818.

Mr. J. A. Phillips gives the first two of the following analyses of this rock :[1]—

| | *a.* Slaty. | *b.* Crystalline. | *c.* Selected. |
|---|---|---|---|
| Water | ·63 | 1·90 | 7·8 |
| Silica | 52·54 | 47·32 | 42·2 |
| Alumina | 23·83 | 18·10 | 7·6 |
| Ferric oxide | 2·44 | 6·21 | 4·1 |
| Ferrous oxide | 4·87 | 7·72 | |
| Lime | 7·89 | 8·24 | 3·3 |
| Magnesia | 2·67 | 7·05 | 33·6 |
| Potash and Soda | 5·06 | 3·80 | ·7 |
| | 99·93 | 100·34 | 99·3 |
| Sp. Gr. | 2·89 | 2·90 | |

*c* is an analysis of selected portions by myself.

Both *a* and *b* contain free quartz—hence the high percentage of silica. This rock seems to be a partially altered hornblende slate, or else an altered diorite; but the serpentinous change has not proceeded very far. I have often seen thin films of serpentine in the joints, and by breaking up masses of the more highly altered portions of the rock, and selecting the more serpentinous grains, I have obtained a substance with the composition given in *c*. The relative proportions of silica, magnesia, and water in this are pretty near what they are in pure serpentine, if we consider that it was impossible to completely separate all the crystals and grains of magnetite, fibres of asbestos, crystals and grains of unaltered or partially altered augite, felspar, hornblende, etc. The approximation is indeed remarkable if we compare the analyses given of the general rock-masses.

Under the microscope, using a low power, it seems to be composed of a green fibrous granular ground-mass, filled with distinct fibres of asbestos; the ground-mass is very slightly dichroic, and includes some crystals and grains of magnetite, with some irregular masses having ill-defined and shadowy boundaries, which I think are highly altered augite. Using the $\frac{1}{4}''$ power, the ground-mass is resolved almost completely into a network of fibres, while the magnetite appears as a congeries of *rounded* grains. In some instances hornblende crystals are seen, which appear to be changing very slightly

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[1] Quart. Journ. Geol. Soc. 1878, vol. xxxiv. p. 487.

into asbestos. The following is an analysis of some of the larger asbestos fibres carefully separated:—

| | |
|---|---|
| Silica | 45·22 |
| Alumina and a little Ferric oxide | 30·09 |
| Lime | 8·00 |
| Magnesia | 10·19 |
| Potash | 1·12 |
| Water | 5·20 |
| | 99·82 |

*Tregerla.*—This rock, which occurs in the neighbouring parish (Menheniot), and under very similar conditions, much resembles the preceding.

*Catacleuse.*—This is a somewhat altered dolerite which has been extensively used in North Cornwall for the ornamentation of ancient pulpits, fonts, etc.; and the interesting tomb of Prior Vivian in Bodmin church, which has been so well described and illustrated by the Rev. W. Jago in the "Journal of the Royal Institution of Cornwall," is made of it. It is only slightly serpentinous, yet the change is distinct, especially near the joints, and in the less compact masses. It is often mistaken for Polyfant stone,[1] but it is much harder. The following are analyses of the rock,—1, of an ordinary mass; 2, of a fragment specially selected as being more highly altered than usual:—

| | 1 | 2 |
|---|---|---|
| Silica | 45·96 | 40·8 |
| Alumina | 15·02 | 10·2 |
| Ferrous oxide | 6·33 | 4·5 |
| Ferric oxide | 8·03 | 12·2 |
| Lime | 6·37 | 5·0 |
| Magnesia | 18·44 | 23·5 |
| Water | ·22 | 5·4 |
| | 100·37 | 101·6 |

Here in 1 serpentinous change is hardly if at all recognizable, while in 2 serpentinous matter exists to a very considerable extent.

Altered eruptive rocks exhibiting serpentinous change occur in a great many other localities in North Cornwall, and especially at Cant Hill near St. Minver. My acquaintance with the rocks of this district dates from the year 1871, and I can quite confirm the observations made by Mr. F. Rutley in his paper.[2] He gives the following examples from this locality:—

No. 1. East end, at top of hill—"bands and small knots of felsitic matter (microcrystalline), separated by bands of translucent greenish-yellow or brownish-yellow serpentine," also "a thin vein of greenish-yellow to brownish-yellow serpentine which is traversed by opaque rust-coloured strings," the bands and the vein being continuous. We seem here as in many other instances to have evidence at once

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[1] See Geol. Mag. Dec. III. Vol. III. 1886, p. 365.

[2] Eruptive Rocks from the Neighbourhood of St. Minver," by F. Rutley, F.G.S., Quart. Journ. Geol. Soc. 1886, vol. xlii.

of "segregation" and of "selective metamorphism" in one and the same slide, the result in each case being serpentine.[1]

No. 2, same locality. Here the serpentine is associated with chalcedony and "a yellowish-white matter, apparently kaolin."

No. 4, same hill, west end. Here there is "a large proportion of serpentinous matter; so large, indeed, that by burnishing a smoothly-cut surface of the rock with an ivory paper-knife, a fairly good polish can be communicated to it. When we examine a section of this rock under the microscope, we find some of the original glassy basis has to a large extent been converted into serpentine, especially along lines which seem to indicate fluxion-structure. There is in addition to the serpentine a large proportion of kaolin present."

Nos. 5 and 6, east side, foot of hill. These also contain a very considerable admixture of serpentine; and the author concludes—"There seems then no doubt that the upper portion of Cant Hill, which has been mapped as 'Greenstone,' is really composed of a basic lava of a once vitreous character, but so altered that its original mineral constitution cannot be inferred with precision."[2] Mr. Rutley goes on to speak of the occurrence of serpentine in other eruptive rocks in the locality, and especially at Carlion near Cant Farm.

The occurrence of kaolin in Nos. 2 and 4 connects them with the Duporth rock already referred to,[3] where also very extensive kaolinization of felspathic matter has taken place.

## IV. Examples from Devonshire.

*Greston Bridge.*—The serpentinous rock of this locality is figured (No. 27) and described by Mr. Rutley in his excellent account of the eruptive rocks of Brent Tor, which is published at a prohibitive price by Her Majesty's Stationery Office. It is very incompletely serpentinized, and no analysis has been published or made so far as I know. A similar rock exists at Dunterton.

*Anstey's Cove, near Torquay.*—This is a coarsely crystalline rock of a dark green colour, and consists of augite, small prisms of triclinic felspar, apatite and magnetite. Some of the augite is but slightly altered; there is a little pale-green serpentine disseminated throughout the mass.[4] In some parts it is very largely serpentinous, much more so than the specimens which Mr. Allport describes would appear to be. The rock occurs distinctly as a dyke cutting through Devonian rocks. No analysis of the rock has been made to my knowledge.

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[1] In a note Mr. Rutley says: "Prof. Bonney, who favoured me with an opinion upon these sections, regards much of the substance which I have here called serpentine as a palagonitic material." But palagonite is a constituent of recent volcanic tufa, and hardly likely to be found in so old a rock as this. Moreover, it is fusible, while this mineral, like serpentine, is very infusible. Further, Mr. Rutley says the serpentinous matter has a hardness of 3 or slightly less, while the hardness of palagonite is from 4 to 5.—J. H. C.

[2] *Op. cit.* p. 397.

[3] See Geol. Mag. August, 1886, p. 362.

[4] Allport, "Metamorphic Rocks surrounding the Land's End Mass of Granite," Quart. Journ. Geol. Soc. 1876, vol. xxxii. p. 423.

*Babbacombe Bay.*—This, like the last, is intrusive in Devonian rocks. "There are here two principal varieties of dolerite—one rather fine-grained and of a uniform grey colour; the other of a lighter shade and porphyritic texture, having conspicuous crystals of felspar scattered through it. Both varieties are highly altered; the secondary products are serpentine and calcite."[1] Much of the original augite of this rock seems to have been converted into hornblende, as in cases already mentioned. No analysis of the rock has been made.

Serpentinous change has been observed in a great many other localities within the two western counties, but probably these will suffice as illustrations.

The methods of the changes which have taken place in these various rocks have been already adverted to (Geol. Mag. 1885, Dec. III. Vol. II. pp. 298–302). It would occupy too much space to discuss these changes completely, as the inquiry is complicated by the great diversity of composition indicated by the various analyses. In comparing these, the very variable amount of iron in its two states of oxidation, of alumina, and of lime, arising from the presence of included crystals and grains of various substances, cannot fail to be noticed; and of course these greatly varying proportions affect those of the water and silica, and especially those of the magnesia. The diversity of composition, however, is more apparent than real, and is owing in some instances to the irregularly porphyritic character of the original rock, and in others to subsequent infiltration and crystallization. Thus the alumina may be generally traced to the presence of still undecomposed crystals of felspar, or else to kaolin resulting from such; to augite, or hornblende; the iron to magnetite or to flocculent masses of peroxide of iron; and the lime either to felspar or else to patches or veins of calcite. Take away these, and the serpentinous ground-mass will often be found to consist of nearly pure serpentine.

## CONCLUSION.

I have thus shown that serpentinous change is extensively met with in both stratified and intrusive rocks in many parts of the two western counties of England. The rocks sometimes change as a whole—as at Botallack and Clicker Tor—or in certain of their foliæ—as at Cant Hill—or thin films of serpentine are produced, bounding the numerous joints which divide the rock into angular fragments, still purer serpentine, with or without asbestiform matter, being deposited wherever the joints are sufficiently open—as at Terras. Crystals of augite, olivite and hornblende all appear to have been frequently changed into serpentine—with or without intermediate changes—while felspar crystals, if present, are either converted into saussurite, or else are more or less completely kaolinized. In the case of the hornblende crystals, the change begins by loss of dichroism. Then, as in the case of augite also, the crystal breaks up into a fibrous mass of acicular crystals; and finally amorphous

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[1] Allport, *ibid.*

serpentine without trace of fibrous structure is produced. The next stage is a general hydration of the whole ground-mass, the disappearance of alumina from its composition, and the oxidation of magnetite into peroxide of iron.

Such changes are analogous to those observed by Prof. Heddle in the serpentinous marbles of Tyree, Lewis, and other places in the North of Scotland, where *augite* has been converted into serpentine; as well as in the *picrolite* of Balta and the *crysotile* of Fetlar, where forms of *hornblende* have been so changed; it is very similar to that which he observed at Beauty Hill near Aberdeen, where waxy *labradorite* (a mineral closely resembling the felspathic component of the Porthalla stone) "*is seen to pass within a space of about an inch into this mineral*" (an aluminous serpentine or pseudophite) "*by insensible gradation.*" The italics are all the Professor's. For the full discussion of the processes of change in these different circumstances, which to me is perfectly conclusive, I must refer to the original paper in the Proceedings of the Royal Society of Edinburgh. On the whole, it seems to me that serpentinous change in hornblendic and augitic substances is little less common than the kaolinization of felspar; and these two modes of metamorphism are not unfrequently to be seen in the same rock-mass, as at Duporth (see Min. Mag. vol. i.), Cant Hill (see *supra*), and many other places.

## REVIEWS.

### I.—DIE VERSTEINERUNGEN DES CAMBRISCHEN SCHICHTENSYSTEMS DER INSEL SARDINIEN, NEBST VERGLEICHENDEN UNTERSUCHUNGEN ÜBER ANALOGE VORKOMMNISSE AUS ANDERN LÄNDERN. Von Dr. J. GEORG BORNEMANN, M.A.N. Erste Abtheilung. Mit 33 Tafeln, No. i.—xxxiii. Nova Acta der Ksl. Leop.-Carol. Deutschen Akademie der Naturforscher. Band LI. No. 1. (Halle, 1886.)

THE FOSSILS OF THE CAMBRIAN STRATA OF THE ISLAND OF SARDINIA, WITH A COMPARATIVE STUDY OF SIMILAR FORMS FROM OTHER COUNTRIES. By Dr. J. G. BORNEMANN. 1st part, 4to. pp. 83, and 33 plates.

THE present is the first portion of a work in which the author proposes to give a complete description of the fossils from the Cambrian strata of Sardinia, which he has collected during successive visits to the island. Owing to the extremely complex manner in which the strata have been disturbed, it has not been possible to make out in detail the succession of the beds; but the oldest fossiliferous rocks near Canalgrande on the west coast of the island, consist of a series of clay-schists, rich in Trilobites, quartzitic sandstones with sponge (?) remains, and dark crystalline, and in part oolitic, limestones. These are succeeded by a great thickness of massive limestones, followed by successive alternations of shales with *Lingula*, sandstones with Trilobites, and limestones containing large numbers of the peculiar Coral-like fossils known generally as *Archæocyathus*. Associated with these Coral (?) bearing limestones and marbles are coarse sandstones filled with *Cruziana*.

The Trilobites of the lower zones are stated by the author to present a general resemblance to *Paradoxides* and *Olenus*, though for the most part they are specifically and even generically distinct from any forms yet described; in a somewhat higher zone examples of *Illænus* are associated with survivors of the older forms.

The description of the Trilobites is, however, reserved for another part: the fossils treated in the present one are ranged under the heads of Plantæ, Spongiæ and Archæocyathinæ. The forms described as plants are, at the best, doubtful. Thus the author, accepting the views of Lebesconte, de Saporta, and Delgado, places *Cruziana* as a genus of Algæ. In Sardinia, as elsewhere, there is not a trace of organic structure in these fossils, and there is nothing to controvert the striking arguments of Nathorst (whose name is not even mentioned by the author) that they are most probably tracks or impressions.

A new genus, *Phytocalyx*, is proposed for conical or hemispherical bodies, which weather out of a sandstone rock in considerable abundance. No structure whatever is preserved. They are regarded as Algæ analogous to Fucoids or Siphoneæ; but, judging from the description and figures, it seems to be equally as probable that they may be inorganic concretionary bodies or infilled casts of hollows made by burrowing organisms.

Another new genus, *Epiphyton*, is stated to consist of fan-shaped groups of cells which are regarded as formed by a lime-secreting Alga allied to the Siphoneæ.

Another form, growing in small rounded masses, like Nullipores, and consisting of an agglomeration of minute curved tubes, is extremely abundant, forming in places whole beds of rock. The author regards it as a new genus of calcareous Alga, and finds a resemblance in the form, arrangement, and dimensions of this Cambrian marine fossil to a species of existing Alga which grows on the surface of calcareous rocks in Switzerland. Some of these land-Algæ also secrete lime, and form hard stony crusts, and the author thinks there is reasonable ground for placing the fossil in the same group with the recent form!

We may here point out the fact, that this genus, which the author names *Siphonema*, is by no means new, as he supposes, since it was clearly described, and the typical form figured, by Nicholson and Etheridge, jun., nine years since, in their Monograph of the Silurian Fossils of Girvan, under the name of *Girvanella* (*l.c.* p. 23, pl. ix. fig. 24). As the writer has had the opportunity of seeing both the specimen described by Dr. Bornemann, as well as that which has received the name of *Girvanella*, he can confidently state that they are generically identical.

Singularly enough, the same fossil occurs at a similar geological horizon in the United States, and it has lately been described by Prof. H. M. Seeley as a genus of free calcareous sponges under the name of *Strephochetus* (American Journal of Science, vol. xxx. 1885, p. 355). Thus for this same fossil we have the following references:—

1878. *Girvanella*, Nicholson and Eth. jun. Probably Rhizopods.
1885. *Strephochetus*, H. M. Seeley. Calcareous Sponges.
1886. *Siphonema*, Bornemann. Algæ allied to living subaerial forms.

Whatever may be said in favour of the alliance of this genus to Rhizopods, on which the writer is not competent to pronounce an opinion, it is quite certain that it has not the least resemblance to Calcisponges, and its affinity to living subaerial Algæ seems very problematical. It is clear, however, that these bodies should retain the generic name first applied to them, and the two later names must be suppressed.

In the class Spongiæ the author proposes a new genus, *Palæospongia*, to include small cylindrical branching bodies, from 1 to 5 mm. in thickness, which in places fill beds of slaty rock, and are exposed in relief on their weathered surfaces. These forms now consist, for the most part, of angular quartz grains; but it is stated that, in microscopic sections, siliceous spicules arranged parallel with each other to form fibres can be distinctly seen, and between the spicules are grey and dark lines, regarded by the author as indications of the keratose materials of the organism, by which, when in the living state, the spicules were held together! The genus is regarded as allied to existing monactinellid sponges, and a photograph of a section of the existing *Axinella polypodioides* is given to show the resemblance between it and sections of these Cambrian fossils! We must confess our inability to perceive this asserted likeness, and we think that the few, scattered, crooked linear bodies shown in the figure, which the author supposes to be spicules, may be otherwise explained. It would indeed be a striking fact, if sponges of this character, which, owing to the fact that their component spicules are only held together by perishable horny material, are of extremely rare occurrence in newer undisturbed strata, should in these disturbed Cambrian rocks be preserved in great abundance.

The author further states that the forms described by Billings as marine plants, under the name of *Palæophycus*, have a remarkable resemblance to his *Palæospongia*. In our own opinion the forms known as *Palæophycus*, Bill., are most probably the infilled tracks and burrows of marine organisms, and we think that *Palæospongia* may have a similar origin. It is to be hoped that, to clear up, if possible, the doubts as to the real nature of this genus, the author will submit his specimens to some one acquainted with the characters of fossil sponges.

The peculiar cylindrical, cup- or funnel-shaped fossils, of which the genus *Archæocyathus*, Billings, may be taken as the type, are placed by the author as a distinct class of Cœlenterates, in proximity to Sponges, Anthozoa, and the Medusoid Polyps. Fossils of this group are present in great abundance in the massive Cambrian Limestones of Sardinia, but they are, for the most part, not well preserved, and can only be studied in microscopic sections. Of these the author prepared a large series, and photographs of them are given in the accompanying plates.

In addition to *Archæocyathus*, Bill., the author proposes two new genera, *Coscinocyathus* and *Anthomorpha*. In the former, regular transverse tabulæ are present, as well as the vertical lamellæ, whilst in the latter, the transverse structures are irregular. Associated with the ordinary forms of *Archæocyathus*, a peculiar fossil, consisting of anastomosing, apparently homogeneous fibres, frequently occurs. It is believed by the author to be the vegetative state of development from which the complete cups of *Archæocyathus* originate, and thus to indicate a true alternation of generations in these Cambrian fossils! To this form, though not regarded as an independent genus, the name *Protopharetra* is given.

An equally surprising statement is, that delicate threads or fibres of calcite present in the interspaces of the walls of some examples of *Archæocyathus* and *Coscinocyathus* are the fossilized remains of such soft organic structures as sarcode-threads, muscle-fibres and tentacles. The author thinks it possible that these structures may have been inclosed by the ooze, and then replaced by calcite!

Though the author has described in detail numerous species, it can hardly be said that our knowledge of the true nature and affinities of *Archæocyathus* and its allies has been increased. The author doubts the correctness of the observation of Billings as to the spicular nature of the walls of *Archæocyathus*, and thinks that the spicules figured were accidental intrusions.

Though we regret our inability to accept most of the determinations and conclusions of the author, we nevertheless readily admit the value of the work which he has done in bringing to light and describing the organisms in these unpromising Cambrian rocks of Sardinia. It is of great interest to know that many of the forms are closely similar to those recorded by Billings from the so-called Calciferous rocks of the Mingan Islands and other localities bordering the St. Lawrence, and this similarity will probably be further shown when the Trilobites and other fossils are described. It may also be mentioned that this work has a direct bearing on questions connected with British geology, since *Archæocyathus* has lately been discovered by members of the Geological Survey of Scotland in the Durness limestones. The specimens, though not uncommon, are but fragmentary and in a poor state of preservation; but, in spite of this, Mr. B. N. Peach, F.G.S., has been able to ascertain from them some important conclusions respecting the relations of *Archæocyathus* to *Calathium*, Bill., which it is hoped will soon be published.

G. J. Hinde.

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## II.—The Origin of Mountain Ranges. By T. Mellard Reade, C.E., F.G.S., F.R.I.B.A. (London, Taylor & Francis, 1886.)

THIS is a handsome octavo volume of 359 pages, profusely illustrated with forty-two full-page or folding lithographic plates. The short final chapter contains the author's main conclusions; and these are further condensed into its first two sentences. "Mountain-ranges are ridgings-up of the Earth's crust, which take place only in areas of great sedimentation. The exciting cause of the various horizontal and vertical strains, ending in the birth of a mountain-chain, is the rise of the isogeotherms, and consequent increase of temperature" [and expansion] "of the new sedimentaries, and that portion of the old crust that they overlie" (p. 326). It will therefore be seen that the theory is founded on what has been termed the Herschel-Babbage hypothesis, that, where thick deposits are laid down, the rise of the isogeotherms into them must needs cause their expansion; coupled with the observation of American geologists, that in general a mountain-range occupies an area where sedimentation has gone on undisturbed, until the deposit has attained a great thickness, and that the event, next in sequence there, has been the elevation of that very tract into a mountain-range. The Americans have attributed this subsequent elevation to the contraction of the Earth's volume through secular cooling, acting upon the newly-deposited matter as a weak place. But Mr. Reade rejects this supposition. In this rejection I agree with him. I think the question may be put simply thus. If any mass contracts equably in all its parts, the rate of shortening of every dimension must be the same. If then the whole Earth had cooled down to the present temperature of the surface, every dimension would have contracted equably, and there would be formed neither wrinkles nor cracks. But in fact the crust has cooled more than the interior. Therefore the circumference of the crust must have contracted in a greater ratio than the radius of the nucleus, which it envelopes. Its tendency would therefore be to crack; and, although the weight of its parts might close up the cracks as they tended to be formed, still no compression would take place, unless we throw more than its proper share of cubical contraction into the vertical dimension.[1] It does not seem that this conclusion will be much affected by the condition of the interior, whether it be solid or liquid.[2]

Accepting the theory of a solid globe, and the view, that the matter of which it consists becomes fluid on the pressure being reduced, the author thinks that this matter is subject to local fluctuations of temperature, a property which it is not easy to reconcile with solidity. Rocks at a depth of two miles and over, whether originally soft mud or clay, may be treated as solid matter. "Solid by compression, but ready to flow, one way or other, as the pressure may be reduced or increased"[3]—a very accommodating condition, but difficult to understand, because, if solid only by compression, one would imagine that *increased* pressure would make them more obstinate to move.

There seems a difficulty in accounting for the accumulation of

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[1] In a paper upon the subject, which I have lately contributed to the Phil. Mag. (Feb. 1887), I have thrown the whole contraction into the vertical, a supposition, as I have expressed it, "too highly favourable."

[2] In considering the possible causes of contraction of the nucleus, perhaps enough has not been made of the evisceration of the interior by volcanic action of various kinds. How much must have been vomited forth to form the great basaltic flows—and the pumice-covered floor of the deep oceans—and the dust clouds, which must often and often in geological ages, for months and years at a time, have covered the sky all round the globe!

[3] p. 91.

thick deposits on the theory of a solid globe. They cannot make a cavity for themselves, because the increase of pressure due to their weight would increase the rigidity of the sea-bed. The cavity must therefore somehow be already hollowed out, and it must conveniently border a continent, to be within reach of the sediment. This is a point which needs to be explained. But suppose that done; and conceive the sediment to be in process of accumulation. A second difficulty presents itself. Mr. Reade appears to consider that the hollow would be first filled up, and that the heat would subsequently be conducted from below into the sediments, and that they would swell up into a mountain region. But as a fact the heat would enter them concurrently with their deposition, so that the swelling up would begin at once. When the top of the deposit had reached the sea-level, deposition must cease; and it would be only the balance of heat remaining to be made up after that time, which could be effective towards raising the deposits above the sea-level. If deposition was a rapid process, the larger part of the heat might remain still due, and therefore available to raise the tract above the sea-level. But it is a very slow process—so slow that Mr. Reade thinks forty-two millions of years not too long for the deposition of the matter from the Carboniferous upwards in Western North America. Surely in that time the sediments would be almost quite warmed up before they got above the sea-level.

A valuable part of Mr. Reade's work consists of the experiments he has made upon the rates of expansion of different kinds of rock. His results agree closely with those obtained by Mr. Adie long ago; giving, as he puts it, 2·77 feet per mile per 100° Fah. He has not referred to Mallet's experiments upon molten slag, of which I have given an account in my "Physics of the Earth's Crust."[1] It is satisfactory to learn that, even at the high temperatures examined by Mallet, the coefficient of expansion keeps fairly near that determined by Adie, and now by Mr. Reade, for lower temperatures. Applying his result to masses of the size contemplated, the linear expansion of 1000 miles raised 1000° Fah. (which he takes as the mean increase of temperature for the new deposits and of the old crust under them) would be about 5½ miles. At p. 158 he assumes a lenticular mass, measuring 1000 × 500 miles, and 20 miles deep in its thickest part, raised to a mean of 1000° F. above its previous temperature. Lying in a rigid dish of crust, the entire cubical expansion would be effective to elevate the surface. The lower strata, being heated more than the upper, expand more, and become crumpled, because their periphery is confined by the rigid crust. They then burst up the superincumbent less-expanded beds, which gape at the anticlinals. Into these the lower heated rocks are intruded, and form plutonic cores. The interstitial differential movements give rise to foliation, and similar phenomena; and in places the hot solid rock beneath, finding weak places, and "struggling" to escape, intrudes itself into dykes, and becoming more and more liquid as it reaches regions of less and less pressure, at last appears at the

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[1] p. 68, note.

surface in volcanic manifestations. Such is an outline, as I understand it, of the theory.

If the two preliminary difficulties can be disposed of, the theory seems well suited to explain the formation of elevated plateaux. But for producing the intense corrugation, which characterizes most mountain ranges, the amount of horizontal expansion which it affords appears inadequate; especially when we consider, that much of the compression would be expended in deforming the material upwards, without rotation of the parts. The scale is made appreciable if one takes a metre rule, and compares five millimetres with the entire length—or a yard measure with less than a quarter of an inch. The corrugation arising from compression on such a scale must be very small. Many of the numerous and interesting sketches given from nature make one feel rather the inadequacy of the theory to account for the disturbances shown. Altogether this part of the theory needs more reasoning out quantitatively.

Chapter xxi. on the connection of volcanic action with mountain-building, is worth studying. The subject is an obscure one, but it is so intimately connected with every manifestation of force in the Earth's crust, as cause with effect, that they cannot be separated. Mr. Reade's leading idea seems to be, that the reservoir of magma is solid, but that it exerts expansive stress to find escape. Being solid, it does not transmit liquid pressure from one vent to another; so that lava can stand at different levels in them.

The experiment represented in figs. 1 and 2 of plate xlii. and the description of it (p. 431) are interesting. Several strips of paper were laid upon each other, and lines were drawn across the edge of the block so formed. It was then bent into folds. The inclination assumed by the lines now indicated the manner in which the strips had slidden longitudinally over one another in the process of folding. I may mention that the position taken by these cross lines exactly agrees with that of the "planes of less perfect cleavage" in Mr. Sorby's well-known diagram of a contorted bed in slate rock at Ilfracombe.[1] This shows that the cleavage follows the lines of distortion, not those of shear; for the latter would, in the experiment, have been along the surfaces of the sheets of paper.[2]

Mr. Reade, in plate xxxviii., gives a good demonstration of the extension that necessarily accompanies the compression of strata into close chevron folds, which, from what has been said in the preceding paragraph, would lead one to expect such folds to be in general affected by cleavage inclined at an angle across them.

There is throughout the book a certain want of precision in scientific language. "Heat" is sometimes used where the word should be "temperature"; "strain" where it should be "stress." At p. 303, having been told that mechanical denudation from the Mississippi basin is one foot in 6000 years, we read, "If we add the

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[1] Edin. New Phil. Journn. vol. lv. p. 138, 1853; and Lyell's Students' Elements, p. 577; also Prestwich's Geology, vol. i. p. 264.

[2] Rev. O. Fisher on Cleavage and Distortion, GEOL. MAG. Decade III. Vol. I. p. 400, line 5, 1884.

matters removed in solution, I have shown that we must reduce the time to one foot in 4500 years." To take notice of a verbal slip, confounding time with feet-per-year, may be making a mountain of a molehill. If I have done that, at any rate I have achieved a success in mountain-building.

In chapter x. our author gives very good reasons for considering the globe to contain a sufficient supply of heat for all the purposes of his theory. But he has made a mistake in supposing (as by working out his figures he seems to have done) that, if the temperature of the whole were reduced to zero Fah., all its heat would be exhausted. To accomplish that result, it would need to be reduced 460° Fah. lower still. O. FISHER.

# REPORTS AND PROCEEDINGS.

## GEOLOGICAL SOCIETY OF LONDON.

I.—March 9, 1887. — Professor J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "On *Chondrosteus acipenseroides*, Ag." By James W. Davis, Esq., F.G.S.

Sir P. Egerton described two species of *Chondrosteus* from the Lias of Lyme Regis, viz. *C. acipenseroides*, Ag., and *C. crassior*, Eg. The author describes an unusually fine specimen from the same locality, 44 inches long, the head, trunk, and tail being exceptionally complete, whilst a considerable portion of the elements of the vertebral column is preserved.

The head is proportionately large and deeper than the body of the fish. It has an almost circular outline with a diameter of about 9 inches, but the snout has been broken off during extraction. The cranium was protected by dermal bones or scutes. The anterior portion of the head, beneath the orbit, does not exhibit any traces of external defence, thus differing from existing Sturgeons. The frontals, postfrontals, parietals, mastoid, and some of the occipital plates are present: all these bones are united by sutures. The external surface of the dermal plates is coarsely striated or ridged; the ridges radiate for the most part from the centre towards the margin, the surface being covered by strips of ganoine. The orbit is oval. The base of the skull is formed by bones more completely ossified than in the existing Sturgeons: these are more extensive than in the Teleostean fishes, being the equivalents of the sphenoid bones of the latter. Sir P. Egerton, in his description of the genus *Chondrosteus*, states that the elements of the scapular arch, which in recent Sturgeons are three in number, are reduced to two in the fossil genus by the coalescence of the scapula and the coracoid. The author describes it as composed of a series of three bones, suprascapula, scapula, and coracoid (or clavicula). The last is united with the pectoral fin by two bones, apparently representing the radius and ulna of Owen (coracoid and scapula of Parker). The pectoral fin is large and comprised forty-two rays. The mandibles and maxillaries are large and well ossified, in this respect differing from existing species; there is no evidence of teeth. From the position of the respective maxillary and premaxillary bones in this specimen there can be no further doubt that the small bifurcated bone of *C. acipenseroides*, Ag., described as the maxillary bone, is really the premaxillary.

Bony neurapophyses are preserved in the anterior portion of the body. There is no trace of the vertebral column nor of ribs or hæmapophyses, except in the caudal fin, where hæmapophyses support the lower lobe. The neurapophyses extend from the occipital region of the skull to the base of the dorsal fin, 13 inches. In this length there are preserved thirty-five neurapophyses, representing the same number of vertebræ. The first ray of the dorsal fin is inserted above the thirtieth vertebra; the total number of vertebræ in the spinal column would be from eighty to eighty-five. The caudal fin is very large and was a powerful organ of propulsion; its upper lobe, as in the recent Sturgeon, is the longer of the two.

The specimen is nearly twice the length of those described by Egerton, and the author indicates the differences in some detail. The division of the scapular arch into three parts, the suprascapula, the scapula, and the coracoid, appears to be undoubted, whilst in the specimens previously described the scapula and coracoid are said to be united. The two latter ossifications of the shoulder-girdle are separate in the existing Sturgeons, and in the Ganoid fishes this is also generally the case.

The author then refers to the opinion expressed by Sir P. Egerton as to the homology of the cranial plates of fossil Sturgeons when compared with recent ones and also with Teleosteans, and to the confirmation of these views by Prof. Parker, who concludes that, although the Sturgeons cannot be said to occupy an intermediate position directly between the Selachians and the Bony Ganoids, yet on the whole that is their position.

Lastly, the author states his belief that there is no specific difference between *C. acipenseroides*, Agassiz, and *C. crassior*, Egerton.

2. "On *Aristosuchus pusillus*, Ow., being further Notes on the Fossils described by Sir R. Owen as *Poikilopleuron pusillus*, Ow." By Prof. H. G. Seeley, F.R.S., F.G.S.

A Wealden fossil, comprising certain dorsal, sacral and caudal vertebræ, with some associated bones belonging to the pubic region, formerly in the collection of the Rev. W. Darwin Fox, but now in the British Museum, was described by Sir R. Owen in 1876 as *Poikilopleuron pusillus*. In the present paper the author showed that the presence of a peculiarly-shaped medullary cavity in certain vertebræ, a character upon the strength of which the bones were referred to *Poikilopleuron*, Desl., was not peculiar to that genus, but had been found in *Megalosaurus* and in other Dinosaurian reptiles, whilst the characters of the sacrum in "*Poikilopleuron pusillus*" differed from those of any Crocodilia. The species was clearly not a *Poikilopleuron*, but was apparently a Dinosaur belonging to an undescribed genus, for which the name of *Aristosuchus* was proposed.

The pubic bones were described and shown to resemble those noticed by Prof. March in *Allosaurus*, *Ceratosaurus*, and *Cœlurus*, and the specimen itself has been referred by Prof. Marsh to the last-named genus. The genera named were, however, placed in distinct Dinosaurian suborders, and consequently it was evident that the pubic bones by themselves were insufficient for generic determination, whilst the dorsal vertebra of the Wealden fossil had the texture usually found in Dinosauria, and not that peculiar to *Cœlurus*. The mode of attachment of the ribs was also different. The sacrum of *Cœlurus* was unknown, but was probably very different from that of *Aristosuchus*. In the latter the transverse processes or sacral ribs were given off from each individual vertebra, as in certain American forms, and not as in *Iguanodon*, *Hylæosaurus*, *Megalosaurus*, etc., from the junction between two centra.

The five sacral vertebræ of the fossil and their apophyses were then separately described in detail, and also an associated fragmentary caudal vertebra; and the conclusion was expressed that *Aristosuchus* was a Dinosaur nearly related to certain imperfectly-described American types, such as *Allosaurus*.

3. "On *Patricosaurus merocratus*, a Lizard from the Cambridge Greensand, preserved in the Woodwardian Museum of the University of Cambridge." By Prof. H. G. Seeley, F.R.S., F.G.S.

No Lacertilian has hitherto been described from the Cambridge Greensand. The only remains of Lizards known to the author as having been derived from that bed consisted of the two bones now described, the proximal end of a femur, and a sacral vertebra with the processes broken away. The former exceeded in size the corresponding bone of the largest living Monitor, and differed from the femora in all recent Lizards in so many respects as to indicate subordinal distinction. The vertebra was not found with the femur, and may have belonged to a different species; but there being nothing in the characteristics of the two bones inconsistent with their having belonged to one specific type, both were fully described as types of a new genus and species.

4. "On *Heterosuchus valdensis*, Seeley, a procœlian Crocodile from the Hastings Sands of Hastings." By Prof. H. G. Seeley, F.R.S., F.G.S.

An ironstone nodule from the Hastings Sands was acquired by the British Museum from Dr. Mantell's collection. The specimen measured 10 centimètres by 6, and displayed on its water-worn surface several procœlian vertebræ of a small Crocodilian, together with some other bones, perhaps belonging to a different reptile. These other bones appeared to comprise portions of a skull with peculiarities not hitherto recognized in procœlian Crocodiles, and a pubis and ischium exhibiting distinct Lacertilian characters, and of comparatively very small size, but still situated in proximity to the sacral vertebræ.

The vertebræ were described in detail in the paper, and referred to a new genus and species. They included one late cervical vertebra, eight dorsal, and two which might be considered as sacral. All appeared to be mature, and were more completely ossified than the same bones in living Crocodiles. The body of each centrum was compressed laterally, the neural arch comparatively depressed and thrown out laterally above by the inferior V-shaped approximation of the side of the centrum. Several other peculiarities were also pointed out.

The paper concluded with notes on other vertebræ of similar character from Tilgate and Brook, and attention was called to a Crocodilian cervical vertebra with the procœlian cup from the Purbeck beds.

5. "On a Sacrum, apparently indicating a new type of Bird (*Ornithodesmus cluniculus*, Seeley), from the Wealden of Brook." By Prof. H. G. Seeley, F.R.S., F.G.S.

After some remarks on the characters of the sacrum in Birds, Ornithosauria, and Dinosauria, the author proceeded to describe a sacrum composed of six vertebræ in the Fox collection, now at the British Museum, and then to compare the fossil with the corresponding bones of the three groups named. The resemblance to the Dinosaurian and Ornithosaurian sacral vertebræ was less than those which connected the fossil with birds. From the latter it was distinguished by the smaller number of vertebræ in the sacrum, the absence of sacral recesses for the lobes of the kidneys, and the form of the articular face of the first sacral vertebra. But the small number of sacral vertebræ in *Archæopteryx*, the want of renal recesses in *Ichthyornis*, and the characters of the articulation in the Solan Goose showed that these differences were not essential; and the author concluded that the fossil belonged to a true Bird, but that it formed a link with lower forms, and approximated more to Dinosaurs than did any other Avian type hitherto described.

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II.—March 23, 1887.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "Notes on the Structures and Relations of some of the older Rocks of Brittany." By T. G. Bonney, D.Sc., LL.D., F.R.S., Professor of Geology in University College, London, and Fellow of St. John's College, Cambridge.

These notes are the results of a visit to some of the more interesting geological sections in Brittany, in the autumn of last year. The author is greatly indebted for information to the Rev. E. Hill, who took part in the summer excursion of the Société Géologique de France, and to Dr. Charles Barrois, who has for long been engaged in investigating the geology of Brittany.

(1). The author briefly noticed the glaucophane-amphibolites and the associated schists of the Ile de Groix, which have been already admirably described by Dr. C. Barrois. He considered the evidence to be on the whole in favour of the view that the former were originally igneous rocks intrusive in the latter, but modified by subsequent pressure (the marks of which are very conspicuous in the schists), and by mineral change, which probably produced the glaucophane, the garnets being anterior to the mechanical disturbance.

(2). The next part of the paper treated of sections in the district about Quimperlé. Cases were cited of granite, modified by pressure so as to result in a gneissoid rock, and of banded gneisses also modified by subsequent pressure, but, in the author's opinion, indubitably banded gneisses anterior to the mechanical disturbance, and exhibiting structures which, in his opinion, lend themselves more readily to a theory of some kind of original stratification of the constituents than to any other. The amphibolites in this region are undoubtedly of igneous origin (intrusive), but subsequently modified. In one part of the district are granitoid gneisses, but little modified by subsequent mechanical action, which in structure differ greatly from the granites, and much resemble the older Archæan gneisses of other regions. A "hälleflinta" to the north of Quimperlé proves to be in part a rhyolitic rock, modified by subsequent pressure; part, however, may be an indurated tuff of similar composition.

(3). In this part of the paper were noticed the crystalline rocks of Roscoff, and (more briefly) the Palæozoic strata about Morlaix, with the mineral and structural modifications due to pressure and to the action of intrusive igneous rocks. The author pointed out that, in the latter case, the results either of pressure-metamorphism or of contact-metamorphism differ much from the crystalline schists, which, both in Brittany and elsewhere, are regarded as of Archæan age; and that here in the north at Roscoff, we have a series of banded gneisses, less modified by subsequent pressure than in the south, the structures of which are very difficult to explain on any theory of a "rolling out" of a complicated association of igneous rocks, but which are such as would naturally result from some kind of stratification of the original constituents.

The result of the author's work is to strengthen the opinion which he has already expressed, that while the structures of some foliated rocks may be regarded as primarily due to pressure operating on suitable materials, the structure of others seems opposed to this explanation. At any rate the latter rocks appear to have assumed a crystalline condition with a semblance of stratification in Pre-Cambrian times; so that, whatever may be their genesis, they are rightly called Archæan gneisses and schists.

2. "The Rocks of Sark, Herm, and Jethou." By Rev. E. Hill, M.A., F.G.S.

The author described the island of Sark, about three miles long by two broad, with the smaller areas of Little Sark and Brecqhou. Little Sark is attached to Great Sark by a narrow ridge (the Coupée), which the weather is rapidly degrading, while Brecqhou is completely separated by a narrow strait. The greater part of these islands consists of dark hornblendic banded rocks, which closely resemble those of the Lizard, and show by their alternation of materials and their phenomena of current-bedding that they have originated by some kind of deposition. These were shown to lie unconformably on a gneiss, seen only at the eastern extremity of the island, in and around the Creux Harbour. Over this the beds lie in a dome, and as they slope away on the N., W., and S., they pass under a highly-crystalline rock, which has been called a metamorphic gneiss. This rock was described, and evidence given to show that it is really a granite,—an igneous rock which has overflowed the hornblendic beds.

Veins and dykes were briefly noticed; they include a dyke of mica-trap. The islands of Herm and Jethou, lying between Guernsey and Sark, were also described. Jethou contains a fine raised beach. They consist of granite which presents signs of an E. and W. dip. A probability was shown that this granite is part of the mass overlying Sark.

Finally, the age of these rocks was shown to be Archæan, and attention was called to the evidence they give that some at least of the Archæan rocks did not originate out of igneous masses by crush, but were formed by some process which, if not aqueous sedimentation, at all events was some kind of successive deposition.

3. "Quartzite Boulders and Grooves in the Roger Mine at Dukinfield." By James Radcliffe, Esq., F.G.S.

Quartzite boulders have from time to time been found imbedded in the roof of the Roger Mine coal-seam. Similar boulders had previously been described from coal-seams both in Leicestershire and the Forest of Dean. The composition of the Roger-Mine boulders was shown by notes furnished by Prof. Bonney to be quartzose grit and quartzite, containing some grains of felspar, epidote, and tourmaline and flakes of mica. This composition resembled that of some of the pebbles in the Bunter conglomerate of the Midland counties, and also that of some of the Loch Maree quartzites. The boulders varied in weight from 166 pounds to 4 pounds, and appeared to have been dropped into the coal, one boulder having been found standing edgeways. They were half imbedded in the seam, half inclosed in the overlying grey shale.

In the upper surface of the coal in the same mine, grooves were found running about S. 50° E., the mean direction of faults, slips, etc., being S. 26° W. The sides of these grooves were raised, as if by pressure, and each depression commenced as a small groove, then increased in depth and breadth, and finally died out.

## CORRESPONDENCE.

### INTERGLACIAL LAND AND MAN.

Sir,—As an item of evidence in favour of the existence of an interglacial land surface, so ably maintained by Mr. Jukes-Browne in this Magazine for March, and of the presence of Man in this country at the time, I send an extract out of a letter (Sept. 30, 1861) from the late Dr. Bowerbank to the late Dr. Bree, of Colchester, which has not, I think, been published. The occasion of its being written was that Dr. Bree had shown him the cut deer's horn from Clacton, described by me in the "Geologist," Aug. 1861, and figured in plate ix. "I have in my possession remains of a human skull, that was found mixed with bones of extinct animals at the bottom of a deep dyke on an axis of elevation, covered by the detritus of the Magnesian Limestone to about one-third of the height of the great crack, and the remainder then covered by the Red Drift of Yorkshire; so that it is fair to infer that it was deposited in the crack, or dyke, before the submergence of that country beneath the sea, and again elevated after being covered by the great northern Drift. This would appear to give an immense period to the existence of Man. The finding of these bones are (*sic*) so well authenticated, that there can be no reasonable doubt of their being in every respect genuine. I have often thought of publishing these facts, and I think I shall do so ere long."

What became of Dr. Bowerbank's collections?

I am quite aware that, as a rule, a geologist will not trust any one to observe correctly except himself. But on questions of this kind, where the evidence is destroyed in the process of being obtained, autopsy is impossible. We are therefore obliged to rely upon cumulative evidence, the weight of which depends upon the circumstance, that it is highly improbable that *every* observation should be erroneous, while at the same time a *single* correct one is sufficient to prove the point at issue. O. FISHER.

HARLTON, CAMBRIDGE, *4th April*.

## FELSPAR IN THE LIZARD SERPENTINE.

SIR,—May I be permitted to state, as briefly as possible, the reasons why the characters described by my friend Mr. Teall in his letter on "The Lizard Serpentines," fail to convince me that the mineral in question, which occurs in the Rill rock, is really felspar? As he rightly says, the identification of a mineral under the microscope is often more or less a matter of inference. Hence it is occasionally quite possible for two observers, both of some experience, to take different views. I do not then attribute a mistake to him in the ordinary sense of the word, nor wish in any degree to detract from the value of his work. The point is one of considerable interest, where there is ample room for two opinions.

To prevent any misunderstanding, let me say that I do not in the least deny that felspar may occur as an accidental constituent in a peridotite, and, if it occurred anywhere in the Lizard Serpentines, I should expect it, as will be seen from my remarks on that of Gue Graze, in the serpentine of the Kynance-Mullion district.[1] The difficulty of determining this particular mineral is not a new one to me, as I had to consider it nine years ago when preparing the above-named paper.

The following are my reasons, so far as they can be expressed on paper:—

1. The texture and aspect of the mineral in question, seen under the microscope, do not appear to me exactly identical with those of a felspar, but remind me rather of a pyroxenic mineral.

2. The brown earthy decomposition of the mineral seems to differ slightly from that of a felspar, and I find a similar decomposition in some grains of decomposing hornblende (mineral identified by cleavage and extinction) in the serpentine of Lower Pradanac, also in that of Mullion and Helston Road. I have also seen a similar decomposition in bastite or enstatite.

3. As to the tints seen between crossed Nicols. Low neutral tints are not rare in enstatites. I have noted them in augites, when somewhat decomposed, and in certain hornblendes. In my slides from Lower Pradanac the hornblende generally shows chromatic polarization, but some grains exhibit these low neutral tints. I believe it indicates incipient decomposition. As we have lately heard much

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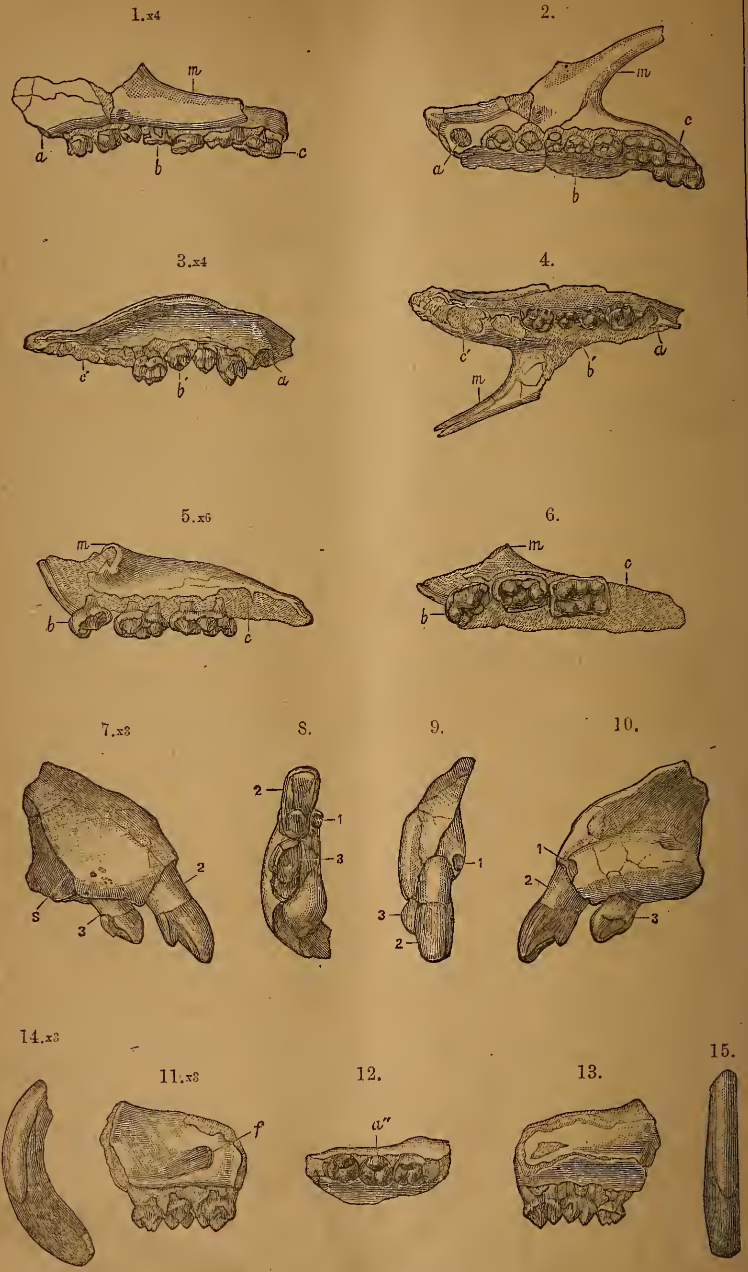
[1] Quart. Journ. Geol. Soc. vol. xxxiii. p. 918.

about the life of minerals, we may say that the flush of health is being replaced by the pallor of approaching death.

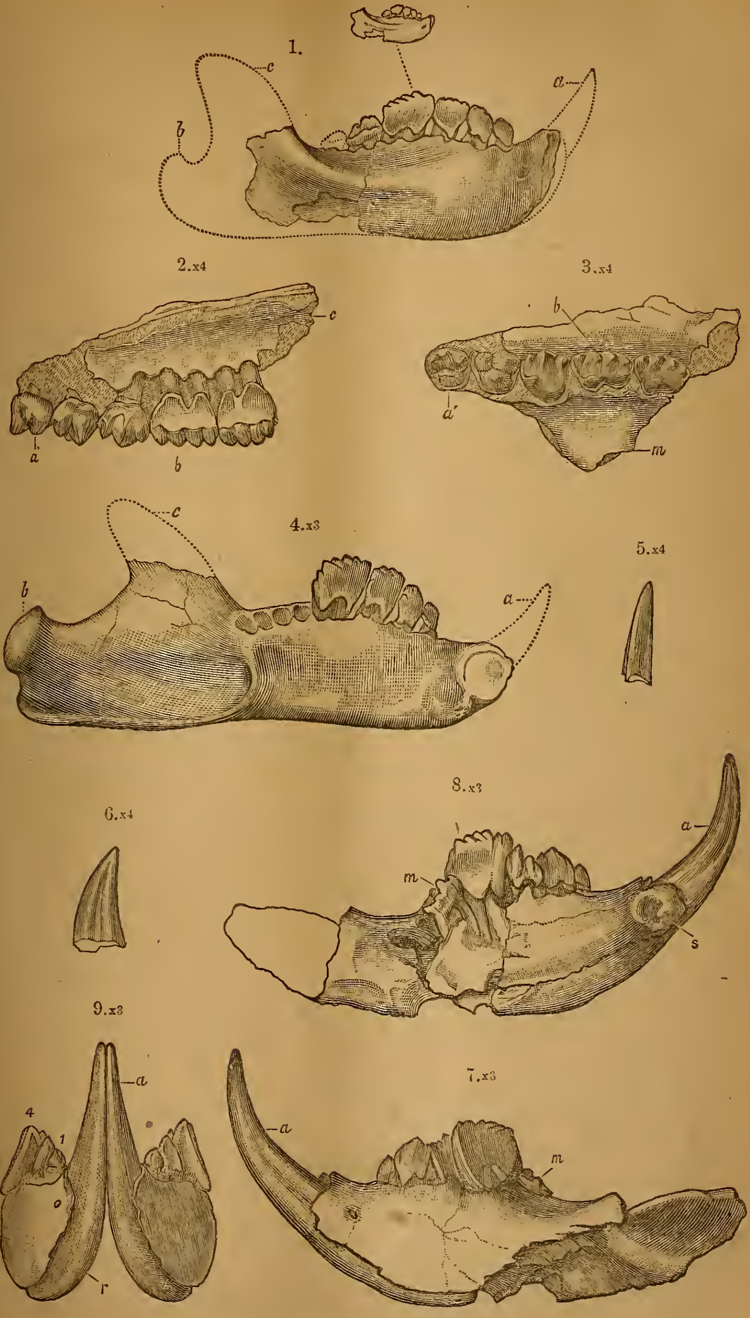
4. As regards the twinning, which is no doubt a very strong argument, I find a rather similar lamellar twinning (as it appears) in hornblende (serpentine of Mullion and Lower Pradanac). These seem to be produced by the formation of a mineral (doubly refracting but with different extinction) along the cleavage planes parallel to ∞ P, but I am by no means sure that this is the explanation of every case. In my slide (of 1878) from the Rill it occurs in a mineral which much more resembles a variety of enstatite than felspar. In the slide cut from Mr. Teall's specimen the twinning both lamellar and in two directions at high angles occurs in minerals which I cannot distinguish from the low-tinted pyroxenes (I use the name generically) in the other slides. Further, the twinning is produced by narrow bands such as one obtains in the almost microlithic felspars of lavas, not in those of holocrystalline rocks such as picrites, gabbro, etc., and the outline of the grains is not that usual in felspars, but curiously irregular. Moreover, I find in a slide cut from the Carn Sparnack serpentine, both lamellar twinning and cross twinning in the less highly altered part of the pyroxenic constituent. I have measured the extinction angles of some of these compound grains, but to discuss the result would unduly extend this letter, so that I must content myself with affirming that these bear as much resemblance to the twinning of a plagioclase felspar as those noted by Mr. Teall, while they occur to such an extent that, if the mineral were felspar, the rock could not fail to give macroscopic indications of its presence. So, though I have endeavoured to approach the subject with the 'open mind' of some modern statesmen, I remain after repeated examination of the question of 'the same opinion still' that the mineral is not felspar. My suggestion as to its name was 'vague' designedly, for two reasons: (*a*) that it is very often easier to say what a mineral is not than what it is; (*b*) that I am by no means sure that these characteristics are exhibited by one mineral only; I believe it, however, to be always a member of the pyroxenic group, viz. some variety of augite, hornblende, or enstatite.

In conclusion, may I add that Mr. Teall appears to have slightly misunderstood the drift of my remark quoted by Colonel McMahon. Whether or not there is evidence of mechanical action on the serpentine at Porthalla is hardly germane to the question. Of course I should say that to assign the banded structure in this rock to pressure is at present just as much an hypothesis as it is in regard to the banded gabbro. But, apart from this, the difficulty, which I had felt and to which Colonel McMahon referred, was this—that, when the gabbro is so remarkably banded, then the serpentine shows little or no sign of mechanical disturbance. Porthalla is some miles from both Karakclews and the Landewednack district, and, so far as I know, gabbro does not occur in association with serpentine either there or near Mullion Cove.

T. G. Bonney.



AMERICAN JURASSIC MAMMALS—ALLODON.



AMERICAN JURASSIC MAMMALS—CTENACODON.

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# ORIGINAL ARTICLES.

## I.—AMERICAN JURASSIC MAMMALS.

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

(PLATES VI. and VII.)

IN previous publications the writer has announced the discovery of Jurassic Mammals in America, and has given brief descriptions of the more important forms brought to light.[1] Since the last article on this subject, a large amount of new material has been secured, including representatives of several hundred individuals. The remains consist not of lower jaws alone, but of various portions of the skull, and not a few vertebræ, limb bones, and other parts of the skeleton.

These fossils, although fragmentary, are usually well preserved, but owing to the peculiar conditions under which they were entombed, no two bones of the skeleton are as a rule found together. This fact, taken in connection with the very diminutive size of the animals themselves, and especially with the present brittle nature of the teeth and jaws, has rendered their investigation a work of great difficulty. The importance of the subject, however, and the fact that all the known remains of mammals from the Jurassic of America are in the collection made by the writer, have led to a careful study of the whole material, and the results will be brought together in a Memoir now in preparation for the United States Geological Survey.

Some of the results of this investigation, and notices of several new forms recently discovered, are given below in the present article.

In connection with this work, the writer has also examined the more important specimens from the Jurassic of Europe, and, likewise, the few specimens known from the Trias, in both Europe and America.

The American Jurassic Mammals hitherto found are all from essentially the same geological horizon, in the Atlantosaurus beds, of the Upper Jurassic. The principal locality is in Wyoming, on the western slope of the Rocky Mountains, and remains of two or three hundred individuals have been obtained at this place alone. At other points in the same region, a few remains have been found. A

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[1] American Journal of Science, vol. xv. p. 459, 1878; vol. xviii. pp. 60, 215, and 396, 1879; vol. xx. p. 235, 1880; vol. xxi. p. 511, 1881; and vol. xxxiii. p. 327, 1887. See, also, Proceedings British Association, Montreal Meeting, p. 734, 1884.

second locality of importance is in Colorado, about three hundred miles south of the most northern known limit of these remains.

The other vertebrate fossils from this horizon are mainly Dinosaurs, many of them of gigantic size, but some scarcely larger than the mammals. Crocodiles, Turtles, small Lizards, and Fishes, are also well represented. A single Bird (*Laopteryx*), and one small Pterodactyl, have likewise been recognized from these deposits. More recently, various bones of small, anourous amphibians (*Eobatrachus agilis*) have been found, the first detected in any Mesozoic formation.[1] The deposits are lacustrine, as shown by the fresh-water shells they contain.

In investigating these American Jurassic Mammals, it was necessary to compare them, first of all, with those from the same formation in Europe. On this subject, the elaborate memoir of Owen, on British Mesozoic Mammals, was taken as the main authority.[2]

The first specimens discovered in America proved to be very near allies of European forms, and most of those since found show a remarkable resemblance to others described by Owen. Some fragmentary specimens cannot indeed be distinguished from the English fossils, but where the remains are more complete, various differences are seen, which appear to be distinctive. A few well-marked American genera have no known representatives in Europe, while some forms found in Europe are unknown in America.

One difficulty in the investigation of the remains from the two widely-separated regions arises from the necessity of relying mainly upon figures for comparison. Again, these minute, delicate fossils are often embedded in a matrix from which they cannot be removed without great danger of injury or destruction. Hence, the jaws and teeth in many cases must be examined and described from the single side exposed. If the opposite side of a similar jaw should be shown in another specimen, the two may easily be regarded as distinct. This may also be the case where upper and lower jaws are found separately. Hence, a large amount of material becomes necessary for even a proximate correlation of the closely-related forms.

## PLAGIAULACIDÆ.

One of the first American specimens discovered resembled strongly the minute lower jaws first described by Falconer, under the name *Plagiaulax*, and since investigated by Owen, Flower, and others, whose discussion of the habits and affinities of those peculiar mammals forms a well-known chapter in the history of palæontology. Of this genus, only the lower jaws were known, and this is one reason for the wide divergence of opinion as to the nature of the animals they represent. The lower jaws found in America were regarded by the writer as indicating a distinct genus, *Ctenacodon*, two species of which he has since described.

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[1] Proceedings British Association, Aberdeen Meeting, p. 1033, 1885.

[2] Monograph of the Fossil Mammalia of the Mesozoic Formations, Palæontographical Society, vol. xxiv. London, 1871.

Among the separate upper jaws found in the Jurassic of England were two or three described by Owen, under the generic name *Bolodon*, but with no suspicion that they were in any way related to *Plagiaulax*. From American deposits, also, somewhat similar jaws were obtained more recently, and as they were apparently quite distinct from *Bolodon*, they were described by the writer as representing a new genus, *Allodon*. The molar teeth in one specimen resembled those of *Plagiaulax*, and the writer in his description expressed the opinion that *Allodon* should probably be placed in the *Plagiaulacidæ*. A natural inference was that *Bolodon* was the upper jaw of *Plagiaulax*, and *Allodon*, of *Ctenacodon*. However this may be in regard to the European forms, the specimens now known make it clear that the American genera are quite distinct.

The molar teeth of *Allodon* and *Ctenacodon* are of the same general type, and it is still difficult, if not impossible, to distinguish them when detached from the jaws. The premolars, however, and especially the incisors, differ in the two genera, and when well preserved may often be separated with certainty.

### ALLODON.

In *Allodon*, the superior dentition on each side appears to be as follows:—Incisors 3; canine 0; premolars 5; molars 2.

The lower dentition is uncertain, but is probably the following:—Incisors 1; canine 0; premolars 4; molars 2.

The upper molar series in the type specimen of *Allodon* is well shown in Plate VI. Figures 1 and 2. The five premolars have tuberculate crowns, and all appear to be inserted by two fangs. The first and second have each one external, and two internal cones. The third premolar has a small additional cusp. These three premolars diminish in size from before backward. The next premolar, or fourth, is much larger, and has its crown flattened on the inner side. There are three tubercles on the outer border, and four on the inner margin. The fifth in the series is still larger, and has a more rounded crown. There are three lobes on the outer side, and the same number on the interior face.

The two true molars have low crowns, which are divided into an outer and inner half, by a deep-worn groove. Each half bears three low tubercules, of nearly equal size. The last molar has its longitudinal groove on a line with the inner margin of the other teeth.

The superior incisors of this genus now known are represented in the detached premaxillary of *Allodon fortis*, Plate VI. Figures 7–10. The first incisor was very small. The second was the main front tooth, much larger than the third. In the type specimen of *Allodon*, represented in Plate VI. Figures 1 and 2, no suture is visible behind the first small tooth (*a*), hence this may possibly be a weak canine instead of the third incisor. In *Allodon fortis*, Fig. 7, and also in the type of *Bolodon*, Owen, the suture between the premaxillary and maxillary is distinct.

The large second incisor of *Allodon* is a peculiar tooth, and was evidently exposed to the full wearing action of a strong lower incisor, somewhat similar to that of a Rodent. This lower tooth has not been found in place, but the one represented in Plate VI. Figures 14 and 15, may, with considerable probability, be referred to this position. The remaining lower teeth have not been found associated with the upper jaws, but they evidently resembled those of *Ctenacodon,* in some of their most important characters.

In comparing *Allodon* with *Bolodon,* we evidently have two nearly related forms. So far as at present known, *Allodon* has three incisors instead of two, a larger number of teeth in the premolar and molar series, and likewise shows other differences of less importance.

The affinities of these peculiar mammals and the inferences in regard to their habits and food, which may be drawn from the specimens now known, will be fully discussed by the writer elsewhere.

### ALLODON FORTIS, Marsh.

The present species appears to be generically identical with the type specimen of *Allodon laticeps,* but is represented by remains of much larger size. The premaxillary shown on Plate VI. Figures 7–10, may be taken as the type specimen. A number of upper molar teeth, and the large lower incisor (Figures 14 and 15 of the same Plate), are also referred to this species.

The first incisor in this premaxillary was very small, and situated close to the median line. It is wanting in the present specimen, but its size and position are indicated in the above figures. The second incisor is large and prominent, and is the principal front tooth. It has a distinct crown, which is covered with enamel, and consists of one large main cusp, with a small posterior cone. The lower surface is much worn, evidently by an opposing lower tooth which bore directly against it, from its apex to the small posterior prominence. The sides of the crowns show no signs of wear. The third and last incisor is much smaller, and is separated from the second by a short diastema. It has a distinct crown covered with enamel, but shows no marks of attrition. It is situated a little in advance of the suture with the maxillary, shown in Figure 7, *s*, Plate VI.

A second specimen referred to this species is shown in Figures 11–13, Plate VI. It is a portion of a left upper jaw containing three premolars, apparently the first, second, and third. The first two of these have a single external cone, and two inner cones, and the second tooth is larger than the first. The third premolar is still larger, unlike the corresponding tooth in *Allodon laticeps,* and has a second exterior cone behind the main one. Above this tooth, there is a large cavity, apparently the entrance of the antorbital foramen. This is shown in Figure 11, *f*, Plate VI.

The large lower incisor which met the prominent one above is probably represented in Figures 14 and 15. This tooth is faced with enamel in front, and grew from a persistent pulp, like the incisor of a Rodent. The summit is incomplete, and hence the shape of the worn surface cannot be determined.

The specimens here described indicate that *Allodon fortis* was the largest mammal of this group hitherto discovered in the Jurassic. In bulk, it was three or four times as large as *Allodon laticeps,* and about the size of a Rat.

The only known remains of this species are from the Atlantosaurus beds of the Upper Jurassic, in Wyoming.

### CTENACODON.

The genus *Ctenacodon* was based upon lower jaws, one of which is represented in Plate VII. Figure 1, and others in Figures 4, 7, and 8. The single, long, pointed incisor, the four, compressed, cutting premolars, and the two, minute, tubercular molars, form together a peculiar dentition. The long, sharp incisor shows no signs of wear whatever, and hence could not be opposed to the large upper incisor of *Allodon.* Its position was close to its fellow, and the two evidently acted together, as indicated in Figure 9, Plate VII. The four premolars form a close-set series, with their upper margins on a curve, all more or less notched. Some specimens, at least, show distinct marks of wear on the outer sides of the crowns, which are sometimes worn to a uniform surface. The two small tuberculate molars are of the *Microlestes* type, with a deep longitudinal groove on the upper surface of the crowns.

The entire upper dentition of *Ctenacodon* is not known with certainty, but it probably corresponded in its main features to that of *Allodon.* A portion of the upper jaw, with typical premolars, is shown in Plate VII. Figures 2 and 3. The posterior premolars, especially the last two, show strong marks of attrition on the inner sides of the crowns, and these were opposed to the compressed premolars below, forming together a most effective apparatus for cutting.

Some of the lower jaws at present referred to *Ctenacodon* apparently show no signs of wear on the premolars, and as the large incisor is not preserved, it is impossible to say definitely that they may not pertain to *Allodon.* It is likewise quite probable that some of the lower jaws considered as *Plagiaulax* may belong with some of the specimens now known as *Bolodon.* The exact correlation of the two forms cannot be determined with certainty until the upper and lower jaws are found together in position.

*Ctenacodon* may be distinguished from the type of *Plagiaulax* (*P. Becklesii*) in having four premolars instead of three. The summits of these teeth alone are notched, and the sides smooth, not obliquely grooved as in *Plagiaulax.* The condyle, moreover, is separated from the angle of the jaw, not confluent with it. *Ctenacodon,* also, has the angle of the jaw not only strongly inflected, but its outer margin effected into a wide horizontal shelf, making this one of the most peculiar features of the genus.

The vertical posterior condyle in *Ctenacodon* implies a strong postglenoid process, that would confine the jaw to a vertical motion.

In *Ctenacodon,* the mental foramen is large, and situated below the middle of the diastema. The dental foramen is under the last molar, but its entrance is partially concealed by a ridge descending from the base of the tooth to the inflected border of the angle.

In none of the specimens of *Ctenacodon* preserved is there any trace of a mylohyoid groove.

### CTENACODON POTENS, Marsh.

A third species of *Ctenacodon*, much larger than *C. serratus*, is represented by several jaws and isolated teeth, discovered since the first species was described. The most important of these specimens, which may be taken as the type, is the right upper jaw represented in Plate VII. Figures 2 and 3. The lower jaw with incisor, figured on the same Plate, may also be referred to this species. A second lower jaw in better preservation, but without the incisor, may likewise be included, although somewhat larger in size.

The upper jaw above mentioned agrees in its general shape with that of *Allodon.* It indicates a short, broad skull, with strong, expanded, zygomatic arches. There is a small antorbital foramen, as in *Allodon.* The four premolars present increase in size from before backward. The first and second are of the *Allodon* type. The last two have strong marks of attrition on the inner surface of their crowns, as shown in Figure 2 of the same Plate. They differ from the corresponding teeth in *Allodon,* in being more compressed, and adapted to cutting.[1] There were apparently two true molars, which are wanting in the present specimen, but their position and size are similar to those of the same teeth in *Allodon.*

The left lower jaw represented in Figures 7, 8, and 9 shows that the incisor in this species was very large in size, and a most effective weapon. It grew from a persistent pulp, and its massive base extended back under the fourth premolar. The crown is oval in outline at the margin of the jaw, somewhat more compressed above, and sharply pointed at the apex. There is a shallow groove on the outer surface of the lower half of the crown, and a corresponding depression along the middle of its inner face. A careful examination shows no signs of wear on any part of the crown.

The premolars are separated from the incisor by a long diastema. The first premolar is small, without serrations, and is placed close to the second. The latter is larger, inserted by two fangs, and has the summit faintly notched. The third premolar was still larger, but is so much fractured in the present specimen that its form and dimensions are uncertain. The fourth premolar is very large, notched at the summit, and with its outer face showing distinct marks of wear.

The first true molar is small, and its crown much inclined backward. The second true molar is wanting, but its alveoli show that it was also small, and placed below the first molar.

In this species, the series of four lower premolars is placed on a curve, and acts as a single cutting blade against the compressed upper premolars. This curve is completed behind by the two molars, which have their crowns inclined outward.

The second and larger lower jaw referred to this species gives some additional characters. The third and fourth premolars show

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[1] A somewhat similar tooth of *Microlestes* is figured by Owen in Mesozoic Mammals, plate i. fig. 16, Mon. Pal. Soc. vol. xxiv. 1871.

distinct traces of wear on their outer surfaces. The first true molar is placed obliquely, as in the previous specimen, and has been subjected to much attrition. The last true molar was situated lower than the first, and was also oblique. In *Ctenacodon serratus,* the two lower molars are nearly on a level. The present specimen shows that the angle of the jaw was strongly inflected, and there was likewise a ridge on the opposite outer margin. The coronoid process had its front border more nearly perpendicular than in *Ctenacodon serratus.* There is no trace of a mylohyoid groove.

The known specimens of this species are from the Upper Jurassic deposits of Wyoming.

## EXPLANATION OF PLATES VI. AND VII.

### PLATE VI.

Fig. 1. Left upper jaw of *Allodon laticeps*, Marsh; outer view.
,, 2. The same specimen; seen from below.
,, 3. Left upper jaw of same species; inner view.
,, 4. The same specimen; seen from below.
,, 5. Left upper jaw of same species; outer view.
,, 6. The same specimen; seen from below.
,, 7. Right premaxillary of *Allodon fortis*, Marsh; outer view.
,, 8. The same specimen; seen from below.
,, 9. The same specimen; seen from in front.
,, 10. The same specimen; inner view.
,, 11. Portion of left upper jaw of *Allodon fortis;* outer view.
,, 12. The same specimen; seen from below.
,, 13. The same specimen; inner view.
,, 14. Lower incisor of *Allodon fortis;* side view.
,, 15. The same incisor; seen from in front.

*a*, last incisor; *a''*, second premolar; *b*, fourth premolar; *b'*, third premolar; *c*, second true molar; *c'*, first molar; *f*, antorbital foramen; *m*, malar arch; *s*, suture with maxillary.

Figures 1–4 are four times natural size; 5 and 6, six times natural size; 7–15, three times natural size.

### PLATE VII.

Fig. 1. Right lower jaw of *Ctenacodon serratus*, Marsh; outer view.
The small figure is natural size, and the larger one is magnified four diameters.
Fig. 2. Right upper jaw of *Ctenacodon potens*, Marsh; inner view.
,, 3. The same jaw; seen from below.
,, 4. Left lower jaw of *Ctenacodon serratus;* inner view.
,, 5. Incisor, probably of same species; seen from in front.
,, 6. The same incisor; seen from the side.
,, 7. Left lower jaw of *Ctenacodon potens*; outer view.
,, 8. The same jaw; inner view.
,, 9. The same jaw; front view, with its fellow restored in place.

In Figures 2 and 3, *a'*, first premolar; *b*, fourth premolar; *c*, second molar; *m*, malar arch. In the lower jaws, *a*, incisor; *b*, condyle; *c*, coronoid process; *m*, molar; *r*, root of incisor; *s*, symphyseal surface.

Figures 2, 3, 5 and 6, are four times natural size, and Figures 4, 7, 8 and 9, are three times natural size.

(*To be continued.*)

## II.—NOTES ON *CHONDROSTEUS ACIPENSEROIDES*, AGASSIZ.

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

THE now well-known Liassic Acipenseroid fish *Chondrosteus acipenseroides* was named by Agassiz in 1843, but not described by him.[1] It subsequently formed the subject of an elaborate memoir by Sir Philip Grey-Egerton, Bart.,[2] in which, besides giving a minute account of the structure of the genus, he named two additional species —*C. pachyurus* and *C. crassior*. Putting the results of Sir Philip's investigations as briefly as possible, he maintained that while "in all essential points" *Chondrosteus* resembled the recent Sturgeon, nevertheless in certain others, and notably in the structure of the opercular and hyoid regions, it constituted a transitional form towards the more ordinary Ganoids. Moreover, the skin of the body presented the same naked condition seen in the recent *Polyodon*.

Eight years afterwards Professor Young read a paper on the subject before the Geological Society of London, of which only an abstract of six lines[3] is given in the Quarterly Journal. The object of the paper was to show that *Chondrosteus* was a Holostean, not a Chondrostean, because it "possesses a well-ossified basioccipital, and the lateral walls of the cranium are composed of bones answering to the cartilage bones of ordinary Teleostei."

In 1877 I placed the family "Chondrosteidæ" (including *Chondrosteus*) in the "Acipenseroid" suborder of Ganoids, between the Spatularidæ and the Palæoniscidæ, which latter family, along with the allied Platysomidæ, I proposed to include in one great group with the Sturgeons.[4]

On the 9th March of the present year, Mr. J. W. Davis read a paper on *Chondrosteus acipenseroides* before the Geological Society of London, of which an abstract has been published. In this paper Mr. Davis interpreted the appearances presented by a single fine specimen in his own collection, and besides giving a detailed account of its anatomical structure, expressed his belief "that there is no specific difference between *C. acipenseroides*, Agassiz, and *C. crassior*, Egerton."

Mr. Davis does not seem, however, to have made use of the magnificent suite of specimens of *Chondrosteus* in the British Museum, which contains not only the types of Sir Philip Egerton's figures, but also a splendid array of additional examples, mostly also from the Egerton and Enniskillen Collections. For the privilege of examining these, and of noting several new and interesting details presented by them, I am indebted to Dr. Woodward, F.R.S., Keeper of the Geological Department, and my thanks are due also to Dr. Geikie, F.R.S., and Mr. E. T. Newton, F.G.S., for kindly permitting me to take notes of the specimens in the Museum of Practical Geology, Jermyn Street. In the present paper I propose to give an

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[1] Poissons Fossiles, t. ii. pt. 2, p. 280.

[2] Phil. Trans. vol. 148 (1858), pp. 871—885.

[3] Q. J. G. S. vol. xxii. (1866), p. 596.

[4] Ganoid Fishes of the British Carboniferous Formations, Pt. I. Palæoniscidæ, p. 42, Pal. Soc. 1877.

outline of the results derived from the study of the specimens in both Museums.

*Cranial Shield.*—The elements of the main portion of the cranial shield have been recognized by Sir P. Egerton and by Mr. Davis, the former of whom enumerates "the parietals, the mastoids, the frontals, and the prefrontals,"—the latter stating that the "frontals, post-frontals, parietals, mastoid, and some of the occipital plates are present." This cranial shield is exhibited in many of the British Museum specimens, but in none have I seen it better displayed than in one belonging to the Museum of Practical Geology, from which Fig. 1 has been taken. Here we have two oblong *parietals* (*p.*)

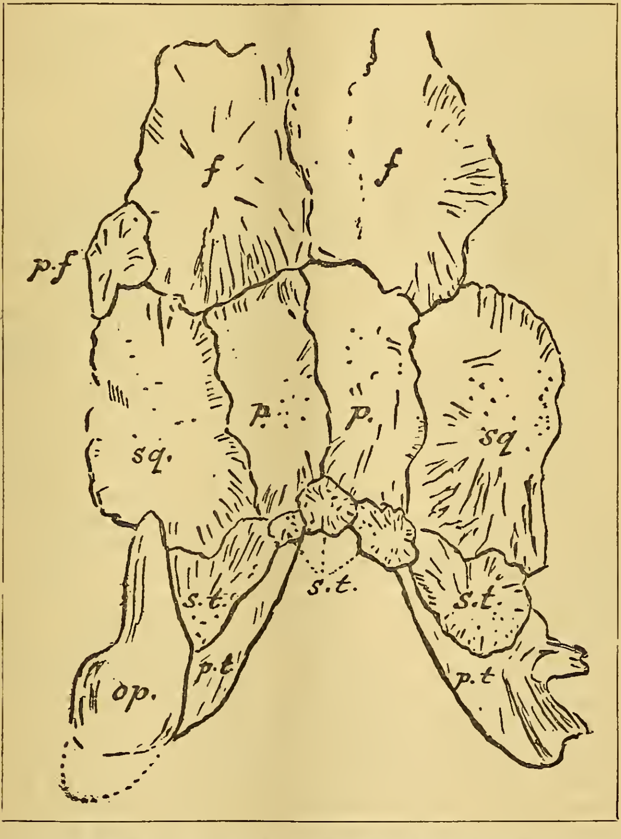

Fig. 1.—Cranial shield of a specimen of *Chondrosteus* in the Museum of Practical Geology, Jermyn Street. On the left side the displaced operculum (*op.*) is seen overlapping the post-temporal (*pt.*) and outer supra-temporal (*st.*).

joining each other in the mesial line, and each is flanked externally by a rather larger *squamosal* (*sq.*), the "mastoid" of a bygone nomenclature. In advance of the two parietals are two large *frontals* (*f.*), also in apposition mesially, while posteriorly, and externally, each of them also touches the squamosal of its own side. Then, occupying a corner between the hinder part of the external margin of each frontal and the anterior external margin of the corresponding squamosal, is a rather small *posterior frontal* (*p.f.*). In no specimen which I have seen are the plates in advance of the frontals in sufficiently good preservation to enable one to map out or describe them: the outline of the snout as given in the restoration (Fig. 5) is therefore conjectural. Behind the posterior margins of the parietals and squamosals, and between these and the post-temporal elements of the shoulder-girdle, is a transverse row of five small plates (*s.t.*). One of these, of a rudely polygonal shape, is median, and placed just at the union of the two parietals, and is flanked on each side by another plate, of which the right is larger, the left smaller than itself. External to each of the latter is the remaining plate of each side, of considerably larger size, of an irregularly triangular shape, and placed between the posterior margin of the squamosal and the post-temporal (*p.t.*), which latter it largely overlaps. These are certainly the plates which in other Ganoid fishes (*Lepidosteus*, *Polypterus*) have sometimes been called "supra-occipitals" and "epiotics," but they are mere scale-bones, and occupy the place of the *supra-temporal* chain in Teleostei.

A very distinct *suborbital* bone (*s.o.* Fig. 5) is seen in a large number of specimens. It consists of two limbs—an upper and longer vertical one meeting below at nearly a right angle with a shorter horizontal portion, the bone being considerably expanded at the junction. Above, the suborbital was suspended from the post-frontal region of the cranial shield,—below, it comes in contact with the middle of the maxilla. This suborbital is the bone which Sir Philip Egerton has interpreted as the "præmaxilla" in his memoir.

All these plates are externally marked with pores, and often with furrows and ridges radiating from the centres of ossification; often also the surface becomes corrugated, sometimes almost granulated; but I have seen no positive traces of ganoine upon the surface.

*Internal Cranial Bones.* — There is a large parasphenoid much resembling that of *Acipenser* in shape; but, unlike Prof. Young, I can find no remains of ossification in the chondrocranium, which can be described, or even relied upon as being such. Although such ossifications may very likely have existed, it seems very improbable that they attained any considerable dimensions.

*Hyoid Arch.*—The most easily recognized bone of the entire head is the *hyomandibular* (*h. m.* Figs. 2 and 5), which passes from the squamosal region obliquely downwards and backwards. It is shaped much as it is both in *Acipenser* and *Polyodon*, being constricted in the middle and flattened anteroposteriorly in its upper part, laterally in its lower. In one specimen in the British Museum there is an appearance as of an ossified symplectic, extending from the lower extremity of the hyomandibular towards the articulation of the mandible; this I do not insist upon, as it is not corroborated by any

FIG. 2.—Head of *Chondrosteus* (British Museum, No. P. 2049). [Egerton Collection.] See explanatory note at foot.

In this specimen the head is seen obliquely from below and affords an excellent view of the shoulder-girdle, opercular apparatus, roof of the mouth, and inner surface of a portion of the cranial shield.

other specimen, though the existence of a cartilaginous one may be safely assumed considering the large space between the lower extremity of the hyomandibular and the articulation of the lower jaw.

The *ceratohyal* (*c. h.* Figs. 2, 3, and 5) is also very easily recognizable, and requires no special description.

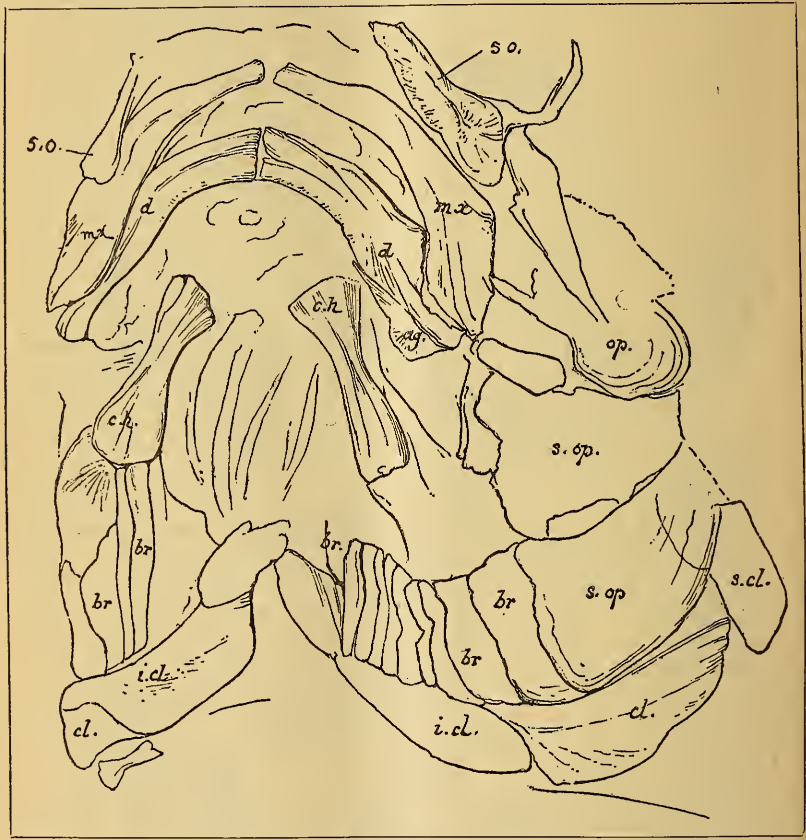

Fig. 3.—Head of *Chondrosteus* (British Museum, P. 2048), seen obliquely from below, showing the position of the mouth and the symphyses of both maxillæ and mandibles. The suboperculum and branchiostegal rays are somewhat injured.

*Opercular apparatus.*—The opercular flap is principally supported by a large, broad, somewhat irregularly rhombic plate (*s. op.* Figs. 2, 3, and 5), overlapping, with its anterior superior angle, the posterior inferior part of the hyomandibular, and leaving a considerable space between its upper concave margin and the edge of the cranial shield. This is the bone which has hitherto been called "operculum" in *Chondrosteus,* and it certainly corresponds exactly in position to the so-called operculum in *Polyodon.* It is, however, equally clear that it corresponds also in position, as well as in general shape, with the suboperculum of *Palæoniscus*;[1] and that this is its true interpretation is proved by the discovery of the proper operculum (*op.*) lying above it and between it and the cranial shield (Figs. 2, 3, 5). The shape of this operculum may be aptly likened to that of an inverted comma, the tail passing upwards and forwards to the cranial shield, the convex margin being posterior and the concave one anterior, a considerable space in front of the bone and above the suboperculum being still left uncovered. The opercular flap is continued downwards and forwards by a series of ten imbricating *branchiostegals* (*br.*), which are broad and plate-like where they immediately follow the suboperculum, though anteriorly they become narrow and slender.

*Jaws and palato-quadrate apparatus.*—The maxilla (*mx.*) is a tolerably stout bone, tapering anteriorly and somewhat expanded in its posterior third—the posterior margin looking very obliquely upwards and backwards. As is well shown in Figures 2 and 3, it is curved inwards in front to meet its fellow of the opposite side in a perfect symphysis; there cannot, therefore, be a true præmaxilla here any more than in *Acipenser* or *Polyodon.* Articulated to the oblique posterior margin of the maxilla is a small flat plate (*j*), whose shape somewhat reminds one of a boot, the sole being in apposition with the maxilla, while the leg is directed upwards and backwards towards the anterior margin of the suboperculum (see Fig. 4, *j*). This is clearly the homologue of the little bone which in the recent Sturgeon is called "præoperculum" by Mr. W. K. Parker,[2] although it seems to me and others to be the same "jugal" element which we find appended to the maxilla in *Amia, Salmo,* etc. In the Sturgeon it has also been called "maxilla" by some who looked upon the real maxilla as a "præmaxilla,"[3] and this seems to have been Sir P. Egerton's view when he assigns a præmaxilla as well as a maxilla to *Chondrosteus.* But an examination of the original specimen represented in pl. lxix. of his memoir shows that his "præmaxilla" is the suborbital bone, and that his maxilla—the small bifurcate bone behind it—appertains to the palate, and will be described immediately as a pterygoid element! The real maxilla in this specimen is interpreted by Sir Philip as a mandible, while to this jugal plate he has assigned the name and position of *hypotympanic* (=quadrate).

Within the space bounded by the maxillæ, the roof of the mouth is principally composed of two plates (*m. pt.* Figs. 2 and 4) of a somewhat oval or ovoid contour, narrower behind than in front. Anteriorly, these plates are placed behind the symphysis of the maxillæ; mesially, they articulate with each other along a portion of their internal margins, while externally each comes into contact with

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[1] Described as "interoperculum" in my Memoir on the Structure of the Palæoniscidæ. I have, however, abandoned that view, and now consider the plate intercalated between it and the operculum in such genera as *Rhabdolepis* to be not a suboperculum, but merely an accessory element.

[2] "On the Structure and Development of the Skull in Sturgeons," Phil. Trans. vol. 173 (1881), p. 172.

[3] See Stannius, "Handbuch der Zootomie der Wirbelthiere," erster Theil, Die Fische, p. 53.

the maxilla of its own side for the anterior half of its length, behind which the margin recedes inwards, the little bone *pt.* being placed just where the recession takes place. These plates were recognized by Sir Philip Egerton as "palatine," and are undoubtedly the representatives of the two plates occupying a corresponding position in *Acipenser*, and which, although formerly usually reckoned as "palatines," are designated as "pterygoids" by Prof. W. K. Parker.[1] To my mind it seems to correspond more with the *mesopterygoid* of other fishes, and I have lettered it accordingly.

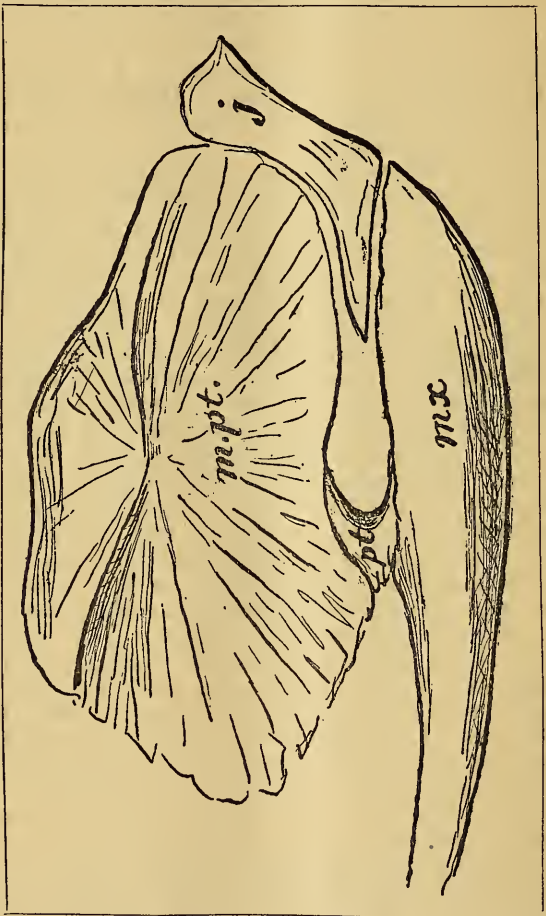

Fig. 4.—Palatal apparatus of left side of head of *Chondrosteus*, seen from above. Drawn from specimen in the Enniskillen Coll. No. P 3367, in the British Museum. *m. pt.*=mesopterygoid. *mx.*=maxilla. *j.*=jugal. *pt.*=pterygoid, or ectopterygoid.

Placed at the middle of the outer edge of this last described bone, and articulating both with it and with the maxilla, is a small

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[1] *Op. cit.* p. 172.

bone (*pt.*) which bifurcates posteriorly, one limb being placed along the middle, the other along the mesopterygoid palate-plate. This is the bone which Sir Philip Egerton has interpreted as "maxilla" (*op. cit.* pl. lxix. 21), but whose true relations are most clearly seen in a large number of specimens in the British Museum. These relations are not obscure even in the specimen figured by Sir Philip; but here, as already explained, he unfortunately mistook the real maxilla for the lower jaw. As the position of this little bone is about the middle of the maxilla and *behind the suborbital,* we may feel a little surprised at the following statement in the published abstract of Mr. Davis's paper:—"From the position of the respective maxillary and premaxillary bones in this (Mr. Davis's) specimen, there can be no further doubt that the small bifurcated bone of *C. acipenseroides,* Ag., described as the maxillary bone, is really the premaxillary."

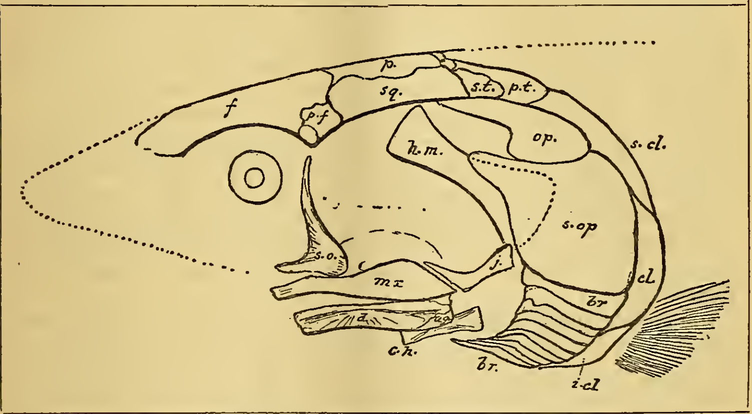

Fig. 5.—Profile of head of *Chondrosteus,* restored.

But if we inquire what this little "bifurcated bone" really is, I answer that it seems to me to occupy, as regards the maxilla and the great palate-plate, a position quite analogous to that of the small bone in *Acipenser* lettered as "palatine" by Professor W. K. Parker, but which I have come to look upon as a *pterygoid* or *ectopterygoid,* for the same reasons which have induced me to regard the great palate-plate as a mesopterygoid, and as such I have accordingly marked it.

I have seen no evidence of ossified quadrate or metapterygoid elements. There can be no doubt that the bone interpreted by Sir Philip Egerton as a combined "mesotympanic" and "hypotympanic" (*symplectic* and *quadrate* of modern nomenclature), is that external plate appended to the hinder extremity of the maxilla, which I have already described as the *jugal.*

The mandible is stout, and anteriorly is, like the maxilla, strongly curved inwards to meet its fellow of the opposite side in a symphysis: its outer surface presents a well-marked longitudinal groove, which approaches close to the superior margin about the middle of its extent, and then diverges downwards and backwards towards the angle. Sir Philip Egerton describes the mandible of each side as a single bone, and no doubt it is mostly composed of a large dentary element (*d.* Fig. 3). But at its posterior extremity two other elements are undoubtedly present, of which one, the upper, may be reckoned as *articular*, while the other beneath it is unquestionably the *angular* (*ag.*).

No trace of teeth can be seen in connection with either jaw; *Chondrosteus* in this respect, as in so many others, resembling the recent *Acipenser.*

*Branchial skeleton.*—Abundant remains of ossified *cerato-branchials* (Fig. 2. *c. b.*) are seen in many of the specimens, but we need not be detained at present by entering into detail as to this part of the skeleton.

*Shoulder-girdle.* — Sir Philip Egerton states that whereas in *Acipenser* three bones are present in the shoulder-girdle, viz. suprascapular (post-temporal), scapular (supra-clavicular), and coracoid (clavicle), in *Chondrosteus* the "scapula" and "coracoid" have coalesced. In *Acipenser* there are, however, at least four membrane bones of the shoulder-girdle; the post-temporal being however immoveably articulated with the cranial shield, while the fourth element is the large infra-clavicular plate. And Mr. Davis, as regards *Chondrosteus*, is undoubtedly right in maintaining that the "scapula" and "coracoid" are not fused, though, as he enumerated only three elements in the shoulder-girdle, he seems not to have observed the infra-clavicular.

The *post-temporal* (Figs. 1 and 2, *p. t.*) is a somewhat three-cornered plate placed behind the posterior margin of the cranial shield, and having its anterior margin overlapped by the supra-temporal bones. This is followed by the *supra-clavicular* (Fig. 2. *s. cl.*), an oblong bone passing obliquely downwards and backwards, and having its upper extremity obliquely perforated by the side-canal. Its distinctness from the clavicle is obvious in every well-preserved specimen. This clavicle (Figs. 2 and 3, *cl.*) differs from that of the Sturgeon in not being so much developed inferiorly, so that the next element, the *infra-clavicular* (*i. cl.*) articulates to its lower margin, extends higher up, and comes to be opposite a considerable portion of the origin of the pectoral fin. There is still another plate (Fig. 3, *p. cl.*), though it is a very small one, appended to the posterior margin of the clavicle, and this we may recognize as corresponding to the *post-clavicular* of *Polyodon* and the Palæoniscidæ.

I have seen no evidence of ossification in the scapulo-coracoid cartilage, nor does any specimen afford a view of the base of the pectoral fin, though in some a few dislocated radials may be seen in this position. It is probable that the arrangements here resembled those in *Acipenser*, and I own I am somewhat at a loss to understand the "two bones" to which Mr. Davis alludes as "apparently representing the radius and ulna of Owen (coracoid and scapula of Parker)."

The limits of the present paper hardly permit my entering into detail as to the rest of the structure of *Chondrosteus*. So far as the internal skeleton is concerned, its remains indicate a structure very similar to that in *Acipenser*, while the fins in shape and arrangement much resemble those of *Polyodon*.

*Conclusion.*—Although there is no evidence of any long snout, *Chondrosteus* resembled *Polyodon* in the general shape of the body, in the form and arrangement of the fins, and, above all, in the absence of *scales* on any part, save the prolongation of the body-axis along the upper lobe of the very heterocercal tail. In other respects its affinities are more with *Acipenser*.

How like the corresponding parts in *Acipenser* are the suborbital bone, the edentulous jaws, the jugal bone, and indeed the palatal apparatus, though that has also its own peculiarities; while it seems highly probable that the mouth was protrusible as in the living Sturgeon.

But where the resemblances to *Acipenser* become weaker, they come to point in another direction, namely, that of *Palæoniscus*, and of course through the Palæoniscidæ to the truly "teleosteoid" Ganoids. This is in the first place well seen in the cranial shield (Fig. 1) where the parietals and frontals are mesially in contact with each other for their whole length, where there is a well-marked supra-temporal chain, and where the post-temporal is moveably articulated, —whereas in *Acipenser* the frontals are entirely separated by an intercalated plate, and the post-temporals and two of the median body-plates are immoveably joined to, and form a part of the cranial buckler itself. Especially palæoniscoid is, however, the aspect of the opercular and branchiostegal apparatus, as will be seen if the reader will compare the restored drawing (Fig. 5) with the figures of the heads of *Palæoniscus* and *Nematoptychius* given in my account of the Palæoniscidæ, although in *Chondrosteus* there is no præoperculum and the series of branchiostegal rays of the two sides may not have met in the middle. The special resemblance of the shoulder-girdle to that of *Palæoniscus* is also very striking, especially in the form of the post-temporal and supra-clavicular bones.

In my already-quoted essay on the structure of the Palæoniscidæ, I pointed out certain strange and previously unrecognized resemblances which *Palæoniscus* bore to *Polyodon*, especially in the internal skeleton, the shoulder-girdle, and the jaws and palato-quadrate apparatus (even although there *are* premaxillary bones and there is no evidence that the palato-quadrate elements met in the middle line in front). I also remarked that the resemblances between *Palæoniscus* and *Acipenser* are of course much less prominent. Here, however, is a form which in many of its features presents strong Palæoniscoid resemblances, but whose affinities are, nevertheless, more with *Acipenser* than with *Polyodon*!

The affinities of *Chondrosteus* seem, therefore, to radiate in three directions, towards *Acipenser*, towards *Polyodon*, and towards the Palæoniscidæ, and certainly, of all the three directions, the distance towards *Acipenser* is the least.

## III.—BRITISH LIASSIC GASTEROPODA.

By E. WILSON, F.G.S.; Curator of the Bristol Museum.

(*Concluded from* p. 202.)

### CERITHIUM TRIGEMMATUM, spec. nov. Pl. V. Figs. 10, 10*a*.

*Description.*—Shell conical, turrited; apex acute; spiral angle regular, whorls 8–9, angularly carinated anteriorly; sutures wide and deep; each whorl bears 3 spiral rows of equally spaced but unequal neatly rounded tubercles; the anterior of these, which are much the largest, are set on the carina; the middle row consists of fine granules, whilst the nodules of the posterior row, which adjoin the posterior suture, are intermediate in size and half-way between the other two. Fine, close-set curved striæ of growth cross the whorls transversely, but are scarcely discernible even with a lens, except on the last whorl of well-preserved specimens. Last whorl bicarinated by a fourth very finely granular raised line, between which and the coarsely nodulated carina is a plain encircling thread; base flattish, bearing a few concentric raised lines. The aperture is imperfect in all the specimens I have examined, but is roundly ovate in form, and occasionally shows slight indications of the commencement of an anterior canal. I therefore assign this species to the genus *Cerithium.*

*Dimensions.*—Length, 7·5 millimètres; diameter, 2·5 mm.; spiral angle, 22°; sutural angle, 97°.

*Geological Position and Locality.* — Lower Lias, zone of *Am. oxynotus*, Railway-tunnel, Old Dalby, Leicestershire.

### ACTÆONINA FERREA, spec. nov. Pl. V. Figs. 11, 11*a*.

*Description.*—Shell pyriform, smooth and shining; spire depressed near the shoulder of the last whorl, but presenting a small pyramidal elevation in the centre; this portion of the shell is badly preserved, but the total number of the whorls appears to be 5; a narrow groove encircles the shoulder of the last whorl above (posterior to) the rectangulated keel. The aperture is almost entirely concealed in my sole specimen, but it widens out somewhat towards the anterior extremity, and the inner lip is thin with a sharp edge anteriorly, without any fold or thickening over the columellar region. A few (5 or 6) fine encircling striæ are discernible on the anterior portion of the last whorl.

*Dimensions.*—Length, 7·5 mm.; diameter, 5 mm.; length of last whorl, 6·75 mm.

*Geological Position and Locality.*—Middle Lias, Marlstone Rock, zone of *Am. spinatus*, East Norton Embankment, derived from Tilton, Leicestershire.

### CYLINDRITES ÆQUALIS, spec. nov. Pl. V. Figs. 12, 12*a*.

*Description.*—Shell ovately and regularly fusiform; spire moderately elevated, obtusely conical; apex acute; whorls 5, slightly convex, embracing, with narrow ill-defined sutures. A narrow impressed line encircles the whorl a little in front of the suture, between which there is a narrow raised encircling band; the aperture is, unfortunately, not well shown; it occupies five-sixths of the length of the last whorl, the anterior extremity is acutely angulated, with thickened margins, and there is a distinct spiral fold on the columellar border anteriorly. The shelly matter has disappeared, but the surface appears to have been originally smooth.

*Dimensions.*—Length, 11·5 millimètres; diameter, 5·75 mm.; length of last whorl, 10 mm.

*Geological Position and Locality.*—Middle Lias, Marlstone Rock, zone of *Am. spinatus*, East Norton Embankment, derived from Tilton, Leicestershire.

### British Liassic Alariæ.

It has often been supposed that the section of winged shells *Aporrhaidæ*, and genus termed *Alaria* by Lycett, but more clearly defined by Piette, did not appear in the British area until the commencement of the Oolitic period. This is certainly a mistake. Although extremely rare in the Lias, there are undoubted instances of the occurrence of *Alariæ* even in the Lower division of that formation. Messrs. Tate and Blake do not record this genus from the Yorkshire Lias. In his valuable "Contributions to the Palæontology of the Yorkshire Oolites," Mr. W. H. Hudleston, F.R.S., referring specially to the Yorkshire area, observes that "It was in the Lower Oolite that the genus *Alaria* first began to flourish, and we find that it became tolerably well represented as low down as the Inferior Oolite or Bajocian subdivision" (Geol. Mag. Dec. III. Vol. I. p. 145, 1884). In the year 1867 the late Charles Moore described three species of *Alaria* from the Upper Lias of Somersetshire, viz. *A. unispinosa*, Moore; *A. coronata*, Moore, and *A. angulata*, Moore. The first of these certainly, and the last two probably, are true *Alariæ*. Since then other examples of this genus have been found in different portions of the English Lias. Mr. T. Beesley, F.C.S., whose valuable labours in the Lias of Oxfordshire are widely known, informs me that he has obtained the moulds of two *Alariæ*, which he takes to be *A. coronata* and *A. angulata*, from the Upper Lias shales (lower portion of zone of *Am. communis?*) of Bloxham, Oxon. Mr. E. A. Walford, F.G.S., of Banbury, records an *Alaria* (*A. unispinosa*, query *A. semicostulata*) from the Upper Lias of Chipping Warden, Northamptonshire. Mr. B. Thompson, F.G.S., has shown me imperfect specimens of an *Alaria*, which may be *A. unispinosa*, from the Upper Lias (zone of *Am. serpentinus*) of Alderton, Gloucestershire, and Mr. W. D. Crick has recently forwarded me specimens from the Upper Lias of Chipping Warden, and of Burrow Hill, Dodford, Northamptonshire, which are very closely allied, if not, indeed, identical with *A. semicostulata*, Piet. et Eug. Desl. Last year I had myself the good fortune to find a single well-marked example of this genus in the Lower Lias of Bitton, near Bristol, Gloucestershire.

In his classical paper on "Abnormal Secondary Deposits in the

West of England," the late Charles Moore described two incomplete shells from the Lower Lias coralliferous conglomerate of Brocastle, Glamorgan, under the names *Alaria rudis*, Moore, and *A. fusiformis*, Moore (Q.J.G.S. vol. xxiii. p. 566, pl. xiv. figs. 24, 25). Having lately examined these specimens in the Bath Museum, I would question very seriously the generic appellation given to these fossils. In their general proportions both these shells are very unlike typical *Alariæ*, and seeing that they show no distinct canal or trace of digitation, their identification as such must be considered doubtful. On the other hand, there are a few forms in the "Moore Collection" at Bath, at present ascribed to other genera, which may eventually be shown to belong to the genus *Alaria*. For the present, the little shell from the Lower Lias of Bitton, Gloucestershire, must, I believe, be considered the earliest definitely established British *Alaria*, if not indeed the earliest known example of that genus.

### ALARIA HUDLESTONI, spec. nov. Pl. V. Fig. 13.

*Description.*—Shell turrited, scalariform; apex acute; spiral angle slightly concave; whorls 8–9, quadrangular and rectangularly bicarinated, with wide and deep sutures; the carinæ each bear a finely-granulated thread over the angle, the posterior of which is rather more prominent, and causes this keel to project a little more than the anterior one; the posterior carina is encircled anteriorly by a narrow impressed line; the whole of the spire and apparently also the base is covered with fine oblique radial lines; in the earlier whorls the anterior carina is submedian and much more prominent, and is coronated over the angle by vertical costæ, whilst the posterior carina is much less prominent; the base of the shell is almost flat, it bears 3 or 4 widely-separated concentric raised lines. The wing consists of a single digitation, which has a general direction at right angles to the axis of the shell; this is wide at its origin, directly below the anterior carina of the last whorl, after proceeding a short distance it suddenly narrows, and then soon tapers away to its rather blunt and slightly recurved extremity. Canal unknown, the canal-sheath being broken off at its origin.

*Dimensions.*—Length of shell without the canal, 7·5 millimètres; diameter of last whorl, 4 mm.; breadth of same, with wing, 8 mm.; spiral angle, 30°; sutural angle, 105°.

*Obs.*—I name this interesting fossil after Mr. W. H. Hudleston, M.A., F.R.S., who has contributed so largely to our knowledge of the Gasteropoda of the British Oolites.

*Geological Position and Locality.*—Lower Lias, zone of *Am. Bucklandi* (lower portion), Stout's Hill, Bitton, near Bristol, Gloucestershire.

### ALARIA SEMICOSTULATA? Piet. et Eug. Desl. Pl. V. Figs. 14 & 15.

1864. *Alaria semicostulata*, Piet. et Eug. Desl. Pal. Fr. Terr. Jur. Gast. vol. iii. p. 18, plate i. figs. 7—9.

The following description of the more perfect of Mr. Crick's specimens will be found to agree pretty closely with that given by Piette (*l.c.*).

*Description.* — Shell turrited, fusiform; spiral angle regular; whorls 9 or thereabouts, convex, very feebly carinated a little anterior to the middle line, and ornamented by several fine spiral threads of unequal thickness. In one specimen (Fig. 14), which is the more complete of the two, but is imbedded in the rock so as not to show the aperture, there are on the penultimate whorl 11–12 threads. Of these four are coarser than the rest; two of those which are most prominent and subcentral in position determine the faint keel; the other two are anterior to these; between the second and third, and also between the third and fourth, of these coarser threads, counting from the anterior suture, there is a fine line; posteriorly to the fourth coarse thread there are two threads of medium coarseness with a fine thread between them, and there are two or three more fine threads between the last of these and the posterior suture. Crossing these are numerous inconspicuous curved radial lines of growth. The earlier whorls are badly preserved, but enough remains to show that they bear strong straight radial costæ; these costæ disappear on the later whorls, and there are no signs of them on the last two or three. The canal-sheath, uniformly slender from its origin, is prolonged in a straight line axially to its termination; it is striated by fine oblique lines. (In Piette's type the canal was broken off short, so that the character of its termination could not be given.) The aperture and ultimate wing (l'aile définitive) are not shown, but the character of the latter is indicated by a single longish slender spine, which originates from the posterior line of the keel, making an angle of 68° with the axis of the spire.

*Dimensions.*—Height, including the canal, 19 mm.; height, without the canal, 14 mm.; greatest breadth of last whorl, exclusive of the wing, 8 mm.; spiral angle, 25°; sutural angle, 115°.

*Geological Position and Locality.*—Upper Lias, zone of *Am. serpentinus*, Burrow Hill, between Dodford and Norton, Northamptonshire.

The other specimen (Fig. 15) is much less perfect, but it agrees pretty closely with the foregoing in its general form and ornamentation. The whorls, however, appear to be more convex, with deeper sutures, and are even less perceptibly carinated; they are crossed by widely spaced slender curved radial costæ, which taper away towards the sutures, and almost disappear on the later whorls; a short spinous process remains at the opposite side to the aperture, from which point a single angular and moderately prominent keel is continued forwards: the base as well as the apex of the shell having suffered considerably, we cannot say for certain whether any more spinous processes were developed on the keel or what were the characters of the canal and the wing.

*Dimensions.*—Spiral angle, 25°; sutural angle, 120°.

*Geological Position and Locality.*—Upper Lias (transition-bed to Middle Lias), Chipping Warden, Northamptonshire.

*Obs.*—There are minor differences in form, and in the number and arrangement of the spiral lines, between the above shells and between each of them and Piette's figure of *Alaria semicostulata*. The shell from Burrow Hill (Fig. 14) evidently does not exhibit its full growth, so that it is impossible to say whether an angular carina sets in on the last whorl or not. Judging by its general agreement with our other specimen, I am inclined to think it would, and in that case the chief difference between this shell and *Alaria semicostulata* disappears. Again, in the Chipping Warden specimen (Fig. 15) the whorls are more rotund and more deeply sutured than in the enlarged figure of *A. semicostulata*, given by Piette, or in the first above-described specimen. Slight variations in the convexity of the whorls, in the depth of the sutures, spiral angle, and arrangement of the spiral lines, are not by themselves characters of specific value amongst otherwise similar *Alariæ*; so that in face of the general agreement of these shells with *A. semicostulata*, and failing definite proof of any important distinction in the keel, the carinal spines, or the canal, I consider it safest to relegate both of the above specimens to that type.

[For the Plate and the Explanation thereof, see the May Number, p. 202.]

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## IV.—The Glacial Deposits of Sudbury, Suffolk.

By J. E. Marr, M.A., F.G.S.,
Fellow of St. John's College, Cambridge.

THE accumulations of drift in the vicinity of the town of Sudbury have been described by Mr. Whitaker in the Geological Survey Memoir upon the N.W. part of Essex and N.E. part of Herts, etc.; and additional notes are given by the same author in the Memoir upon the Geology of Ipswich, etc. Since the appearance of these memoirs the sections have altered considerably, and one of the exposures is of such interest, that a record of it seems to me desirable, as in a few years it will be doubtless destroyed, and one more link in the chain of facts which have to be considered in attempting to account for the mode of formation of these drifts will have disappeared.

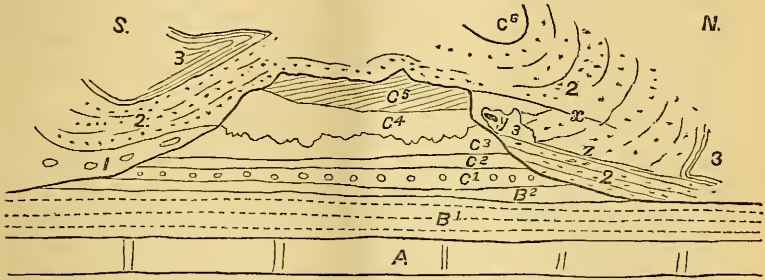
I wish to express my indebtedness to Dr. J. S. Holden, F.G.S., who has kindly accompanied me to the principal exposures, and furnished me with much information.

Fig. 1.—Section in Mr. Green's Pit N.E. of Sudbury.
S. Length of Section about 100 feet. N.

*A.* Chalk. 1. Boulder-clay. *D.* Gravel dug over and filled in.
*B.* Thanet Sands. 2. Gravel and sand. *T.* Talus.
*C.* Red Crag. 3. Loam.
*C'.* Red Crag caught up in drift.

The section to which I would call special attention is seen in Mr. Green's pit, about a quarter of a mile N.E. of Sudbury Town Hall. The accompanying Figure (Fig. 1) shows its appearance at the present time (March, 1887). The Chalk, which is worked to a depth of many feet, is succeeded by the clayey green sand with green-coated flints, referred by Mr. Whitaker to the Thanet Sands. The bed is partly removed at one point, near the north end of the section, but elsewhere it has its full thickness, which is ascertained where the green sand is succeeded by an upper deposit resting conformably upon it; this is the red clay, $B^2$ of Fig. 2, which only occurs in one part of the pit underneath a remarkable ridge of Red Crag to be now described. The ridge is marked C in Fig. 1, and an enlarged sketch of it is given in Fig. 2. The lower part consists of the pebble-bed with phosphatic nodules described by Mr. Whitaker (Q.J.G.S. vol. xxx. p. 401). This is marked $C^1$ in Fig. 2. Next above it is a coarse sandstone $C^2$ with a few pebbles, the whole being hardened by a ferruginous cement which gives the rock a very dark-brown colour. The united thickness of these beds is about 2 feet 6 inches. The main part of the ridge is formed of about 8 feet of fine incoherent quartz-sand, stained rusty red at the summit, but bleached to a pale yellow-green hue at the base. The bleached part $C^3$ and the lower portion of the unbleached part $C^4$ are devoid of lamination planes, though some planes of deposition are visible; but the top of the ridge $C^5$ is formed of a finely-laminated sand, the laminæ being quite regularly inclined at a very low angle towards the south. It will be seen that not only are the bedding planes between the Chalk and the Thanet Sands, and between the latter and the Red Crag, quite regular, but that the divisional planes of stratification and lamination in the latter, which stands up as a ridge in the middle of the drift accumulations, are absolutely undisturbed.

Fig. 2.—Enlargement of the Crag Ridge in Fig. 1 (Mr. Green's Pit).



$A^1$. Chalk.
$B^1$. Green clayey sand } Thanet Sand.
$B^2$. Red clay
$C^1$. Pebble bed.
$C^2$. Hard dark brown very ferruginous gravel } Red Crag
$C^3$. Bleached (yellow-green) sand
$C^4$. Rust-red sand, not laminated
$C^5$. Rust-red sand, very finely laminated
$C^6$. Bleached (yellow-green) sand in the drift

1. Boulder-clay.
2. Sand and gravel.
3. Loam.

*x*. Iron staining from Crag Ridge.
*y*. Fragment of Bed $C^2$ included in drift.
*z*. Marked divisional plane (fault ?).

Very different is the condition of the overlying drifts. Before proceeding to describe them, I may refer to the section fig. 17 of the Geological Survey Memoir on the Geology of N.W. Essex, etc. This section is described by Mr. Whitaker as occurring on the footpath to Chilton; it would therefore lie somewhere to the east of the section now under consideration. The structure of the Crag ridge and the disposition of the overlying drifts would seem to indicate that there was a continuation of the ridge now visible in Mr. Green's pit, in which case the ridge probably has a general E.—W. direction, as may indeed be gathered from an examination of Mr. Green's pit itself. The section figured by Mr. Whitaker is now destroyed.

The ridge in Mr. Green's pit increases in height and breadth towards the west, as shown by comparing a photograph which I caused to be taken at the end of the year 1885 with the present exposure, several feet of the face of the cliff having been cut away in the interval.

The description of the drift deposits of this pit is not quite so easy as that of the older formations. Mr. Whitaker describes the Boulder-clay in the pit on the footpath to Chilton as filling up a hollow in the gravel, but the section as drawn by him is explicable also upon the supposition that the gravel fills up a hollow in the Boulder-clay. In the case of Mr. Green's pit, I came to the conclusion that the latter was the case, and have therefore taken the Boulder-clay as the deposit which would under ordinary circumstances be the lowest. This may be the case here, even if the Boulder-clay in the pit on the footpath to Chilton is above the gravel, as Mr. Whitaker shows that there are two Boulder-clays in the area. The succession, as gathered from a careful examination of Mr. Green's pit, appears to be as follows:—

1. Boulder-clay.
2. Coarse sand and gravel.
3. Fine loam.

And this is the order in which I shall describe the accumulations.

The Boulder-clay 1—Figs. 1 and 2—consists of a very stiff brown or leaden-blue clay, having at the south end of the pit a series of wavy divisional planes. Besides this, it in places contains very close-set divisional planes, reminding one strongly of the "fluxion-structure" of igneous rocks. Along some of these carbonate of lime has collected, giving the deposit here and there a marked banded appearance. The deposit is full of boulders, mostly small, the greater number being of white chalk (often striated) and flint, but blocks of sandstone also occur, especially a port-wine red sandstone. In the north part of the pit a small patch of Boulder-clay occurs in a depression of the Thanet Sands, but separated from them by gravel. This clay forms a horizontal tongue a yard or two long, and 2 ft. 6 in. high. At the bottom of the clay, and resting on the gravel, are patches of red clay, clayey green sand, and a mixture of the two, evidently torn off from the rocks close by. The Boulder-clay probably owes its position here to a fault which appears to run almost horizontally from the upper portion of the Crag ridge, and which brings the deposits below against beds above inclined at quite different angles. The whole arrangement of the drifts at this part of the pit is extremely difficult to comprehend.

The gravel and sand 2—Figs. 1 and 2—are stratified and frequently false-bedded. They contain a considerable intermixture of argillaceous material. The boulders are similar to those in the Boulder-clay, mainly chalk and flint. I noticed two small fragments of red chalk. The carbonate of lime has collected along divisional planes, as in the case of the Boulder-clay and of the loam. In the central part of the section the gravel undoubtedly does at present overlie the Boulder-clay, and though it is underneath it at the south end, this seems to be due to the thrusting of a trough of gravel and loam under the Boulder-clay.

The gravel is arranged around the Crag ridge in two loops, and in the northerly one a mass of sand (Fig. 1, $C^1$) is involved; this sand is almost certainly a piece torn off from the Crag. It is entirely different from the gravels and loams, and resembles precisely the bleached portion of the Crag ridge, being, like it, a pale yellow-green quartzose sand, devoid of lamination; moreover, here and there a few brown patches show parts that have escaped the bleaching, as is also the case with the Crag of the ridge.

The drift-gravel is in one place coloured red, viz. along a line (Fig. 2) proceeding from the northern edge of the Crag ridge. This is possibly due to subsequent infiltration, but it is also possible that small particles of the Crag have been carried down along this line. The latter certainly seemed to me to be the case on examining the coloured seam closely.

Immediately below this stained line occurred a fragment of the bed $C^2$ (y. Fig. 2) caught up in a small patch of loam in the centre of the gravel.

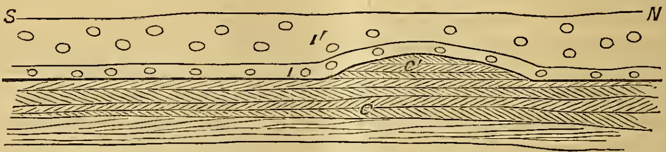
The loam 3—Figs. 1 and 2—is a stiff yellowish-brown clay, sometimes sandy, and containing comparatively few boulders. It is very finely laminated throughout. It occurs in the loop just south of the Crag ridge, and in the centre of the loop now underlying the Boulder-clay in the southern portion of the pit-face. It again occurs in a very narrow loop to the north of the Crag ridge; this expands above the plane, which is, as I have suggested, possibly a fault plane, and is then continued along this plane as a very narrow seam, sometimes only a couple of inches in thickness, above the patch of Boulder-clay before referred to, and beyond it for some yards to the extreme north end of the section.

In a pit to the east of Mr. Green's, a considerable mass of the ferruginous sands of the Crag is seen, succeeded by coarse gravels, above which comes contorted loam, in some cases bent into long horizontal loops, but no Boulder-clay is now visible. Here again the Crag sands are absolutely undisturbed, notwithstanding the violent contortion of the drifts immediately above.

Two important sections occur near the town upon the right bank of the Stour. One of these is near the summit of Balingdon Hill

(Fig. 3). The pit here is mainly cut in the ferruginous sands of the Crag, which show a total thickness of 30 feet here, without any signs of approaching the base. The beds are quite like those of the Crag ridge in Mr. Green's pit, save that they are here markedly false-bedded. The surface is perfectly even except in one place, where a rounded ridge rises up five feet above the surface of the surrounding sand ($C^1$, Fig. 3). The Crag is succeeded here by Boulder-clay, which is at the top an ordinary blue laminated Boulder-clay, with the usual scratched chalk boulders, as well as others of flint, oolitic limestones, sandstones, etc., and below this two feet of a sandy laminated Boulder-clay, of a reddish colour, the sand being evidently derived from the underlying Crag.

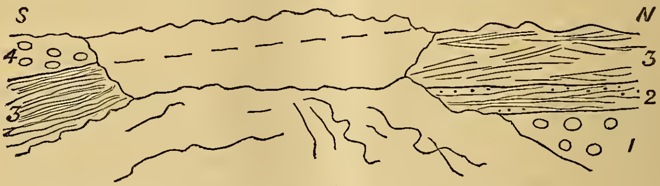
Fig. 3.—Pit on Balingdon Hill.



C. False-bedded sands, ferruginous above, bleached at base, 25 feet seen } Red
C′. Ditto bleached, projecting into drift, 5 ft. } Crag.
1. Sandy laminated Boulder-clay, 2 ft.
1′. Blue laminated Boulder-clay, to 10 ft.

The last section I shall notice is in Mr. Allen's pit, close to the river-side, and about half a mile south-east of the last-mentioned exposure. This appears to be the pit described by Mr. Whitaker as the 'Grove.' It is of interest as showing two Boulder-clays (cf. Fig. 4). The lower one is a leaden-blue clay, often very dark, laminated, and with many chalk boulders, twenty feet being seen, and Mr. Allen informed me that below it a hard sandy rock occurred with a band of round pebbles below, almost immediately underlain by the Chalk. The hard sandy rock and pebble bed are most probably the beds of the Crag which are seen at the bottom of the ridge in Mr. Green's pit. It will be noticed that the base of the drift is here about 150 feet below its position on Balingdon Hill.

Fig. 4.—S. end of Mr. Allen's Pit, Sudbury.



1. Lower Boulder-clay, 20 ft. seen.
2. Sand and gravel, 10-12 ft.
3. Loam, to 15 ft.
4. Upper Boulder-clay, to 16 ft.

The Lower Boulder-clay is succeeded by sand and gravel, altogether like that of Mr. Green's pit, so that description is unnecessary. The same may be said of the succeeding loam, which is here rather more sandy than on the left bank of the Stour.

The Upper Boulder-clay is lighter than the Lower, but otherwise altogether like it; but it contains thin seams of gravel and loam. A large number of boulders were lying in the pit, probably from both clay and gravel, and consisting of various schists, granites, fragments of basaltic columns, limestones, sandstones, etc.

The sands, gravels, and loams in this pit are, as in the case of those on the left bank of the Stour, very extensively contorted.

So much for the facts. It remains to be considered what light, if any, they throw upon the origin of these particular drifts. That we do want some light is evident, when we find some writers assigning a marine origin to the East Anglian drifts, others a terrestrial one, whilst Mr. Searles Wood, jun., in his last communication concerning these drifts (Q.J.G.S. vol. xxxvi. p. 457), calls into play the agency of both land-ice and the sea. I wish it to be understood that the following remarks apply only to the actual Sudbury sections.

The great difficulty connected with the above-described sections is the occurrence of intensely-contorted drifts upon an irregular surface of absolutely undisturbed Tertiary beds, which are now, with one exception (the top of the Crag pebble bed), in a soft and incoherent state. Two questions suggest themselves:

1. Were the contortions produced in the area in which the contorted beds now lie, or were the contorted deposits borne from a distance?

2. If the former, why are not the incoherent beds, on which these contorted deposits rest, themselves disturbed?

In answer to the first question, it may be confidently stated that the contortions were produced in the beds in the area in which they now lie, firstly, because the contortions adapt themselves to the irregularities of the surface on which the contorted beds rest, as seen in the case of the Crag ridge in Mr. Green's pit, and of a section figured by Mr. Whitaker as occurring on the east side of a chalk-pit about half a mile east of St. Peter's Church (Geol. of N.W. Essex, etc.), where the drifts are looped into a hollow in the Chalk; secondly, because the contorted deposits have been largely derived from the local rocks. Thus we find many fragments of Crag, large and small, in the gravel north of the Crag ridge in Mr. Green's pit, and fragments of the green Thanet Sand scarcely even re-made in the patch of Boulder-clay in the northern part of that pit just where the green Thanet Sand has been scooped out. Similarly, at the top of Balingdon Hill, the base of the Boulder-clay contains much Crag material. Again, Mr. Whitaker describes the passage of re-made green Thanet Sand into the actual deposit, so that the line of junction is not to be ascertained. Mr. Penning, in the same Memoir, p. 59, remarks that "the main substance of the [Boulder-]clay indeed consists of material received from rocks at no great distance from the point where it may be observed," and Mr. Dalton adds that "some parts of the Boulder-clay consist almost entirely of chalk. Where it lies directly upon the London Clay, it is often mainly composed of the latter, being a blackish or reddish-brown clay with a few pieces of chalk or other rocks." It is clear then that the contortion was actually produced in the Sudbury area, and consequently we are led to ask the second question, why are not the incoherent beds below also disturbed?

Four suggestions have been made to account for the contortion of drift deposits:

(i.) The pressure of material from an adjoining elevation, either rock or ice.

(ii.) The removal of soluble material, as chalk or ice, from the drift.

(iii.) The grounding of true or false icebergs.

(iv.) The pressure of superincumbent land-ice.

The first explanation is inapplicable here. Not only do contortions occur in the drifts which occupy the valley bottoms, but they are also found in the accumulations which lie on the summits of ridges, as at Mr. Green's pit, and the pits near the Cemetery. As the summits of these ridges are covered with these drifts, it is clear that no higher land occurred here in Glacial times.

The second cause seems inadequate to produce the intense contortion observed in many of the pits. The amount of chalk removed cannot be very great, for the drifts are still very calcareous. A great quantity of interstratified ice may have disappeared, but would this produce such violent folds as that seen at the southern end of Mr. Green's pit? Overfolds of this nature are produced by lateral pressure, but it is difficult to see how the removal of interstratified material could cause the folding of one deposit nearly horizontally over another for distances of several yards.

In both of these cases, we have no explanation of the undoubted fact that the drifts are largely derived from the underlying rocks. The third explanation requires fuller consideration. Local rocks might undoubtedly become churned up and included in the drifts by the grounding of icebergs, and no doubt contortion can be caused thereby, though we should also expect partial obliteration of the lamination planes. Several difficulties confront us if we adopt this explanation. Firstly, the derivation of a great part of the material from local sources. If this material was denuded by icebergs, whence comes its lamination? If, on the other hand, the deposits are ordinary marine accumulations, how are we to account for the absence of fossils? The loam, which is admirably adapted for the preservation of organisms, contains patches of lignitic material, which are apparently boulders derived from some earlier forest bed, but no marine organisms. Of course, the sea might be too cold for the existence of Molluscs, but the bones of Seals ought to occur. The Greenlanders thaw out the seals which have been frozen in winter whilst diving below the ice, and other seals are taken in nets below the ice (K. J. V. Steenstrup, "Meddelelser om Grönland," part iv. p. 99). The great difficulty in the way of accepting the view that the drifts of this area were contorted by icebergs is the fact that *the incoherent Tertiary rocks immediately underneath the violently folded Glacial deposits are never contorted even when standing up in ridges* (such as that in Mr. Green's pit), *around which the drifts have been folded.* It seems absolutely impossible that they should escape such contortion, unless they were themselves consolidated, and their nature is such that they can have been consolidated only by being frozen, which could not occur over large areas at the bottom of the muddy sea, in which according to this view the icebergs were drifted.

The conformation of the ground around Sudbury is of such a nature that it is extremely difficult to account for the stranding of icebergs in some of the spots where the contorted drifts occur, as, for instance, at the bottom of the Stour valley.

We come now to the last suggested cause of the production of contortion, viz. by the passage of land-ice. This agency is considered by Mr. Searles V. Wood, jun. (Q J.G.S. vol. xxxvi. p. 479), to have produced the Chalky Boulder-clay with which the so-called Upper Boulder-clay of this district is identified. The map No. 4 of Mr. Wood (Q.J.G.S. vol. xxxviii. plate xxvi.) shows the ice which produced this clay blocked by the British ice to the north, and spreading over East Anglia parallel with the southern trend of this clay, *i.e.* in a general east and west direction. Could not such a mass of ice produce all the phenomena which are observable in the Sudbury area? The difficulty of accounting for the undisturbed state of the Tertiary rocks disappears at once upon this view. If the area over which the ice passed was a land-surface, it would be frozen so hard that the now incoherent rocks would be solid, and would be treated in a similar way to the harder rocks of other districts. Such seems to be the case. We find a series of ridges having a general E.—W. trend, composed of Crag sands, with intervening depressions sometimes cut deeply into the Chalk, as in the case already referred to, and figured by Mr. Whitaker. These ridges would be veritable *roches moutonnées*, which accords well with the appearance presented by that on Balingdon Hill. The fragments torn off and included in the drifts, being frozen, would not be crushed, but retain their form of large and small subangular boulders, such as that seen in Mr. Green's pit. Only on this view is the regular bedding of the torn Tertiary beds comprehensible.

Next, the contortion of the drifts, the relationship of the folds to the inequalities below, the large quantities of local material which enters into their composition, and the absence of marine organisms, is satisfactorily explained upon this supposition. I have already referred to the similarity of the divisional planes to those of the fluxion-structure of igneous rocks, which is not to be confused with the fluxion-structure described by Mr. Hugh Miller (Rep. Brit. Assoc. 1884, p. 720) as occurring in Till. Moreover, the great overfolds in the drift, as above remarked, seem to require the occurrence of considerable lateral pressure to produce them. That lateral pressure does produce a similar structure in the stratified deposits of land-ice is apparently indicated by the case figured in the "Meddelelser om Grönland," part iv. pl. iii., where a glacier ending in a narrow valley has its stratified sand and clay thus overfolded where the ice has been compressed against the sides of the valley. That this sand and clay may be interstratified with Boulder-clay produced by the same agent as the bedded deposits is shown in a figure on the next plate of the same work, where a mass of Boulder-clay overlies such materials in the ice. The *moraine profonde* (including under this term all the drifts carried at and towards the base of the ice, whether derived from upland districts, or caught up from an ancient sea-floor over which the ice passed) coming from the flat tracts of the extreme East of England and the North Sea would be driven through the lateral valleys of the Sudbury area, and compressed laterally owing to the smaller space necessarily occupied by the lower parts of the ice under these circumstances. In this manner the contortion would be produced, accompanied by the small faults which are so common in these drifts, and so difficult to account for except upon the view that the drifts were solid at the time of faulting. Upon the melting of the ice, the drifts of this moraine,—Boulder-clays, gravel, and loam,—would be left standing upon the undisturbed beds of the irregular floor, once frozen, but resuming their incoherent condition upon the passing away of the cold.

In this way, and apparently in this way only, can we account for the phenomena of the Sudbury district, and the explanation has the advantage that it brings into play an agent which we know, from the researches of the Danish explorers upon the Greenland ice, does produce similar features at the present day, whereas all other explanations require the operation of agents, whose asserted mode of procedure is purely hypothetical.

## V.—NOTES ON CHELONIA FROM THE PURBECK, WEALDEN AND LONDON-CLAY.

By R. LYDEKKER B.A., F.G.S., and G. A. BOULENGER, F.Z.S.

*Introductory.*—The writers having had occasion, in company with Mr. Davies, to examine the greater number of the remains of English fossil Emydine and Pleurodiran Chelonia in the collection of the British Museum, with a view both to their rearrangement in the cases and the determination of their affinities, and having in the course of such examination been enabled to add several genera to the British fauna, as well as to make certain emendations in regard to the age and affinity of some of the previously-described forms, have thought it advisable to put their observations on record. Several of these observations are, indeed, only supplemental to those already published by Prof. Rütimeyer, of Basle, in the invaluable memoirs quoted below, but the writers have been able in some instances to add to his conclusions, owing to facts with which the learned Professor was necessarily unacquainted.

The reference by M. Dollo, of the Brussels Museum, of three of the Lower Eocene English species described by Sir R. Owen under the generic name of *Chelone* to a distinct genus *Pachyrhynchus*, has been already noticed by one of the present writers in last year's volume[1] of this MAGAZINE. The term *Pachyrhynchus* is, however,

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[1] Page 521. I must apologize to M. Dollo for having in this notice misinterpreted him as retaining Prof. Cope's family *Propleuridæ*. In the same notice I have quoted English forms under the generic names assigned to them by Owen, not having at that time entered on the question of the correctness of their determinations.—[R. L.]

preoccupied; and Prof. Cope had previously applied the generic term *Puppigerus* to several of Owen's species; some of which may, however, belong to other North American genera.[1] At least one of the carapaces of the Chelonians from the London Clay has nine costal bones, which is a character of Cope's *Propleuridæ.*[2] This group does not, however, form the proper subject of the present communication.[3]

*Purbeck and Wealden.*—The first genus for consideration is *Pleurosternum,* in which there appears a considerable amount of confusion. In their 'Monograph of the Chelonian Reptilia of the London Clay' (Pal. Soc. 1849) Owen and Bell figured in pl. xxi. a Chelonian plastron under the name of *Platemys Bullocki,* the specific name[4] dating from 1842. This specimen, now in the British Museum, is characterized by the presence of a mesoplastral bone, and also by an intergular epidermal shield. Owing to the former feature Prof. Rütimeyer[5] pointed out that the specimen could not have belonged to *Platemys,* but must be referred to the genus *Pleurosternum* of the Purbeck; he was, however, necessarily unaware that the specimen is really from the Purbeck, and not from the London Clay as stated by Owen and Bell. A comparison of this plastron with other Purbeck examples of *Pleurosternum* shows that it cannot be distinguished from the form figured by Owen in his Purbeck and Wealden Reptilia (Mon. Pal. Soc. 1853) under the name of *Pleurosternum ovatum,* with which the specimen figured in pl. vii. under the name of *P. emarginatum* appears also specifically identical; under these circumstances the name *Pleurosternum Bullocki,* as being the earliest, must be adopted for the common Purbeck form.[6] It should further be observed that it has been stated by Prof.

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[1] See Amer. Nat. vol. xx. p. 968 (1886).

[2] Cope (*loc. cit.*) states that his *Propleuridæ* is identical with Dollo's *Pachyrhynchidæ.* The type species of the latter is, however, expressly stated to have only eight costals, which Cope makes a character of *Puppigerus.*

[3] It is usual among English writers to term the bony parts of the Chelonian shell "plates," and the horny epidermal covering "scutes"; but Prof. Huxley, "Anatomy of Vertebrated Animals," 1st edition, pp. 197, 200 (1871), uses the former term for both. Since, however, the term "scute" is applied to the dermal bones of the Crocodilia and of the Armadillos (*vide* Huxley, *op. cit.* pp. 250, 338), which are homologous with some of the bony elements of the Chelonian shell, this use is certainly objectionable; and in previous works I have reversed the application of the two terms. This application is not, however, thought advisable by Mr. Boulenger, who usually employs the terms in their older sense; as a compromise, in the present paper the bony elements will therefore be alluded to as "bones," and the elements of the epidermal layer as "shields."—[R. L.]

[4] Rep. Brit. Assoc. for 1841, p. 164 (1842).

[5] Verh. Nat. Ges. Basel, vol. vi. p. 121 (1873).

[6] Specimens of Purbeck Chelonia in the Cambridge Museum have been referred by Prof. Seeley (Index to Aves, Ornithosauria, etc., in the Cambridge Museum, pp. 86, 87 [1869]) to *Pleurosternum,* under the names of *P. Sedgwicki, P. Vansittarti, P. Oweni,* and *P. typocardium.* These specimens have, however, not been figured, and cannot therefore be compared with those in the British Museum; some of them may perhaps belong to *Plesiochelys,* while the distinction of others from *P. Bullocki* is not clear.

Cope[1] that the plastron of *Pleurosternum* has no intergular shield,[2] and the genus is accordingly referred by him to the Cryptodira; whereas its true position, as was pointed out by Prof. Rütimeyer, is with the Pleurodira; and with that group—the *Pelomedusidæ* and *Peltocephalidæ* of Gray—characterized by the presence of eleven, instead of nine, plastral bones.

With regard to the carapace figured by Sir R. Owen in pl. iv. of his "Wealden and Purbeck Reptilia," under the name of *Pleurosternum emarginatum* (of which it is the type), it appears from the emargination of the anterior border that the specimen does not belong to that genus at all; and it is highly probable that it should be referred to *Plesiochelys*, although, as only the ventral aspect of the carapace is visible, this cannot be definitely determined; the other specimen figured by Sir R. Owen under the same name cannot apparently be distinguished from *Pleurosternum Bullocki.* Another carapace from the Purbeck has been figured by Sir R. Owen in pl. i. of the above-mentioned work under the name of *Pleurosternum latiscutatum*, which differs from *P. Bullocki* by the notch in its anterior border, in the presence of a nuchal epidermal shield, and in the narrowness and length of the neural (vertebral) bones. A specimen of both carapace and plastron in the Museum (No. 23624) from the Wealden, which is evidently specifically identical, shows that there was no mesoplastron, and the species may apparently therefore be referred to the genus *Plesiochelys*.[3] A second English species of that genus is indicated by an imperfect shell from the Wealden in the collection of the Museum (No. 28967) which evidently belongs to the group containing the Upper Jurassic *P. Soluthurnensis* and *P. Sanctæ-Verenæ* of Rütimeyer,[4] and agrees so closely with the latter that it may apparently be referred to the same species; a younger shell of the species (No. R. 583) from the Wealden near Hastings is also contained in the collection. Two plastra from the Purbeck (No. 45937) have a large central vacuity, and thereby agree with *P. Etalloni*, Rütimeyer.[5] Prof. Rütimeyer[6] has already observed that the fragmentary remains from the Wealden figured by Sir R. Owen[7] under the name of *Platemys* and *Chelone costata* do not belong to those genera, and he has suggested that they may be Thallasemydians, but there seems no reason why they should not be referred to that group of *Plesiochelys* in which there is a large plastral vacuity. The occurrence in the English Wealden and Purbeck of several species of *Plesiochelys* apparently closely allied to those of the Upper Jurassic of the Continent is a matter of considerable interest.

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[1] Proc. Amer. Phil. Soc. 1882, p. 143.

[2] The presence of an intergular shield is distinctly mentioned on page 5 of Owen's "Wealden and Purbeck Reptilia," although it is not shown in a complete state in any of the figured specimens.

[3] Mr. Boulenger takes this view.—[R. L.]

[4] Neue Denks. schweiz. Ges. Nat. vol. xxv. pls. xii. xiii.

[5] *Ibid.* pl. xi.

[6] Verh. Nat. Ges. Basel, *op. cit.* p. 166.

[7] Wealden and Purbeck Reptilia, pls. viii. and ix.

A crushed and broken shell with several of the bones of the pectoral and pelvic girdles, obtained by the late Mr. Fox from the Wealden of Brook, in the Isle of Wight, and now preserved in the Museum (No. R. 171), together with another crushed specimen (No. 48349) from the Wealden, and the anterior portion of a plastron (No. 46325) from the Purbeck, belong to the genus *Tretosternum*, and enable us to arrive at a conclusion as to the affinities of that genus. These specimens show, moreover, that the Chelonian remains from the Wealden of Bernissart in Belgium, described by M. Dollo,[1] under the name of *Peltochelys Duchastelii*, are not separable from the English *Tretosternum Bakewelli* (Mantell[2] sp.). M. Dollo was led to separate the Belgian form because Sir R. Owen[3] has suggested that *Tretosternum* may have had incomplete marginals; which the present specimens show is not the case. The suggestion of Sir R. Owen[4] that *Tretosternum* had a permanent plastral vacuity is shown by these specimens to be incorrect, although a small one exists in the young. M. Dollo places the genus in the Pleurodira, a view which is not supported by the examination of the remains in the Museum.

As may be seen from M. Dollo's figure, and still better from the Museum specimens, the anterior border of the nuchal bone is broadly emarginate, a character which occurs in none of the *Pleurodira,* for the reason that the head takes shelter on the side; but is found in all Cryptodira in which the head is particularly large and non-retractile, with the temporal fossæ roofed over by bone, as in *Chelydra, Platysternum, Chelone,* etc. Another peculiarity shown by the nuchal before us lies in the presence of a costiform process on each side, as in *Chelydra*; a process which, judging from Dollo's figures, is also shown in the young specimens from Bernissart. Important again is the fact, shown by our specimens, that the plastron articulates with the carapace by gomphosis, exactly as in *Chelydra,* and does not send off any axillary and inguinal peduncles like those so highly developed in all known Pleurodira. The plastron is essentially of the *Dactylosternine*-type of Cope. M. Dollo has, it is true, recognized the presence of an intergular shield, a character which has hitherto been regarded as infallibly diagnostic of the Pleurodiran group; this shield is also well shown in the type-specimen of *Tretosternum.* A careful examination shows, however, that this intergular is, in addition to only five pairs of plastral shields, exactly as in

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[1] Bull. Mus. R. Hist. Nat. Belg. vol. iii. p. 78 (1884). The name itself is not very happily selected, since Prof. Seeley (Quart. Journ. Geol. Soc. vol. xxxvi. p. 412, 1880), has proposed the name *Peltochelyidæ* for an entirely different group of Chelonia.

[2] Geology of S.E. of England, p. 255 (1833)—*Trionyx. Tretosternum punctatum,* Owen, dates from 1842.

[3] Rep. Brit. Assoc. for 1841, pp. 165–7 (1842). Sir R. Owen's words are, "The entire and rounded margins of the truncated and expanded extremities of the ribs, beyond which there is not the slightest trace of projecting tooth-like processes, strongly indicates that the marginal plates [bones] were either wanting or rudimental, as in the genus *Cryptopus* [*Trionyx*]."

[4] *Op. cit.* p. 167. The generic name was given upon the assumed existence of this feature; since, however, the vacuity occurs in the young, no reasons can be adduced for changing the name.

certain specimens of *Dermatemys*, instead of the six pairs of all recent Pleurodira; and we think too great importance has hitherto been attached to the disposition of the epidermic plastral shields, as is shown by a specimen of *Macroclemmys Temminckii* in the Museum, which exhibits an intergular shield situated within the margin of the plastron, exactly as in the Australian *Chelodina*. Again, the number of plastral shields of *Tretosternum*, viz. 11, is that of a Cryptodiran, and not of a Pleurodiran. In addition to the above arguments, the remains before us give elucidation on a point which is in itself decisive; *viz.* the attachment of the pelvis. Two bones only are preserved, but they will suffice for our purpose; these are a sacral vertebra and a pubis. The former bone shows a large articular surface for a sacral rib, which was therefore present, and gave attachment to the ilium. In the Pleurodira, in which the ilium anchyloses with the carapace, sacral ribs are either atrophied or disappear altogether in the adult. The pubis, of a rather peculiar shape, owing to the great elongation and distal expansion of the inner or symphysial branch, is intact and shows that the extremity of the outer process was thin and compressed, and did not anchylose with the plastron.[1]

In the absence of any remains of the caudal vertebral column, it is impossible to say for certain that *Tretosternum* belongs to the family *Chelydridæ*, but we may surmise that such was probably the case. As far as can be judged from a comparison with Leidy's figure of *Anostira*, the two genera were very closely allied.

The last of the Chelonians from the Wealden and Purbeck that we have to notice is a small cordiform carapace from the latter formation (B. M. No. 40676), which may confidently be referred to the Thallasemydes of Prof. Rütimeyer (*Eurysternidæ* of Dollo), and may probably be referred to the genus *Eurysternum*.[2]

*London Clay.*—The first specimen from this formation that calls for notice is the hinder portion of a carapace in the Museum (No. 40099), which evidently belongs to the genus *Pseudotrionyx*, Dollo,[3] from the Middle Eocene (Bruxellian) of Belgium, and is apparently specifically identical with the typical *P. Delheidi*, Dollo. This genus is included by its founder in the *Chelydridæ*, but from the absence of epidermal shields may probably be regarded as belonging to a distinct family.[4]

The next species for notice is founded on the shell figured by Owen and Bell[5] under the name of *Platemys Bowerbanki*;[6] in regard

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[1] On this occasion it may be well to observe that Rütimeyer's statement, made with due reserve, but since repeated by others as an admitted fact, that, in some recent *Pleurodira*, the ischium anchyloses with the plastron before the pubis, was derived from the examination of figures accompanying one of Gray's memoirs; and that an investigation of the actual specimens which gave rise to this statement has proved it to be erroneous.—[G. A. B.]

[2] = *Acichelys* = *Aplax* = *Palæomedusa* = *Achelonia* = *Euryaspis* = *Parachelys*.

[3] Bull. Mus. R. Hist. Nat. Belg. vol. iv. p. 96 (1886).

[4] The suggestion made in the above-quoted notice in the GEOLOGICAL MAGAZINE that the genus might perhaps be referred to the *Trionychidæ* will not hold.—[R. L.]

[5] Reptilia of the London Clay, pt. i. pl. xxiii.

[6] Rep. Brit. Assoc. for 1841, pp. 163 (1842).

to which Prof. Rütimeyer[1] has already pointed out that the specimen figured by the same writers[2] under the name of *Emys lævis* is merely the young of the former, and that owing to the presence of a small mesoplastral bone the reference to *Platemys* is incorrect, and it is suggested that the species may probably belong either to *Podocnemis* or *Peltocephalus*. The type is unfortunately not in the collection of the Museum, but the figure shows that the length of the bony union between the carapace and plastron is comparatively long, from which its affinity appears to be rather with the former than the latter, and it may accordingly be provisionally referred to that genus.

With regard to the large Chelonian figured by Owen[3] under the name of *Emys Conybeari*, which appears specifically identical with the younger specimen figured as *Emys Delabechi*, Bell,[4] Professor Rütimeyer[5] has observed that it is difficult to say whether these forms belong to the *Emydidæ* or the *Chelydidæ*, but this difficulty has now been decisively solved. The best preserved and larger of the two specimens, or that figured under the name of *E. Conybeari*, shows both carapace and plastron, and exhibits in the latter distinct mesoplastral bones like those of *Podocnemis*. The matrix between the carapace and plastron has recently been chiselled away, and the characteristic Pleurodiran anchylosis of the ischium and pubis to the plastron is thus exhibited. In the number of the neural (vertebral) bones, in the flatness and general contour of the carapace, in the shape of the plastron and the relative length of the bridge uniting the latter with the carapace, and in the absence of a nuchal epidermal shield, the specimen accords so well with *Podocnemis*, that it may be pretty safely referred to that genus, under the name of *P. Delabechi*. The presence of two epidermal pygal shields differentiates it from the allied genus *Peltocephalus*; the vertebral shields agree in form very closely with those of *Podocnemis Dumeriliana*, although the contour of the carapace accords more closely with that of *P. expansa*. With regard to the so-called *Emys bicarinata*[6] from the same formation, a cutting-away of the matrix shows no trace of the pelvis, which was probably, therefore, of the Cryptodiran type, and the species may accordingly, in the absence of any evidence to the contrary, be included in the genus *Clemmys*. The occurrence of *Podocnemis* in the London Clay indicates that the *Pleurodira*, which are now almost entirely relegated to the Southern Hemisphere, were dominant forms at that period in the European area, as they also were in the corresponding epoch in India, where there were representatives of both *Podocnemis* and *Platemys* in the Lower Eocene.[7]

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[1] Verh. Nat. Ges. Basel, p. 121.

[2] *Op. cit.* pl. xxii.

[3] Reptilia of London Clay, Supplement, pls. xxviii. A, B.

[4] *Ibid.* pl. xxviii.

[5] Verh. Nat. Ges. Basle, *op. cit.* p. 121.

[6] Owen and Bell, Reptilia of the London Clay, pt. i. pls. xxv. xxvi.

[7] These species will be described in a forthcoming memoir in the "Palæontologia Indica," ser. 10, vol. iv. pt. 3.—[R. L.]

## REVIEWS.

### 1.—Professor Dr. Hermann Credner on the Development of Branchiosaurus.[1]

IN this valuable communication to Palæontological science Prof. Credner gives us the result of his observations on the life-history of a single species of Labyrinthodont, or Stegocephalian, based on the study of no less than 76 specimens.

The paper commences with a discussion of nomenclature and synonymy; but here we regret to say that we cannot quite agree with the author's conclusions. Prof. Credner states that in 1881 he described the skeleton of a small Labyrinthodont from the 'Rothliegendes' of Saxony under the name of *Branchiosaurus gracilis*, while on a subsequent page of the same memoir he described a second specimen as *B. amblystomus*. Subsequent 'finds' showed that the former is but the larval condition of the latter, and Prof. Credner proposes to adopt the name *B. amblystomus* for the species. He proceeds, however, to mention that Messrs. Geinitz and Deichmüller have pointed out that *B. gracilis* is probably identical with *Protriton petrolei* of Gaudry, from the Permian of France and Thuringia, and he therefore concludes that the latter is also a larval form, of which the adult may be perhaps still unknown, or may be the so-called *B. amblystomus*. So far no objection can be taken to Prof. Credner's views; but when he proceeds to observe that the name *Protriton petrolei*, as being founded on a larval form, ought to be withdrawn, we cannot agree with him. There appears, indeed, to be no doubt that Messrs. Geinitz and Deichmüller are right in regarding *Branchiosaurus* and *Protriton* as generically the same, and there is also a very strong presumption that *B. gracilis* (*B. amblystomus*) and *P. petrolei* are also specifically identical. Now the generic name *Protriton* was first published (with figures of the type specimen) by Gaudry in the "Bull. Soc. Géol. France," sér. 3, vol. iii. p. 300 (March 29, 1875); the type specimen having been previously recorded under the name of *Salamandrella petrolei* in the "Comptes Rendus," vol. lxxx. p. 442 (Feb. 15th, 1875), the earlier generic name being withdrawn on account of being preoccupied. The term *Branchiosaurus* was first published by Fritsch in the "Sitz. k. bohm. Ges. Wiss." (19th March, 1875),[2] p. 72; but was not figured till 1879, in the "Fauna der Gaskohle," etc., pt. 1, p. 69, pl. i.–iv. The generic name *Protriton* is therefore, strictly speaking (if we count from the date of the reading of the memoir), of ten days' later date than *Branchiosaurus*; but since the date of figuring gives no less than four years' advantage on the side of the former, we think that the generic name *Protriton* ought

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[1] "Die Stegocephalen aus dem Rothliegenden des Plauen'schen Grundes bei Dresden," VI. Theil.—Zeitschr. deutsch. Geol. Ges. pp. 576–633, pls. xvi.–xix. (1886).

[2] Fritsch (Fauna der Gaskohle, etc., pt. i. p. 69 [1879]) totally ignores his previous preliminary notice of the genus, and expressly states that it should date only from the time of figuring (1879).

to stand; and if *P. petrolei* be identical with *B. gracilis*, there can be no question as to the right of the former specific name to supersede the latter.

Coming to the proper subject of the paper under consideration, it appears that the youngest specimen which came under the author's notice was about 25 mm. in length. In this stage the animal was aquatic, and breathed by gills, which were supported by four pairs of branchial arches. The cartilaginous dorsal segments of these arches were furnished with small calcified denticules; and the ventral segment of the first was ossified. By the time, however, these animals had attained a length of from 60 to 70 mm., they cast their branchial arches and became air-breathers; their development being thus analogous to that obtaining among the *Salamandridæ* of the present day. The adults measure from 100 to 130 mm. in length.

This metamorphosis from a water- to an air-breather was accompanied by the following changes in the structure of the skeleton. The short and wide skull of the larva becomes relatively narrower; the proportion of the transverse to the longitudinal diameter being 2 to 3 in the larva, whereas these two diameters in the adult are subequal. The relative increase in length is mainly confined to the anterior cranial bones; and the orbits, and more especially the parietal foramen, do not enlarge at the same rate as the surrounding bones. In the pectoral-girdle,[1] while the coracoid and supra-clavicle only increase in size proportionately with the general growth of the animal, the median element (interclavicle) of the ventral buckler, which is very minute in the larva, attains a length of 8 or 9 mm. and forms a pentagonal bone, interpenetrated by slits from the anterior border. The lateral bones (clavicles) of the shield in the larva are small and in contact with each other in the median lines; but as development advances they become relatively broader, and separate. In the vertebral column it has been found that while in the larva the presacral vertebra are 20 in number, they are 26 in the adult, this being accompanied by a diminution in the relative length of the tail in the former. This remarkable change Prof. Credner explains by a gradual backward shifting of the pelvis as the animal increases in age, from which it necessarily follows that the sacral vertebra of the larva become lumbar in the adult. With the lengthening of the presacral vertebral column the bones of the limbs do not keep pace; so that the limbs of the adults are relatively much shorter than those of the larva. During the above-mentioned changes the dermal and epidermal skeleton is likewise undergoing evolution; and in the adult the ventral surface of the body is protected by a complete and complex covering of dermal scutes, of which the author has succeeded in tracing out the arrangement; while in the young larva this covering is totally wanting.

Prof. Credner is indeed to be congratulated on having traced in

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[1] Prof. Credner employs a nomenclature of the elements of the shoulder-girdle different from that adopted by many writers; but the equivalent terms are noticed on p. 607 of his memoir. In this notice we employ the terms used in the "British Association Report" on the Labyrinthodontia.

this able and interesting manner the development of a water-breathing naked larva of the Palæozoic epoch into an air-breathing adult, clad in a strong coat of mail; and we shall welcome with much interest future work on kindred subjects. R. L.

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## II.—On Certain Borings in Manitoba and the North-west Territory.

By George M. Dawson, D.Sc., A.R.S.M., F.G.S. [From the Transactions of the Royal Society of Canada, vol. iv. 1886.] Montreal, 1887.

VARIOUS useful purposes are subserved by boring operations, such as the procuring a supply of pure water in arid regions; the search for useful minerals, petroleum, etc., in which case boring may be regarded as an expeditious, and, upon the whole, economical method of prospecting; and finally, as a means of gaining a knowledge of the nature of the subjacent strata when these are concealed by drift deposits.

We shall dwell more particularly upon the results of these borings from the geological standpoint, as being that which is most likely to interest the readers of this Magazine.

We have then 1, "Boring at Rosenfeld Station." This is a station on the South-Western Branch of the Canadian Pacific Railway, about fifteen miles north of the 49th parallel and ten miles west of the Red River Valley. In this boring, which was undertaken by the C. P. Railway Co., a depth of 1037 feet was attained by means of an ordinary percussion drill.

The nature of the beds passed through, with their probable geological age, is indicated in the accompanying slightly abridged section:

| | Feet. | Formations. |
|---|---|---|
| 1. Black soil ... ... ... ... ... ... ... ... ... | 4 | ... ... ... |
| 2. Fine silt or clay ... ... ... ... ... ... ... | 111 | ... . . ... |
| 3. Sand and gravel ... ... ... ... ... ... ... | 10 | ... ... ... |
| 4. Boulder-clay ("hard-pan") ... ... ... | 12 | ... ... ... |
| 5. Boulders ... ... ... ... ... ... ... ... | 6 | ... ... ... |
| 6 to 9. Grey and red shales and limestone ... | 92 | Maquoketa shales. |
| 10 to 13. Limestone, sandstone, and red shale | 260 | |
| 14. Cream-coloured limestone... ... ... ... | 305 | Galena limestone passing below into Trenton. |
| 15. Red shale ... ... ... ... ... ... ... ... | 75 | |
| 16. Soft sandstone ... ....... ... ... ... | 50 | St. Peter Sandstone |
| 17 to 20. Red, green, blue, and grey shales ... | 110 | L. Magnesian limestone (?). |
| 21. "Granite"... ... ... ... ... ... ... ... | 2 | Laurentian. |
| Total ... ... ... ... ... ... | 1037 | |

A detailed analysis here follows, which may be thus briefly summarized:—The soil was of the character common in that region, and consisted of the underlying silts mixed with vegetable matter. "The silts are those of the ancient lake which, about the close of the Glacial Period, occupied the Red River Valley, and which has been called 'Lake Agassiz' by Mr. Upham."[1] The gravel consisted of rounded Laurentian and limestone pebbles. "The 'hard-pan,'

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[1] See Geological Magazine, 1883, p. 427, "Lake Agassiz; a Chapter in Glacial Geology," by Warren Upham.

while evidently representing the Boulder-clay, is unusually pale in colour, being apparently composed of limestone debris."

Passing on to the consideration of the beds underlying the drift, we learn that their geological age was considered by the author to be doubtful, owing to the entire absence of palæontological evidence or of any outcrops in the vicinity of the boring, by which the result of the operations might have been checked.

However, pretty strong presumptive evidence seems to have been elicited regarding the age of the beds supposed to represent the "Maquoketa shales," so named by Dr. C. A. White, in Iowa. In Iowa these shales are about 75 feet in thickness, and consist of bluish and brownish shales with calcareous layers. In Wisconsin, they average about 200 feet in thickness, and are composed of grey, green, blue, red, purple, buff and brown shales with thin limestones. These beds are met with also in Minnesota, but owing to the want of complete sections they could not be compared with those of the Rosenfeld boring. But at Stony Mountain, Manitoba, fifty-eight miles north, strata determined by their fossils to be of the horizon of the Hudson River were met with. A section made at this locality showed that the rocks consisted of dolomitic and other limestones, and red and yellow shales, resembling very closely those referred to the Maquoketa Shales (Nos. 10 to 13 in the section) in the Rosenfeld boring.

The limestone (No. 14) underlying the Maquoketa shales is assigned to the horizon of the Galena limestone of the west, which it was found to resemble in character; while the red shale at the base (No. 15) was supposed to be the equivalent of the Trenton.

"The Galena limestone of the West, which is nearly equivalent to the Utica of the New York series, is about 180 feet thick in Minnesota; 250 feet thick in Wisconsin; and from 100 to 250 feet thick in Iowa.

"The Trenton in Minnesota consists of flaggy limestones, with interbedded greenish shales, and is nearly 160 feet in thickness. In Iowa it consists of clayey shales and shaly and compact limestone, 200 feet in thickness. The reddish colours of the Rosenfeld shales and their apparently more complete separation from the limestone and want of interlamination with it, constitute the chief point of dissimilarity. The massive buff limestones of Selkirk and Stone Fort in Manitoba, resemble the Rosenfeld bed in character, and are known by the evidence of fossils to represent the Galena."

No. 16 in the section, an "unconsolidated sand-bed," is described as resembling precisely the "St. Peter Sandstone," as typically developed near St. Paul, Minnesota.

Assuming that the geological horizons of the preceding beds have been accurately determined, then it is held that beds 17 to 20 (both inclusive) must be referred to the "Lower Magnesian Limestone," equivalent in age to the Calciferous [Tremadoc] of the New York section. This limestone in Iowa and Wisconsin has a thickness of 65 to 250 feet. In Minnesota it is a magnesian rock, sandy towards the top, and with beds of greenish shale. At Rosenfeld there is no limestone, and Dr. Dawson concludes, therefore, that we have here "a littoral formation directly overlying the subjacent Laurentian, and marking the limit at this place of the Lower Magnesian Sea."

The most remarkable feature of the Rosenfeld well was the strong flow of brine which issued from it, especially at the level of the St. Peter Sandstone, whence it rose in a pipe to a height of 18 feet above the surface of the ground. The author calls attention to the great age of the rocks yielding the brine. "It appears," he says, "not improbable that the shoaling of the Cambro-Silurian sea evidenced by the widespread littoral deposit known as the St. Peter sandstone resulted in the enclosure of salt lagoons in this portion of the interior basin, while it merely produced an increased land area further south in Iowa and Wisconsin."

The brine is said to be well adapted for the manufacture of salt.

Another fact of geological importance was elicited by the Rosenfeld boring, viz. "the comparatively thin covering of Palæozoic rocks which here overlaps the Archæan, and the very gradually shelving character of the surface of the latter westward."

Passing over the records of borings at various places (numbered 2 to 6) in which there appears to be nothing worthy of special note, we reach No. 7:—"Boring at Langevin Station."—This place is also on the line of the Canadian Pacific Railway, 35 miles west of Medicine Hat, on the South Saskatchewan River, at an elevation of 2471 feet above the sea-level. Two borings were made here, the one attaining a depth of 1155 feet, and the other 1400 feet. The result of these operations was somewhat unexpected, and, in the first case disastrous, a heavy flow of combustible gas having been discharged from the bore-hole, and this becoming ignited, destroyed the works at the surface. This boring had consequently to be abandoned, and another undertaken, the gas being now utilized for working the engine.

This second boring showed (1) Drift deposits, estimated at 88 feet in thickness; with (2) about 223 feet of beds consisting probably of the lower part of the "Belly River Series"[1] (Upper Cretaceous) underlying them. Beneath the latter there were found beds aggregating 1099 feet in thickness; these are considered by Dr. Dawson to be probably of the age of the "Lower Dark Shales,"[2] passing down into the "Fort Benton Group" (?) (Lower Cretaceous).

The result of the operations at Langevin proves the existence of a large quantity of combustible gas in the district; a matter of great economical importance. The supply of gas comes from the sandy layers of the "Lower Dark Shales" at depths of 900 feet and over, and is derived, in the opinion of the author, from the decomposition of the organic matter of the dark Carbonaceous shales.

Arthur H. Foord.

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[1] See Geol. Surv. of Canada, Report of Progress, 1882–83–84, p. 112*c*.

[2] *Loc. cit.* p. 42*c*.

# REPORTS AND PROCEEDINGS.

## Geological Society of London.

I.—April 6, 1887.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Rocks of the Malvern Hills." Part II. By Frank Rutley, Esq., F.G.S.

The details of the microscopic examination of the rocks constituted the principal part of the present paper. The author finds that the truly eruptive rocks are more plentiful in the range than he was at first led to suppose. In all 33 rock-specimens were described, and in some cases Mr. Timmins's analyses were quoted. The author commenced with the rocks of the North Hill and concluded with those of the Raggedstone Hill. Rocks between a little south of the summit of the Worcestershire Beacon on to Wind's Point, those of Midsummer Hill, and those of Keys Hill were not collected. The following are the general results:—

| | Eruptive. | Foliated. | Stratified. |
|---|---|---|---|
| North Hill ...... | Hornblende-gabbro.<br>Diorite.<br>Quartz-syenite. | Gneissic Syenite.<br>Gneissic Diorite. | Altered Tuff? |
| North Hill (above West Malvern). | Mica-diorite. | Biotite-gneiss. | |
| North Hill (The Dingle).......... | Mica-diorite. | | |
| Worcestershire Beacon ...... | Granulite?<br>Granite.<br>Diorite.<br>Epidotite? | | |
| Herefordshire Beacon....... | Eucrite.<br>Basalt.<br>Devitrified Obsidian. | Hornblendic Gneiss. | Diabase-tuff? |
| Swinyard's Hill.. | Pegmatite.<br>Hornblende-pegmatite<br>Diorite. | Biotite-gneiss.<br>Biotite-muscovite.<br>Gneiss. | |
| Hollybush Pass... | Diabase. | | |
| Raggedstone Hill. | ......... | Mica-schist.<br>Micaceous Quartzite-schist. | Altered Sandstone. |

In the first instance a separation must be effected of rocks showing foliation or lamination, or of which the origin has been sedimentary, from those which show no such structure, and which must be regarded as eruptive: there is, in fact, a banded and an unbanded series. The gneisses are altered volcanic tuffs or sedimentary rocks of eruptive material derived from the disintegration of rocks of dioritic or syenitic character.

The rocks of the North Hill, as may be gathered from the tabular classification, are truly eruptive in many cases; whilst the foliated varieties are made up of the *débris* of rocks rich in hornblende, which may have had an eruptive origin. The rocks of the Herefordshire Beacon are chiefly gneissic: the eucrite-basalt occurs at a buttress of the hill. The pegmatite of Swinyard's Hill has apparently been faulted into its present position. South of Midsummer Hill fine-grained gneissic rocks, quartzite-schists, etc., are met with.

There is no reason to suppose that the alteration of any ordinary sedimentary rocks could have resulted in such a vast amount of hornblende as is found in these gneisses. The gneissic rocks of the Malvern Hills may be composed of the detritus of eruptive rocks.

The rocks of the Malvern Hills show in their structure but little resemblance to the foliation induced by shearing, the crystals seldom exhibiting any marked lenticular form, while there is but little likeness to the pseudo-fluxion structure described by Lehmann, etc.

The author concluded that the rocks of the Malvern Hills represent part of an old district consisting of plutonic and, possibly, of volcanic rocks associated with tuffs, sedimentary rocks composed mainly or wholly of eruptive materials, and grits and sandstones; that the structural planes in these rocks (sometimes certainly, at others possibly) indicate planes of stratification, and that the foliation, in many cases if not in all, denotes lamination due to deposition either in water or on land surfaces, probably more or less accentuated or altered by the movements which produced the upheavals, subsidences, and flexures prevalent in the range.

2. "On the alleged Conversion of Crystalline Schists into Igneous Rocks in County Galway." By C. Callaway, Esq., D.Sc., F.G.S.

This paper was an inquiry into the theory, held by many Irish geologists, that granite and other igneous rocks are the last term in a progressive series in the metamorphism of aqueous sediments. The evidence collected by the author was regarded as entirely hostile to this view. In Knockseefin, the typical section, he found diorite intrusive in gneiss and granite intrusive in the diorite, but no passage between any two. The igneous veins sometimes displayed a foliated structure. At Shaunarea the phenomena were similar; but the granite in contact with the gneiss was much crushed and decomposed. In the region south of Glendalough the intrusion of granite in diorite and schist gave rise to the peculiar mixtures which had been described as "metamorphosed conglomerate." The granite was intruded along the joints of the diorite, sometimes separating the joint-blocks from each other, and completely enclosing them. It was noticed that when schists were penetrated by granite isolated folia often retained their parallelism, and this was accounted for partly by the slowness of the intrusion, partly by regional pressure. Even when mere flakes of the schist were enclosed in granite there was no passage between the two. The granite, both in masses and veins, was often foliated, but the blocks of included diorite were not; and this seemed to suggest that the foliation of the granite was acquired before complete congelation of the larger masses. There was also a foliation concentric to included blocks of diorite.

At the town of Galway the "metamorphic sedimentary" rocks were a coarse-grained hornblendic gneiss of Hebridean aspect, and in some parts of it was a structure similar to that of the "metamorphosed conglomerate"; but the included blocks of diorite had acquired a definite orientation, apparently due to pressure. An igneous origin for some of the coarser gneisses was thus suggested. It was concluded that there was no proof of the conversion of schists into igneous rocks, the evidence collected tending to show, on the other hand, that igneous rocks were sometimes converted into schists.

3. "A Preliminary Inquiry into the Genesis of the Crystalline Schists of the Malvern Hills." By C. Callaway, Esq., D.Sc., F.G.S.

The author's researches amongst the crystalline rocks of Connaught had suggested certain lines of investigation which had subsequently been followed out in the Malvern district. He had satisfied himself that many of the Malvern schists had been formed out of igneous rocks; but at present he limited himself to certain varieties.

The materials from which these schists were produced were diorite (several varieties), granite, and felsite.

The metamorphism had been brought about by lateral pressure. Evidence of this was seen in the intense contortion of granite-veins and in the effects of crushing as observed under the microscope.

The products of the metamorphism were divided into two groups:—

A. Simple schists, or those formed from one kind of rock. The varieties described were the following:—*Hornblende-gneiss,* or diorite which had been crushed and modified. *Mica-gneiss,* formed from granite. In the first stage of the crushing, the quartz and felspar lay in lenticular fragments, separated from each other by cracks, the fragments and cracks being roughly parallel. As the metamorphism proceeded, the cracks became less evident, and the respective minerals were flattened out into comparatively uniform folia. Mica gradually came in, at first in the form of a partial coating to felspar crystals, and, at a further stage, in regular folia. *Mica-schist,* formed from felsite. The felsite gradually acquired a parallel structure. *Pari passu* with this mechanical alteration, a mineral change was observed. Mica at first appears in very small quantity, either filling cracks or accentuating the parallelism. In a more advanced stage, the mica lies in imperfect folia, and sometimes forms a partial coating to grains of quartz. At last there is little left but quartz and mica, the latter in folia, and enveloping individual quartz granules.

B. Injection schists, formed by the intrusion of veins, which had acquired parallelism by pressure. Veins of diorite in diorite produced *duplex diorite-gneiss,* and veins of granite in diorite originated *granite diorite-gneiss.*

It was further noted that

(1). Generally the particular varieties of schist occurred in the vicinity of the igneous masses to which they were most nearly related in mineral composition.

(2). The mineral banding of the rocks in the field was more like vein-structure than stratification.

The author accepted the received view of the age of the schists. The parallel structure was clearly antecedent to the Cambrian epoch, and the occurrence of similar rocks as fragments in the Uriconian conglomerate of Shropshire seemed to indicate that the Malvernian schists were older Archæan.

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II.—April 27, 1887.—Professor J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "On the London Clay and Bagshot Beds of Aldershot." By H. G. Lyons, Esq., R.E., F.G.S.

The author first described the section from Thorn Hill on the N. to Redan Hill on the S., plotted from the 6-in. Ordnance Survey on a scale of 6 in. to 1 mile horizontal, and 12 in. to 1 mile vertical. This section comprises beds from the Woolwich and Reading series to the Upper Bagshot inclusive. He showed a dip of 2¼° to the N. which is regular or nearly so throughout. A few feet of Upper Bagshots occur on Thorn Hill (365 feet); at the base of these the Pebble-Bed crops out, forming also much of the surface of the South Camp. The Middle Bagshots on the south slope of the hill are estimated from the South Camp boring at 53 feet, with a marked clay-bed at the base; and below these a few feet of the Lower Bagshots are exposed in the intervening valley. The greater part of Redan Hill (364 feet) is made up of Lower Bagshots; but towards the top a few feet of the basal clays of the Middle Bagshots have been exposed by a recent trench. Although the elevation is practically the same as that of Thorn Hill, the rest of the Bagshot series is cut out owing to the northerly dip. These results differ from those of previous observers, *e.g.* the Geological Survey carry the Lower Bagshots to the top of the Redan Hill, as do Messrs. Monckton and Herries; whilst of the anticlinal, alleged by Mr. Irving to exist in this traverse, there appears to be no trace. The author also observed that the arguments for overlap of the upper beds and for the erosion of the London Clay are not borne out by the facts.

The second section described runs from Gravel-Pit Hill on the N. to Ash Green on the S. It was drawn to the same scale, and showed the beds from the Chalk to the Middle Bagshots inclusive. Dip northerly 2¼° to 2° 50′ at south end. A spur of the Fox Hills (Gravel-Pit Hill) is seen to consist of Upper Bagshots of the normal type down to the lower shoulder of the spur, which is capped by the Pebble-beds marking the junction of the Upper and Middle Bagshots. The Ash-station well shows the basement-beds of the Lower Bagshots, of a character very similar to those in the Brookwood and South-Camp deep boring. The position of the outcrop of the London Clay also is in favour of a regular and persistent northerly dip, corresponding in degree with that given at East Wyke farm by Messrs. Monckton and Herries. The thickness of the London Clay was calculated at 330 feet, which is about the same as at South Camp, leaving no margin for its erosion before the deposition of the Bagshots.—The third section was drawn, also on the same scale, through Aldershot town, showing the beds from the Woolwich and Reading series to the Middle Bagshots inclusive. The dip is 2¼° to the N., and regular, as in the other two cases. The following thicknesses are given:—

| | | |
|---|---|---|
| Middle Bagshots | about | 55 feet. |
| Lower Bagshots | ,, | 115 ,, |
| London Clay | ,, | 335 ,, |

It was inferred from various calculations, as also from direct observation, that the thickness of the London Clay shows no diminution throughout the section, being nearly the same also at Ash and at Aldershot Place.

In "Cæsar's Camp" the Pebble-bed occurs at altitudes ranging from 500 to 550 feet.

The author concluded that wherever we can fix the top or base of the London Clay, we get a northerly dip of 2¼° to 3°, showing a fairly constant thickness of from 330 to 340 feet. The same thing occurs from Odiham on the west to Ash on the east, whilst at Brookwood the London Clay is thicker. He also assumed the existence of a passage from the London Clay up into the Bagshot beds in the deep wells or borings at Wellington College, at Brookwood, and at South Camp. Hence at these points there can have been no great erosion or unconformity. The overlying Bagshots lie conformably on the London Clay and on each other.

2. "Supplementary Note on the Walton Common Section." By W. H. Hudleston, Esq., M.A., F.R.S., Sec.G.S.

The principal object of this paper was to point out the occurrence of certain beds of clay or loam in what are usually known as the "Lower Bagshot Sands" of West Surrey. It was shown that the sandy series, No. 3, of the previous paper is overlain by a second clay series, No. 4, whose mode of occurrence and lithology were described. This is again succeeded by a third sandy series, No. 5, which, it is believed, is maintained throughout the remainder of the cutting as far as the River Wey, with occasional clay patches deposited in small basin-shaped hollows of the sand.

The nature and geological position of the brick-earth of Hatch on Woburn Hill was next described. This forms a portion of the "clays most extensively developed between Addlestone and Chertsey," referred by Professor Prestwich to his Middle Bagshots, and mapped as such by the Geological Survey. The clay is seen to occur as a lenticular mass, 21 ft. thick at its maximum, in a hollow of loose yellow sand; the current-bedding of the upper loamy layers is very marked towards the north end, with a strong false dip to the south, *i.e.* towards the centre of the basin.

Accepting as the true datum line for the base of the Middle Bagshots in this district, "the foliated clays, more or less sandy, having a thickness of 14 ft.," which are shown by Prof. Prestwich to be typically developed in the railway-cutting on Goldsworth Hill, it was contended that the Hatch brick-earth cannot be correlated with these. The true basal beds of the Middle Bagshots in this district differ somewhat in their physical characters; but it was on stratigraphical grounds mainly that the author endeavoured to show that the Hatch brick-earth should, despite its argillaceous nature, be assigned to the Lower Bagshots. A diagrammatic section from St. George's Hill (245 ft.), through Woburn Hill (92 ft.), to St.

Ann's Hill (230 ft.), was given, and the possible existence of a trough or synclinal towards the centre of the section discussed. It was shown from the position of the Hatch brick-earth that if the Lower Bagshots retain anything like the mean thickness of, say, 120 ft., which prevails in this district, the London Clay surface must here be 60 ft. *below* O.D., on the supposition that these beds represent the basal clays of the Middle Bagshots; whereas, at Chertsey, in the valley of the Thames itself, the London clay surface coincides with O. D.

In conclusion, it was held (1) that the more we study the Bagshot beds of this area, the less likely are we to see a passage between the curiously diversified Lower Bagshots and the much more uniform and homogeneous London Clay; (2) that, until we realize the considerable though sporadic development of clays in the Lower Bagshots, we shall be in danger of referring beds to the Middle Bagshots which do not belong to them, and thereby give encouragement to a speculative stratigraphy which can only mislead.

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III.—May 11, 1887.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "Further Observations on *Hyperodapedon Gordoni.*" By Prof. T. H. Huxley, LL.D., F.R.S., F.G.S.

The author briefly noticed the circumstances under which he first described the occurrence of Lacertilian and Crocodilian fossils in the Elgin Sandstones, and the confirmation which his views as to the Mesozoic age of these remains had received from the discovery of *Hyperodapedon* in English Triassic rocks and in India. The original type of *Hyperodapedon Gordoni* from Elgin was, however, in bad condition, and the receipt at the British Museum of a second much better preserved skeleton, found in the Lossiemouth quarries of the same neighbourhood, had enabled him to add considerably to the known characters of the genus, and to compare it more thoroughly both with the recent *Sphenodon* (or *Hatteria*) of New Zealand and with the Triassic *Rhynchosaurus articeps*, several specimens of which are in the British Museum palæontological collection.

The recently-discovered *Hyperodapedon*-skeleton was of nearly the same size as that formerly described, and must have belonged to an individual about 6 or 7 feet in length. The specimen was exposed by the splitting of a large block of sandstone, and comprised the skull, the vetebral column as far as the root of the tail, all the bones of the left and of part of the right fore limb, and those of the right hind limb, the whole almost in their original relations.

The bones were described in order and compared with those of *Sphenodon*, the most important differences in *Hyperodapedon* being the following:—

1. The centra of the presacral vertebræ are ossified throughout and more or less opisthocœlous, especially in the cervical region.
2. The anterior cervical vertebræ have long and strong ribs.
3. The external nares are not separated by bone.
4. Conjoined premaxillary bones form a long, conical, curved, pointed rostrum, which is received between the rostral processes of the mandible. All these were devoid of teeth and probably sheathed in horn.

5. The palatal area is very narrow in front and wide behind, with strongly curved lateral boundaries.
6. The posterior maxillary and palatal teeth are multiserial.
7. The rami of the mandible are united in a long symphysis, behind which they diverge widely, and the dentigerous edges are strongly concave upwards as well as outwards.
8. The mandibular teeth in front are set into a close, apparently continuous palisade, and become distinct and conical only at the posterior end of the series.
9. The fore foot is remarkably short and stout, with metacarpals of equal length.

The relations of *Rhynchosaurus* to *Hyperodapedon* and *Sphenodon* were then dealt with, the first-named being shown to occupy in some respects an intermediate place between the two others. The skull of *Rhynchosaurus* resembles that of *Hyperodapedon* in its single anterior nasal aperture, its premaxillary and mandibular rostral processes, and in having more than one series of palatal teeth; but in general form and in the shape of the maxillæ, palatal bones, and rami of the mandible, it departs far less from *Sphenodon* than *Hyperodapedon* does. Some comparisons of limb-bones were also made.

The three genera mentioned were shown to form a particular group, which, however, had no claim to ordinal distinction, and appeared to form a family, Sphenodontidæ, of the Lacertilia, comprising two subfamilies, Rhynchosaurinæ (including *Rhynchosaurus* and *Hyperodapedon*) and Sphenodontinæ.

The fact that in this Lacertilian group the highest known degree of specialization, as shown in *Hyperodapedon*, was attained as early as the Triassic epoch, showed that in Permian times, or earlier, Lacertilia existed which differed less from *Sphenodon* than either of the Rhynchosaurinæ did. Not only was the Lacertilian type of organization clearly defined in the Triassic epoch, but it attained a degree of specialization equal to that exhibited by any modern lizard.

2. "Rocks of the Essex Drift." By Rev. A. W. Rowe, M.A., F.G.S.

The rocks of the Essex drift are of great variety. There is a remarkable absence of granite of any kind, and only two specimens of syenite have been found. Quartz-porphyrites and quartz-tourmaline rocks are fairly abundant, felsites are rarely met with, but felspar porphyrites are very abundant; trachytes also are found, but there is some reason for suspecting that these do not really belong to the drift, but have been imported in very early times. The most abundant of the igneous rocks are the dolerites; but all the coarser dolerites and those of a true ophitic character are wanting. Many of the specimens are of subophitic texture, and bear a general likeness to the subophitic dolerites of Central England. Some specimens, however, are strikingly like the rocks of the Whin Sill, in certain special points. The dolerites of trachytic texture, or basalts, do not at all resemble those of the North of England, but some of them are almost identical with certain Scandinavian basalts. One or two specimens deserve special mention, and among them a hypersthene-bearing dolerite that is more nearly ophitic than any of the others. Two specimens of granulite containing hypersthene are interesting as belonging to a well-characterized type. The crystalline schists are not abundant; among them is a hornblende schist containing abundance of tourmaline. The sandstones, some of which are of very large size, belong chiefly to the Carboniferous series, and, as a rule, are unfossiliferous. Two blocks of fossiliferous sandstone have been identified with the sandstone of the Lower Neocomian series in Lincolnshire. Of the limestones there are a great number of blocks of a hard grey crystalline limestone of the Carboniferous series containing some very perfect specimens of Foraminifera; and two specimens from the Rhætic beds, which are of peculiar interest if, as it is said, the Rhætic beds do not now come to the surface anywhere in the North of England. The greater number, however, of the limestones belong to the Jurassic series; there are also many lumps of very hard chalk which have been identified with the hard chalk of Cambridgeshire. The microscopic sections of the Chalky Boulder-clay show that amid grains of quartz, sand, etc., there are a great number of minute Foraminifera still wonderfully well preserved. The way in which the Chalky Boulder-clay and the gravels lie was well shown in a railway-cutting near Dunmow some short time ago, and happily a small photograph of the section was taken at the time, for that part of the cutting has now been covered in. It is possible that this attempt at classifying and describing the rocks of the drift may be of some assistance to those who are considering the general question of the glacial drift.

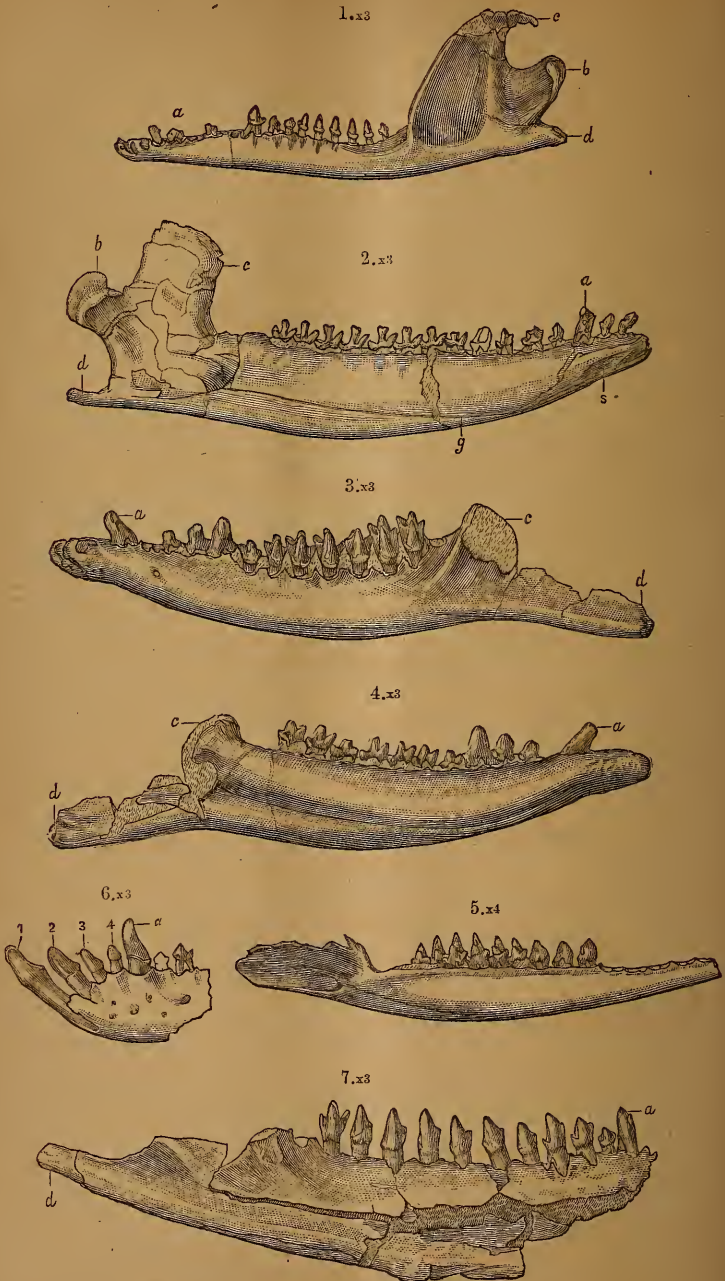
3. "On Tertiary Cyclostomatous Bryozoa from New Zealand." By Arthur W. Waters, Esq., F.G.S.

The Cyclostomata noticed in this paper were from the same collections as the Chilostomata described in the last volume of the Quarterly Journal, and this part was kept back a short time, in the hope that the publication of the Report of the "Challenger" expedition might throw some light upon this unsatisfactory suborder; but the results are very disappointing in this respect, as only thirty-three species are recorded, and these for the most part well known and common ones.

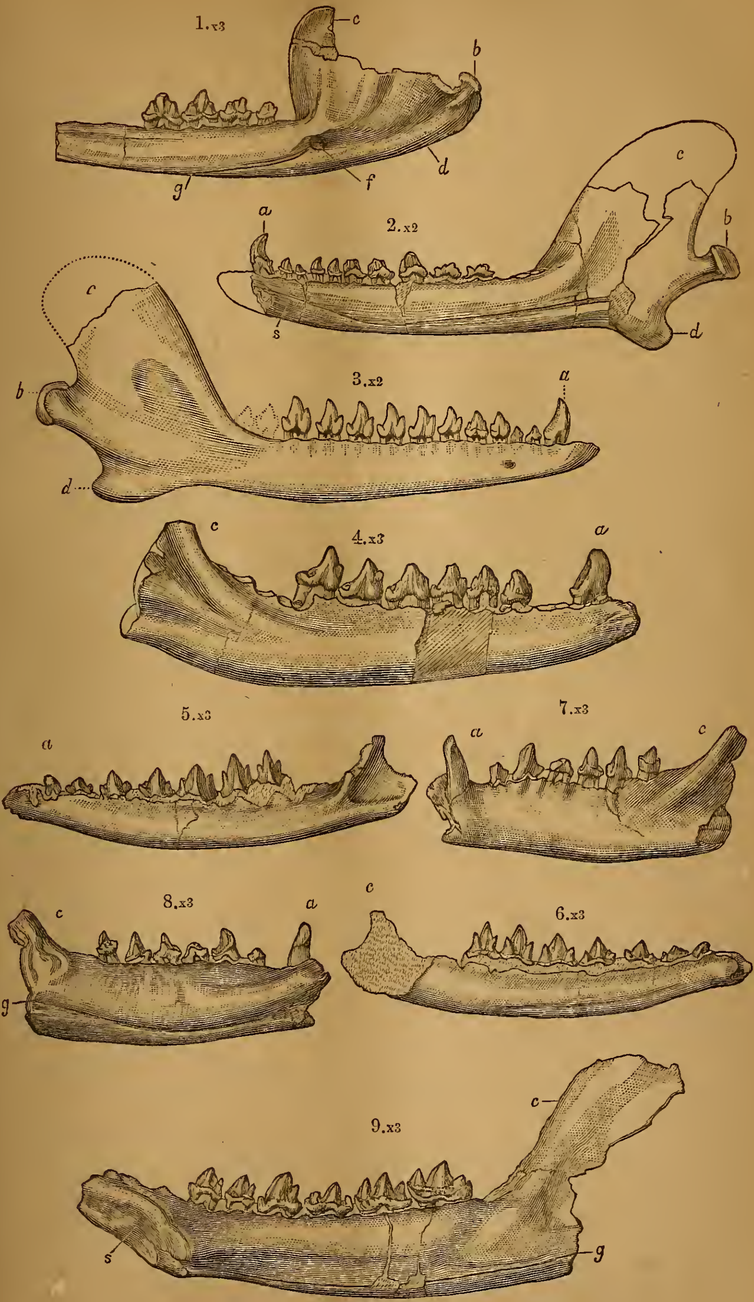
It was proposed to subdivide the Cyclostomata into two sections, namely:—1, those in which the surface of the zoarium is to a considerable extent formed of the lateral walls of the zoœcia, as *Entalophora*, etc.; and 2, those in which the zoœcia or cancelli open for the most part at right angles to the axis, or surface of the zoarium, or subcolony, of which *Heteropora* and *Lichenopora* are typical.

The author recorded the preservation of the extremely delicate and fragile rays or "hair-like teeth" in the interior of the fossil *Entalophora intricaria.*

Out of the twenty-eight species or varieties eighteen are known living, and this part of the collection agrees with the former in indicating that it is comparatively recent. The number of these fossil Bryozoa is now brought up to 106. The new species described by the author were:—*Entalophora wanganuiensis, Tubulipora tubipora, Lichenopora wanganuiensis, Reptocavea aspera, Heteropora napierensis,* and *Crassohornera waipukurensis;* and he also noted a new variety, *perangusta,* of *Diastopora sarniensis.*



American Jurassic Mammals.



AMERICAN JURASSIC MAMMALS.

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## ORIGINAL ARTICLES.

### I.—AMERICAN JURASSIC MAMMALS.

By Professor O. C. MARSH, M.A., LL.D., F.G.S.

(PLATES VIII. AND IX.)

(*Concluded from page* 247.)

#### DRYOLESTIDÆ.

THE first American mammal found in the Jurassic, and a large proportion of those since discovered, belong to a peculiar family which the writer has called the *Dryolestidæ*. It includes several genera and numerous species from America, and is likewise represented among the forms found in Europe.

The type species of the group, *Dryolestes priscus*, was based upon a characteristic lower jaw, although the specimen was imperfect. A nearly complete lower jaw of the species is represented on Plate VIII. Fig. 2. An allied species, *Dryolestes vorax*, is shown on the same Plate, by Figures 3 and 4. *Stylacodon*, *Asthenodon*, and *Laodon*, other genera of this family, are likewise represented on the same Plate.

The upper jaws of several genera of this family are now known with tolerable certainty, and these will be figured and described fully in the Memoir now in preparation.

All the genera of this family have more than the typical number of teeth (44), and the general characters of the inferior dentition are well shown in Plate VIII. The lower teeth form a close-set series, without diastemas, or marked interspaces.

There are three, or four, incisors, and in those preserved, each has a distinct crown, and the series diminishes in size from in front backward. The canine is inserted by two fangs, more or less distinct, and in most forms its crown is prominent and trenchant. Three or four premolars follow, increasing in size backward, with the last usually very prominent, and in some forms larger than the canine. These premolars all have two roots, and a compressed crown. All have one main cusp, and a small posterior heel. There is usually a small anterior cusp, especially on the posterior teeth.

The molar teeth are from six to eight in number, and are essentially identical in form, and usually distinct from the premolars. The crown consists of one main external cone, high and pointed, and three internal cusps, which vary much in development in the different genera. Seen from the outside, these teeth appear to be inserted by a single fang, but, in most cases, each has two roots, although these are nearly or quite connate. When the jaw is imbedded in the matrix, and the diminutive teeth uncovered as far as safety will permit, the features of one side only of the molars can be determined. Thus in Figure 1, Plate VIII. the outer exposed side of one lower jaw (*Stylacodon*) is shown, while in Figure 2, the inner side of another jaw (*Dryolestes*) is represented. In Figures 3 and 4, the two sides of the same jaw are placed together, and the main characters of the lower molar teeth of *Dryolestes* are thus made evident.

There are seven superior molars, and these have one main inner cone, and three outside cusps that vary in size and proportions in the different genera.

## DRYOLESTES AND STYLACODON.

The two genera most nearly allied in dentition are *Dryolestes* and *Stylacodon*, typical examples of which are shown on Plate VIII. The number of lower teeth in the best preserved specimens appears to be the same in each, while the incisors, canine, and four premolars, show no marked differences. In *Dryolestes*, the eight molars which follow are all of one type, and differ but little except in size. All have the inner middle cone of the crown as high as, or higher than the outer main cone. In *Stylacodon*, the first two of these teeth resemble the anterior premolars in shape, and like them show from the outside double fangs. The main external cone is quite as high as the opposite cusp.

In *Dryolestes*, moreover, the lower jaw is comparatively short and massive, deep below the molar teeth, with its lower margin strongly convex. The condyle in the best-preserved specimen is concave transversely, and has its lower margin nearly on a line with the summits of the molar teeth.

In *Stylacodon*, the lower jaw is long and slender, and constricted in front of the coronoid process, which slopes well upward and backward. The condyle is convex transversely, and placed considerably above the line of the teeth. The jaw is shallow below the molars, scarcely exceeding the height of the teeth themselves, while the lower border in this region is nearly straight. These differences may be readily seen in the two specimens shown on Plate VIII. Figures 1 and 2. The mylohyoid groove is well developed in both genera, and its position is essentially the same in each.

In *Dryolestes*, the mental foramen is below the first premolar. The dental foramen is beneath the front margin of the coronoid process, and at this aperture, the mylohyoid groove begins.

## ASTHENODON.

The genus *Asthenodon*, the type species of which is described below, agrees with the above genera in the more important characters of the lower dentition, but differs, in having the entire series of teeth much more uniform in size, and but eleven teeth behind the canine. The type of this species is the lower jaw shown in Plate

VIII. Figure 7. A second specimen referred to this species is the anterior part of another jaw, shown in Figure 6. The former jaw shows a weak canine (*a*), followed by three premolars, each with two fangs. Behind these, in place of the large, trenchant premolar seen in *Dryolestes* and *Stylacodon*, is a small tooth, which from its shape may be regarded as the first molar. The remaining teeth agree in their more important characters with the corresponding molars of *Dryolestes*. The second specimen, Figure 6, shows a similar weak canine, and in front of it, the four incisors in place, increasing rapidly in size forward, the front one being larger than the canine.

### ASTHENODON SEGNIS, Marsh.

In the genus *Asthenodon*, the inferior dentition on each side is as follows:—Incisors 4; canine 1; premolars 3; molars 8.

The largest tooth in the entire lower series is the first incisor, Plate VIII. Figure 6, $_1$. The remaining incisors decrease in size backward, as shown in the same Figure, $_2$, $_3$, and $_4$. The canine (*a*) is small and weak, and its crown resembles that of the incisors. It is implanted by two roots, which are nearly connate. The three premolars behind the canine have each two fangs, and increase in size from first to last, as shown in Figure 7 of the same Plate. The following seven teeth, judging from the shape, are molars, and behind them is the alveole of one more. These molars agree in general form with those of *Dryolestes*. The form of the lower jaw also is similar in the two genera. The upper jaw of this genus is not known.

The specimens representing this species indicate an animal about the size of a Weasel. They are from the Atlantosaurus beds of Wyoming Territory.

### LAODON.

A fourth genus, *Laodon*, while agreeing in the general type of lower molar teeth with the above forms, differs widely from them in other respects. The molars in this genus have the outer main cone high and pointed, as in the above genera, but the inner opposite cusp is greatly reduced in size, as shown in the type specimen represented in Plate VIII. Figure 5. There appear to have been eight molar teeth, six of which are well preserved. In front of these, are two premolars of nearly equal size, and between these and the canine, there were apparently three more, each with two fangs, making thirteen teeth in the premolar and molar series. The canine had two roots, and the last incisor was placed closely in front of it.

In this specimen the dental foramen is situated below the summit of the coronoid process. Its aperture is placed obliquely, opening backward and upward, and from its outer margin, the deep mylohyoid groove extends forward and downward, rapidly descending below the lower border of the ramus.

This lower jaw is intermediate in form between *Dryolestes* and *Stylacodon*. It has the slender straight ramus of *Stylacodon*, with even a stronger constriction behind the molar teeth, but the jaw is deeper below the molar series, and the lower margin is convex, as in *Dryolestes.* The molar teeth resemble those of *Peraspalax,* Owen, but in that genus there is a less number of teeth, and other features, not seen in the present specimen.

The upper jaw of this genus has not yet been identified.

### Laodon venustus, Marsh.

In the type specimen of this species, the inner side only of the lower jaw is shown. The alveolar border is nearly straight, while the lower margin is strongly convex. The anterior portion of the ramus is very shallow, but little, if any, deeper than the crowns of the teeth it contained. There is a well-marked mylohyoid groove, which begins at the dental foramen, and extends forward and downward, until it is lost below, directly under the second molar. The angle of the jaw extends well backward, and was not inflected, although somewhat thickened along the lower margin. The pterygoid fossa is deep and wide. The coronoid process was large, but its exact form cannot be determined.

The type specimen of the present species is from the Upper Jurassic deposits of Wyoming.

### Diplocynodontidæ.

A third group of Jurassic Mammals is known at present from three genera, which have been found only in America. The most typical form, *Diplocynodon,* is represented on Plate IX. Figure 3, by the specimen first described. This fossil indicates one of the largest mammals yet found in the Jurassic. In this genus, there were at least three lower incisors, directed well forward. The canine is very large, elevated and trenchant, and inserted by two strong fangs. Behind this, there are twelve teeth, all essentially of the same type, so that, from the outer side alone, it is difficult, if not impossible, to distinguish the premolars from the molars. The crowns of these teeth are composed of a main external cone, with a small, elevated lobe in front, and a lower one behind. This is repeated on a reduced scale on the inner side, except that the posterior cusp is rudimentary, or wanting. The antero-posterior faces of the crowns are deeply excavated, and grooved.

The jaw is elongate, and gently curved below. The coronoid process is large and elevated. The condyle is placed very low, nearly on a line with the teeth. The angle of the jaw is produced into a distinct process (*d*), the lower margin of which bends outwards, although the process as a whole has a slight inward direction.

An upper jaw referred to this species contains the canine and eight succeeding teeth in excellent preservation. The canine is very large, and has two distinct fangs. The molar teeth have one, main, external cone, and two lateral cusps, which rise from a strong basal ridge. On the inner side, there is one main cone, with a small posterior heel. The outer face and the sides of the upper molars are deeply sculptured with irregular grooves.

The European genus *Amphitherium* may possibly belong to this family, but the lower canine has only a single root, and the molars appear quite different from those of the American forms.

### DOCODON.

Another genus (*Docodon*) of this family may be distinguished from *Diplocynodon* by having, in the lower jaw behind the canine, eleven teeth instead of twelve. The canine has two fangs, as in the latter genus, and the molar teeth correspond closely in form. The symphysis is very long, and the mylohyoid groove extends forward to its upper border. The type specimen of this genus is shown in Plate IX. Figure 2.

### ENNEODON.

A third genus, *Enneodon*, described below, is represented by two specimens, one of which is shown on Plate IX. Figure 4. The lower jaw is comparatively short and robust, and contained only nine post-canine teeth, all of the same type.

The canine in *Enneodon* is large, and, as in other genera of this family, is inserted by two well-separated fangs. Seen from the outside, its crown resembles that of a true molar, but the anterior lobe is wanting. The second premolar is larger than the first, not smaller, as in the type of *Diplocynodon*. The premolars, although of the same general form as the molars, have the surface of the crown more grooved, or striate.

A second specimen of this genus agrees with that last described in the main features of its dentition, but the lower jaw is less robust. The canine is also more slender, and there is a small diastema behind it. The first three premolars increase in size backward, but are all of similar form. The angle of the jaw is considerably below the lower margin of the ramus.

The fossils on which the two species of *Enneodon* are based were found in the Atlantosaurus beds of the Upper Jurassic, in Wyoming.

### SPALACOTHERIDÆ.

The type genus of this family is *Spalacotherium* of Owen, but it is probable that he included more than one generic form under this name, in the various specimens described. In America, one well-preserved jaw has been found, which appears to indicate a distinct genus (*Menacodon*), and is described below. This specimen is represented on Plate IX. Figures 5 and 6.

In the typical specimens of *Spalacotherium*, the premolars and molar teeth are ten in number, and of the same general form. The crown consists of one, main, external cone, high and pointed, and two, short, inner cusps, nearly equal in size, in front of and behind the main cone. The canine has two fangs, and there is little or no diastema behind it.

In *Menacodon*, the molars have the same general form, but there appear to be but seven in the post-canine series. The crowns also are shorter and more robust. The canine is small, and has two roots.

### MENACODON RARUS, Marsh.

In this species, the lower jaw is comparatively slender, and its inferior border is strongly convex, longitudinally. The canine was small, and directed well forward. The first three premolars are separated slightly from the canine, and from each other. The three following teeth, which may be regarded as true molars, are larger and more elevated, and behind these was the last molar, somewhat smaller in size.

In the type specimen of *Menacodon*, there is no sharply defined mylohyoid groove, but a shallow depression takes its place, as indicated in Plate IX. Figure 6.

In *Spalacotherium* there is a well-defined mylohyoid groove.

The unique specimen on which the present species is established was found in the Upper Jurassic of Wyoming.

### TINODONTIDÆ.

This family is well represented by American forms, one of which, the type species of *Tinodon*, is shown on Plate IX. Figure 1. *Phascolotherium*, Owen, appears from its dentition to be an allied form, but differs in several important points, and may yet be found to represent a distinct family. The premolar and molar teeth have nearly the same form in both genera, but in *Tinodon*, there is a larger number of post-canine teeth. The coronoid process, also, is vertical, and the angle of the jaw is not inflected. The premolars have the same general shape as the molars, the crowns being composed essentially of three pointed cusps, one, main, outer cone, and two, smaller cusps, one in front and one behind, on the inner side. There is a strong cingulum on the inner surface, which may develop into an anterior lobe, or posterior heel. The mylohyoid groove is distinct. The condyle in *Tinodon* is rounded, and somewhat transverse, and is separated from the jaw by a distinct neck.

In *Tinodon bellus*, the dental foramen is large (Plate IX. Fig. 1, *f*), and looks downward and backward. It is placed somewhat behind the anterior margin of the coronoid process, and somewhat above the middle line of the ramus. The deep mylohyoid groove (*g*) leads from this opening, forward and downward.

### TRICONODONTIDÆ.

Another family related to the one last described is represented by the genus *Triconodon* of Owen, and by one or two American forms. In this group, the premolars are unlike the molars. The latter are large, and their crowns are composed of three, nearly equal, trenchant cusps. The premolars are compressed and trenchant, but lack the anterior cusp. There is apparently more than one genus included under the specimens referred by Owen to *Triconodon*, but more specimens will be required to separate them.

### PRIACODON.

One of the American forms, which appears to be generically distinct from the type of *Triconodon*, is represented below, on Plate IX. Figure 9, under the name *Priacondon ferox*. The type specimen, on which it is based, was originally placed by the writer in the genus *Tinodon*, and the species named *Tinodon ferox*. This specimen is a right lower jaw, with most of the teeth in position. There are three premolars, and four molars. The premolars have one main cone, pointed and compressed, with a low cusp in front, and a larger one behind. The last premolar is large. The penultimate molar has four distinct cones instead of three. The canine was large, and directed well forward. The coronoid process is high, and inclined backward. The mylohyoid groove is nearly parallel with the lower margin of the jaw, and extends forward to the symphysis. The latter is strongly marked.

### PAURODONTIDÆ.

A peculiar genus, *Paurodon*, widely different from any form hitherto found in America, or Europe, is represented at present by a single specimen, a left lower jaw. This is shown on Plate IX. Figures 7 and 8. The entire premolar and molar series consists of only six teeth, the main features of which are seen in the figures cited. The canine is large, nearly erect, and is apparently inserted by a single fang. There is a distinct diastema between this and the first premolar. The latter is small. The lower jaw is short and massive, and there is a deep mylohyoid groove (*g*).

The molar teeth of *Paurodon* appear to agree in the general features of their crowns with those of *Achyrodon* and *Peralestes*, but the figures given by Owen of the specimens described under these names show them to be quite distinct from the present genus.

### PAURODON VALENS, Marsh.

In this genus there were apparently two lower premolars, and four molars, all separated somewhat from each other. The premolars have a single main cusp, and a low posterior heel. Each is implanted by two roots. The molars have a single main external cone, and two low inner cusps. The mylohyoid groove extends from the pterygoid fossa to the symphyseal surface, which is large. The mental foramen is below the diastema between the canine and the first premolar.

The upper jaw of this peculiar fossil is not known.

The type specimen of this unique form is from the Upper Jurassic deposits of Wyoming Territory.

The main object of the present article is to present a typical series of the remains of known American Jurassic mammals. A discussion of the closer relations of these to the mammals from the same formation in Europe, as well as to both older and more recent forms, will be reserved for the Memoir now in course of preparation.

The vertebræ, limb bones, and other parts of the skeleton of mammals, found with the jaws and teeth here described, cannot yet be definitely associated with the latter, but an attempt to do this will be made in the Memoir.

The genera and species of American Jurassic mammals now known are given in the list below. All have been described by the writer, in the American Journal of Science. One figure, at least, of a typical form of each new genus proposed, has also been given, either in the original description, or in the present article.

The list is as follows:—

### PLAGIAULACIDÆ.

| | | | | |
|---|---|---|---|---|
| *Allodon laticeps.* | Amer. | Journ. | Sci., vol. | xxi. p. 511, 1881. |
| ,, *fortis.* | ,, | ,, | ,, | xxxiii. p. 331, 1887. |
| *Ctenacodon serratus.* | ,, | ,, | ,, | xviii. p. 396, 1879. |
| ,, *nanus.* | ,, | ,, | ,, | xxi. p. 512, 1881. |
| ,, *potens.* | ,, | ,, | ,, | xxxiii. p. 333, 1887. |

### DRYOLESTIDÆ.

| | | | | |
|---|---|---|---|---|
| *Dryolestes priscus.* | Amer. | Journ. | Sci. vol. | xv. p. 459, 1878. |
| ,, *vorax.* | ,, | ,, | ,, | xviii. p. 215, 1879. |
| ,, *arcuatus.* | ,, | ,, | ,, | xviii. p. 397, 1879. |
| ,, *obtusus.* | ,, | ,, | ,, | xx. p. 237, 1880. |
| ,, *gracilis.* | ,, | ,, | ,, | xxi. p. 513, 1881. |
| *Stylacodon gracilis.* | ,, | ,, | ,, | xviii. p. 60, 1879. |
| ,, *validus.* | ,, | ,, | ,, | xx. p. 236, 1880. |
| *Asthenodon segnis.* | ,, | ,, | ,, | xxxiii. p. 336, 1887. |
| *Laodon venustus.* | ,, | ,, | ,, | xxxiii. p. 337, 1887. |

### DIPLOCYNODONTIDÆ.

| | | | | |
|---|---|---|---|---|
| *Diplocynodon victor.* | Amer. | Journ. | Sci. vol. | xx. p. 235, 1880. |
| *Docodon striatus.* | ,, | ,, | ,, | xxi. p. 512, 1881. |
| *Enneodon crassus.* | ,, | ,, | ,, | xxxiii. p. 339, 1887. |
| ,, *affinis.* | ,, | ,, | ,, | xxxiii. p. 339, 1887. |

### SPALACOTHERIDÆ.

| | | | | |
|---|---|---|---|---|
| *Menacodon rarus.* | Amer. | Journ. | Sci. vol. | xxxiii. p. 340, 1887. |

### TINODONTIDÆ.

| | | | | |
|---|---|---|---|---|
| *Tinodon bellus.* | Amer. | Journ. | Sci. vol. | xviii. p. 216, 1879. |
| ,, *robustus.* | ,, | ,, | ,, | xviii. p. 397, 1879. |
| ,, *lepidus.* | ,, | ,, | ,, | xviii. p. 398, 1879. |

### TRICONODONTIDÆ.

| | | | | |
|---|---|---|---|---|
| *Triconodon bisulcus.* | Amer. | Journ. | Sci. vol. | xx. p. 237, 1880. |
| *Priacodon ferox.* | ,, | ,, | ,, | xxxiii. p. 341, 1887. |
| (*Tinodon ferox*). | ,, | ,, | ,, | xx. p. 236, 1880. |

### PAURODONTIDÆ.

| | | | | |
|---|---|---|---|---|
| *Paurodon valens.* | Amer. | Journ. | Sci. vol. | xxxiii. p. 342, 1887. |

Nearly all the mammals older than the Tertiary, judging from their dentition alone, may have lived mainly upon insects, with such accessory diet as modern Insectivores affect. The *Plagiaulacidæ,* however, show evidence of marked adaptation to some peculiar food, whether animal or vegetable cannot yet be determined with certainty. Now that the upper teeth of *Ctenacodon* are known, and trenchant teeth are found opposed to the lower cutting premolars, and tubercular molars to those below, the problem is simplified, but not solved. The evidence at present points to an animal, rather than to a vegetable, diet for all the *Allotheria.*

It is not improbable that there was a gradual change in diet in the later forms, until vegetable food predominated. The fact that the Tertiary genus *Neoplagiaulax,* Lemoine, has only a single lower premolar coincides with this view, and if *Hypsiprymnus* is a still later descendant, the additional molars, and other herbivorous features, may be the result of this gradual change.

The few mammals known from the Trias may be placed in two families, *Dromotheridæ,* including the American specimens, and *Microlestidæ,* those of the old world. They are all quite distinct from any of the Jurassic forms, either those found in America or in Europe. Below the Trias, no Mammals have hitherto been discovered; and none are known with certainty from the Cretaceous.

Mesozoic Mammals have very generally been referred hitherto to the *Marsupialia.* An examination of the known remains of American Mesozoic Mammalia, now representing upwards of two hundred distinct individuals, has convinced the writer that they cannot be satisfactorily placed in any of the present orders. This appears to be equally true of the European forms which the writer has had the opportunity of examining. With a few exceptions, the Mesozoic Mammals best preserved are manifestly low generalized forms, without any distinctive Marsupial characters. Many of them show features that point more directly to Insectivores, and present evidence, based on specimens alone, would transfer them to the latter group, if they are to be retained in any modern order. This, however, has not yet been systematically attempted, and the known facts are against it.

In view of this uncertainty, it seems more in accordance with the present state of science, to recognize the importance of the generalized characters of these early mammals, as at least of ordinal value, rather than attempt to measure them by specialized features of modern types, with which they may have little real affinity. With the exception of a very few aberrant forms, the known Mesozoic mammals may be placed in a single order, which the writer has named *Pantotheria.*[1] Some of the more important characters of this group are as follows:—

(1.) Cerebral hemispheres smooth.
(2.) Teeth exceeding, or equalling, the normal number, 44.[2]
(3.) Canine teeth with bifid or grooved roots.[2]
(4.) Premolars and molars imperfectly differentiated.
(5.) Rami of lower jaw unankylosed at symphysis.
(6.) Mylohyoid groove on inside of lower jaw.
(7.) Angle of lower jaw without inflection.
(8.) Condyle of lower jaw near horizon of teeth.
(9.) Condyle vertical or round, not transverse.

The generalized members of this order were doubtless the forms from which the modern, specialized, Insectivores, at least, were derived.

Another order of Mesozoic mammals is evidently represented by *Allodon*, *Bolodon*, *Ctenacodon*, *Plagiaulax*, and a few other genera. These are all highly specialized, aberrant, forms, which apparently have left few, if any, descendants later than the Tertiary. This

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[1] American Journal of Science, vol. xx. p. 239, 1880.

[2] The genus *Paurodon* may be an exception.

order, which the writer has termed the *Allotheria*,[1] can be distinguished from the previous group by the following characters:—

(1.) Teeth much below the normal number.
(2.) Canine teeth wanting.
(3.) Premolar and molar teeth specialized.
(4.) Mylohyoid groove wanting.
(5.) Angle of lower jaw distinctly inflected.

These characters alone do not separate the *Plagiaulacidæ* and *Microlestidæ* from some of the Marsupials, and the facts now known seem to prove that they belong to that group, where they represent, at least, a well-marked sub-order.

Of the two families of Triassic Mammals now known, the *Dromotheridæ* may be placed in the order *Pantotheria*, and the *Microlestidæ* in the *Allotheria*. According to present evidence, the former were probably placental, and the latter non-placental, and marsupial.

The modern Placental mammals were evidently not derived from Marsupials, as is generally supposed. Each group has apparently come down to the present time, by separate lines, from primitive oviparous, forms, of which the living Monotremes may be the more direct but specialized representatives. Among the diversified members of Placental mammals, the Insectivores are probably the nearest to the early type, and hence they show many features seen in the Jurassic and Triassic mammals of the order *Pantotheria*.

Among the various existing Marsupials, the Rat-Kangaroos (*Hypsiprymnidæ*) appear to be nearest to the oldest known forms represented in the order *Allotheria*, but future discoveries may, at any time, bring to light new Mesozoic mammals allied to other Marsupials.

So far as at present known, the two great groups of Placental and Non-placental mammals appear to be distinct in the oldest known form, and this makes it clear that, for the primitive generalized forms (*Hypotheria*), from which both were derived, we must look back to the Palæozoic.

## EXPLANATION OF PLATES VIII. AND IX.

### PLATE VIII.

Fig. 1. Left lower jaw of *Stylacodon gracilis*, Marsh; outer view.
,, 2. Left lower jaw of *Dryolestes priscus*, Marsh; inner view.
,, 3. Left lower jaw of *Dryolestes vorax*, Marsh; outer view.
,, 4. The same jaw; inner view.
,, 5. Left lower jaw of *Laodon venustus*, Marsh; inner view.
,, 6. Left lower jaw of *Asthenodon segnis*, Marsh; anterior part, outer view.
,, 7. Right lower jaw of same species; outer view.

*a*, canine; *b*, condyle; *c*, coronoid process; *d*, angle; *g*, mylohyoid groove; *s*, symphyseal surface.

All the Figures are three times natural size, except Figure 5, which is four times natural size.

### PLATE IX.

Fig. 1. Right lower jaw of *Tinodon bellus*, Marsh; inner view.
,, 2. Right lower jaw of *Docodon striatus*, Marsh; inner view.
,, 3. Right lower jaw of *Diphocynodon victor*, Marsh; outer view.

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[1] American Journal of Science, vol. xx. p. 239, 1880.

Fig. 4. Right lower jaw of *Enneodon crassus*, Marsh; outer view.
,, 5. Left lower jaw of *Menacodon rarus*, Marsh; outer view.
,, 6. The same jaw; inner view.
,, 7. Left lower jaw of *Paurodon valens*, Marsh; outer view.
,, 8. The same jaw; inner view.
,, 9. Right lower jaw of *Priacodon ferox*, Marsh; inner view.

*a*, canine; *b*, condyle; *c*, coronoid process; *d*, angle; *f*, dental foramen; *g*, mylohyoid groove; *s*, symphyseal surface.

Figures 2 and 3 are twice natural size, and the others three times natural size.

Yale College, New Haven, March 26, 1887.

## II.—The Rhyolites of Wuenheim, Vosges.

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Royal School of Mines.

In a paper recently read before the Geological Society,[1] I ventured the conclusion that the bulk at least of the "pyromerides" of the Continent would be found to be altered lavas of an originally glassy character. The careful drawings and descriptions of various petrographers formed a strong chain of evidence; and the observations of Mr. T. Davies[2] on materials from Bouley Bay, Jersey, seemed to establish beyond a doubt the connection between rocks authoritatively styled pyromerides and those regarded in this country as ancient rhyolites. Last autumn I visited one of the most typical continental localities, the richly-wooded Tiefenbach valley west of Wuenheim in the Vosges, and a few notes on specimens then collected may possibly be of interest to workers in a similar field.

It is at once apparent in the steep cliff-like exposure, with old slaty and sandy rocks towards its base, situated just beyond the junction of the roads from Wuenheim and Sulz, that one is dealing, not with a massive "porphyry," but with materials as diverse as those of the famous quarry near the Wrekin. Thus one rock is distinctly banded in tints of grey and yellow-brown, and proves under the microscope to be a devitrified perlite, an old obsidian rather than a stony rhyolite; while the "globular" types, made famous, since their discovery by M. Koechlin-Schlumberger, through the detailed investigations of Delesse,[3] occur in considerable variety, as may be seen even in the metal of the neighbouring roads. In some instances the spherulites, 5 millimetres to 1 centimetre in diameter, are purple-red in a yellowish matrix; in other cases they have a grey and flinty aspect. Many have become chalcedonic in the centre, and may have passed through a hollow stage before this final alteration. Radial structure is visible in the spherulites to the naked eye, and the surrounding material is evidently perlitic.

So much did the spherules at the time of their origin partake of the character of the matrix from which they were derived, that the larger lines of perlitic jointing pass frequently from one into the

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[1] Quart. Journ. Geol. Soc. vol. xlii. p. 188.

[2] Min. Mag. vol. iii. p. 118.

[3] Mémoires de la Soc. géol. de France, 2me série, tome iv. p. 308, etc.

other, and aid doubtless in bringing about the alteration of the spherulites. It is to this admixture of glass and this slight differentiation from it that I would prefer to ascribe the absence of double refraction in so many incipient spherulites of modern date, rather than adopt the view held by some petrographers that such bodies may largely consist of opal.

Delesse, with his usual perception, detected in the matrix of the rock of Wuenheim the perlitic jointing, the "structure fendillée et globuleuse entrelacée," explaining it as a product of contraction when the mass had become practically solid. Microscopic sections would have revealed it to him in exceptional completeness, and the former glassy condition of these dull felsitic rocks may be considered as proved by the presence of the structure in such perfection. The spherulites, whether grey or red, are alike brown in section, and resemble the well-known type, the "felsospherites" of German authors; while their minute globulitic constitution seems to be still retained, despite the secondary granulation visible under polarised light. Vogelsang,[1] indeed, comments on the "surprising resemblance" between the structures of the rock of Wuenheim and certain Hungarian lavas; and it is interesting to note that Faujas de St.-Fond[2] described, eighty years ago, the similar pyromeride of Corsica under the name of *Roche porphyroïde* rather than *porphyre*, stating his belief that the constituents had consolidated more rapidly than is the case in the latter class of rocks.

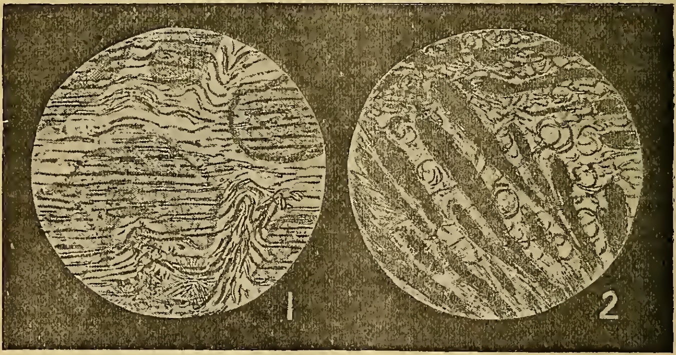

Fig. 1.—Section of rock of Tolcsva, showing disturbance of the lines of flow between the components of the large irregular spherulites. × 80.

Fig. 2.—Section of altered perlitic lava of Wuenheim, showing rays belonging to two large "skeleton-spherulites." × 18.

The most remarkable rock from the "globular" series of Wuenheim is one of limited occurrence, in which the spherulites, about 1 centimetre in diameter, are closely crowded together, apparently to the almost complete exclusion of the matrix. Instead of being compact and homogeneous, these spherulites are seen on broken surfaces to be composed of alternating red and lighter rays, suggesting the

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[1] Die Krystalliten, p. 168.

[2] Essai de Géologie, tome ii. p. 245.

presence of a coarse granophyric structure. Under the microscope, however, while the red rays resemble in constitution the ordinary spherules, the intervening matter proves to represent the matrix, now petrosiliceous, it is true, but retaining the characteristic perlitic curves, marked out often by ferruginous stains and granular products of alteration. The spherulites are, in fact, imperfect, being constructed of radially-grouped rods, circular in cross-section, stretching outwards from a more compact and normal centre. That the alternating and more transparent layers consist, not of original quartz, nor chalcedony, but of a devitrified glassy matrix, the specimen figured leaves, I think, no room for doubt. (Fig. 2.)

Further alteration might convert this material into the semblance of chalcedonic veinules, or might even replace it by bands of secondary quartz. The frequent mention by older writers—Monteiro,[1] for example—of interlamination of "quartz and felspar" in the nodules of pyromerides makes one certainly prepared for the development of granophyric structure in such masses on a handsome scale. Delesse[2] even held that the "quartz" in the rock of Wuenheim exerted some influence on the globular forms of the spherules at the time of their development, and that the alternating bands were due to a primary separation of the constituents. But in another place[3] he shows that the more siliceous fibres are probably chalcedonic, since the etching of polished surfaces of the rock with hydrofluoric acid destroys them more rapidly than the felspathic rays. M. Michel Lévy,[4] accepting the siliceous rays and veinules in the pyromeride of Gargalong as consisting of chalcedony, believes them to be primary, and to characterise a distinct type of rock, peculiar to Permian and Triassic days; that is, a rock intermediate in structure between the micropegmatites with their radial quartz and the modern lavas with spherules largely made of opal.

The example from Wuenheim, however, recalls forcibly a structure occurring in glassy rocks of comparatively recent date. Von Richthofen[5] noted in the perlites of Tolcsva and Erdobenye in Hungary certain groups, one or two inches across, of radially divergent rays, interpenetrated by the homogeneous magma, and regarded them as coarse spherulites extended outwards in this open fibrous manner until they were checked by coming into contact. Vogelsang,[6] seeking for an explanation of this abnormal mode of growth, observed that the general direction of flow of the rock, as indicated by the lines of trichites, was the same in the spherulitic rays as in the matrix, but that local disturbances in this arrangement occurred in the glassy interspaces, where the trichites seemed even to follow the outlines of the several rays. He was thus led to the conclusion

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[1] Journal des Mines, tome xxxv. (1814), pp. 347 and 407.

[2] Bull. de la Soc. géol. de France, tome ix. p. 177.

[3] Mém. de la Soc. géol. de Fr. 2me série, tome iv. p. 313.

[4] Bull. de la Soc. géol. de Fr. 3me série, tome iii. (1875), p. 226. *Cf.* Noury. "Géologie de Jersey," p. 33.

[5] Jahrbuch der k.k. geol. Reichsanstalt, vol. ix. (1860), p. 180.

[6] Die Krystalliten, p. 148; also plate xvi. fig. 1.

that the spherules had originally been formed as compact and normal aggregations, but that the rock had undergone a second fusion; the glass had then penetrated the spherulites along their lines of radial structure, corroding but not destroying them, nor yet disturbing, by shifting of their parts, the parallelism of the earliest-formed crystallites within. Each spherule became thus split up into a bundle of diverging and rounded rays; and Vogelsang remarks in a later passage[1] on the similarity between this structure and that of certain felsospherites in the "kugelporphyr" of the Vosges, in which the place of the glass, however, is taken by a granular siliceous aggregate affecting polarised light.

That Vogelsang's explanation will not satisfy certain cases, while it may probably in others be regarded more as an ingenious than an inevitable deduction, is clear from sections of Hungarian "strahlige sphaerolithe" in the collection of the Normal School of Science and Royal School of Mines. In the instance figured (Fig. 1), the fluidal structure of the obsidian passes continuously through the matrix and the spherulitic matter, and is merely disturbed, not broken, in the interspaces between the rays. While this continuity excludes the idea of a second fusion, the local disturbances must have arisen from the opposition offered by the rays themselves. In a glassy lava moving with some rapidity, large spherulites are impossible, the separated globulitic materials being carried out into parallel bands. As the movement becomes slower, however, and as consolidation proceeds, nodular aggregations appear locally along this banding, and, if the crystallisation is finally arrested at this stage, their outer margins are seen to be ill-defined and ragged, set with, in fact, irregular but fairly radial rays.[2] It is conceivable that as we frequently meet in rocks with the mere skeletons of crystals planned on a scale too ambitious for the time occupied in the consolidation of the mass, so even *skeleton-spherulites* may arise, the whole product being similar in structure to the arrested external layers of the instances above described. The diverging rays, set at all angles to the direction of flow, will gradually interfere, after the manner of embedded crystals, with the further uniform progress of the glass; and the last movements in the mass, together with the pressure of upper layers, will serve to distort the lines of crystallites between the rays, or even to break them through and rearrange the particles into local lines of flow.

In some of the Hungarian cases examined, the interstitial matrix has itself become finally spherulitic, but on a minute and delicate scale, showing a mosaic of dark-cross areas when viewed between crossed Nicols. In the rock of Wuenheim, however, it seems for the most part to have remained glassy until the period of its secondary alteration into granules. The individualised fibrous structure of the spherulitic rays, which are well compared to axiolites by Rosenbusch,[3] would in itself assign to them an origin independent of one another in all but the tendency to develope in groups about

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[1] *Ibid.* p. 168

[2] See Quart. Journ. Geol. Soc. vol. xli. plate iv. fig. 1.

[3] Mikroskop. Physiogr. 2nd edit. (1886), p. 395.

certain centres. The second, third, or fourth series of spikelets attaching themselves to one of the rays of a skeleton-crystal of magnetite may be considered as independent of the similar additions, whether simultaneous or not, made during consolidation to the other primary arms. One arm, moreover, in such examples frequently attains to a much greater development than the rest, and corresponding phenomena may be expected among skeleton spherulites.

I would submit these few observations as further evidence in favour of regarding the pyromerides as the altered representatives of the rhyolites of to-day, of which they reproduce, not only the familiar, but also some of the rarer types. It is interesting to observe that, equally with those of Jersey, the Wuenheim lavas are held to be of Permian age.

In the microscopic work relating to this subject, I have been much indebted to preparations made in the Geological Laboratory of the Normal School of Science and Royal School of Mines.

## III.—ON SOME REMAINS OF SILUROID FISHES FROM BRITISH EOCENE FORMATIONS.

By A. SMITH WOODWARD, F.G.S., F.Z.S.,
of the British Museum (Natural History).

AMONG the early Tertiary Fishes in the British Museum, there are a number of detached spines and cranial fragments from the Middle and Upper Eocene beds of Bracklesham and Barton, which are undoubtedly referable to extinct members of the family of Siluridæ. With the exception, however, of three specimens figured and briefly noticed by Dixon in his work on the fossils of Sussex,[1] all have remained hitherto undescribed; nor is it an easy task to base any satisfactory identifications upon such fragmentary materials. But as it has sometimes been asserted that no traces of this family have yet been discovered in European formations,—and, as moreover, at least one important generalization has been based upon the supposed fact,[2]—it will perhaps be of interest to offer a few notes upon these fossils, to show that their non-recognition is due rather to the imperfection of the geological record, than to their actual absence in the rocks. And some slight notice is all the more desirable, since Dixon's reference of the Bracklesham specimens to the temperate genus *Silurus* is obviously erroneous, and the mistake has escaped correction in the second and revised edition of his great work.

It is impossible, of course, to attempt any precise specific diagnoses equivalent to those recognized by the zoologist among living forms; for no evidence is yet forthcoming as to the arrangement and proportions of the fins, which constitute so prominent a character of note in systematic works. But there is very good reason to believe

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[1] F. Dixon, "Geology and Fossils of Sussex," 1st edit. 1850, p. 204, pl. xi. figs. 11–12 [2nd ed. p. 244, pl. 11, figs. 11–13.]

[2] "The Siluroids . . . . came into existence after the Cyprinoids, fossil remains being known only from Tertiary deposits in India, none from Europe." (A. Günther, "Study of Fishes," 1880, p. 216.)

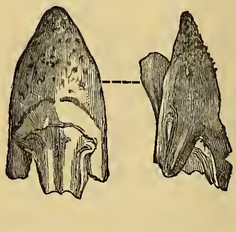
that the fossils indicate two distinct types, and it therefore seems advisable to adopt the usual palæontological expedient of applying a provisional name to each, merely for convenience of reference; and in the first case, at least, there can be little doubt that the present determination will prove well founded.

### ARIUS EGERTONI, Dixon sp.

1850. *Silurus Egertoni*, F. Dixon, Geol. and Foss. Sussex, p. 204, pl. xi. figs. 11–13.

*Pectoral Arch and Spine.*—The finest specimen figured by Dixon among the types of this species is a right pectoral spine in natural association with the clavicular element of the supporting arch (Brit. Mus. No. 25612). A triangular dermal plate, ornamented with irregularly-disposed, large conical tubercles, is firmly merged with the clavicle in its middle portion, and extends backwards for a distance equalling half the length of the spine; and the bone is evidently preserved as far upwards as its sutural connection with the supra-clavicle, though unfortuately mutilated near the rigid lower symphysis.

Of the spine itself, the National Collection comprises several examples, which render it possible to define its characters completely. These specimens vary considerably in size, though agreeing in every other respect, and the beautiful fossil already mentioned is much the largest, while one of the smaller ones (B. M. 25736) was originally selected to show the form of the proximal articulation. All are of the ordinary laterally-compressed shape, and, when well preserved, exhibit an ornament of closely-approximated, short irregular ridges, rising at intervals into small conical bosses. In the distal half of the spine, the denticles upon the edges are large and recurved, but more proximally they become much smaller, and the points incline in the opposite direction.



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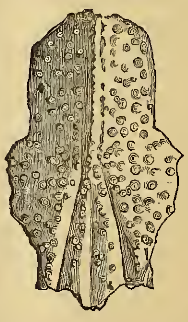

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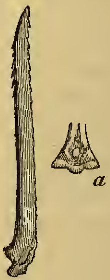

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FIGS. 1 and 2. *Arius Egertoni*, Dixon sp., M. Eocene, Bracklesham Bay, Sussex, etc.
FIG. 3. *Arius ? Bartonensis*, sp. nov., U. Eocene, Barton Cliff, Hampshire, etc.
*a*, median view of proximal articular end of Fig. 3.

*Dorsal Spine, etc.*—The dorsal spine, associated by Dixon with "*Silurus Egertoni*," corresponds so closely in the character of its ornamentation with the pectoral appendage already referred to, that there can be little doubt as to the correctness of the correlation.

But the British Museum does not appear to possess any example sufficiently large to have pertained to a fish of the dimensions indicated by the pectoral arch No. 25612; and the fossil figured by Dixon (No. 25735*a*) is one of the finest and best preserved. The spine is remarkably straight, neither the anterior nor the posterior border exhibiting more than the slightest curvature, and the distal tapering is but gradual. The lower end shows the usual facettes for its connection with the interspinous bones, and there is the ordinary "shackle joint." The row of denticles upon the anterior edge is prominent in unabraded specimens, and they are largest in the middle, diminishing towards either extremity; those at the base are merely minute tubercles, but those still higher are well-defined hooklets, with the points at first directed upwards and finally downwards.

The short blunt spine, with bifurcating base, situated in front of the larger weapon, and serving as a kind of "bolt" or fulcrum, has also been met with at Bracklesham, and is shown of the natural size in Fig. 1. There are likewise some fragments of the modified interspinous bones, though these exhibit no special features of interest.

*Cranial Bones.*—But the most satisfactory materials for discussion consist in a number of fragments of the cranium, which were long ago labelled by Sir Philip Egerton and Mr. William Davies as pertaining to the present species, though no description of them seems to have been hitherto published. These bones are ornamented externally in a very similar manner to the clavicular plate already noted, and their size is such that they may well have belonged to the fishes indicated by the detached fin-spines. The only element, however, that is capable of certain determination, is the supra-occipital bone—fortunately one of the most characteristic bones in the Siluroid skull—and of this four good examples are preserved: the finest is shown of the natural size, viewed from above, in Fig. 2. Anteriorly, there is a small median process dividing the posterior ends of the frontals; on either side, the sutural connections with the successive laterally-placed bones are more or less distinguishable, and the greatest breadth is attained between the squamosals; and posteriorly, where the lateral borders are free, the element exhibits scarcely any tapering, and has a comparatively abrupt termination. The upper surface is raised into a median longitudinal keel in the hinder half of the bone, and from the anterior extremity of this there diverge two well-marked mucus-canals, which appear to extend towards the point of junction of the frontal and postfrontal on each side. On the inferior aspect, the most noteworthy feature is the strength of the septum between the lateral muscles, below the post-cranial extension of the bone. There is no trace of a supraoccipital fontanelle.

*Systematic Position.*—From the foregoing facts, it is obvious, that the Siluroid species under consideration was characterized (i.) by the presence of a strong dorsal fin-spine in addition to the pectorals; (ii.) by a large, ornamented dermal plate attached to the scapular arch; and (iii.) by the ornamentation of the upper cranial bones, which are evidently not covered with more than a very thin skin. In all these respects, the present species differs widely from the *Silurus*-type, and the first two characters alone, which were originally indicated by Dixon, are quite sufficient to exclude it from the genus just mentioned. Sir Philip Egerton, indeed, seems to have already recognized the fact, and has labelled some of his specimens as *Pimelodus*. But a careful comparison of the supraoccipital bone with the corresponding element in the large series of recent Siluroids in the British Museum can leave little doubt that the fossil really belongs to the well-known genus *Arius*, or to some closely allied form which cannot be distinguished upon present evidence. There is the most striking similarity in the few points as yet known, and it is scarcely likely that any great divergence will be noted in the other structures still to be revealed.

If such a conclusion be substantiated by future discoveries, the fact will become of considerable interest, as showing that this Siluroid fish belonged to a type now characteristic of tropical waters, instead of representing an existing form (*Silurus*) that rarely transgresses beyond the temperate zone; and this circumstance, of course, is in harmony with all the indications of the associated fauna. Nothing, however, can be said as to its having its nearest ally in the forms now inhabiting any particular region, for the living species of *Arius* have an extraordinarily wide distribution, and are scattered throughout the freshwaters and littoral areas in almost all tropical parts both of the Old World and the New.

*Formation and Locality.*—Middle Eocene: Bracklesham Bay, Sussex. Probably also Upper Eocene, Barton Cliff, Hampshire. [Egerton Collection, B. M. P. 1894*a*.]

### ARIUS? BARTONENSIS, sp. nov.

The second species of Siluroid is indicated by some small spines from the Barton Clay of High Cliff, near Christchurch, Hampshire, but in this case it is impossible to determine the genus even approximately. It may belong to *Arius*, or may represent some other generic type; and the name by which we venture to designate it is, therefore, as provisional as those already applied to detached examples elsewhere. The *dorsal spine* has a very characteristic curvature, being gradually arched backwards for three-quarters of its length, and assuming a more upward direction in the distal fourth,—a peculiarity shown in the accompanying Fig. 3, though still more marked in two other less perfect specimens: and the largest example is almost twice the size of the one here represented. The sides are ornamented with irregular, delicate longitudinal ridges, exhibiting but the slightest traces of the thickenings or nodose expansions so conspicuous in the rugæ of *A. Egertoni*. The anterior edge is provided in its lower part with a short series of small, blunt tubercles; and towards the distal extremity, which becomes much compressed and sharp, there are little downwardly-directed denticles both in front and behind, imparting to the tip somewhat of a "barbed-arrow" appearance. Posteriorly, the denticles are almost destroyed in the figured specimen, but another fossil shows that they are largest in the middle, decreasing towards either end, and the points are all inclined downwards.

The only *pectoral spines* that can be associated with this species are, unfortunately, too imperfect for description. They seem to have been considerably arched, and have an ornamentation similar to that of the dorsals.

*Formation and Locality.*—Upper Eocene: Barton Cliff and High Cliff, Hampshire.

Such, unfortunately, is the most complete evidence of early Tertiary Siluroids that appears to have been hitherto discovered in the European area. Among Continental works, I have only succeeded in meeting with the single description of a dorsal fin-ray ("second") and a fragment of a pectoral spine, from the Eocene (?) Beds of Austria,[1] in addition to a brief notice of the presence of the family in the Belgian Eocenes.[2] And from rocks of still earlier date, only one fish seems to have yet been referred to the same systematic position—the *Telepholis acrocephalus* of von der Marck, from the Upper Cretaceous of Westphalia;[3] and this determination, it must be admitted, is scarcely placed beyond all doubt.

## IV.—NOTE ON THE HORDWELL AND OTHER CROCODILIANS.

By R. LYDEKKER, B.A., F.G.S.

THE two admirable summaries of our knowledge of fossil Crocodilia recently published by Mr. A. Smith Woodward—the one relating to British forms, in this MAGAZINE,[4] and the other, comprising the whole order, in the "Proceedings of the Geologists' Association"[5]—render it a comparatively easy matter to find out what is known concerning any particular species or genus; and I may accordingly at once proceed to the proper subject of this paper.

*Hordwell Crocodiles.*—In the above memoirs Mr. Woodward[6] follows the original suggestion of Sir R. Owen—more fully confirmed by Prof. Huxley—that the Crocodilian remains from the Upper Eocene (Lower Oligocene) of Hordwell described under the names of *Alligator Hantoniensis* and *Crocodilus Hastingsiæ* belong to one and the same species. The author adopts for this species the trivial name *Hastingsiæ* (although *Hantoniensis* has the priority), and retains it in the genus *Crocodilus*; remarking, however, that it presents characters which under certain circumstances might entitle it to rank as generically distinct. Sir R. Owen, in his original description of the so-called *C. Hastingsiæ*, remarked that the skull

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[1] *Pimelodus Sadleri*, J. J. Heckel, "Beiträge zur Kentniss der fossilen Fische Oesterreicher," i. (1849), p. 15, pl. ii. fig. 3.

[2] H. Le Hon, "Préliminaires d'un Mémoire sur les Poissons Tertiaires de Belgique," 1871, p. 15.

[3] W. von der Marck, "Neue Fische und Krebse aus der Kreide von Westphalen," Palæontogr., vol. xv. p. 276, pl. xliii. figs. 6, 7; also *ib.* vol. xxxi. p. 248.

[4] *Suprà*, Vol. II. pp. 496—510 (1885).

[5] Vol. ix. No. 5 (1886).

[6] GEOL. MAG. *op. cit.* p. 509.

presented many Alligatoroid features (which are of course enhanced by the inclusion of *A. Hantoniensis* in the same species), and that it was difficult to say whether the species should really be included among the Crocodiles or the Alligators. Prof. Huxley's observations, which proved the existence of a ventral dermal armour, showed that the Hordwell Crocodilian in this respect differed decidedly from all known members of the genus *Crocodilus*; but since such an armour is present in some species of *Alligator* (including[1] *Cayman* and *Jacare*) and absent in others, this feature would not of itself necessarily exclude the species from the former genus. Professor Huxley showed, moreover, that in having the upper teeth more numerous than the lower, the species differed from *Alligator* and agreed with *Crocodilus;* while the usual presence of a notch in the skull for the reception of the fourth lower tooth is a character of the latter genus. It will suffice to mention here that the cranium is characterized by the peculiar circumstance that the premaxillæ are united superiorly, and thus separate the nasals from the anterior nares.

The reader's attention must now be directed to the genus *Diplocynodon,* which was founded by Pomel[2] upon the lower jaw of an Alligatoroid Crocodilian from the Lower Miocene (Upper Oligocene) of Allier, which presented the peculiar feature of having the third lower tooth nearly as much enlarged as the fourth—from which feature the generic name was chosen. To the type specimen Pomel applied the name *D. Rateli,* and subsequently[3] referred to the same genus the so-called *Alligator Hantoniensis.* Subsequently again H. von Meyer[4] identified with this *D. Rateli* both a Crocodilian mentioned by Bravard from Allier under the name of *Crocodilus elaverensis,* and also others from the equivalent beds of Weissenau and other places in the Mayence basin to which he had previously applied the names *C. Rathi, C. Bruchi, C. medius,* and *C. Brauniorum.* At the same time Meyer observed that this form agreed with the so-called *Crocodilus Hastingsiæ* in the peculiar relations of the pre-maxillæ and nasals; and he consequently came to the conclusion that both were very closely allied, if not specifically the same.

At a much later period M. Vaillant[5] described the Crocodilian remains from Allier and proposed for one form, in which the nasals reach the nares, the name of *Diplocynodon gracilis*; retaining that of *D. rateli* for the type mandible, which he regarded as probably distinct from his *D. gracilis.* His researches proved that *Diplocynodon* was furnished with ventral dermal armour.

In 1877 Herr Ludwig[6] described and figured the Crocodilians from the Mayence basin, and re-named the form in which the nasals did not reach the nares *Alligator Darwini* (including in that species the

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[1] I follow the views of Dr. Günther in this respect.
[2] Bull. Soc. Géol. France, ser. 2, vol. iv. p. 383 (1847).
[3] Catalogue Méthodique, p. 124 (1853).
[4] Neues Jahrbuch, 1857, p 538.
[5] Ann Sci. Géol. vol. iii. art. 1 (1872).
[6] Palæontographica, suppl. vol. iii. pt. 4.

four above-mentioned names previously applied by Meyer); while to another form, in which the nasals reach the nares, he gave the name of *Crocodilus Ebertsi.* Both forms show the enlarged third lower tooth characteristic of *Diplocynodon,* and from the equivalence of the Mayence and Allier deposits and the specific identity of many of their Mammals, the *primâ facie* presumption is that they are respectively identical with the two Allier forms.

Turning once more to the Hordwell Crocodilian, an examination of the skull figured by Owen in pl. vi. of his "Crocodilia, etc., of the London Clay" (Mon. Pal. Soc.), now in the British Museum (No. 30393), shows that it has the enlargement of the third lower tooth characteristic of *Diplocynodon*; and also that the smaller upper teeth bite on the outer side of the lower ones as in the Alligators, instead of interlocking with them as in the Crocodiles; and I therefore come to the conclusion that Pomel's reference of this species to *Diplocynodon* is correct, and consequently that it should be known as *D. Hantoniensis.* I should observe, moreover, that I think there is no doubt but that *Diplocynodon* is a valid genus, presenting the peculiar feature of the enlargement of the third lower tooth, but otherwise intermediate between *Alligator* and that group of *Crocodilus* comprising the existing Indian *C. palustris* and the fossil *C. Sivalensis.* As I shall allude more fully on a subsequent occasion to the distinctive features of the genus, I will only observe here that if it be not adopted it would be necessary to include both it and *Alligator* in *Crocodilus.*

With regard to the so-called *Alligator Darwini,* I cannot observe from the characters of the figured imperfect skulls any characters by which it can be distinguished from *D. Hantoniensis*; but since it occurs on a higher horizon it may be entitled to specific distinction, and I therefore propose that it should be provisionally known as *D. Darwini*; the specific name being adopted in preference to either of the four proposed by Von Meyer, which were never properly described or figured. With this form *D. Rateli,* Pomel, is probably also identical, but the unsatisfactory character afforded by the type renders it inadvisable to adopt this name. With regard to the so-called *Crocodilus Ebertsi* the figured cranium appears to me to show no characters by which it can be specifically distinguished from the younger type cranium of *D. gracilis* from Allier; the difference in the contour of the two being apparently merely due to the different ages of the two specimens.

It will be apparent from the above that all the so-called fossil Alligators of the Old World really belong to the genus *Diplocynodon;* and since the Crocodiles (*C. palustris* and *C. Sivalensis*) which approach nearest to this genus in the structure of the cranium and form of the maxillo-premaxillary suture on the palate are confined to India,[1] it becomes an interesting question to know whether the existing Alligator recently described from China may not show signs of affinity with *Diplocynodon.*

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[1] See Lydekker, "Palæontologia Indica" (Mem. Geol. Surv. Ind.), ser. 10, vol. iii. p. 216 (1886).

*London Clay Crocodilians.*—Having concluded what I have to say in regard to *Diplocynodon*, I may mention that a comparison of the type skulls of the so-called *Crocodilus champsoides* and *C. toliapicus*, Owen, from the London Clay, has convinced me that these forms are nothing more than young and old individuals of a single species,[1] for which we should therefore adopt the original name *C. Spenceri*, Buckland.[2] The so-called *C. Arduini*, Zigno,[3] from the Nummulitics of Verona, appears to be specifically indistinguishable from the English form.

*The Wealden genus Hylæochampsa.*—In his sixth supplement to the Reptilia of the Wealden and Purbeck (Mon. Pal. Soc. 1873), p. 1, Prof. Sir R. Owen applied the name of *Hylæochampsa* to the imperfect posterior part of the cranium of a small Crocodilian from the Wealden of Brook, which was figured in pl. v. figs. 23–25 of the preceding supplement of the same monograph. This specimen is new in the British Museum (No. R. 177), and differs from all other English Wealden Crocodilians by the extremely backward position of the posterior nares, which are situated immediately in advance of the pterygoids; and by the supratemporal fossæ being decidedly inferior in size to the orbits. It is further characterized by the orbits communicating freely with the lateral temporal fossæ[4] as in recent Crocodilia, instead of being completely shut off from them as in the *Teleosauridæ*. Now the above features being those given by M. Dollo[5] as characteristic of his so-called *Bernissartia*,[6] the type of the family *Bernissartiidæ*, from the Wealden of Belgium, it becomes necessary to consider in what respects that form differs from *Hylæochampsa*. On page 322 of his memoir M. Dollo observes that *Bernissartia* is distinguished from "*Hylæochampsa* par l'absence de tout échancrure orbito-latéro-temporale"; but as this statement is entirely erroneous,[7] the one point of distinction which he indicates is invalid. As far, indeed, as I can see, the cranium of *Hylæochampsa* appears to agree exactly not only in form, but also in size with that of *Bernissartia*, and I accordingly regard the two as specifically identical; in which opinion I have the support of my friend Mr. G. A. Boulenger, who has been good enough to compare the type specimen with M. Dollo's description and figure.[8] Under these circumstances the name *Bernissartia Fagesi* must apparently give way to that of *Hylæochampsa Vectiana*. The perfect preservation of

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[1] Analogous modifications in a still more marked degree are exhibited in the three crania of the existing long-nosed *C. intermedius* figured by Lütken in the "Vidensk. Meddell," 1884, p. 61, pl. v.

[2] Woodward, GEOL. MAG. *op. cit.* p. 508.

[3] Mem. Ac. R. Lincei, ser. 3, vol. v. p. 67, pl. i. (1880).

[4] The "échancrure orbito-latéro-temporale" of Dollo.

[5] Bull. R. Hist. Nat. Belg. vol. ii. p. 334, pl. xii. (1883).

[6] *Ibid.* p. 222.

[7] M. Dollo's statement was probably derived from Sir R. Owen's figures, but fig. 24 shows most clearly the vertical bar occurring in the middle of this vacuity; the rims of the parieto-frontal and quadrato-jugal regions having been broken away.

[8] The *onus* of proving any distinction between *Hylæochampsa* and *Bernissartia* now rests entirely with M. Dollo.

the Belgian specimens renders our knowledge of the affinities and structure of *Hylæochampsa* almost as well known as that of recent Crocodilians; and this we owe to M. Dollo's careful description.

The hinder portion of a Crocodilian skull with attached cervical vertebræ and dorsal scutes from the Wealden of Brook, preserved in the British Museum (No. 28966), appears to indicate a genus hitherto unknown in Britain. The vertebræ are amphicœlous, the scutes apparently without a peg-and-socket articulation, the orbits communicating with the lateral temporal fossæ, the posterior nares placed as in *Goniopholis*, the orbits only slightly smaller than the supratemporal fossæ, and the few remaining teeth small and slender. The whole contour of the skull is essentially Garial-like, and I have little doubt that it was produced into a rostrum. As far as I can see, it apparently agrees precisely with the skull figured in Dunker's "Mon. norddeutsch. Wealden," under the name of *Macrorhynchus Meyeri* (of which it is the type), although the palate of the latter is unfortunately not shown. Dr. Koken, who regards[1] *Macrorhynchus* as identical with *Pholidosaurus*, of the German Wealden, has, however, been good enough to send me a sketch of the palate of *Pholidosaurus Schaumburgensis*, which shows that the English specimen is generically identical with that form. The generic term *Macrorhynchus*, Dunker, which dates from 1844, is of later date than *Pholidosaurus*, and as it is preoccupied by Lacépede (1880) for a genus of Pisces, it cannot stand. Under these circumstances I propose to provisionally refer the English specimen to the second German species, which should be known as *Pholidosaurus Meyeri* (Dunker). This genus appears to bear the same relation to the existing Garials as is presented by *Goniopholis* to the Crocodiles and thus connects the former group with the typical *Teleosauridæ*; and I propose to include in the family *Goniopholididæ* all the Amphicœlian forms (*e.g. Hylæochampsa*, *Theriosuchus*, *Goniopholis*, *Petrosuchus*, and *Pholidosaurus*) in which the orbit communicates with the lateral temporal fossa; such family being divided into groups according to the position of the posterior nares, the form of the skull, and the nature of the armour; and occupying an intermediate position between the *Crocodilidæ* and the *Teleosauridæ*.

*Classification.*—In conclusion, I may observe, that since observations made subsequently to the publication of Prof. Huxley's classic memoir on the "Evolution of the Crocodilia" have tended to approximate his suborders Eusuchia and Mesosuchia, and to accentuate the distinction of the two from the Parasuchia, it appears inadvisable to continue to divide the Crocodilia into these three groups, which are certainly not of equivalent value; and I accordingly think it would be preferable, while retaining the suborder Parasuchia for those extremely generalized Crocodilians which show many points of kinship to other orders, to unite the other two groups in a single suborder which might be termed Crocodilia Vera. For the two sub-

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[1] Zeitschr. deutsch Geol. Ger. vol. xxxv. p. 824, note (1883). The suggestion here made that the vertebræ are procœlous has proved unfounded.

divisions of the latter, since it would perhaps be inadvisable to retain the names Eusuchia and Mesosuchia in a minor sense to their original usage, and as it is in many cases important to have a classification not depending solely upon cranial characters, I would adopt the earlier Owenian names to form a Procœlian and an Amphicœlian series. The former series would be characterized by the possession of procœlous vertebræ, and at least usually by the union of the pterygoids in a palatal plate below the narial canal. I add the saving clause in the last paragraph because it is highly probable that in some of the procœlous Crocodilia of the Cretaceous the pterygoids did not unite inferiorly.

The following table gives the grouping of the families under this scheme; the definition of the various groups being reserved for a future occasion.

Order CROCODILIA.
- *A.* Suborder CROCODILIA VERA.
  - *a.* Procœlian series.
    - *Crocodilidæ.*
  - *b.* Amphicœlian series.
    - *Goniopholididæ.*
    - *Teleosauridæ.*
- *B.* Suborder PARASUCHIA.
  - *Belodontidæ.*
  - *Parasuchidæ.*
  - *Stagonolepididæ.*

P.S.—Since the above was in type I have received a memoir by Dr. Koken on the Crocodilia of the German Wealden (Paläontologische Abhandlungen, vol. iii. pt. 5, 1887), in which the skull of *Pholidosaurus* (*Macrorhynchus*) is figured. In this memoir the author has proposed precisely the same classification as that given above, although he adopts one or two more families, and has not proposed a name for the first suborder.

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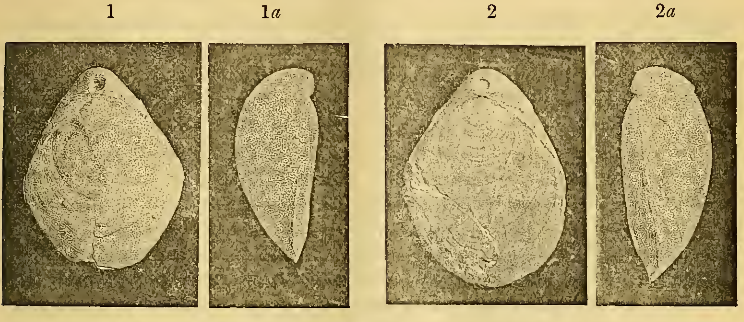
## V.—ON A TEREBRATULA FROM THE UPPER CHALK OF SALISBURY.

By E. WESTLAKE, F.G.S.

THE two specimens figured below are from the collection of Mr. C. J. Read, of Salisbury, who obtained them from the Upper Chalk (Senonian) of the neighbourhood. Some uncertainty has attached to the exact locality, Mr. Read having told me that he had found them in the *Mucronata*-Chalk of Clarendon; but he now writes, 18th Jan. 1887—"My belief, on thinking the matter over, is that the right locality is the 'Devizes Road,' as they were originally marked." The locality referred to is Old Camp Down lime-pit, three miles N.W. of Salisbury on the Devizes Road. This pit is characterized by an abundance of *Micraster coranguinum* and *Echinoconus conicus*; but *Terebratula semiglobosa*, Sow., usually present in this zone, does not occur, and the only Terebratulæ we have found there are the two specimens figured. As the pit is seldom worked and we have no prospect of obtaining others, it has seemed best to describe them.

Mr. Thos. Davidson, who examined them, wrote to me, 28th Feb. 1884—"These specimens are peculiar and puzzle me. They are not *T. carnea*, nor *T. semiglobosa*, and I am uncertain as to their proper identification. They approach most in shape to some specimens of *Ter. semiglobosa*, but I would not like to refer them to that species. They almost look to me a new species."



*Terebratula obesa*, Sowerby, var. *cuneata*.

Enlarged about nine-tenths natural size. The figures are photo-facsimiles. The fine surface-marking is due to the process employed (Dallastint).

DIMENSIONS—FIG. 1. length 23·9, width 19·1, depth 10·2, foramen 1·6 mm.
FIG. 2. ,, 26·2, ,, 19·8, ,, 11·2, ,, 1·6 ,,

Shell obtusely pentagonal, elongated, depressed, slender and thin; dorsal valve nearly flat; beak projects ·8 mm. in front of the deltidium, stands off from the dorsal valve ·5 mm., and is obliquely truncated by a circular edged foramen 1·6 mm. in diameter. The pieces of the deltidium are about ·5 mm. in width. Front margin very slightly undulated.

In the British Museum are twelve specimens of "*Terebratula obesa*, Sow., from Greenhithe," (B. M. 20289) identical with the above, excepting that the dorsal valves of the B. M. specimens are rather more convex. The Chalk of Greenhithe contains *M. coranguinum* and *Echinoconus conicus*. From this zone in Hampshire I have about a thousand Terebratulæ, all of which, however, are referable to *T. semiglobosa* or *T. carnea*. I have not yet met with *T. obesa* in the Hampshire Basin.

*Affinities and Differences.*—Their large foramen and flattened dorsal valve include them in the *Ter. biplicata* group, which is represented in the Middle and Upper Chalk by *T. obesa*. With this species, and more especially with the large form from the Norwich Chalk, the specimens figured agree in most respects. They differ chiefly in their flatter dorsal valve and in the absence of lateral plaits, both of which may be characters of young shells. On the other hand, the same form having occurred elsewhere on the same horizon, it may be convenient to distinguish them as a variety. They differ from *T. Ciplyensis*, von Hanstein, by their thiner shell, flatter dorsal valve, more recurved beak, and smaller foramen.

## REVIEWS.

### I.—The Geology of England and Wales. By Horace B. Woodward, F.G.S., of the Geological Survey of England and Wales. Second Edition, pp. 670, with Geological Map and 103 Illustrations. (London: George Philip & Son, 1887.)

MORE than ten years have elapsed, as the author reminds us, since the first edition of this work was published. During the interval a considerable amount of new material had accumulated, so that the geological public were quite prepared for the revision of the original work which had been so fully appreciated that it was already well nigh out of print. A comparison of the two editions may be said to afford an outline of the progress of geology during the last decade in the Old Country, which still continues to furnish useful matter to investigators, notwithstanding the more colossal features of continental and trans-European areas, which have lately been brought to light. "The original plan of the book has not been altered, but the volume has attained a larger size, owing to the many additions necessary to do justice to the subject. Nor is this increase surprising when it is remembered that, sixty-five years ago, the excellent and in great measure original 'Outlines of the Geology of England and Wales,' by Conybeare and Phillips, filled 531 pages; and only the first part of that work was published. The aim of the present work is to afford a book of reference, useful not only to students of the scientific aspect of the subject, but also to engineers and others in its practical applications."

On the question of Nomenclature and Classification Mr. Woodward observes that, in the absence of a definite scheme formulated on the part of the International Geological Commission, the classification in the previous edition has been in the main retained. "As before, alternative groupings are stated, and, wherever possible, old and well-established names of formations are employed, while the synonyms are also mentioned. Numerous tables are given with the view of explaining more clearly the relations of the various divisions of the stratified rocks. An attempt has been made to give some historical value to the work by indicating the labours of the many geologists to whose observations our present knowledge is due." He also alludes to the assistance rendered by many of the leading geologists of the day; and expresses his indebtedness to the Councils of the Geological Society and the Geologists' Association, as also to the Editor of the Geological Magazine in the matter of reproducing illustrations. These have been further supplemented by some effective etchings by Mr. Alfred Dawson of scenery in the Isle of Purbeck, which seem to take the place of the woodcuts of the previous edition borrowed from Mackintosh's "Scenery of England and Wales." Thus we lose the illustration of the action of atmospheric disintegration afforded by the Millstone Grit of Brimham rocks (1st ed. p. 90), to have it replaced by an etching of the Agglestone near Studland, an isolated remnant of Lower Bagshot beds, locally hardened, which tells the same story (2nd ed. p. 607).

This is a book without chapters. The Introduction contains a few pages explanatory of the principles of geology, with a brief history of English geologic research. There is a very neat section across England and Wales about the parallel of Lincoln, which shows the outcrop of the Coal-measures in three distinct Coal-fields, together with their relations to the Lower Palæozoics of Wales and to the Lower Carboniferous of the Pennine anticlinal.

Part I. is devoted to the PALÆOZOIC, which is made to include the Archæan, the term now adopted instead of the Lewisian, or Laurentian, of the previous edition. So much has been done during the last ten years below the region of ascertained life that this portion of the second edition is altogether new. "The determination of the Archæan rocks in England and Wales is mainly due to the researches of Dr. H. Hicks, Prof. T. McK. Hughes, Dr. C. Callaway, and Prof. T. G. Bonney." As some portions of the evidence have been controverted by Dr. A. Geikie, the author proceeds to point out the differences of opinion which have been expressed on this most disputed subject, more especially in Pembrokeshire. "These differences in the interpretation of this ancient 'Geological Record' are serious, but perhaps not quite so serious as they at first appear. It is admitted that the rocks termed Pebidian underlie the oldest fossiliferous Cambrian strata, and rest on the rocks termed Arvonian. The relative position and origin of the Dimetian granitoid rock are the main points in question. It may be mentioned, however, that in other areas, where Archæan rocks have been identified, two main divisions are recognized, one of coarsely crystalline rocks (Dimetian), and the other of eruptive rocks (Pebidian)."

The readers of the first edition of Mr. Woodward's Geology of England and Wales will bear in mind that he fully identified himself with the Sedgwickian view of the classification of the Lower Palæozoic rocks. Hence, for him, the Cambrian system includes everything to the very top of the Bala beds. According to this arrangement his Middle Cambrian consists of the Tremadoc Slates and Lingula Flags: and further on he says, "The Middle Cambrian rocks introduce many forms of Graptolites." This is not exactly the case. The point perhaps is not one of much importance; but when we bear in mind the great change in life-forms which occurs between the Tremadoc series and the Arenig series, we must confess that the Sedgwickian is apt to minimize this biological hiatus, just as the opposite side desires to minimize the local unconformity in connection with the Llandovery series.

The correlation of the Lake-district rocks with those of Wales is very fully treated. We miss the section by Harkness at the foot of the Cross Fell range; but on the other hand there is an interesting generalized section across the Lake-district by Goodchild. Speaking generally, however, the junction line of the Skiddaws and the Volcanics should be somewhat more excavated than is there represented.

The Old Red Sandstone and Devonian, and the question of their relations to each other, are ably treated by the author, whose personal experience in surveying some of these districts lends additional weight to his conclusions. "The relations between the Old Red Sandstone and the underlying Silurian and overlying Carboniferous rocks have been long since established. In both instances a perfect conformity exists. But only in recent years has it been fully realized that there is a great unconformity between the Upper and Lower Old Red Sandstone." In the Devonshire area there is a conformable sequence in the strata, and the Middle Devonian (marine) bridges over the interval between the Upper and Lower Old Red Sandstone in Wales, etc. In Scotland also, as pointed out by Dr. Geikie, the Old Red Sandstone must be placed in two divisions with a complete discordance between the two, the lower passing conformably into the Silurian, the Upper graduating into the Carboniferous. In the district of the Cheviot Hills, however, owing to the accumulation of volcanic material, a marked discordance is shown in Mr. Goodchild's section (fig. 16) between the "Cheviot Series" (Lower Old Red Sandstone) and the underlying Silurian, but this is evidently an exception.

When a system is thus weakened by internal discordance, whilst its extremities exhibit a disposition to amalgamate with their respective neighbours, a period of annexation seems to be at hand. At present the fossiliferous Devonian maintains a firm front against all comers, though there are not wanting geologists who would hand it over to the Silurian by way of compensation for the loss of the Ordovician rocks.

Grouping the Upper Old Red Sandstone with the Carboniferous System, the latter is held to comprise the following formations:—

| | | |
|---|---|---|
| Upper Carboniferous. | Coal Measures. | |
| | Millstone Grit. | |
| Lower Carboniferous. | Upper Limestone Shales and Yoredale Rocks. | Bernician and Calciferous Sandstone Series. |
| | Carboniferous and Mountain Limestone. | |
| | Lower Limestone Shales and Tuedian Beds. | |
| | Basement Conglomerate and Upper Old Red Sandstone. | |

Nearly sixty pages are devoted to this most important system, and there are nearly a dozen sections, by way of illustration, from various authors. To begin with, there is a very effective section by J. W. Davis, showing the separation of the Yorkshire from the Lancashire Coal-fields by means of the Pennine anticlinal. The various "edges" of the Millstone Grit on the Yorkshire side are particularly well brought out. This originally appeared in the Geol. Mag. (1878, p. 504) in a paper on the Valley of the Calder. The following sections also occur:—Draughton Quarry near Skipton (Dr. C. Ricketts), to show contortions in the Carboniferous Limestone; across the Eglwyseg Rocks, Denbighshire (Prof. A. H. Green), to show an ascending sequence; across part of Charnwood Forest (Prof. E. Hull), to show Carboniferous strata lying on the edge of the older rocks; across the Mendips (H. B. W.), to show position of the Carboniferous rocks on either side of the anticlinal; across Ingleborough (J. G. Goodchild), to show relations of the Carboniferous beds to the "Cambrian" rocks, and how they are affected by the Craven faults: from Durdham Down to the City of Bristol (R. Etheridge), to show the relations of the Carboniferous Limestone, Millstone Grit and Coal-measures to the Mesozoic rocks; ideal section across the S.W. extremity of the Pendle Range (Prof. E. Hull), showing, *inter alia*, the position of the Wigan Coal-field: southern side of the South Wales Coal-field (Sir W. E. Logan): generalized section from Dartmoor to Great Haldon (H. B. W.), to show the position of the Culm Measures.

Lastly, the author devotes a few pages to the possible existence of the Coal-measures in the East and South-East of England. Figure 31 is an interesting diagram, which shows the probable curvatures of the Palæozoic beds beneath the Mesozoic rocks; but, since the undoubted discovery of the Great Oolite beneath London and Richmond, that portion of the diagram may require some reconsideration.

Amongst the economic products, he fails to give an account of the celebrated Harrogate waters, but at p. 539, under the head Mineral Springs, we find the sulphuretted springs of Harrogate duly recorded as issuing from a deep source along an anticlinal axis of the Carboniferous rocks.

PART II. MESOZOIC.—The Permian rocks are grouped along with the Trias under the general title of New Red Sandstone. Doubtless there are some advantages in this arrangement, but it does seem strange to find, for instance, the Magnesian Limstone of Durham with its rich store of Palæozoic fossils being classified under this heading. That the Permian, in England, should be placed with the Secondary rather than with the Palæozoic rocks is reasonable; since there seems to have been considerable identity of physical conditions throughout the Permio-Triassic period. This indeed was one of revolution and decay, during which, but for the most part in other areas, the elements of the World's Middle Life were being slowly evolved. As a matter of fact the author's New Red Sandstone, or Poikilitic (Conybeare), to a certain extent stands alone, although biologically its lower division inclines to the Palæozoic and its Upper to the Mesozoic. The Rhætic or Penarth beds are also included here.

Mr. Woodward divides the Jurassic into Lias and Oolitic, and with the latter he includes the beds originally called by Mr. William Smith "The Sand of the Inferior Oolite." In adopting Phillips' name of "Midford Sands" for this group, we are not sure that the author is on very safe ground. What is the evidence that the Sands of Midford represent the zones of *Am. opalinus* and of *Am. Jurensis*? At this village the *Parkinsoni*-zone is seen to rest directly on certain sands of the Inferior Oolite. If the Cephalopoda-bed of the Cotteswolds occurs immediately below the junction, the name holds good; otherwise the age of the upper part of the sand is uncertain.

Nearly 100 pages are devoted to the Jurassic rocks, which have lately enjoyed a special share of the author's attention, and sections are given by himself, Sir A. Ramsay, Messrs. Dalton, Topley, Sharp, Hudleston, Blake, Damon, Weston, and Bristow. The table on p. 286, showing the subdivisions of the Lower Oolitic rocks, may not meet the views of every geologist; but at any rate it grapples with a very difficult piece of correlation throughout this variable series in different parts of England. The Middle and Upper Oolitic beds are also very fully treated.

The Cretaceous occupy rather over 70 pages, and include sections by the author, Messrs. Topley, Bristow, Prestwich, Whitaker, Strahan, Hughes, and Dowker. The following are the divisions adopted:

| | | |
|---|---|---|
| Upper Cretaceous | Chalk<br>Upper Greensand<br>Gault | |
| Lower Cretaceous | Lower Greensand<br>Wealden Beds | Neocomian of some Authors |

It is almost unnecessary to add that both as regards lithology and palæontology this system is most thoroughly dealt with; the researches of Dr. Hinde meet with frequent mention, and in addition to the names already quoted in this connection we find those of Messrs. Price, Meyer, Penning, Jukes-Browne, Barrois, and many others. As regards the Chalk itself there is a table (pp. 402, 403) showing the distribution of life zones in Yorkshire, Norfolk, Cambridgeshire, Bedfordshire, Surrey, Kent, and the Isle of Wight. The determination of these zones is due, he says, to the researches of Prof. Hébert and Mr. Caleb Evans, and particularly of Dr. C. Barrois. These have been followed out in various parts of England by several geologists. "But Mr. Whitaker has remarked that although they are very valuable when applied to particular sections, yet their application to great inland stretches of country without continuous sections, and when the structure of the deposits could be seen only in occasional pits, was by no means safe." As a surveyor, always on the look out for a feature, Mr. Whitaker prefers lithological divisions such as the Chalk Rock, the Melbourn Rock, and the Totternhoe Stone, which themselves appear to mark certain zones for a considerable distance.

Part III. Cœnozoic.—This is divided into Tertiary and Quaternary. The Tertiary rocks include all, from the Thanet Sands to the Cromer Forest Bed inclusive, and are illustrated by sections from the author and Messrs. Whitaker, Bristow, Holmes, and Prestwich. The Quaternary he divides into Pleistocene and Recent. "The Pleistocene period, so named by Lyell in 1830, includes Terrestrial, Alluvial, Estuarine, Marine, and Glacial accumulations; and the organic remains found in certain Caverns and River-deposits, being associated with relics of Palæolithic Man, these deposits are sometimes regarded as of Palæolithic age." Then follows a list of the Mammalia characteristic of the Pleistocene Beds such as *Ovibos moschatus*, *Bison priscus*, etc. The Glacial Beds are illustrated by sections from the author, Sir A. Ramsay, and Messrs. De Rance, Mellard Reade, Ussher, Searles Wood, Lamplugh, Jukes-Browne, Clement Reid, Rev. O. Fisher, whilst illustrations of the Victoria Cave and of the Coygan Cave are borrowed from the works of Messrs. Tiddeman and Hicks respectively.

Under the head of Recent, besides the various deposits of Modern Age, he partly includes the Cave deposits, and under the subdivision Terrestrial Phenomena, refers to Springs, Swallow Holes, Tufa, Blown Sands, and Soils; and under the subdivision Marine Deposits, to Sea Beaches and Raised Beaches.

There is a supplementary section on Eruptive and Metamorphic Rocks, in which he refers to the progress in their study of late, particularly alluding to the works of Allport, Forbes, Sorby, Phillips, Rutley, Clifton Ward, Bonney, Davies, Teall, and Cole. A very useful, condensed account of these rocks has been furnished by Mr. Rutley. A "chapter" on Mineral Veins and Metalliferous Deposits, and one on Denudation and Scenery, complete the work. Appendix No. 1 records some of the more important well-sinkings and borings in England and Wales; and Appendix No. 2 gives a Synopsis of the Animal Kingdom by Mr. E. T. Newton. There is a very copious index—a matter of considerable importance in a work so comprehensive and so full of references.

A geological map 24 in. × 19·5 in. accompanies the volume. It is no longer attempted, as in the map of the previous edition, to show the East Anglian Boulder-clay and Gravels. The colours are less vivid than in the old map, and more in accordance with established usage. By colouring all the Cretaceous beds below the Gault as one, the difficulty of deciding which is Wealden and which Lower Greensand is avoided. In the same way by colouring the Trias and Permian as one, not only is the definition of their boundary avoided, but their general relations to the Carboniferous rocks of the great Pennine *massif* is made exceedingly clear and effective. We regret that the South Yorkshire Coal-field, the least exhausted in Britain, has not been differentiated from the Millstone Grit; but this is one of those accidents in printing which are apt to befall the most careful.[1] The two great volcanic areas of the Cheviot and of the Lake-district are well shown, and the chartographer judiciously colours the Archæan and Metamorphic alike. The map bears the name of Mr. Goodchild, and does him much credit.

The entire work must be regarded as a most complete compendium of English geology. The author has brought to bear upon his task an assiduity in labour and an impartiality in judgment alike remarkable. To these qualifications he adds a grasp of the subject, which years of experience in the field and in the study could alone produce. Not only is the information conveyed of the greatest utility and interest to every student of English geology, but whosoever wishes to pursue any particular subject further may obtain in this book many of the references required. Bearing in mind the enormous and varied mass of material thus sifted, it is not surprising that the publication has been a little delayed. The artist (p. 24) shows how blithely the field geologist may set

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[1] We are informed that this omission has been corrected in the later-issued copies. —EDIT.

about his task; but ere the consummation is reached (p. 670), ere those innumerable volumes have been consulted and annotated, the work seems to have told its tale. At the same time we hope that the author may survive to give us a third edition in due course.

W. H. H.

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### II.—GEOLOGIE DU DÉPARTMENT DE LA SARTHE. Par ALBERT GUILLIER. 4to pp. xii. and 430, with numerous Woodcuts. Published at Le Mans and Paris, 1886. Price 16 francs.

THIS monograph is published by the local authorities of the Department, and is intended as an explanation of the Geological Map of the Department, which is founded on the work of M. Triger, An Agricultural Map is also published by the same authority, and notes on the soils produced by the various rocks are given in this volume.

All this is very creditable to the local government, and one wonders if we shall ever have a similar county government in England, viz. councils by which local county affairs might be managed and from which scientific knowledge might be disseminated. During the last few years the Geological Survey has issued many descriptive memoirs, at reasonable prices, which contain much useful information, but neither the maps nor the explanations of the Survey are so well known throughout the country as they ought to be, because no steps are taken to make people in the country aware of their existence.

The Department of the Sarthe has a varied geological structure, for it possesses representatives of the following systems;—

9. Quaternary.
8. Eocene and Miocene.
7. Upper Cretaceous.
6. Jurassic.
5. Carboniferous.
4. Lower Devonian.
3. Upper Silurian.
2. Lower Silurian.
1. Cambrian (or Archæan).

Full descriptions are given of the rocks and their stratgraphical relations, with lists of the fossils found in them. There are also diagrammatic sections, but we wish that the vertical scale of these had not been so greatly exaggerated; this is a fault which the French are only slowly learning to correct.

In his first chapter M. Guillier refers to the Murchison and Sedgwick controversy, but he has hardly grasped the details of the Cambrian question, and seems to think that Murchison had independently given the name of Cambrian to rocks that were older than his Lower Silurian. He therefore applies the term Cambrian to rocks which are older than Barrande's Primordial Silurian; but these in modern nomenclature are the Pre-Cambrian or Archæan rocks. The strata actually referred to are the Phyllades de St. Lo and the Ardoises de Parennes, and it so happens that Prof. Hebert and Dr. Ch. Barrois are now at variance on the very question of whether these Phyllades should be referred to the Archæan or to the Cambrian. M. Guillier's view is that recently advocated by Prof. Hebert, though it would not appear so from his nomenclature.

Under the head of Primordial Silurian he ranges a series of schists and flaggy beds with bands of dolomite, which are stated to occur in certain localities between the Phyllades and the Grès Armoricain; but the only fossil hitherto found is a *Lingula* which Dr. Davidson identified with *L. crumena,* and this same Lingula is found in the overlying series.

The representatives of the Lower Silurian (Ordovician) are the following:—

3. White sandstones without fossils (? Grès du May).
2. Shales with *Calymene Tristani.*
1. The Armorican sandstone and red shales.

The two lower stages are probably of Arenig age, No. 2, containing also *Calymene arago, Asaphus nobilis, Illænus giganteus, Placoparia Tournemmei,* and *Cheirurus Guillieri.*

The beds of true Silurian age are (1) Sandstones and Carbonaceous Shales with *Graptolithus colonus*; (2) Shales with *Cardiola interrupta.* We may notice that neither here nor in treating of the other Palæozoic groups are any estimates of their thicknesses given.

Of the Devonian system only the lower portion is found, and this consists of (1) Sandstone; (2) Shales; (3) Limestone, the last being rich in fossils.

A great break then supervenes, neither Middle nor Upper Devonian nor the lowest part of the Carboniferous being represented. The Devonian Limestone is succeeded by a series of sandstones and shales which include beds of workable anthracite and a band of limestone containing *Producta gigantea*—a series which is referable to the upper part of our Carboniferous Limestone. No true Coal-measures occur nor any strata of Permian or Triassic age.

The succeeding beds are Jurassic and belong to the Middle Lias (limestone with *Pecten equivalvis,* 18 feet) and to the Upper Lias (marls and limestones with *Am. bifrons* and *Am. serpentinus,* thickness 24 feet).

The Oolitic series is well represented, as shown by the following tabular view:—

| | |
|---|---|
| KIMERIDGIEN. | Limestone with *Astarte minima.* |
| CORALLIEN. | Sandstone with *Trigonia.*<br>Oolitic Limestone.<br>Ferruginous sands. |
| OXFORDIEN. | Clay and Limestone of Aubigné.<br>Clay and Limestone of La Vacherie. |
| CALLOVIEN. | Ferruginous Limestone with *Am. coronatus.*<br>Clay and Limestone with *Am. macrocephalus.* |
| BATHONIEN. | Montlivaltia Limestone.<br>Marls with *Terebratula cardium.*<br>Oolite of Mamers.<br>Lithographic Limestone.<br>Oolite with *Rhynch. spinosa.* |
| BAJOCIEN. | Oolite with *Am. Parkinsoni.*<br>Oolites with *Ter. perovalis.* |

The Cretaceous rocks of Sarthe possess a peculiar interest because they include the type of D'Orbigny's Cenomanien stage; the beds composing this stage are evidently shore deposits of the Cenomanien sea and beds of sand with *Rhynchonella compressa, Terebratella*

*Menardi*, and *Ammonites navicularis* occur near the top of the division, showing that these species continued to exist along the shores throughout the Cenomanien stage. The local succession, however, is just as clear as our own, and according to M. Guillier the arenaceous beds pass laterally into the ordinary chalky facies or Normandy type, the parallelism being as follows:—

| | |
|---|---|
| 6. Marne à *Ostrea biauriculata.* | Craie à *Bel. plena.* |
| 5. Sables à *Rhynch. compressa.* | |
| 4. Sables et grès du Mans passing into Craie de Theligny, both with *Turrilites costatus.* | Craie de Rouen. |
| 3. Sable à *Perna lanceolata.* | |
| 2. Craie et argile glauconieuse à *Pecten asper.* | |
| 1. Glauconie à *Ostrea vesiculosa* = Gaize des Ardennes. | |

In this he differs from Prof. Hebert, who does not admit the synchronism of the Grès du Maine and the Craie de Rouen. He also differs from the same authority in regarding the Cenomanien as succeeded conformably by the Turonien, which is divisible into three zones.

3. Craie à *Terebratella Bourgeoisii.*
2. Craie à *Inoceramus problematicus* (*mytiloides*).
1. Craie à *Terebratella Carentonensis.*

These are succeeded by Chalk with *Spondylus truncatus*, which is classed as Senonien.

At the base of the Eocene are placed certain sands and clays with flints, but English geologists would probably doubt the evidence of stratigraphical succession and the propriety of classing them as Eocene. The true Eocene strata are as follows:—

4. Clay of La Bosse.
3. Freshwater Limestone of St. Aubin.
2. Sands with Sabalites.
1. Conglomerates.

The conglomerates and sands are correlated with our Middle Bagshots and the limestone with the upper part of the Calcaire Grossier (Bracklesham).

A small area of Faluns (Miocene) comes into the Department. Lastly the so-called Quaternary deposits are described, and there are short chapters on Metamorphic and Eruptive Rocks, on Building Stones, and Mineral Waters, while a Bibliography and Index complete the volume.

We regret to find that the author died before its publication, so that the revision of the latter part was performed by one of his pupils.

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## III.—THE GEOLOGICAL AND NATURAL-HISTORY SURVEY OF MINNESOTA.

The Thirteenth Annual Report, for 1884, pp. 196; the Fourteenth Annual Report, for 1885, pp. 353, 8vo. (St. Paul's, 1885 and 1886.)

WITH the exception of some valuable information to farmers and others as to Insects injurious to the Cabbage, by O. W. Oestlund, some Notes on the Mammals of Big-Stone Lake, by C. L. Herrick, and a paper on Minnesota Geographical Names derived from the Dakota Language, by Prof. A. W. Williamson, the whole of the Thirteenth Report is devoted to Geology. After a few notes on reconnoitering trips into Pope County, and to Vermilion Lake, we come to a paper on the Vermilion Iron-ores of Minnesota. Full details are given of the various mines, with a table showing that in ten years the gross product of metal has been 6,831,285 tons. Some important analyses of the hard hæmatites are given. The crystalline rocks of Minnesota, which appear to consist of gneisses and "soft red granites," are treated of at pp. 36–38. Information as to the Humboldt Salt Well in Kittson Co. is given, with details of a boring to a depth of 644 feet; "it remains for the future to determine whether these salt-deposits shall become economically of importance to the North-west." Details of other wells are given, bored apparently for fresh water, one reaching a depth of 1800 feet (p. 54), and a second 1160 feet (p. 57). The geological formations through which these two wells pass are not given, but the latter begins about 90 feet below the top of the St. Lawrence limestone. Two interesting finds are those of *Lingula Calumet* and *Paradoxides Barberi*, in the blood-red catlinite of the Great Pipestone Quarry in Pipestone Co., a rock of Huronian age (pp. 65—72). Figures of these interesting but rather obscure organisms are given in plate i. A catalogue of the specimens registered in the General Museum in 1884 occupies nine closely-printed pages and contains many interesting specimens of local and other rocks. Mr. Warren Upham (pp. 88—97) gives some notes on the geology of Minnehaha Co., Dakota, where Potsdam quartzite seems to predominate. Professor H. W. Winchell's valuable paper on "The Crystalline Rocks of the North-west" (pp. 124—140), read before the American Association in 1884, is here printed. The peat, clay, and "Cretaceous" leaves of Blue-earth Co. are noticed; and a fossil Elephant tooth, from Winona Co., is described and figured (pl. ii.) as being probably *E. primigenius*. The glacial deposits receive a due share of attention. Dr. G. M. Dawson has a paper on the microscopic structure of some Boulder-clays, and the organisms found in them (pp. 150—163). He seems to have recognized certain minute bodies as Annelid jaws, and compares them with those described by Dr. Hinde in the Silurian and Devonian Rocks of Canada. Foraminifera are also abundant, and a special paper by Messrs A. Woodward and B. W. Thomas on some specimens from the Boulder-clay of Meeker Co. is given at pp. 164—177. These fossils were found in fragments of shale derived from the Cretaceous beds of Pembina Mountain, in Manitoba, whence Dr. G. M. Dawson obtained similar specimens. Two plates are given (pl. iii. and iv.), but they are unfortunately very inferior to the plates usually seen in American Governmental Reports.

The first paper with which we are concerned in the Fourteenth Report is on some deep wells in Minnesota, by N. H. Winchell, with an appendix at p. 348. The second is by E. O. Ulrich on Lower Silurian Bryozoa (pp. 57–103), mostly obtained from the Trenton Shales. A list of 92 species is given, and of these about 50 are described, but not figured. The Survey, however, proposes to publish a monograph of the Silurian Polyzoa before long. Mr. Ulrich also contributes a paper on Crinoidea, and describes three new genera, *Cremacrinus, Deltacrinus,* and *Halysiocrinus* (pp. 104–113). The list of specimens acquired by the Museum in 1885 fills ten pages, and shows, we should imagine, a very satisfactory state of things. Some new fossils are described at pp. 313–318 (pl. i. and ii.), by Prof. Winchell, one of them being a specimen of the peculiar form, *Cryptozoon,* described recently by Prof. James Hall. Mr. Winchell also writes upon a peculiar ore and the Cambrian rocks of the State of Minnesota (pp. 319–337). The most bulky contribution to this Report is "The Bibliography of the Foraminifera," by Prof. Anthony Woodward (pp. 167–312). His work having been anticipated by Mr. H. B. Brady's bibliography in the "Challenger" Report, so well known to workers on the subject, Prof. Woodward has rearranged the results of his own work with the materials of the published list, and has given it in alphabetical order in groups under countries. His work, though, as he truly says, incomplete, is useful; but unfortunately it is marred by very numerous typographical and bibliographic errors. The page and a half of *errata* for the list stop hopelessly at seventy pages from its end. Such errors as occur unnoticed in the references will prove serious hindrances to the utility of his work. Instances taken at random,—such as duplicate entries and wrong dates given with Dawson, at p. 180; with Jones at pp. 184 and 202, and with Ehrenberg at pp. 193 and 194; errors at p. 271, "Bisherigebnisseder Tiefbohrung," etc.; p. 252, Tregnem; p. 245, Milne-Ewards; p. 286, Summersetshire, etc., make the reader regret that so useful a work should have been printed without correction. *Eozoon* has a separate bibliography; and *Receptaculites* is included in the general list.

Besides a few pages of matter relating to geological and chemical research not mentioned above, there is Mr. O. W. Oestlund's "List of the Aphididæ of Minnesota, with descriptions of some new species" (pp. 17–56), unfortunately without figures; also Conchological Notes, by U. S. Grant (pp. 114–124). T. R. J.

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## IV.—Physical Geology of West British Garwhal, with Notes on a Route Traverse through Jaunsar Bawar, and Tiri-Garwhal. By C. S. Middlemiss, B.A. Records of the Geological Survey of India, vol. xx. Part i. 1887, pp. 26–40, with 2 maps and plates of sections.

THE second and most important part of this memoir deals with the geological structure of a tract situated 120 miles N.E. of Delhi, and bordered on the N. and S. by the Sub-Himalayan boundary and the Nyar river, and E. and W. by the Ganges at Hardwar and Ghungti mountain. It is illustrated by a small-scale map of the whole area and its N.W. corner by one on the one-inch scale. In the district are found Tertiary strata (Nummulitic and Sub-Himalayan), Mesozoic grits and impure limestones, both fossiliferous; massive unfossiliferous limestones, purple slates and volcanic breccia, and a schistose series, all of uncertain age. Mr. Middlemiss designated the oval tract of schistose rocks running N.W. and S.E. as the *Inner Formation*, and the oval rings of the other formations which sweep round it the *Outer Formations*. He finds that the outer formations at every point dip into and under the central tract, and that the schistose rocks themselves are arranged in an elongated quaquaversal so as to complete the appearance of a synclinal whose highest rocks are the schists. That the whole area is not inverted is proved by the constant sequence of the fossiliferous horizons (Mesozoic below Nummulitic), and as these are in their proper place, the massive limestone and volcanic series are pretty certainly in their right order beneath. What then is the true place of the schists? At some spots Mesozoic beds dip directly beneath the schists, but at others the Nummulitic intervenes and is found actually in contact with schists and quartzites "without any semblance of what can be called a transition rock." "To satisfy a condition of this kind the most glaring case of selective metamorphism would be totally inadequate;" and therefore the whole set of outer formations must be younger than the inner formations. The author then urges that the constant infraposition of the outer formations must be more than a coincidence, indeed a necessary concomitant of the Post-Nummulitic mountain building of the Himalayas, in which the rocks were compelled to take up less horizontal room by sigmoidal-flexure and over-faulting;—it is the story of the Highlands told in a new country. The Scotch work of Lapworth and the Alpine work of Heim are bearing good fruit in India, and we may be sure the Himalayas will do their share in elucidating the principles of mountain structure and earth-movement.

W. W. W.

## V.—The Essex Field Club.

AMONG the most enterprising of our local scientific societies is the Essex Field Club. Like the Cumberland Association, its aim is to record facts of local importance; but its publications, while illustrating the Natural History, Geology, and Pre-historic Archæology of Essex, include some essays and memoirs of much wider interest. In 1885 the first of a series of special memoirs was published, and this, the work of Prof. Meldola and Mr. William White, was a Report on the East Anglian Earthquake of April 22nd, 1884. It contains a list of British Earthquakes which have caused structural damage, and full particulars of the last important earthquake which originated beneath the surface of Essex, and was attended by so much damage to buildings. The report should be in the hands of all those interested in Earthquakes; it is a model upon which other reports might be based, and furnishes many suggestions on what to observe in connection with the catastrophes. Of great interest also is the Presidential Address delivered by Mr. T. V. Holmes at the annual meeting of the Club in 1886; it deals with British Ethnology, being a review of the evidence of characteristics and race-affinities of the various settlers in the British Islands, and the extent of their probable survival at the present day.

The Council of the Essex Field Club have resolved now to issue their "Transactions" and "Proceedings" combined in the form of a monthly periodical under the name of the "Essex Naturalist." This periodical should command an extensive circulation, for it includes many short notes of interest connected with the county, as well as papers read before the club; among the illustrations is a reproduction of Norden's Map of Essex, printed in 1594.

### VI.—Transactions of the Leeds Geological Association.

THIS Geological Association, which has been established twelve years, commenced in 1885 the publication of its Transactions. The first part contained the papers read during the sessions 1883–85, and the second part (just received) contains the record of the Proceedings during 1885–86. The papers are printed only in abstract, and they include the Inaugural Address of the President, Mr. C. D. Hardcastle, on the Geology of Ingleton and the neighbourhood; an account of Recent Discoveries of Carboniferous Vegetation in Yorkshire, by the Hon. Secretary, Mr. S. A. Adamson; notes on the Drift of the North of England by Prof. Green: and various other papers. There are also reports of Field Excursions, which contain information of much local interest.

## REPORTS AND PROCEEDINGS.

### Geological Society of London.

I.—May 25, 1887.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Remains of Fishes from the Keuper of Warwick and Nottingham." By E. T. Newton, Esq., F.G.S.; with Notes on their Mode of Occurrence by the Rev. P. B. Brodie, M.A., F.G.S., and E. Wilson, Esq., F.G.S.

This paper gave an account of two series of fossil fishes which have been discovered in British Triassic strata. The specimens are very fragmentary, but the rarity of Ganoid fish-remains in the English Trias lends considerable interest to these discoveries. The first series noticed were obtained by the Rev. P. Brodie in the Upper Keuper of Shrewby, and consist of some half dozen portions of fish, all small and much broken. The characters of the scales and the positions of the fins, together with as much of the form as can be made out, point to their belonging to the genus *Semionotus*. The second series were obtained by Mr. E. Wilson, F.G.S., of the Bristol Museum, from Keuper Beds near Nottingham. A large number of specimens were in this case collected; but all of them are too much broken and crushed out of shape to allow anything very definite to be said about them. Some of these also appear to be *Semionotus*; they agree in size, as well as in some other particulars, with the Shrewby fishes, and may perhaps belong to the same species; but others, on account of their strongly heterocercal tail and ornamented scales, seem to belong to the Palæoniscidæ. The presence of a third form among these Nottingham fishes is indicated by masses of larger scales. The Rev. P. B. Brodie and Mr. Edward Wilson each appended notes on the Triassic beds from which the fishes were obtained.

2. "Considerations on the Date, Duration, and Conditions of the Glacial Period with reference to the Antiquity of Man." By Prof. Joseph Prestwich, M.A., F.R.S., F.G.S.

After showing how the discoveries in the valley of the Somme and elsewhere, 28 years ago, led geologists who had previously been disposed to restrict the age of man, to exaggerate the period during which the human race had existed, the author proceeded to discuss the views of Dr. Croll on the date of the Glacial epoch. Dr. Croll, who had at first referred this to an earlier phase of orbital eccentricity, commencing 980,000 years ago, subsequently regarded it as coinciding with a minor period of eccentricity that commenced 240,000 and terminated 80,000 years since. This last estimate was chiefly supported by the amount of denudation that had subsequently taken place.

The efficacy of the increased eccentricity of the earth's orbit in producing the cold of the Glacial epoch was shown to be very doubtful; for as similar changes in the eccentricity had occurred 165 times in the last 100 millions of years, there must have been many glacial epochs in geological times, several of them much more severe than that of the Pleistocene period. But of such glacial epochs there was no valid evidence. Another inference from Dr. Croll's theories, that each glacial epoch consisted of a succession of alternating cold and warm or interglacial phases was also questioned, such alternations as had been indicated having probably been due to changes in the distribution of land and water, not to cosmical causes. The time requisite for such interglacial periods as were supported by geological evidence was more probably hundreds than thousands of years.

Recent observations in Greenland by Professor Helland, Mr. V. Steenstrup, and Dr. Rink, had shown that the movement of ice in large quantities was much more rapid, and consequently the denudation produced much greater than was formerly supposed. The average rate of progress in several of the large iceberg-producing glacers in Greenland had been found to be 36 feet daily. Applying these data and the probable accumulation of ice due to the rainfall and condensation to the determination of the time necessary for the formation of the ice-sheet, the author was disposed to limit the duration of the Glacial epoch to from 15,000 to 20,000 years, including in this estimate the time during which the cold was diminishing, or Postglacial time.

Details were then given to show that the estimate of one foot on an average being removed from the surface by denudation in 6000 years, on which estimate was founded the hypothesis of 80,000 years having elapsed since the Glacial epoch, was insufficient, as a somewhat heavier rainfall and the disintegrating effects of frost would produce far more rapid denudation. It was incredible that man should have remained physically unchanged throughout so long a period. At the same time the evidence brought forward by Mr. Tiddeman, Dr. Hicks, and Mr. Skertchly of the occurrence of human relics in preglacial times, had led the author to change his views as to the age of the high-level gravels in the Somme, Seine, Thames, and Avon valleys, and he was now disposed to assign these beds to the early part of the Glacial epoch, when the ice-sheet was advancing. This advance drove the men who then inhabited western Europe to localities such as those mentioned which were not covered with ice. Man must, however, have occupied the country but a short time before the land was overwhelmed by the ice-sheet. The close of the Glacial epoch, *i.e.* the final melting of the ice-sheet, might have taken place from 8000 to 10,000 years since. Neolithic man made his appearance in Europe 3000 to 4000 years B.C., but may have existed for a long time previously in the east, as in Egypt and Asia Minor civilized communities and large States flourished at an earlier date than 4000 B.C.

3. "Notes on some Carboniferous Species of *Murchisonia* in our Public Museums." By Miss Jane Donald. Communicated by J. G. Goodchild, Esq., F.G.S.

The paper gave a history of the genus *Murchisonia*, an account of the relations between it and *Pleurotomaria*, and of the resemblances to it afforded by certain recently discovered species of *Turritella*. The synonymy and a new description of the genus followed, and then of the species *M. angulata, M. Kendalensis, M. Verneuilliana*, and four forms, for which new names were proposed, were described and discussed, with notes on the localities where each had been found and the museums in which the specimens described were preserved. The new species were named :—*M. pyramidata, zonata, sphærulata*, and *tenuissima*.

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II.—June 8, 1887.—Professor J. W. Judd, F.R.S., President, in the Chair.—The following communications were read :—

1. "A Revision of the Echinoidea from the Australian Tertiaries." By Prof. P. Martin Duncan, M.B., F.R.S., F.G.S.

After calling attention to a previous paper by himself published in the Society's Journal for 1877, and to additions to the fauna made by Prof. R. Tate and Prof. M'Coy, the author proceeded to give notes on the characters, relations, and nomenclature of the following 29 species of Echinoidea :—

*Cidaris* (*Liocidaris Australiæ*).
*Cidaris* (*Liocidaris*), sp.
*Goniocidaris*, sp. spines.
*Salenia tertiaria.*
*Psammechinus Woodsi.*
*Ortholophus lineatus.*
*Paradoxechinus nodus.*
*Clypeaster folium*, var. *elongata.*
*C. gippslandicus.*
*C.* (*Monostichia*) *australis.*
*C.* (*Monostichia*) *Loveni.*
*Echinobrissus Australiæ.*
*Catopygus elegans.*
*Pygorhynchus Vassalei.*
*Echinolampas ovulum.*
*Holaster Australiæ.*
*H. difficilis* (*Rhynchopygus dysasteroides*).
*Micraster brevistella.*
*Maretia anomala.*
*Megalaster compressus.*
*Pericosmus gigas.*
*P. Nelsoni.*
*P. compressus.*
*Lovenia Forbesi.*
*Euspatangus rotundus.*
*E. Laubei.*
*E. murrayensis.*
*E. Wrightii.*
*Schizaster ventricosus.*

A few notes were added on the relations between this fauna and that now inhabiting the Australian seas, also on the connexions with the Tertiary Echinoidea of New Zealand, Sind, etc.

2. "On the Lower Part of the Upper Cretaceous Series in West Suffolk and Norfolk." By A. J. Jukes-Browne, Esq., B.A., F.G.S., and W. Hill, Esq., F.G.S.

The district described in this paper is that of West Suffolk and Norfolk, and is one which has never been thoroughly examined; for no one has yet attempted to trace the beds and zonal divisions which are found at Cambridge through the tract of country which lies between Newmarket and Hunstanton. Until this was done the Hunstanton section could not be correlated definitely with that of the neighbourhood of Cambridge. It was the authors' endeavour to accomplish this, and the following is an outline of the results obtained by them.

The paper was divided into six parts:—(1) Stratigraphical, (2) Palæontological, (3) Microscopical, (4) Chemical Analyses, (5) Faults and Alteration of Strike, (6) Summary and Inferences. In the first four parts separate lines of argument were followed, and each led to the same set of conclusions.

The chief interest of the paper probably centres in the Gault, and its relation to the Chalk Marl and the Red Chalk. Quite recently the very existence of Gault in Norfolk has been disputed, but the authors think the facts they adduce and the fossils they have found will decide that point. The Gault at Stoke Ferry is about 60 feet thick, and in the outlier at Muzzle Farm *Ammonites interruptus* occurs plentifully in the form of clay-casts with the inner whorls phosphatized. At Roydon a boring was made which showed the Gault to be about 20 feet thick, the lower part being a dark blue clay, above which were two bands of limestone enclosing a layer of red marl, and the upper 10 feet were soft grey marl; the limestones contained *Amm. rostratus*, *Amm. lautus*, *Inoceramus sulcatus* and *Inoc. concentricus* (?), while the marls above contained *Belemnites minimus* in abundance. At Dersingham another boring was made which proved the grey marl (2 feet) to overlie hard yellow marl, passing down into red marl which rests on Carstone. The grey marl thins out northward, and as the red marl occupies the position of the Red Chalk, the authors believe them to be on the same horizon, an inference confirmed by the presence of Gault *Ammonites* in the Red Chalk.

Another point of importance is the increasingly calcareous nature of the Gault as it is followed northward through Norfolk. This was regarded as evidence of passing away from the land supplying inorganic matter, and approaching what was then a deeper part of the sea; this inference is borne out by the microscopical evidence.

As regards the Chalk Marl, it also becomes more calcareous: at Stoke it is still over 70 feet thick, and its base is a glauconitic marl which can be traced to Shouldham and Marham, but beyond this the base is a hard chalk or limestone, which is conspicuous near Grimston and Roydon, and passes, as the authors believe, into the so-called "sponge bed" at Hunstanton.

The Totternhoe Stone is traced through Norfolk, but is thin at Hunstanton (2 feet); its existence, however, enables the limits of the Chalk Marl to be defined, with the result that some 13 feet of the hard Chalk at Hunstanton must be referred to that subdivision.

The Grey Chalk also thins northward, and from 90 feet near Cambridge, is reduced to about 30 at Hunstanton. The Belemnite-marls are traceable in Norfolk, but either thin out or are replaced by hard white chalk near Heacham.

The Melbourn Rock is continuous, and maintains similar characters throughout.

The total diminution in the thickness of Lower Chalk is from 170 feet at Newmarket to 55 feet at Hunstanton, viz. 115 feet. An endeavour was made to estimate the amount and extent of Gault removed by erosion from Arlesey and Stoke Ferry.

3. "On some Occurrences of Piedmontite-schist in Japan." By B. Kotô, Esq. Communicated by Frank Rutley, Esq., F.G.S.

The occurrence of mangan-epidote or piedmontite in connexion with the glaucophane-bearing rocks, in the crystalline schists of Japan, had already been indicated by the author. But the "*murasaki*" or violet-rock contains it as an essential component. This is well developed near Tokusima, and its geological range has been traced further. The piedmontite occurs in this rock along with fine quartz-grains under a schistose arrangement, the accessories being muscovite, greenish-yellow garnet, rutile, some felspars, iron-glance, etc.

The crystals of piedmontite are elongated, cracked, and much striated, and occur with the orthopinacoid parallel to the planes of schistosity. The crystal faces are, as a rule, well developed, thus differing from common epidote, regarded as a rock-forming mineral. Twinning is rare; cleavages upon the base and orthopinacoid are sometimes observed. The clino-pinacoidal sections of the mineral show the most intense colours; the polarization-colours are magnificent. The following is the analysis:—

| | |
|---|---|
| $SiO_2$ ... ... ... ... ... ... ... | 36·16 |
| $Al_2O_3$ ... ... ... ... ... ... ... | 22·52 |
| $Fe_2O_3$ ... ... ... ... ... ... ... | 9·33 |
| $Mn_2O_3$ ... ... ... ... ... ... ... | 6·43 |
| CaO ... ... ... ... ... ... ... | 22·05 |
| NgO $K_2O$, $Na_2O$ ... ... ... ... ... | 0·84 |
| $H_2O$ ... ... ... ... ... ... ... | 3·20 |
| | 100·53 |

The chemist expresses a doubt as to whether the iron exists in the state of sesquioxide or monoxide. The author then alludes to the difference of opinion as to the state of oxidation of iron in the Swedish and Alpine piedmontites, and suggested that the Japanese mineral supplies a missing link between the two. The Japanese mineral was originally mistaken for tourmaline, and the rock called Tourmaline-schist by E. Naumann. Although comparatively rare both in Piedmont and Sweden, in certain parts of Japan it is so abundant as to constitute a rock-forming mineral, whilst as an accessory it occurs also in the glaucophane-schist.

The author further describes a peculiar epidote, containing iron, from the glaucophane-schist, and also a peculiar garnet, occurring in rhombic dodecahedra about the size of a pea, which includes many other minerals, but no glaucophane. The garnet is of a deep yellow colour, and is anisotropic, a circumstance probably due to strain from the interposition of other minerals.

## CORRESPONDENCE.

### NORWEGIAN "RHOMBEN-PORPHYR" FROM THE CROMER BOULDER-DRIFT.

Sir,—In 1884 I collected some erratics from the cliff-sections near East Runton, amongst which was a specimen which proves to be exactly similar to the well-known "Rhomben-Porphyr" of Southern Norway and elsewhere. It will be interesting, perhaps, to put on record the occurrence of this uncommon and local rock. A small piece of this specimen has been sent to the Mineral Department, British Museum (Natural History).

540, King's Road, London, S.W. Chas. D. Sherborne.

### THE GLACIAL DEPOSITS OF SUDBURY.

Sir,—As one of those who believe that sea-ice was the main agent in the formation of the East Anglian Drifts, allow me to enter a protest against the conclusions drawn by Mr. J. E. Marr in his paper on the Sudbury sections in the June Number of this Magazine.

He entirely omits to consider the action of coast-ice on a sinking shore, though he must be well aware that this agency has been prominently referred to as concerned in the formation of Boulder-clay.

He asks the question, "Why are not the incoherent Tertiary beds, on which the contorted Glacial deposits rest, themselves disturbed?" and he thinks that this fact is incapable of explanation except by the theory which invokes the passage of land-ice over the East of England. I perfectly agree with him on the point that the incoherent Tertiary beds could only escape contortion by being frozen hard so as to behave like the harder rocks of other districts; but is it, I would ask, only on an actual land surface that such sands could be frozen into a solid mass? I am writing in the country away from books of reference, but think I am correct in saying that the sand on the shores of Siberia is frozen into a perfectly hard and solid mass for some distance below the water, and I think the fact is mentioned in Nordenskiöld's "Voyage of the Vega."

Mr. Marr dismisses the agency of icebergs because he thinks the deposits could not be frozen "over large areas at the bottom of the muddy sea in which the icebergs were drifted;" this is probably true of those parts of such seas in which large and massive icebergs would ground, but it is not true of the shallower parts near the shore on which the coast-ice acts and on to which floe-ice and pack-ice is often driven with immense force,—agencies which seem to be quite as capable of carrying with them the masses of partially frozen materials and of pushing them over a floor of solid frozen sand as Land- or Glacier-ice could be.

Mr. Marr refers to a recently-described case where a glacier *traversing a narrow valley* seems to have overfolded certain deposits of stratified sand and clay; thus comparing what may happen in a narrow valley with the phenomena of a district of which he himself says "not only do the contortions occur in the drifts which occupy the valley bottoms, but they are also found in the accumulations which lie on the summits of ridges." Are we to suppose that so able a geologist as Mr. Marr thinks an ice-sheet over-riding a ridge will act in the same way as a glacier pushing itself through a narrow valley?

The sections round Sudbury are exceedingly interesting, and Mr. Marr deserves our thanks for calling further attention to them and for recording new aspects of the changing pit-faces, but in his charge to the jury he has not put all the possible alternatives, and consequently his summing-up is biassed in favour of one explanation.

June 6, 1887. A. J. Jukes-Browne.

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## THE CAUSES OF GLACIATION.

Sir,—I ask leave for a few remarks on the question of the causes of glaciation, as there are some points connected with it on which I think sufficient stress has not hitherto been laid.

The total amount of direct solar heat received at any place is admittedly nearly constant whatever be the eccentricity of the earth's orbit. The amount indirectly received through the medium of air-currents, clouds, and ocean-currents may vary; but if the variations of this indirect heat are ascribed to the raising or lowering of the temperature, the causes of this raising or lowering must be sought for in the distribution of the direct heat. We come, therefore, to the question, What distribution of direct heat over the various seasons (the total amount being unaltered) is most favourable to glaciation?

In the first place, then, it seems clear that the Glacial period could not have been produced by the freezing of water *in situ.* A snow-cap or ice-cap reaching an elevation of hundreds or thousands of feet over the sea-level could only have resulted from falls of snow. The former question is therefore resolved into the following, What distribution of direct heat is best calculated to increase the annual snow-fall?

In answering this question, two principles must be borne in mind. First, that snow will not fall, or at least will not lie, if the temperature is much above freezing-point. In such cases either rain would take the place of snow, or else the snow would melt at once. Second, that very little snow falls when the temperature is very low. Great cold preserves the snow that has fallen, but it seems necessary for a heavy fall that the temperature should not be much below freezing-point.

I now distinguish three cases.

1st. Where the mean temperature is above freezing-point. Here, if we could distribute equally throughout the year, no snow would fall. Unequal distribution might, however, produce a considerable snow-fall, though not a permanent snow-cap. In mountainous districts extensive glaciers might be produced in this way.

2nd. Where the mean temperature is below, but not much below, freezing-point. Here an equal distribution of heat throughout the year is most favourable to the formation of a snow-cap. Snow would fall at all seasons of the year, and the melting-point being rarely, if ever, attained, the snow-cap would continue to accumulate.

3rd. Where the temperature is much below freezing-point. Here an unequal distribution of heat is most favourable to glaciation, because we must bring the temperature nearly up to freezing-point at one season of the year in order to obtain the heavy falls of snow which are required to form a snow-cap or ice-cap of considerable thickness.

If these principles are correct, they lead to the following results. A high eccentricity of the earth's orbit when the earth is in aphelion at mid-winter is favourable to glaciation in two regions of the Northern Hemisphere, one immediately round the pole and the other much further south (where, however, the result would be rather extensive detached glaciers than general glaciation). But between these two regions there is an intervening one in which the conditions for glaciation would be unfavourable, the snow-fall being less than if the distribution of heat was equable, while a good deal of this lessened snow-fall would be melted by the increased quantity of heat received during the summer. If the earth was in perihelion at mid-winter, this state of things would be reversed. The polar snow-cap would be diminished, but there would be more glaciation in the southern portion of the Arctic region and the northern portion of the Temperate Zone. As far south as Switzerland, however, the glaciation might perhaps again diminish.

In confirmation of these views, I may add that I do not see how the snow-fall could be increased over the entire region from, say, the fiftieth degree of North Latitude to the Pole at the same time. For high eccentricity would not, I apprehend, increase the difference of temperatures between the Equatorial and Polar Regions. It would produce a summer and winter at the Equator—the former when the earth was in perihelion and the latter when the earth was in aphelion; but when the Equatorial and Polar summers and winters synchronized, the contrast of temperatures would not be greater than at present. During the long cold northern winter, on which Dr. Croll lays so much stress, there would also be winter at the Equator, and if we regard the Equatorial region as the generator of vapour or steam and the Polar region as the condenser, the apparatus as a whole would not be more powerful but less powerful than before. There would be no increase in the quantity of aqueous vapour available for the production of falls of snow in the higher northern latitudes, and, therefore, an increased snow-fall in one portion of these latitudes must be compensated by diminished snow-fall in another portion.

I have omitted to notice the effects which might be produced when the snow-caps thus formed were set in motion. Moving masses of ice or snow might considerably alter the general phenomena of glaciation. If we take the most southerly portion of our hemisphere in which permanent glaciation is possible, the snow-cap would form most readily if the irruption of northern ice commenced about the same period when the conditions for local glaciation were becoming favourable. These latter conditions would, I apprehend, be most favourable when the earth was in aphelion at midsummer; but the Polar Pack would not attain its full dimensions until some time after the mid-winter aphelion, and in its slow southward motion it might not begin to overrun the northern portion of the Temperate Zone until a still later period. The invasion of Polar ice might nearly coincide with the commencement of the local glaciation produced by very different causes, and a Glacial period would result.

13, Belvidere Place, Dublin,
May 7th, 1887.

W. H. S. Monck.

## OBITUARY.

### EDWARD TOWNLEY HARDMAN, F.C.S., F.R.G.S.I., ETC.

Born 6th April, 1845; Died 30th April, 1887.

GEOLOGICAL science has suffered a serious loss in the early death, from typhoid fever, of Mr. Hardman, of the Irish branch of the Geological Survey of the United Kingdom.

Descended from an old and respected Drogheda family, Mr. Hardman received his early education at that town. Having by his ability won a Government Exhibition and entered the Royal College of Science, Dublin, in 1867, he obtained a diploma in mining, etc., as well as numerous prizes, and in 1870, he was appointed to the staff of the Geological Survey of Ireland. In 1871 he was elected a Fellow of the Geological Society of Ireland, and in 1874 of the Chemical Society of London.

He examined, and prepared a Memoir upon, the Geology of the Coal-fields of Kilkenny and Tyrone, and prepared a list of papers on the Geology of the North of Ireland. Mr. Hardman was also an active and earnest antiquary, and communicated several papers to the Royal Irish Academy.

In 1883 he was selected by the Colonial Office to examine and report upon the geology and mineral resources of the Kimberley district of the colony of West Australia. Here he was attached to a local surveying expedition, under the direction of the Hon. J. Forrest, C.M.G., Crown Surveyor General to the Colony, and set out for the North-East Territory. Having a camera, he was enabled to photograph numerous points of interest, and also to make sketches of characteristic geological sections. The most important practical result of his investigations was the discovery of an extensive gold-field in the vicinity of the Napier Range in the Kimberley district, where by actual experiments he was able to attest the presence of auriferous deposits at various points.

There is no doubt that Mr. Hardman's work was performed in such an efficient and satisfactory manner that he would have been at once appointed as geologist to the Colony, but for the difficulties raised by the Legislative Council on the subject of expenditure. His engagement having terminated, he returned home in October, 1885, bearing however the assurance that he would certainly be appointed if the post was created.

Last year he was called upon to assist in the arrangement of the rocks, fossils, and minerals sent by West Australia for the Colonial and Indian Exhibition in London.

He had returned to his duties on the Irish Survey, and in March last he inspected a district in the Wicklow Mountains and adjacent country, with the view to compiling a second Survey Memoir thereon; his constitution no doubt suffered owing to the inclemency of the weather and frequent exposure to swnostorms and rain amongst the hills, so that when attacked by fever he was too reduced in health to withstand its effects, and he passed away after only a few days' illness, leaving a widow and two young children quite unprovided to face the struggle for existence deprived of a father's protection and support.

It is all the more sad to think that had he lived the long-desired post of geologist to West Australia would have been offered to Mr. Hardman, the financial difficulties in the way of his appointment having been removed just before he died.

A considerable reward had been offered by the Government for the discovery of gold in the colony, and Mr. Hardman was at the time of his death a claimant for the prize. It is earnestly to be hoped that the Legislative Council will be pleased to award at least a part of such premium to the widow of the man who discovered the Kimberley Gold-field.

The following is a list of the papers of which Mr. Hardman is the author:—

1. On the Analysis of Trachyte Porphyry from Tardree Quarry near Antrim. Roy. Geol. Soc. Ireland, May 10, 1871.
2. On the Analysis of a Limestone compared with that of the same rock where it is in close proximity to a Doleritic Dyke. R.G.S.I., June 14, 1871.
3. On the Occurrence of Gypsum in Keuper Marls near Coagh, Co. Tyrone. R G.S.I., June 12, 1872.
4. On the Recent state of Coal Mining in the County of Tyrone. Roy. Dub. Soc., Nov. 18, 1872.
5. List of Geological Papers on North of Ireland. Mems. G. Sur. I., 1872.
6. On the Occurrence of Silicious Nodular Brown Hæmatite (Gothite) in the Carboniferous Limestone beds near Cookstown, Co. Tyrone. R.G.S.I., May 14, 1873.
7. On Analysis of White Chalk from the Co. Tyrone; with Notes on the occurrence of Lime therein. R.G.S.I., June 11, 1873.
8. Notes on a Small Raised Beach at Tramore Bay, Co. Waterford, showing traces of severe oscillatory movements during the recent period. R.G.S.I., Dec. 10, 1873.

9. On the Substitution of Zinc for Magnesium in Minerals. Roy. Irish Acad. vol. i. 1870, p. 533; Geol. Mag., May, 1874.
10. Further Researches on the supposed Substitution of Zinc for Magnesium in Minerals. R.I.A., vol. iii. p. 146.
11. On Bones discovered in a Cave of Dunmore, Co. Kilkenny. Proc.R.I.A., 1870-1879, p. 354.
12. On Two new Deposits of Human and other Bones discovered in the Cave of Dunmore, Co. Kilkenny. P.R.I.A., February 22, 1875.
13. On the Age and Mode of Formation of Lough Neagh, Ireland; with Notes on the Physical Geography and Geology of the surrounding country. R.G.S.I., January 13, 1875.
14. On the Origin of Anthracite, with suggestions as to the possible Correlation in time and manner of Production of the Anthracite of Southern Ireland, Wales, Devonshire, and France. R.G.S.I., 1875.
15. On the Sub-Glacial Theory of Gravels. Geol. Mag., April, 1875.
16. Analysis of Coals and Ironstones from the Dungannon Coal-fields, Co. Tyrone. R.I.Acad., February 28, 1876.
17. A Contribution to the History of Dolomite (with plates). R.I.Acad. (xli. and xlii.) vol. ii. p. 705.
18. The Dolomites of the Carboniferous Limestones of Ireland. R.I.A., May 8, 1876.
19. Fossiliferous Pliocene Clays. Geol. Mag. Dec. II. Vol. III. p. 556, 1876.
20. On a Triple System of Post-Miocene Faults in the Basaltic Region around Lough Neagh. R.G.S.I., April 11, 1877.
21. Memoir on Tyrone Coal-field. Mems. G.S.I., 1877.
22. Chemical Notes in Connection with Prof. Hull's paper on the Nature and Origin of the Beds of Chert in the Upper Carboniferous Limestone of Ireland. R.G.S.I., May 9, 1877.
23. On the Barytes Mines near Bantry. R.G.S.I., January 21, 1878.
24. On Hullite: a hitherto undescribed mineral: a hydrous Silicate of peculiar composition from Carnmoney Hill, Co. Antrim, with analysis. R.I.Acad., June 24, 1878.
25. Preliminary Report on Soundings in Lough Gill, Co. Sligo. R.I.A., vol. iii. p. 473.
26. Memoir on the Kilkenny Coal-field. Mems. G.S.I., 1881.
27. First Report to Government on the Geology of the Kimberley District, West Australia. 1884.
28. Second Report to Government on the Geology of the Kimberley District, West Australia. 1885.
29. Notes on a Collection of Flint Implements and other Weapons, etc., from Tropical Western Australia. R.I.A. (in course of publication). Read 22 February, 1886.
30. Catalogue of the Geological Survey (Ireland) Library (for private official use). 1886.
31. Notes on some Habits and Customs of the Natives of Kimberley, West Australia. R.I.A. (in course of publication). Read 10 January, 1887.
32. Memoir on the Geology of the Country in Sheets 148-49 Geol. Surv. Ireland. Mems. G.S.I. (in the press). 1887.
33. Note on Professor Hull's paper with reference to Dr. Hinde's paper on Beds of Sponge Remains; Greensand. Royal Society, Lond., April 28, 1887.

A. B. W.

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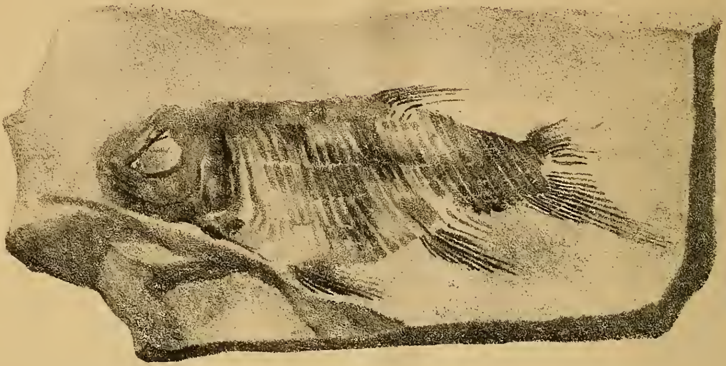
It is with deep and sincere regret that we record the death, on the 5th June, of our friend and fellow-worker in geology, Arthur Champernowne, Esq., M.A., F.G.S., of Dartington Hall, Totnes, S. Devon, aged 48 years. We hope to publish a notice of his life and work in our next Number.—Edit. Geol. Mag.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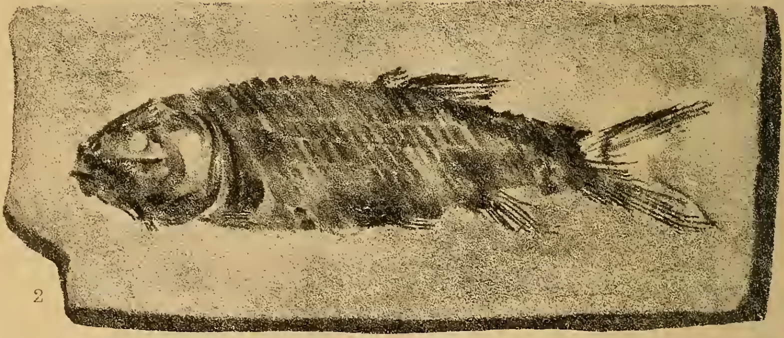
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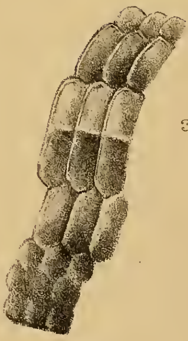
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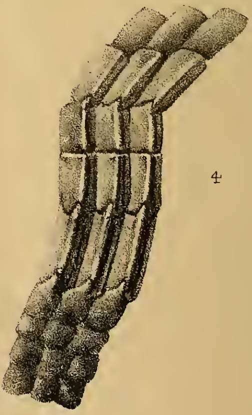
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Pholidophorus, Purbeck, Dorsetshire.

THE

GEOLOGICAL MAGAZINE

NEW SERIES. DECADE III. VOL. IV.

No. VIII.—AUGUST, 1887.

## ORIGINAL ARTICLES.

### I.—On New Species of *Pholidophorus* from the Purbeck Beds of Dorsetshire.

By William Davies, F.G.S.,
of the British Museum (Natural History).

(PLATE X.)

FEW genera of Fossil Fishes contain so large a number of well-defined species as Agassiz's widely-distributed and well-known genus *Pholidophorus.* Above forty species have been more or less fully described by Agassiz and subsequent authors; the geological range extending from the Rhætic to the Purbeck Beds inclusive. The group consists mainly of small or moderate-sized fishes, but few that can be termed large; and with the exception of one species (*P. maximus*),[1] the generic identity of which is doubtful, it contains no fishes of magnitude. Fifteen species have hitherto been recorded as occurring in British rocks by Agassiz[2] and Egerton[3] respectively, the geological distribution being as follows:—Two species from the Rhætic Beds at Aust; nine from the Lower Lias (Lyme Regis; Street; and Barrow-on-Soar); one species from the Inferior Oolite of Blisworth; one from the Great Oolite, Stonesfield; and lastly, two from the Purbeck Beds of Swanage, namely *Pholidophorus ornatus*, Ag., and *P. granulatus*, Egert. These last are fishes of moderate size; with crenulated and otherwise ornamented scales. The fishes which form the subject of this article differ in some important characters from the above-named species; inasmuch that they are diminutive in size, have smooth unornamented scales with entire free margins, another feature being the reduced number of the vertical series covering the flanks. They are apparently rare, the specimens here described being the only examples that have come under my observation. They comprise two forms, one short and deep, the other more elongate.

Pholidophorus purbeckensis, sp. nov. (Plate X. Fig. 2.)

This species is founded upon two specimens, one in the private cabinet of Mr. Damon, of Weymouth, who has kindly submitted it to me for examination, the other on counterpart slabs in the National Collection (B.M. 40635). They are elegant fusiform fishes, less

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[1] Agassiz, "Rech. Poiss. Foss." tom. ii. p. 287.

[2] *Op. cit.* tom. ii.

[3] Mem. Geol. Surv. Decades vi. and viii.

than 3½ inches (85 mm.) in length. Unfortunately the head in each specimen is so much crushed, that, with the exception of the opercular plates, the component elements are too indistinct for separate description; but its form and relative proportions are fairly well preserved. The orbits are of moderate size; the operculum is oblong, the upper margin being slightly convex, and the sub-operculum is triangular in form. The head forms one-fourth of the entire length of the fish, and is equal to the depth of the body a little in advance of the ventral fins. The scapular arch is nearly concealed by the opercular plates. The paired fins are imperfect, a few rays of each only being preserved, which suffice to indicate their position. The ventrals are placed midway between the attachment of the pectorals and the anterior ray of the anal fin. The latter fin is also imperfect, insomuch that the distal bifurcated extremities of the rays are wanting. It consists of ten strong and unarticulated rays, and is 9 mm. in length; no fulcral scales are preserved on either specimen. The dorsal fin rises from the middle of the back and opposite the interspace dividing the anal and ventral fins. It is short but incomplete, the few rays preserved are moderately thick, the anterior ray being strengthened by several imbricating and elongate fulcra. The caudal fin is deeply cleft and equilobed, like the tail of the contemporary *P. ornatus*. There are sixteen articulated rays, eight in each lobe, preceded by acutely pointed fulcral scales, those on the upper lobe being the largest. The scales on the Museum specimen are all more or less broken, but the characteristic or principal series covering the flanks are well preserved on Mr. Damon's specimen.[1] These form four rows of high and narrow scales which gradually diminish in height as they approach the tail, and are completed by smaller scales above and below. The upper or dorsal row of large scales are slightly curved, the anterior series of the other rows are nearly rectilinear in form. Those of the second, or lateral line series of scales are the largest, being four times as high as they are broad, whilst in the next series these proportions are as three to one. There are from 32 to 34 scales in each longitudinal row. The lateral line is prominent and continuous, with a slight curve, from the operculum to the caudal fin. The side scales show the peg and notch articulation, and are strengthened on the inner surface by the continuation of the peg as a mesial vertical ridge to the articulating depression on the lower margin of the scale. The scales are coated with shiny ganoine, upon which may be seen with a lens a few striæ, or lines of growth, and, compared with most species of *Pholidophorus*, the scales are relatively thin, hence their imperfect preservation. The specimens are from the Lower Purbeck Beds of the Isle of Portland.

### Pholidophorus brevis, sp. nov. (Plate X. Fig. 1.)

The little fish I have thus designated is in the National Collection (P. 1074), and is readily distinguished from the preceding species

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[1] See Plate X. Fig. 3. The entire fish has been drawn (but not yet published), for a new edition of the Supplement to the Geology of Weymouth and the Isle of Portland.

by its shorter and deeper body. In shape and relative proportion it resembles *P. granulatus*, and might be taken for its young form: but the unornamented scales with entire margins preclude its being referred to that species. The extreme length is 77 mm. (3 inches) of which the head occupies the fourth part; between the hinder margin of the operculum and the insertion of the caudal fin the body measures 40 mm., and the depth in front of the ventral fins is 25 mm. The head is crushed, and but little of the external surfaces of the bones are preserved. The orbits are not large, nor are any teeth visible. There is not the slightest evidence by depression or otherwise of the presence of the notochord. The fins appear to have been small and the rays few. The insertion of the dorsal fin is a little in advance of the opposite anal fin. Long acute imbricating scales cover the front ray of both fins. The caudal fin is composed of about 20 strong and jointed rays with several fulcral scales above and below, and is not deeply cleft. The structure and general form of the scales are the same as in *P. purbeckensis*; namely, high and narrow scales on the flanks, which gradually decrease posteriorly, with small scales on the dorsal and abdominal regions. Most of the larger scales are either wanting or broken; but well-marked impressions of the outer surfaces of those missing are preserved on the matrix. On another fragment of a larger individual (B. M. P 3607), the scales are in better position, and also show the inner side. Both specimens are from the Upper Purbeck Beds at Upway, near Weymouth; and formed part of the Egerton and Enniskillen collections respectively.

It is deserving of remark that *Pholidophorus* is found associated with *Lepidotus* in many of the marine formations of the Jurassic period, and also in the estuarine deposits of the Purbecks, proving that species of both genera frequented estuarine waters.

### DESCRIPTION OF PLATE X.

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| Fig. 1. | *Pholidophorus brevis.* | British Museum (P 1074). |
| ,, 2. | *Pholidophorus purbeckensis,* | drawn from the two slabs in the British Museum (40635). |
| ,, 3. | ,, ,, | enlarged external view of the flank scales on Mr. Damon's specimen. |
| ,, 4. | ,, ,, | restored inner view of the same scales showing the medial ridge. |

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## II.—On the Occurrence of a New Fossiliferous Horizon in the Ordovician Series of the Lake-District.

By H. Alleyne Nicholson, M.D., D.Sc., F.G.S., and
John E. Marr, M.A., F.G.S.

BELOW the "Coniston Limestone Series"—if we include under this general title not only the Coniston Limestone proper, but also the "Style End Grassing Beds" of Long Sleddale and the "Dufton Shales" of the Cross Fell area—no fossiliferous beds have hitherto been detected in the Lake-district till the horizon of the Upper Skiddaw Slates (Llanvirn Series) is reached. Between these two horizons are placed the thick and varied volcanic rocks which have usually been grouped together under the name of the "Borrowdale Series" (the "Green Slates and Porphyries" of Prof. Sedgwick); though it may be taken as certain that this name covers more than one series of volcanic ejecta. Up to the present time, no strata containing fossils have been detected in connection with any of the rocks which have been included under the general title of the "Borrowdale Series." The object of the present communication, however, is to draw attention to a group of fossiliferous shales which we have found to be associated with certain of these volcanic rocks.

The shales in question occur on the north side of the great mass of the Skiddaw Slates of the Lake-district, in what has been spoken of as the "Caldbeck Fells Area"; and their general position will be made clear by the accompanying sketch-map.

Sketch-map of Carrock Pike and the district immediately round it, on the scale of one inch to a mile. (The boundaries of the intrusive igneous rocks are in part taken from Mr. Clifton Ward.) *S.* Skiddaw Slates, for the most part highly metamorphosed; *d.* Drygill Shales; *e.* Lavas and ashes ("Eycott Series"); *c.* Carboniferous rocks; *g.* Granite. *G.* Gabbro (the "hypersthenite" of Mr. Ward); *D.* Intrusive diorite (?); *F.* Sphærulitic felsite.

The main area of the Skiddaw Slates in the Lake-district, as is well known, is followed to the south by the main area of the so-called Borrowdale rocks, while it is flanked on the north and north-east by a narrow strip of volcanic rocks which runs from Eycott Hill near Troutbeck Station, through the range of the Caldbeck Fells, to Binsey Crag and Torpenhow Common. The upward sequence of the volcanic rocks of the Caldbeck Fells is concealed from view by the overlapping Carboniferous Limestone. On the other hand, the relations which these rocks bear to the Skiddaw Slates to the south of them have not hitherto been precisely ascertained, partly from an insufficiency of sections, and partly owing to the intercalation between the two series at the eastern end of the range of the great intrusive igneous masses of Carrock Pike and Great Lingy.

The strata to which we wish to direct attention here are situated immediately to the north of the intrusive masses just spoken of, and are, therefore, of special interest as lying between the Skiddaw Slates on the one hand and the volcanic rocks of the Caldbeck Fells on the other hand; though it cannot be said that their stratigraphical relations with either of these are absolutely clear. They occupy the summit of the valley between High Pike and Carrock Pike, and are fully exposed in the course of Drygill Beck, the head tributary of Carrock Beck. We shall, therefore, speak of them as the "Drygill Shales." The following is the section seen in Drygill in descending the stream. The ridge from which Drygill Beck flows north-eastwards is probably composed of intrusive igneous rocks, but the summit of the ridge is covered with peat, and no rock is seen in place. The first rocks seen in the highest part of Drygill are pale drab-coloured shales, which dip at tolerably high angles to the S.S.W. and strike W.S.W. and E.N.E. No fossils were detected in these beds; but a more prolonged search would probably bring organic remains to light. These are succeeded below by blue-grey shales, weathering white, and similarly coloured mudstones, with iron-stained joints, containing ill-preserved Brachiopods and other fossils. These beds are best seen in Drygill itself, but are also exhibited in the western fork of the stream.

The beds just spoken of abut against a mass of intrusive igneous rock, which occupies both sides of the stream for some little distance below the point where the eastern and western forks unite. This rock decomposes by exposure to the weather to a soft brownish-green ashy-looking rock, but it seems really to be very similar to the intrusive mass which occurs in Brandy Gill, and which Ward has spoken of as a "diorite." Very probably the mass in Drygill is only an offshoot from this.

Below the preceding, the stream cuts through a series of dark blue-grey or nearly black mudstones, crowded with fossils, which are fairly preserved, though slightly distorted by cleavage. The general strike of the beds here varies from S.W. to W.S.W., the dip still being southerly; and the whole series is much broken and intersected by mineral veins. These beds rest upon a series, of no great thickness, of remarkable contemporaneous volcanic rocks in the form of breccias with associated bands of quartz-felsite, which are unlike the ordinary lavas and ashes of the Lake-district in their nearly white colour.[1] Lastly, these volcanic beds are underlaid by a final mass of dark fossiliferous mudstones, full of Brachiopods and Trilobites.

The following is a list of the fossils which we have obtained from the Drygill Shales :—

*Ampyx rostratus*, Sars.
*Calymene cambrensis*, Salt.
*Lichas laciniatus*, Wahl. ?
*Stygina Murchisoniæ*, Murch.
*Trinucleus favus*, Salt. ?
*Beyrichia complicata*, Salt.
*Leptæna sericea*, Sow.
*Obolella ?*
*Orthis testudinaria*, Dalm. (abundant).

The strata above described are not exposed elsewhere in the Caldbeck Fells, to our knowledge, nor are we acquainted with any rocks in the Lake-district which can be precisely paralleled with them. Moreover, the relations of the strata of this small, disturbed, and shattered area to the rocks in the immediate neighbourhood are not at all clear. Their northern boundary is probably a faulted one, since the whole series is dipping in a southerly direction, whereas the general dip of the volcanic rocks of the Caldbeck Fells is northerly. No actual junction, however, is seen between the lowest mass of the Drygill Shales and the volcanic rocks in question. Below the lowest exposure of Drygill Shales is an interval of barren ground, followed by an exposure of a hard grey lava. Then there is a long interval in which no rock at all is exposed to view, and, finally, the lower part of Carrock Beck is excavated in a series of lavas which may be regarded as a direct continuation of those of Eycott Hill, with which they agree in all essential particulars.

The relations of the Drygill Shales to the south are still more obscure, since no rocks of any kind are exposed between the head of Drygill Beck and the head of Brandy Gill (see sketch-map). Here we meet with a mass of an imperfect granite, with the general aspect of a felsite. Following the stream downwards, this is seen to be succeeded by a mass of intrusive igneous rock, which Mr. Clifton Ward identified with some doubt as a diorite (Quart. Journ. Geol. Soc. vol. xxxii. p. 16). Southwards of this, again, is the westward continuation of the gabbro ("hypersthenite" of Ward) of Mosedale Crags. This, finally, is succeeded to the south by the highly-altered Skiddaw Slates which occupy this portion of the valley of the Caldew, and which appear to be cut off from the igneous rocks on the north by a great fault.

The stratigraphical relations of the Drygill Shales are, thus, obscure. So far as we are aware, the only published notice of these beds is the incidental mention of them by the late Mr. Clifton Ward in his memoir on "The Granitic, Granitoid, and Associated Metamorphic Rocks of the Lake District" (Quart. Journ. Geol. Soc. vol.

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[1] From a remark made by Mr. Ward (Quart. Journ. Geol. Soc. vol. xxxii. p. 24), we should be disposed to infer that this observer regarded the peculiar characters of these beds as due to extreme weathering. Mr. Teall has been good enough to examine for us a specimen of one of the felsitic bands associated with these light-coloured breccias, and informs us that it exhibits porphyritic quartz and felspar in a cryptocrystalline ground-mass. Assuming it to be a lava, he would consider it to be a slightly altered liparite.

xxxii. pp. 17 and 24). This gifted observer considered the Drygill Beds as being referable to the Skiddaw Slates. He was, in fact, of opinion that we had here an instance of a passage between the Skiddaw Slates and the Volcanic Series, by the intercalation of the highest portion of the former with the base of the latter in alternating succession—a phenomenon of which he believed he had found instances in other localities in the Lake-district. It is certain, however, that, as regards the rocks here in question, this conclusion could not have been arrived at by a geologist of such experience except under the influence of a preconceived theory. Lithologically, the Drygill Shales do not at all resemble any members of the Skiddaw Series, and they do not precisely resemble any rocks which are known to us as occurring in the Lake-district. They are of the nature of mudstones, with a rough cleavage; and of all the Ordovician rocks of the North of England, it is, perhaps, the "Dufton Shales" which they most nearly resemble. Some of the beds are also very like parts of the "Skelgill Series." Apart, however, from the comparatively unimportant character of their lithological nature, the Drygill Shales swarm with fossils—of few *species* certainly, but of great abundance as *individuals*—which leave no doubt at all as to their *general* position in the Ordovician Series. The presence in abundance of such fossils as *Orthis testudinaria*, Dalm., *Leptæna sericea*, Sow., and *Calymene cambrensis*, Salt., *Ampyx rostratus*, Sars., and *Stygina Murchisoniæ*, Murch., renders it certain that the Drygill Shales are of Llandeilo-Bala age. Upon the whole, the general characters of the fossils would lead us to refer the Drygill Shales to about the horizon of the Llandeilo Limestone, or to a slightly higher point in the series.

As regards the Lake-district succession, the palæontological evidence renders it absolutely certain that the Drygill Shales are younger than the Upper Skiddaw Slates and older than the Coniston Limestone proper. They agree most nearly with the "Dufton Shales" as regards their fauna, but they differ from these in the predominance of *Orthides* of the type of *O. testudinaria*, Dalm., and in various other points. On the other hand, it is not at present possible to decide positively as to the relations which the Drygill Shales bear to the Volcanic Series. From their general position between the Skiddaw Slates on the one hand and the lavas and ashes ("Eycott Series") of the Caldbeck Fells on the other hand, we should be led to conclude that they occupy a place low down in the latter series. It is quite certain that they do not belong to any part of the Skiddaw Series; and there is, in fact, no evidence that the series of the *Upper* Skiddaw Slates is present at all in this particular area. On the contrary, the Skiddaw Slates of the Caldew Valley appear to be faulted down against the igneous rocks to the north of them, and it is probable that the Upper Skiddaws are thus completely cut out. Again, the Drygill Shales are lithologically and palæontologically distinct from any of the fossiliferous rocks which can clearly be shown to lie *above* the Volcanic Series. It would thus seem almost certain that, though their present position is probably largely affected by faulting, they must be referred to the Volcanic Series itself.

In corroboration of our view that the Drygill Shales form part of the Volcanic Series, we may draw attention for a moment to the unequivocal occurrence of bands of mudstone—unfortunately apparently not fossiliferous—in the lavas and ashes of this series in another locality. The locality alluded to is Falcon Crag, near Keswick, selected by Mr. Ward as affording a typical section of the Volcanic Series (Geology of the English Lake-district, p. 13), though he does not mention the particular feature here in question. Above the lowest lava in this section, as seen in Cat Gill, we find a series of unaltered ashes and breccias, sometimes fine, sometimes of coarser grain, which alternate with thin bands of grey shaly mudstone. These alternating beds are sometimes so mixed and blended together at their lines of junction, that it is clear that the ashes were from time to time abundantly showered into the sea in which the grey mud of the shales was in course of deposition. The mudstones have no resemblance lithologically to the Skiddaw Slates, and they are so much squeezed and jointed that all attempts to detect fossils in them have hitherto proved abortive. They are, however, full of ferruginous stains and cavities which may possibly represent organic remains now destroyed. We have here, then, an unquestionable instance of the occurrence of contemporaneous mudstones among the lavas and ashes of the Volcanic Series; and this would so far support our reference of the Drygill Shales to the same series. At the same time, it should be added that we are not disposed to regard the mudstones of Falcon Crag as being the precise equivalent of the Drygill Shales. On the contrary, the latter not only have a vastly greater thickness, but are associated with a peculiar type of volcanic ejecta, of which we find no representative in the section at Falcon Crag.

## III.—ON SOME CHANGES OF LEVEL DURING THE GLACIAL PERIOD AND THEIR SUPPOSED CAUSE.

By T. F. JAMIESON, F.G.S., Ellon, Aberdeenshire.

AT the close of the Glacial Period in North America the basin of the Red River was occupied by a large lake which has received the name of Lake Agassiz. It extended from what is now Lake Winnipeg southward for some hundreds of miles to the watershed of the Minnesota River. The bottom of this old lake now forms an extensive level plain famous for its fertility and the fine crops of wheat it produces.

At present the drainage of the Red River Valley flows northward into Lake Winnipeg and from thence along the Nelson River into Hudson's Bay; but during the existence of the lake in question this outlet is supposed to have been blocked by the great glacier which formerly covered all the region to the north, and which was then slowly retreating owing to the advent of a milder climate. As the drainage of the glacier went into the lake, there must have been an ample supply of water to keep it constantly brimming. The quantity of water it discharged, and the length of time the lake existed, is further shown by the size of the channel which the river flowing out of it has cut through the thick bed of drift to the southward. This channel forms a long trough, from 100 to 225 feet in depth, commencing at Lake Traverse and extending for about 250 miles along the course of the Minnesota River to its junction with the Mississippi. The fact of the excavation of this remarkable trough being due to the outflow of the lake which formerly filled the basin of the Red River was pointed out by Gen. G. K. Warren in 1868.

The beaches left along the margin of the vanished lake are still quite distinct, and have lately been made the subject of careful examination by Mr. Warren Upham, of the U. S. Geological Survey.[1] He has executed a series of levellings along the uppermost beach for a distance of 142 miles, extending from its outlet at Lake Traverse northward to Maple Lake, which is about 20 miles east of Crookston, and one interesting result of his work is to show that the beach does not form a horizontal line, but slopes gradually upwards from south to north along the whole distance he carried his levels. Its height at the south end is about 85 feet above the present level of Lake Traverse, or 1055 feet above the sea; while at Maple Lake, where the levelling stopped, it is 1180 feet above the sea, showing a gradual rise of 125 feet in the course of 142 miles. "Through this distance," says Mr. Upham, "the upper beach clearly marks one continuous shore-line, and the accuracy of our levelling is attested by close agreement with railroad surveys at five widely-separated points."

The ascent of this beach from Lake Traverse northward is at the rate of about $\frac{4}{10}$ of a foot per mile for the first 60 miles. Further north, through the next 80 miles, its rate of ascent is somewhat greater, varying from three-fourths of a foot to 1½ foot per mile. The portion of the upper beach thus examined extends through a prairie region very favourable for exploration and levelling. Further on it turns to the E. and N. through a trackless forest with impassable swamps, where it would be difficult to trace its course.

There are two other beaches, at lower levels, left by the lake as it gradually subsided, owing to the wearing down of its outlet. These also have been examined by Mr. Upham with somewhat similar results. Both are found to have a gradual upward slope to the north, as compared with the surface which a sheet of water would now have if confined in this valley. The second beach, in the space of 150 miles, rises about 70 feet with a nearly uniform slope of a little less than half a foot per mile. While the third or lowermost beach was found in the course of 135 miles to rise northward to the extent of 50 feet, and at a later period of the lake's existence to half that amount.

Assuming these levellings to be correct, and assuming also that each of the supposed beaches does actually represent one of the old

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[1] W. Upham, Lake Agassiz, Bulletin of the Minnesota Acad. of Nat. Science, vol. ii. p. 290, 1882.

water-lines at which the surface of the lake formerly stood, we have here a very interesting question presented to us. How is it that these old beaches are not now horizontal, but rise gradually as we follow them to the north? Has the ground risen to the northward since the lake disappeared, or did the surface of the lake form a plane which was not horizontal, while the land remained all along stationary as it is? The latter is the explanation Mr. Upham adopts.

According to the law of gravitation, matter of all kinds exerts an attractive force in proportion to its mass, and varying inversely as the square of its distance from the body it attracts. Mr. Upham, therefore, supposes that the glacier, by virtue of this attractive force, drew the water towards it, so that the lake rose to a higher level near the glacier than it did farther off. The northern barrier of the lake, he says,[1] "was the receding Continental glacier. All the differences of the once (?) level lines of Lake Agassiz from our present level-line would be produced by the gravitation of the water of the lake towards this ice-sheet. At first this attraction had a large effect upon the lake-level, because of the nearness of a great depth of ice on the east in Northern Minnesota, and northward in British America; but it was gradually diminished to a comparatively small influence when these ice-masses had been melted and the attracting force proceeded from the region far north between Lake Winnipeg and Hudson Bay."

Whether we can agree with Mr. Upham in this explanation or not, we are certainly much indebted to him for the discovery of a very remarkable and interesting fact. Another explanation, however, may be offered.

If, as some geologists believe,[2] the outer crust of the earth reposes at no great depth upon a stratum of mineral matter in a state of fusion, we may without violence suppose that the addition of a heavy load upon the surface would cause the crust to press deeper down into this soft stratum and drive part of it away to where the pressure was less. Then, if the load was afterwards removed, and the pressure on the surface thereby relieved, the subterranean fluid or semifluid matter would tend to return towards the place it formerly occupied, until an equilibrium of pressure was restored, thus causing the surface of the depressed tract to rise again. In accordance, therefore, with this notion we may conceive that the weight of the great glacier had caused a depression of the northern region on which it lay, and that afterwards, when the ice melted, the land, being relieved from its load, gradually rose again, so that the old beach, which was formerly horizontal, now presents an upward slope to the north, such as Mr. Upham has found.[3]

Both explanations would account for the facts. In either case the result would be that the old shore of the lake would now rise towards the place where the glacier formerly existed. To the one theory it may be objected that it overestimates the attractive force of

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[1] *loc. cit.* p. 313.

[2] See O. Fisher, Physics of the Earth's Crust, p. 223, and elsewhere.

[3] See T. F. Jamieson, Geol. Mag. Sept. 1882.

the ice, to the other that it overestimates the flexibility of the earth's crust. Here both causes operate to produce the same result; but if we could find a case where we could test the two under conditions where the results would be different or opposite, then it might be seen which would prevail.

Such a case would seem to be found in another great lake called Lake Bonneville, which formerly existed in the salt desert of Utah during the Quaternary period. This lake arose from a change in the climatic conditions of that region. Now it is so dry that the water has evaporated from the greater part of the basin, leaving it a salt desert; but formerly the precipitation of moisture was so much greater that the basin was filled by a body of water as large as Lake Huron, and nearly 1000 feet deep. Here, then, we have a tract of ground which formerly sustained the pressure of a heavy load of water that has now disappeared. If the surface of Lake Bonneville was influenced by the attraction of surrounding masses, its waters should have stood highest at their margin, where they adjoined the mountain ranges which encompassed them, and its shore-lines (which are still remarkably distinct) ought to find their greatest altitude in such places. On the other hand, if the land rose in any degree when the load of water was taken off it, the old beaches should now be highest towards the centre of the basin where the water was deepest and the load heaviest. Whereas, at the outer rim of the lake, where the water was shallow, no material rise might be expected. This, I think, is a fair inference in regard to both theories. Now, what do we find?

According to Mr. G. K. Gilbert,[1] who has devoted much time and labour to the exploration of the locality, the answer would seem to be decidedly in favour of the latter supposition. There were numerous islands in this old lake, and its shore-line encircles them so distinctly that its level can be ascertained not only round the margin, but also in the midst of the basin. This shore-line is not now level, but rises higher in some parts than in others. A map of the lake was made, its shore-lines carefully traced, and the altitudes marked upon the map. The final result of the whole survey went to show that the highest parts of the beach lie within the area of the main body of the lake, while the lowest ones are at the extreme north and south ends, and the general expression of the deformation of the surface indicated a low broad dome of elevation to have taken place, having its crest situated over the centre of the main body of the lake. The difference of level between the margin of the main body of the lake and its centre is not less than 100 feet, but including observations on outlying bays it amounts to 168 feet. Gilbert, therefore, believes that the bottom of the lake has risen since the water disappeared, and he seems to think it probable that the cause of this is to be found in the removal of the load of water that formerly lay upon it. He discusses two other theories, but finds them both inadequate to account for the facts.

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[1] G. K. Gilbert, "On the Inculcation of Scientific Method by Example," Amer. Journ. of Science, vol. 31, April, 1886.

I am far, however, from wishing to lay too much stress on this case of Lake Bonneville. Its outline is intricate and extensive, and it may be that a more exhaustive survey would modify the results arrived at by Mr. Gilbert. It is quite possible also, as he himself remarks, that the deformation of the old shores may be due to subterranean movements proceeding from an entirely different cause. But, so far as the Survey has gone, it certainly fails to show that there was any notable gravitation of the lake-waters towards the high mountains on the East, such as might have been expected upon the hypothesis that a strong attractive force was exerted by these mountain-masses.

Assuming, for the present, that the bottom of the lake has actually risen 168 feet in consequence of being relieved from the pressure of 1000 feet deep of water, we may use this result to ascertain what might be the effect produced by the disappearance of a like depth of ice. Taking the specific gravity of glacier-ice at 875 as compared with water at 1000, the result would be a rise of 147 feet—or say in round numbers 150 feet for a thousand feet of ice. This would agree tolerably well with some of the changes of level that have been observed in regions formerly occupied by large glaciers.

## IV.—ON A METHOD OF DETERMINING A LOWER LIMIT TO THE AGE OF THE STRATIFIED ROCKS.

By CHARLES DAVISON, M.A.,
Mathematical Master at King Edward's High School, Birmingham.

1. THE following is an attempt to determine a lower limit to the time required for the accumulation of the stratified rocks. It is not supposed to be an accurate estimate, for the data on which it is based are confessedly imperfect; but it is thought that the method employed may be of some little use when more exact determinations can be made of the physical constants involved.

The first part of the method is founded upon the observed fact that most, if not all, of the stratified rocks, throughout the period of their formation were deposited in shallow water; the latter part on the law of secular cooling deduced by Sir W. Thomson for the case of a solid earth, though not on the value of the initial temperature used by him. As a consequence of secular cooling the outer parts of the earth's crust are folded by lateral pressure, the rocks above the troughs gradually subsiding as the troughs of the folds deepen, by reason of the weight of the rocks, and of the sediment, if any, deposited above them.

2. The fact that stratified rocks are chiefly shallow-water deposits indicates that the rate of sedimentation is generally, and on the whole has been, greater than the rate of subsidence.[1] Now, the sediment brought down by a river is used: first, for keeping the level of the delta-surface close to the level of the sea; secondly, for extending the delta laterally by means of the surplus sediment.

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[1] The rate of subsidence at any time is here measured with respect to the level of the sea at that time.

Let $V$ be the number of cubic feet of sediment brought down by a river every year, and $A$ the area of its delta in square feet. If the whole of the sediment were spread over the present delta, so as to keep its surface close to the surface of the sea without enlarging the area of the delta, the average rate of subsidence would be $V \div A$ feet per year. If, however, as is generally the case, the sediment is spread over a larger area, increasing the delta laterally, then the average rate of subsidence must be less than $V \div A$ feet per year. Thus, *the volume of sediment brought down by a river in a year, divided by the area of the delta, gives a superior limit to the average rate of annual subsidence in the region of the delta.*

As the area of the delta increases, this limit decreases, continually approaching the true mean rate of subsidence. The true mean rate would also of course be known, if we could ascertain the amount of surplus sediment used for increasing the area of the delta, and therefore the amount left for keeping the delta-surface in shallow water.

It should be noticed that the mean rate of subsidence is independent of the recurrence of glacial periods and of all changes that may take place in the intensity of the denuding forces. True, in estimating its superior limit, we have left out of account the materials derived from littoral erosion and from some volcanic eruptions that may be swept by currents into the delta-area; but we cannot err greatly in neglecting them.

As an example, let us take the case of the Mississippi. Dr. A. Geikie states that the area of its delta is 12,300 square miles, or 342,204,320,000 square feet; and that the volume of sediment brought down by the river every year is 7,459,267,200 cubic feet.[1] Hence, the average rate of subsidence throughout the area of the delta cannot be greater than $\frac{1}{46}$ of a foot per year, or, more exactly, 2·18 feet per century.

Now, the mean rate of subsidence is not uniform throughout the whole period of formation of a fold, for it is evidently zero at the very commencement and also at the epoch when subsidence changes to elevation, and there may be pauses in the process. But, in different parts of the earth, there must be folds in different stages of formation; and the average of the mean rates of subsidence of all known areas of sedimentation will give the true mean rate of subsidence for the present time. Not having the necessary data, however, for river-deltas other than that of the Mississippi, we may assume the highest value of the mean rate of subsidence at the present time to be $\frac{1}{46}$ of a foot per year, which, it is worth noticing, is of the same order of magnitude as the estimated rate of elevation of the north coast of Scandinavia.

3. The mean rate of subsidence over the whole earth has not, however, been uniform throughout geological time; and it remains for us to determine, as nearly as we can, the law according to which it changes. This, I believe, it is possible to do, if we accept the hypothesis of a solid globe cooling from a high initial temperature. In a paper lately read before the Royal Society, I have shown that

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[1] Text-book of Geology, pp. 389, 444.

the following laws are very nearly true, and that they do not depend on the initial temperature of the earth (except in so far as the rate of conductivity of rock may vary with the temperature) :—

(*a.*) Folding by lateral pressure takes place only to a limited depth from the earth's surface, below this depth giving place to stretching by lateral tension; and the depth at which folding changes to stretching varies directly as the square root of the time since consolidation. Also, the rate at which the unstrained surface recedes from the surface of the earth varies inversely as the square root of the same time.

(*b.*) The total amount of rock folded in any given interval also varies inversely as the square root of the time since consolidation.[1]

On both accounts, then, it would seem probable, though not, it should be remembered, actually proved, that the mean rate of subsidence, due to folding by lateral pressure, should vary according to the same law.

Assuming this to be the case, let the total amount of subsidence in $t$ years be $x$ feet, so that $\frac{dx}{dt}$ measures the rate of subsidence at the time $t$. Also, let $a$ feet be the average thickness of the stratified rocks deposited throughout geological time, and $T$ years the time required for its deposition.

Then, $\frac{dx}{dt} = \frac{\lambda}{\sqrt{t}}$, where $\lambda$ is a constant; and $x = 2\lambda\sqrt{t}$, no constant of integration being required, for $x$ and $t$ vanish together.

But, when $t = T$, we have $x = a$, and $\frac{dx}{dt} = \frac{1}{46}$, taking the mean rate of subsidence at its highest value;

$$\text{so that} \quad \lambda = \frac{\sqrt{T}}{46};$$

$$\therefore \quad x = \frac{\sqrt{Tt}}{23}, \text{ and } a = \frac{T}{23},$$

$$\therefore \quad T = 23\,a.$$

If we knew the average thickness of the sediment deposited throughout the whole of geological time, the value of $T$ obtained from the last equation would give a lower limit to the length of time required for the formation of the stratified rocks; but unfortunately, the necessary data are not to be had. The maximum thickness of the sedimentary rocks has, however, been estimated by Dr. S. Haughton and Prof. E. Hull, at 177,200 feet; and I cannot think we shall be far wrong if we take this as the average thickness

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[1] "On the Distribution of Strain in the Earth's Crust, resulting from Secular Cooling; with special reference to the Growth of Continents and the Formation of Mountain Chains," read May 5, 1887.

of the sediment deposited within the limited delta-areas,[1] remembering:—(1), that all stratified rocks are largely formed from the denudation of those previously existing, and (2), that there may have been intervals between successive geological periods represented by formations now unknown to us or not included in the above estimate.

Putting, then, $a = 177{,}200$ feet in the last equation, we find

$$T = 23 \times 177{,}200 = 4{,}075{,}600 \text{ years},$$

*i.e.* just half what it would have been had the rate of subsidence been uniform and equal to the rate at the present time.

But, if we may have over-estimated the average thickness of the stratified rocks, we have, on the other hand, taken a superior limit to the rate of subsidence. Also, in the above calculation, it was supposed that sedimentation, like subsidence, began as soon as the earth solidified; whereas, it is possible that a considerable interval elapsed, thereby postponing the formation of the stratified rocks to a time when the rate of subsidence was slower than at first.

We may conclude, therefore, on both accounts, that for the formation of the sedimentary rocks a time is required of *not less than four million years,* and possibly of a period very much longer than this.

## V.—On Parallel Structure in Rocks as indicating a Sedimentary Origin.

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

IGNEOUS rocks and crystalline schists are often associated with each other in such a manner as to compel the conclusion that either the igneous rocks have been formed out of the schists or the schists out of the igneous rocks. There are other cases in which the two kinds of rock are less intimately related; parallel structure is wanting, the junctions are sharply defined, and there is no evidence of an original mineral gradation. These are examples of the ordinary irregular intrusion of igneous rocks in schists. But there is a third group in which the characters are intermediate. In these rocks, structural parallelism is more or less distinct, and there is often a partial blending of the two kinds of rock at the line of contact; but other indications forbid the belief that the schists have been elaborated out of the associated igneous masses. The question then arises: Are we here dealing with cases of intrusion, or are we driven to conclude that the igneous rocks have resulted from the fusion of schists? The answer to this question has obviously an important bearing upon the genesis of the crystalline schists.

The conversion of schists into granite and the like is maintained by the officers of the Geological Survey of Ireland,[2] and I have dealt with their evidence in a paper published in the Journal of the

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[1] Dr. Croll has very clearly shown that there may be a considerable difference between the maximum and average thicknesses of a formation; but it will be remembered that he calculated the average over a belt 100 miles broad round the whole coast-line.—Geol. Mag. 1871, Vol. VIII. p. 101.

[2] Survey Memoirs, Nos. 93, 94, 95, 104, 105, 113, 114, *passim.*

Geological Society,[1] and in a second communication read before the Society on the 6th of April last. My contention is that in the districts examined there is no gradation whatever between schist and granite; but that, on the other hand, the igneous rocks frequently acquire a foliated structure. My chief object in writing, however, is to call attention to a series of articles by Prof. J. D. Dana, which appeared in this MAGAZINE[2] in 1881. These papers deserve special notice, not only for the interest of the facts described, but because they present the case for the sedimentary origin of igneous rocks with exceptional force.

Prof. Dana's theory is expressed in the title of his memoir:—"On a Case in which various massive Crystalline Rocks including Soda-Granite, Quartz-Diorite, Norite, Hornblendite, Pyroxenite, and different Chrysolitic Rocks, were made through Metamorphic Agencies in one Metamorphic Process." The district described is in the township of Cortland, to the north of New York City, and lies on both sides of the River Hudson. Associated with the above-named plutonic rocks are gneiss, mica-schist, and limestone. Minute details of the various rocks are unnecessary for my present purpose.

The argument of Prof. Dana is arranged under the following heads:—

"1. *Evidences of more or less Complete Fusion.*"—The evidence in this section simply goes to prove that the *igneous* rocks have crystallized from a state of fusion. So far from affirming a passage between these and the schists, the author states that at Cruger's Point, at a junction between schist and soda-granite, the former "bears evidence of partial fusion and exhibits other contact-phenomena." If there are "contact-phenomena," there cannot be a gradual transition.

"2. *Evidences as to Condition of Fusion.*"—Were these rocks fused *in situ*, or were they erupted from below? Prof. Dana considers that in the former case the results of fusion "are likely to vary at comparatively short intervals, because sedimentary beds often vary thus." "Sediments . . . are liable to frequent and sudden changes as to material, which igneous outflows cannot imitate." Here I must distinctly join issue with Prof. Dana. Some of the banded gneisses of the Malvern Hills show alternations of different kinds of mineral matter as "frequent and sudden" as of any sedimentary strata in the world. Thin red seams in a black groundmass form a banding as clear and vivid as the stripes in the American flag. But the seams are granite and the groundmass is diorite, and the rock with this parallel banding passes, sometimes abruptly, into ordinary diorite with irregular veins of granite. In illustration of the singular way in which igneous rocks mimic sedimentaries, I may refer to the so-called "conglomerates"[3] in the crystalline region west of Galway. Granite veins, intruded into jointed diorites, have lapped round and enclosed joint-blocks in such numbers as to suggest the inclusion of pebbles in sediment. Where the rocks have

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[1] May, 1885, p. 221.

[2] Feb. p. 59; March, p. 110; April, p. 162.

[3] Described in my paper read before the Geological Society on April 6th.

been exposed to regional pressure, there is produced a rough parallelism amongst the fragments, and this enhances the sedimentary appearance.

"3. *Special Facts from the Cortland Region.*"—I shall confine myself to the essential points, omitting those which, though not irrelevant, would count for little if my main contentions are sustained.

Some interesting contact-phenomena are seen near Cruger's Point (p. 114). The mica-schist towards the north comes to an end against soda-granite and quartz-diorite. Approaching the igneous rocks, the schist "becomes increasingly staurolitic and garnetiferous, and passes in places into a true gneiss." *Pari passu* with this mineral change, the schist becomes more and more contorted, and is "interlaminated with nodose-lines of quartz, vein-like in origin." At the junction, "the schist is mostly a garnet rock containing much fibrolite and staurolite, and the latter is in some places granular-massive in a small way. Just below the granite, the layers are a compact body of flexures, and *in the soda-granite*[1] there is another flexed layer rather faintly indicated."

Assuming the accuracy of Prof. Dana's data, which I am doing throughout this paper, I find myself unable to accept his inferences. He considers that the phenomena just described confirm his theory; but, with deference to the opinion of so eminent a scientist, I venture to maintain that they more justly fit the theory of intrusion. It is not unusual for schists to undergo increased contortion at the contact with a large intrusive mass. I have described cases of this in my paper on Donegal.[2] This fact suits me quite as well as Prof. Dana. The production of secondary minerals I have also noticed at and near the contact of granite and schist (*loc. cit.*). The composition of these minerals would of course depend upon the composition of the surrounding masses, but at Dunlewy one of the contact-minerals was "allied to kyanite," and therefore not far removed from staurolite. Heated waters, soaking through granite or schist, could hardly fail to give rise to chemical changes in the other rock, and these would under favourable conditions reach to a considerable distance from the line of contact. Mica-schist could obviously cause little change in other rocks; but the felspar and hornblende in the granite and diorite would readily furnish materials for the production of such minerals as kyanite, staurolite, and some garnets. The abundance of quartz-veins tells strongly in favour of my view, the silica set free in the genesis of the basic minerals being redeposited.

The "flexed layer rather faintly indicated" demands special attention. According to Prof. Dana, it is a bed which originally "approached somewhat the granite in character, but which, owing to the nature of its material, was not wholly obliterated." To the enquiry whether such masses may have been fragments of schist entangled in the granite, Prof. Dana replies that "they lie so conformably to the flexures of the" main body of "schist as to suggest a negative reply." He rightly attaches great importance to this parallelism of strike,

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[1] The italics are Professor Dana's.

[2] Quart. Journ. Geol. Soc, May, 1885, pp. 225, 226.

He sees that it is the key of his position. Referring (p. 163) to certain masses of schist in granite, he says:—"Since it is obviously impossible that the inclusions taken in and carried up by rocks erupted through deep fissures should be beds of schist 100 to 200 feet long, and a series of such beds separated by the fused rock retaining together their parallel position, we have to admit that these indications of bedding are of *unobliterated*[1] bedding."

In the year of the publication of these views (1881), I first saw the tremendous Highland earth-thrusts, and every succeeding season has taught me more of the wonderful results of earth-pressures. Other workers have been under instruction in the same school; so that some things which seemed impossible in 1881 have, in 1887, become not only possible, but credible. In the light of recent discovery, I venture to suggest that the parallel structure described by Prof. Dana is susceptible of explanation on the theory of intrusion. Igneous rocks forced upwards by tangential pressure would necessarily follow the lines of least resistance. These lines might be planes of cleavage or jointing, or, in the case of some schists, seams of soft mineral matter, such as mica or chlorite. We are here concerned with mica-schists, in which we should naturally expect intrusion to correspond with foliation. From this consideration alone, it would therefore seem that the strips of schist lying between intrusive bands would be approximately parallel. But we have not taken into account the horizontal pressure. This cause would produce parallelism even if it did not previously exist. It would compel flattened fragments, lying pell-mell in a plastic ground-mass, to arrange themselves in planes parallel to each other. The size of the fragments would be quite immaterial. The forces which, in the North of Scotland, sent a mass as large as the County of Rutland sliding up-hill for more than a mile, would take small account of little strips, "100 to 200 feet long," lying immersed in a granitic magma.

But I am not indulging in mere speculation. In Donegal, I often saw outlying masses of schist immersed in granite, and in some districts their foliation was regularly parallel to the foliation of the region. In these cases, Prof. Dana's theory was clearly inapplicable; for the junctions between schist and granite were quite sharp, and the mineral variations sometimes observed at junctions indicated, not a gradation of conditions, but contact alteration. Similar cases were also seen in Connemara. Even in hand-specimens, the parallelism of mineral folia was conspicuous; but, under the microscope, the boundaries of the schist-fragments were perfectly defined. Considerable changes, however, had been produced in the enclosing granite, secondary mica and other minerals having originated at the junctions.

Many other points of great interest are discussed in Prof. Dana's papers; but some are not essential to my argument, and others are hardly ripe for adequate debate.

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[1] The italics are Prof. Dana's.

## VI.—On a New Species of *Holocentrum* from the Miocene of Malta; with a List of Fossil Berycidæ hitherto Described.

By A. Smith Woodward, F.G.S., F.Z.S.,
of the British Museum (Natural History).

Very little information has hitherto been published in regard to the fossil fishes of the well-known Miocene formation of the Maltese Islands. Dr. Leith Adams enumerates[1] seventeen species in his latest contribution to the subject, but these are almost exclusively founded upon detached teeth. It is, therefore, of considerable interest to be able to place on record the discovery of a new and tolerably complete fish, obtained from an excavation made some months ago for new docks in the harbour of Valetta.

The fossil in question has lately been received by the British Museum from the Marquis of Lorne, who is of opinion that it was derived from a horizon referable to division No. 4 of the section described in Leith Adams' "Notes of a Naturalist in the Nile Valley and Malta," p. 138. The right side of the fish is exposed to view, showing the general outline of the body; and its salient features are sufficiently well displayed to allow of its certain determination. Unfortunately, however, the bones of the head and pectoral arch are almost entirely broken away; and the right pectoral fin is likewise destroyed, while the left remains inextricably buried in the matrix. One of the pelvic fins, and the right "pelvic" bone, are beautifully preserved. The caudal fin is equally well shown, and the dorsal and anal, though somewhat mutilated, are also recognisable. For a small extent anteriorly, there is a good view of the external surface of the scales of the right side, but posteriorly both the scales of this side and the axial skeleton are removed, so that the left dermal covering is extensively exposed from within.

The specimen must have originally measured about 0·33 m. in total length, and its greatest depth, beneath the anterior part of the dorsal fin, is 0·125 m. The deep, laterally compressed body rapidly narrows posteriorly, leaving a long caudal pedicle, which commences just behind the termination of the dorsal and anal fins, and is about 0·04 m. in length.

Proceeding to the more technical points, there is nothing worthy of note in the axial skeleton, which has mostly been destroyed. Of the appendicular skeleton, the right "pelvic" bone may be observed: it is very robust, gradually widening proximally, and exhibits a prominent median longitudinal rising on its exterior lateral aspect. Correspondingly robust is the pelvic fin. The most anterior ray is a strong spine, sharply pointed at the extremity, and marked by well-defined, more or less obliquely placed ribs. This is followed by seven, or perhaps eight, equally powerful rays, similarly ornamented at their base, but divided distally.

Of the median fins, the dorsal seems to have been divided into two

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[1] A. Leith Adams, "On Remains of Mastodon and other Vertebrata of the Miocene beds of the Maltese Islands," Quart. Journ. Geol. Soc. xxxv. (1879), pp. 527-529.

portions, the anterior being the longer and spinous, the posterior consisting entirely of soft rays. The spines are remarkably stout, ornamented with oblique ridges, and diminishing backwards; and at least six are preserved, though appearances are suggestive of others having been broken away in front. Of the soft rays, seven can be distinguished, and these were evidently succeeded by a few more now slightly indicated. Both parts of the fin are comparatively low, but the soft rays originally exceeded the height of the spinous portion. The anal fin is only shown partially, and as a faint impression. Anteriorly there are traces of powerful ribbed spines, supported upon strong interspinous bones, and these are succeeded by at least ten other rays, probably all soft and divided. The total length of the fin is 0·06, and it seems to terminate exactly opposite the posterior extremity of the opposing dorsal. At the base of the caudal fin, both above and below, there are two or three small smooth spines; and in each half of the fin, which is but slightly forked, there are thirteen dichotomous rays, which become closely jointed and commence to branch near the base, ending in very delicate terminal filaments.

Impressions of opercular bones show that these were ornamented to some extent with fine ridges, and small backwardly-directed spines; and the exposed enamel-like surface of each scale is marked anteriorly by a slight rugosity, passing behind into radiating furrows, with intervening ridges, which terminate in the points of the ctenoid border. The scales are very large and thick, having a vertical measurement, in the front portion of the body, of 0·025—0·028, and a total breadth of 0·012. They are deeply overlapping, the covered surface being destitute of the enamel layer, and exhibiting delicate concentric lines of growth.

Such being the main characters of the fossil, it remains to determine its systematic position.

The nature of the dorsal and anal fins, and the situation of the pelvics, are features at once referring the fish to the Acanthopterygian suborder. The relations of the median fins, moreover, and the presence of more than five divided rays in each of the pelvic pair, indicate its affinities still more precisely, and prove it to belong to the family of Berycidæ.

The characters of the dorsal fin determine, further, the generic position of the fish. The separation of the spinous portion of the dorsal from the soft portion, is a feature only met with in two known genera of the family in question, namely, *Myripristis* and *Holocentrum*. From the former, the Maltese fossil differs in having the two divisions more closely approximated, and in this respect it agrees exactly with *Holocentrum*. Its general aspect, also, is very suggestive of the latter genus, and the impression of the anal fin may well be interpreted as showing a great development of the third spinous ray. We may, therefore, safely conclude that we are dealing with a Miocene representative of this well-known surface fish of the present tropical seas.

With regard to specific characters, a careful comparison soon reveals a divergence from all the forms of *Holocentrum* as yet known. Only one extinct species appears to have been hitherto described, namely, the little *H. macrocephalum*, de Blainv. (=*H. pygmæum*, Ag.), from the Eocene of Monte Bolca, near Verona. This is readily distinguished by its more elongated shape, relatively smaller scales, and the presence of a large spine in advance of the soft rays in the posterior division of the dorsal fin. Twenty-four of the twenty-six recent species enumerated by Dr. Günther[1] are also separated, among other characters, by the greater elongation of the body and the relatively smaller size of the scales; and the remaining two short-bodied types—*H. spinosum* and *H. retrospinis*, from West Indian seas—though very similar in proportions, and apparently with a corresponding opercular armature, have much more strongly serrated scales, and are of considerably smaller dimensions. It is proposed accordingly to designate the Maltese species *H. melitense.*

In conclusion, it may be of value to append a list of the fossil Berycidæ hitherto described. Since the earlier works, numerous emendations and additions have been made to our knowledge of the subject, and some genera and species at first supposed to be rightly placed with this family, are now known to be truly referable to other groups. The determinations here enumerated are such as are adopted in the latest memoirs, and to each species is added the name of the formation and country or district whence the type-specimen was obtained.

ACROGASTER, Agassiz.
——— *brevicostatus*, v. der Marck, Palæontogr. vol. xi. p. 24, pl. 7, fig. 2. Cretaceous, Westphalia.
——— *minutus*, v. der Marck, *ibid.* p. 23, pl. 7, fig. 1. Cretaceous, Westphalia.
——— *parvus*, Ag., Rech. Poiss. Foss. vol. iv. p. 134, pl. 17, fig. 2. W. v. der Marck, Palæontogr. vol. xi. p. 23. Cretaceous, Westphalia.

BERYCOPSIS, Dixon.
——— *elegans*, Dixon, Geol. and Foss. Sussex (1850), p. 372, pl. 35, fig. 8. Cretaceous, England.

BERYX, Cuvier.
——— *dalmaticus*, Bassani (Steindachner), Denkschr. Math.-Naturw, Cl. kais. Akad. Wiss., vol. 45 (1882), p. 70. Originally described in error as obtained from the Isle of Lesina, under the name of *B. lesinensis*, Steind., Sitzb. kais. Akad. Wiss. vol. 47 (1863), pt. 1, p. 128, pl. 1. fig. 1. Cretaceous, Dalmatia.
——— *dinolepidotus*, Fischer de Waldheim, Bull. Soc. Imp. Nat. Moscou, 1841. p. 465, pl. 8. Cretaceous, Russia.
——— *insculptus*, Cope, Proc. Amer. Phil. Soc. 1869, p. 240; and "Vert. Cret. Form. West," 1875, pl. 52, fig. 4. Cretaceous, United States.
——— *lewesiensis*: *Zeus lewesiensis*, Mantell, Geol. Sussex, 1822, p. 234, pls. 35, 36. *Beryx ornatus*, Ag. *op. cit.* iv. p. 115, pl. 14*a*; pl. 14*b*, figs. 1 and 2; pl. 14*c*, figs. 1-6; pl. 14*d*. Also Dixon, *op. cit.* p. 371, pl. 36, fig. 3; pl. 34, figs. 1, 4 and 5. Cretaceous, England.
——— *microcephalus*, Ag. *op. cit.* iv. p. 119, pl. 14*b*, figs. 3-6; pl. 14*c*, fig. 10. Dixon, *op. cit.* p. 372, pl. 34, fig. 3. Cretaceous, England.
——— *ovalis*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. iii. 1887, p. 508, pl. 27, fig. 4. Cretaceous, Lebanon.
——— *radians*, Ag. *op. cit.* iv. p. 118, pl. 14*b*, fig. 7; pl. 14*c*. figs. 7-9. Dixon, *op. cit.* p. 371, pl. 36, fig. 4. Cretaceous, England.
——— *subovatus*, Bassani, Denkschr. Math.-Naturw. Cl. kais. Akad. Wiss. vol. 45 (1882), p. 34, pl. 8, fig. 4. Cretaceous, Isle of Lesina, Dalmatia.

[1] A. Günther, Cat. Fishes Brit. Mus. vol. i. pp. 28-50.

Beryx *vexillifer*, Pictet, Poiss. Foss. M. Liban, 1850, p. 8, pl. 1, fig. 1. Pictet et Humbert, Nouv. Rech. Poiss. Foss. M. Liban, 1866, p. 30, pl. 2, figs. 1-3. Cretaceous, Lebanon.

Holocentrum, Artedi.

——— *macrocephalum*, de Blainville, Nouv. Dict. d'Hist. Nat. vol. 27 (1818), p. 349. *H. pygmæum*, Ag., *op. cit.* iv. p. 107, pl. 14; pl. 15, fig. 1. Eocene, Monte Bolca, Verona.

——— *melitense*, A. S. Woodw., 1887. Miocene, Malta.

Homonotus, Dixon.

——— *dorsalis*, Dixon, *op. cit.* p. 372, pl. 35, fig. 2. Cretaceous, England.

——— *pulcher*, Davis, *loc. cit.* p. 519, pl. 25, fig. 3. Cretaceous, Lebanon.

Hoplopteryx, Agassiz.

——— *antiquus*, Ag. *op. cit.* iv. p. 131, pl. 17, figs. 6-8. W. v. der Marck, Palæontogr. xi. pp. 13, 14, pl. 1, fig. 4; pl. 2, fig. 1; *ibid.* xxxi. p. 243. Cretaceous, Westphalia.

——— *gibbus*, v. der Marck, Palæontogr. xi. p. 15, pl. 1, figs. 5, 6. Cretaceous, Westphalia.

——— *oblongus*, Davis, *loc. cit.* p. 515, pl. 25, fig. 1. Cretaceous, Lebanon.

——— *spinosus*, Davis, *loc. cit.* p. 516, pl. 28, fig. 1. Cretaceous, Lebanon.

——— *superbus*, Davis, *loc. cit.* p. 514. *Beryx superbus*, Dixon, *op. cit.* p. 372, pl. 36, fig. 5. Cretaceous, England.

——— *syriacus*, Davis, *loc. cit.* p. 514. *Beryx syriacus*, Pictet et Humbert, *op. cit.* p. 28, pl. 1. Cretaceous, Lebanon.

——— *Zippei*, Davis, *loc. cit.* p. 514. *Beryx Zippei*, Ag. *op. cit.* iv. p. 120, pl. 15, fig. 2. Reuss, Verst. böhm. Kreideform. 1845, pt. 1, p. 12, pl. 1; pl. 2, fig. 1. Fritsch, Rept. u. Fische böhm. Kreideform. 1878, p. 41, pl. 5, fig. 1. Cretaceous, Bohemia.

Myripristis, Cuvier.

——— *homopterygius*, Ag. *op. cit.* iv. p. 112, pl. 15, fig. 3. Eocene, Monte Bolca, Verona.

——— *leptacanthus*, Ag. *op. cit.* iv. p. 111, pl. 15, fig. 4. Eocene, Monte Bolca, Verona.

Pristigenys, Agassiz.

——— *macrophthalmus*, Ag. *op. cit.* iv. p. 136, pl. 18, fig. 2. Eocene, Monte Bolca, Verona.

Pseudoberyx, Pictet et Humbert.

——— *Bottæ*, Pict. et Humb. *op. cit.* p. 34, pl. 2, fig. 7. Cretaceous, Lebanon.

——— *grandis*, Davis, *loc. cit.* p. 510, pl. 28, fig. 4. Cretaceous, Lebanon.

——— *longispinus*, Davis, *loc. cit.* p. 511, pl. 25, fig. 2. Cretaceous, Lebanon.

——— *syriacus*, Pict. et Humb. *op. cit.* p. 33, pl. 2, figs. 4–6. Cretaceous, Lebanon.

Sphenocephalus, Agassiz.

——— *cataphractus*, v. der Marck, *loc. cit.* xi. p. 18, pl. 3, fig. 1; pl. 7, figs. 3–5. Cretaceous, Westphalia.

——— *fissicaudus*, Ag. *op. cit.* iv. p. 129, pl. 17, figs. 3-5. W. v. der Marck, *loc. cit.* xi. p. 17, pl. 3, fig. 2. Cretaceous, Westphalia.

Stenostoma, Dixon.

——— *pulchella*, Dixon, *op. cit.* p. 373, pl. 36, fig. 2. Cretaceous, England.

Among other forms originally included in the Berycidæ may be particularly mentioned the genera *Platycormus, Acanus, Podocys,* and *Rhacolepis.* The type-species of the first of these was described by Agassiz under the name of *Beryx germanus*, and removed to the Squamipinnes, in 1858, by W. von der Marck,[1] under the new generic title. The most recent researches upon *Acanus* and *Podocys*[2]

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[1] W. v. der Marck, "Ueber einige Wirbelthiere, Krusten, und Cephalopoden der Westfälischen Kreide," Zeitschr. deutsch. geol. Gesell. vol. x. 1858, p. 251. See also papers in Palæontographica, vols. xi. xv. xxxi.

[2] A. Wettstein, "Ueber die Fischfauna des Tertiaeren Glarnerschiefers" (Mém. Soc. Pal. Suisse, 1886), pp. 62, 69.

appear to show that the first is a true Percoid, and the second probably the same; while there can be no longer any doubt that *Rhacolepis* is a physostomous fish, having its nearest living ally in the clupeoid genus *Elops.*[1] It may also be added that *Beryx niger*, Costa,[2] from the Cretaceous of Mount Lebanon, is undoubtedly a *Pycnosterinx.*[3]

## VII.—ON THE TERTIARY FLORA OF AUSTRALIA.

By Dr. CONSTANTIN Baron von ETTINGSHAUSEN, F.C.G.S.,
Professor of Botany, University of Graz, Austria.

MR. C. S. WILKINSON, Government Geologist for New South Wales, had the kindness to entrust his collection of Australian Tertiary plant-remains to me, for which I now express my most sincere thanks to him. I laid the results of my investigations before the Imperial Academy of Sciences of Vienna, in a Memoir, entitled: "Contributions to the Tertiary Flora of Australia, Part II.," which follows a Memoir already published under the same title, Part I., in the forty-seventh volume of the "Denkschriften" of the same Academy.

It is highly satisfactory to me that the general results I obtained from my first efforts were not alone strengthened, but materially completed by the second Part. The 128 species of fossil plants described and figured in it mostly come from Vegetable Creek, near Emmaville, in New England, N. S. W. Twenty-one species have been collected from Elsmore, and only five species from Tingha, in New England. Mr. Wilkinson, who has examined these localities, referred them to the Lower Tertiary formation. The species are distributed into 36 orders and 72 genera. Of the former 35, and of the latter 52, are also represented in the Tertiary Flora of Europe. Respecting the principal sections of the Vegetable Kingdom the Cryptogamæ contain 2 species, the Gymnospermæ 12, the Monocotyledons 2, the Apetalæ 56, the Gamopetalæ 11, and the Dialypetalæ 40. Of the orders represented by several species, the Proteaceæ contain 20 species, the Cupuliferæ 14, the Coniferæ 11, the Myrtaceæ 10, the Laurineæ 7, the Leguminosæ 6, whereas the Moreæ, Apocynaceæ, and Celastrineæ contain 5 species each.

The results respecting the character of the Flora confirm Mr. Wilkinson's statement. We cannot find any reason for supposing the above-named localities to be different in age. It is at first sight evident that the character of their flora (especially of that of Vegetable Creek and of Elsmore) deviates strikingly from the character of the living Australian Flora. According to the latter difference, which indicates a greater divergence of age between both these floras, as well as regarding the close relationship of some

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[1] Smith Woodward, "On the Fossil Teleostean Genus *Rhacolepis*," Proc. Zool. Soc. June 23rd, 1887.

[2] O. G. Costa, "Descrizione di alcuni Pesci fossili del Libano," Mem. R. Acad. Sci. Napoli, vol. ii. 1855, p. 100, pl. ii. fig. 1.

[3] Pictet and Humbert, "Nouv. Rech. Poiss. Foss. Liban," p. 43.

of the species to those of the Eocene and of the Cretaceous period, we may conclude that the Fossil Flora described in the above-mentioned memoir might be referred to the Lower Eocene.

When we take into consideration only those fossil species which are represented by fruits, seeds, and characteristic forms of leaves, we obtain new and sufficient proofs concerning the view which I have brought forward in the first part of these contributions, that the elements of the floras are mixed together in the Tertiary Flora of Australia. These proofs consist of facts relative to the common appearance of the genera endemic in Australia with genera we find represented in other floras, but which are strange to the Australian one. For example, there occur in the Fossil Flora of Vegetable Creek and Elsmore the following genera of the Australian element: *Phyllocladus*, *Casuarina*, *Santalum*, *Persoonia*, *Grevillea*, *Hakea*, *Lomatia*, *Banksia*, *Dryandra*, *Callicoma*, *Ceratopetalum*, *Pomaderris*, *Boronia* and *Eucalyptus*. On the other hand we find here, intermixed with the former, types belonging to: *Sequoia* (California), *Myrica* (Europe, North America, Asia, South Africa), *Alnus* (Northern Hemisphere), *Quercus* (Northern Hemisphere), *Cinnamomum* (Asia), *Sassafras* (North America and East India), *Aralia* (North America, Japan and New Zealand), *Elæocarpus* (Tropical Asia), *Acer* (Northern Hemisphere), *Copaifera* (Tropical America). In Part I. of the Contributions quoted above I have already stated that the elements of the floras are united not only in the Tertiary Flora of Europe, of the Arctic Regions, of North America and of Australia, but also in the Tertiary Floras of the other portions of the globe. The above-mentioned facts confirm this even more strongly. Besides, I am able to state the same result from facts which I obtained by examining the Tertiary Flora of New Zealand, with collections of which Prof. (now Sir) Julius von Haast and Prof. T. J. Parker have kindly forwarded to me.[1]

There is now scarcely any doubt that the general character of all Tertiary Floras of the globe is one and the same in regard to the mixture which they exhibit, and continued so until the separation of the elements of floras into the existing special floras towards the commencement of the present period.

The relationship of all the Tertiary Floras of the globe to one another is based upon the common elements of floras. The comparison of the Australian Tertiary Flora to the European one shows at once not only many orders and genera which are common to both, but also many species of the one are more or less corresponding to species of the other. For example the following species are closely related; *Callitris prisca* is closely related to *C. Brongniarti*, *Sequoia Australiensis* to *S. Langsdorfii*, *Podocarpus præ-cupressina* to *P. elegans*, *Casuarina Cookii* to *C. sotzkiana*, *Alnus MacCoyi* to *A. Kefersteinii*, *Quercus Wilkinsoni* to *Q. chlorophylla*, *Q. Hartogi* to *Q. drymeja*, *Fagus Benthami* to *F. Feroniæ*, *Ficus Gidleyi* to *F. arcinervis*, *F. Solanderi* to

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[1] A Notice of the Palæo-Botanical Investigations of the Fossil Flora of New Zealand will follow.

*F. Reussii, F. Willsii* to *F. Jynx, Cinnamomum polymorphoides* to *C. polymorphum, C. Leichardtii* to *C. spectabile, C. Nuytsii* to *C. lanceolatum, Grevillea proxima* to *G. hæringiana, Banksia Lawsoni* to *B. Deikeana, B. Hovelli* to *B. hæringiana, B. myricæfolia* to *B. Ungeri, Dryandra Benthami* to *D. acutiloba, Callicoma primæva* to *C. pannonica, Ceratopetalum MacDonaldi* to *C. bilinicum, Elæocarpus Muelleri* to *E. Albrechti, Acer sub-productum* to *A. trilobatum, A. sub-integrilobum* to *A. integrilobum.*

I have selected the following few from among numerous new forms, as possessing greater interest. A remarkable *Anomozamites*-species, related to an *Anomozamites* of Greenland, indicates some affinity of the flora to that of the Cretaceous period. *Heterocladiscos*, a *Cupressinea*, shows dimorphous branchlets, the primary ones being cylindrical, their leaves lanceolate, close to one another in spiral order; the secondary ones being four-edged and their leaves rhomboidal-ovate, imbricate and set in four rows. Thus this remarkable plant combines the facies of *Glyptostrobus* with that of *Thuites Mengeanus*, a *Cupressinea* from the amber. Most remarkable is the appearance of *Pseudo-Pinus*, a representative genus of *Pinus*, which perhaps might be even a subgenus of *Pinus*. Cones, seeds, leafed branchlets, rachis of branchlets and single leaves have been found at Vegetable Creek. The cones are smaller than those of any living *Pinus*-species. The size and form of the leaves, as well as their arrangement, and the shape of the branchlets, remind us of *Pinus canadensis.* Besides *Phyllocladus* two separate genera bearing phyllodes also occur at Vegetable Creek, *Palæocladus*, the primary branchlets of which are also phyllodineous, and *Ginkgocladus*, a genus common also to the fossil flora of New Zealand, and combining the facies of *Phyllocladus* with that of *Ginkgo*. A *Sassafras*-species has affinity to Cretaceous species as well as to an Eocene one of the European Tertiary Flora, and points to an early state of the Tertiary Flora to which our flora belongs. The same fact may be admitted respecting some *Aralia*-species. Examples regarding the attachment of our (Australian) flora to that of the Cretaceous period appear, however, to be only isolated when we take into consideration its numerous analogies to known Tertiary plants. *Diemenia*, a peculiar genus of Laurineæ, uniting the facies of *Cinnamomum* with that of other Laurineæ (*Laurus, Persea*), occurs in Elsmore, where two species have been collected.

Besides Proteaceæ showing their Australian type, the appearance of *Rhopala*, a genus of tropical America, is remarkable. It is represented in the beds of Vegetable Creek by two species. Not less worthy of note is the appearance of *Banksia*-types exhibiting leaves which are acuminate at their apex, and thus are closely allied to the *Banksia*-species of the European Tertiary Flora. Two species of *Boronia*, an Australian genus, have been found, one of which unites distinctly the characters of two living species. Doubtlessly they have been differentiated from this ancestral species. A calyx in some degree corresponding to those of *Getonia* of the European Tertiary Flora possesses a special interest.

It may be worthy of notice that *Fagus*, distributed over both Hemispheres, is represented in Vegetable Creek not only by types of the Southern, but also by one of the Northern Hemisphere. Whilst the former, belonging to the section *Notofagus*, exhibits coriaceous and persistent leaves, the latter closely corresponds to *Fagus ferruginea*, a species of the section *Eufagus*, bearing membranaceous and deciduous leaves. In accordance with these facts the representation of *Quercus* in the Tertiary Flora of Australia might be considered not less interesting. They have collected in Vegetable Creek leaf-fossils of *Quercus*, belonging to species which are analogous to species now living in North America, in Mexico, on Lebanon, in East India, in Japan, and in the Isle of Hong-kong. Whilst types of *Fagus* are still existing in the present flora of Australia, those of *Quercus* seem to be quite extinct there.

Although the Tertiary Flora of Australia deviates very much from the living one, we find numerous points of connexion between them. A species of *Callitris* closely approaches the *C. robusta*, R. Brown; a *Dammara*-species is very near to *D. australis*, Lamb.; a *Phyllocladus*-species, which on one side unites the characters of all the three living ones, is allied on the other side to types of Mesozoic, especially Cretaceous floras; the genera *Casuarina*, *Santalum*, *Boronia*, *Eucalyptus*, the *Proteaceæ*, *Saxifragaceæ*, etc., are represented by species, more or less closely related to living Australian forms.

A brief synopsis of the conclusions drawn from the general results which the investigation of the Tertiary Flora of Australia have offered may be given as follows :—

*Firstly.*—The geographical distribution of plants in Australia at the Tertiary period deviated in many respects from the present one. Therefore, the materials for comparison obtainable from the present flora of Australia are not at all sufficient for the investigation of the Tertiary one, and must consequently be completed from other floras of the globe.

*Secondly.*—Types of plants of the Southern as well as of the Northern Hemisphere of the globe are associated together in the Tertiary Flora of Australia.

*Thirdly.*—The flora-elements represented in the Tertiary Flora of Australia chiefly contain Phylones (ancestor-types), which are also common to other Tertiary Floras of the globe. The character of the Tertiary Flora of Australia cannot therefore be considered essentially different from that of the latter.

*Fourthly.*—The Australian Tertiary Flora, in accordance with the preceding statements, is but a part of one and the same Original-flora upon which all living floras of the globe are founded.

*Fifthly.*—The comparison of this Original-flora to the present floras of the globe shows that in Australia the differentiation of the Phylones has reached its highest degree.

*Sixthly.*—Many analogies to the Tertiary Flora are nevertheless to be found in the living Australian Flora.

## VIII.—On the Fossil Flora of New Zealand.

By Dr. Constantin Baron von Ettingshausen, F.C.G.S.,
Professor of Botany, University of Graz, Austria.

It was my good fortune in 1884 to receive two interesting collections of fossil plants from New Zealand, for which I am indebted to the kindness of Professor (now Sir Julius) von Haast, of Christchurch, and Professor T. J. Parker, of Dunedin. In these collections seventeen localities of fossil plants are represented which belong to three formations: the Tertiary, the Cretaceous, and the Triassic formations.

The relation of the living flora of New Zealand to its Tertiary one has already formed the subject of a paper submitted by me to the Imperial Academy of Sciences in Vienna, under the title "Genetische Gliederung der Flora Neuseelands" (Sitzungsberichte vol. 58, part i. p. 953). I have pointed out in it that the endemic New Zealand flora not only contains types which may probably descend from the principal element of its Tertiary Flora, but also such ones probably being derivable from some accessory elements of the latter flora.

Only a brief time has elapsed since my attention has been again drawn to the subject, and I have been enabled by the examination of the above-mentioned collections to lay a Memoir before the Vienna Academy, entitled: "Contributions to the Fossil Flora of New Zealand" (Denkschriften, vol. 53, part 1, 1887), of which I now have the pleasure to give a brief account.

The Tertiary Flora of New Zealand, collected from eight localities, as Shag Point, Dunstan, Landslip Hill, Malvern Hills, Racacliff Gully, Weka Pass, Amuri and Murderer's Creek, comprises till now as far as investigations could bring to light, 52 species which are distributed into 39 genera and 26 families. Of these species 3 are Cryptogamæ, 11 Gymnospermæ, 2 Monocotyledons, 22 Apetalæ, 3 Gamopetalæ and 10 Dialypetalæ. Regarding the general character of the flora, it by no means essentially deviates from that of the hitherto known Tertiary Flora. We find here the same mixed character as in the Tertiary Flora of Europe, of North America, and of Australia, the analogies of which to the New Zealand Tertiary species may easily be surveyed in a table appended to the above-mentioned Memoir.

Although the Tertiary Flora of New Zealand is very different from the living one, yet with regard to several species a close relationship is clearly indicated between them. Thus, *Aspidium tertiario-zelandicum* and *A. Novæ-Zelandiæ, Dammara Oweni* and *D. australis*, Lamb., *Podocarpus Parkeri* and *P. Totara*, Don., *Decrydium præ-cupressinum* and *D. cupressinum*, Sol., etc., are closely allied. Besides several genera, for instance, *Fagus, Hedycarya, Santalum, Loranthus*, etc., are represented in both, whereas others seem to be in a genetic relation to living ones, and the latter may in some degree be transmuted from the former. Thus, *Daphnophyllum* or

*Laurophyllum* may have been evolved from *Nesodaphne*, likewise *Apocynophyllum* from *Parsonsia*, *Aralia* from *Schefflera*, *Sapindus* from *Alectryon*, etc. On the contrary, we miss in the recent endemic flora of New Zealand a considerable series of genera belonging to its Tertiary flora, for instance: *Lomariopsis*, *Sequoia*, *Araucaria*, *Seaforthia*, *Casuarina*, *Myrica*, *Alnus*, *Quercus*, *Ulmus*, *Planera*, *Ficus*, *Cinnamomum*, *Dryandra*, *Diospyros*, *Aralia*, *Acer*, *Sapindus*, *Elæodendron*, etc.

According to the preceding statements, the principal results of my memoir are as follows :—

*Firstly.*—In New Zealand there exists a genetic relationship between its Tertiary and its living flora.

*Secondly.*—The Tertiary Flora of New Zealand contains the elements of floras.

*Thirdly.*—The Tertiary Flora of New Zealand is a part of that universal Original-flora from which all living floras of the globe descend.

*Fourthly.*—In New Zealand only one part of its Tertiary Flora has changed into its living flora, the other has become extinct.

I proceed now to give a brief record of the fossil plants occurring in the above-named localities.

I. Of all the localities ascribed to the Tertiary formation, that of Shag Point is the richest and most interesting. Of Cryptogamæ two species of *Aspidium*, and of *Cycadeæ* one specimen, betraying some resemblance to *Zamites tertiarius*, Heer, have been found there. Of Coniferæ 10 species have been discovered there, belonging to 7 genera. Of Monocotyledons one *Caulinites* species, and of Dicotyledons a considerable series occur there, namely :—One *Casuarina* species; two species of *Myrica*, the one allied to *M. integrifolia*, Ung., of the European Tertiary Flora, the other similar to *M. quercifolia*, L., a native of the Cape of Good Hope; one *Alnus* species, closely allied to the European Tertiary, *A. Kefersteinii*, as well as to the Australian Tertiary *A. MacCoyi*, M.; four *Quercus* species, one of them related to *Q. macranthera*, native of the Caucasus, another allied to the European Tertiary *Q. lonchitis*, Ung.; two species of *Fagus*, the one related to *F. procera* and *F. alpina*, both natives of Chili; the other very similar to *F. Deucalionis*, Ung., as well as to the North American *F. ferruginea*. One *Ulmus* and one *Planera* species, both analogous to species of the European Tertiary Flora; one *Ficus* species corresponding to *F. lanceolata* of the European Tertiary, and to *F. Burkei*, m., of the Australian Tertiary Flora; one *Hedycarya* species, analogous to the Tertiary *H. europeæ*, as well as to the Australian Tertiary *H. Wickami*; one *Cinnamomum* species, closely allied to *C. polymorphum* and to *C. polymorphoides*; two *Cassia* species, the one closely related to *C. phaseolites* and *C. phaseolitoides*, the other to *C. Memnonia*. Besides, species of the genera *Santalum*, *Diospyros*, *Aralia*, *Loranthus*, *Acer*, and *Carpolithes*, their analogues being represented in the Tertiary of Europe, North America, and Australia having been found there.

From the flora of the above-mentioned locality we may safely conclude that it, and probably also the following localities belong to the Lower Tertiary. As many species of this flora are closely allied, or at least analogous to Eocene species, I refer it to the Eocene Period.

II. From Dunstan the following species are now before us:—One *Lomariopsis* species, analogous to *L. bilinica* from the Eocene strata of Kutschlin, near Bilin, and related to *L. triquetra*, a native of Nepal; the *Aspidium* species which has also been collected from the preceding locality; and one *Seaforthia* species, analogous to *S. Mellingii* of the fossil Flora of Eibiswald, and to *S. robusta*, R. Brown, living in Australia.

III. From Landslip Hill the following came:—The *Sequoia* species also found at Shag Point; one *Dryophyllum* species, being analogous to *D. lineare* from the Eocene Flora of Sézanne; two *Apocynophyllum* species, the one corresponding to *A. helveticum* of the European Tertiary, and to *A. MacKinlayi* of the Australian Eocene Flora, the other related to *A. Tabernæmontana* of the fossil Flora of Radoboj; one *Elæodendron*-species corresponding to *E. helveticum* of the European Tertiary Flora and *E. curtipendulum*, a native of Norfolk Island.

IV. At Malvern Hill I., the following species have been found:—An *Araucaria* and a *Dammara* species, both also occurring at Shag Point; a *Myrica*, representing the widely-spread Tertiary *Myrica lignitum*; a *Quercus*-species coming also from Shag Point; a *Fagus* corresponding to *F. Wilkinsoni* of the Australian Tertiary; a *Planera* which appears also at Shag Point and at Murderer's Creek; a *Cissophyllum*, approaching the genera *Cissites* and *Ampelophyllum*.

V. At Racacliff Gully the following fossil plants have been found:—An *Alnus* and a *Quercus*, both also occurring at Shag Point; a *Sapindus*, corresponding to *S. falcifolius* of the European, and to *S. caudatus* of the American, as well as to *S. Gossei* of the Australian Tertiary Flora.

VI. From Weka Pass, a *Daphnophyllum*-species, related to *D. ellipticum*, Heer, has been collected.

VII. At Amuri a fragment of wood has been discovered. I referred it to *Dammara Oweni*, a species occurring also at Shag Point and at Malvern Hills I.

VIII. At Murderer's Creek the following fossils have been obtained: A *Quercus*, a *Planera*, a *Cinnamomum*, and a *Cassia*, all also collected from the preceding localities I.—V.; a *Dryandra*, closely related to *D. acutiloba* of the European and to *D. Benthami* of the Australian Tertiary Flora.

Taking into consideration that although only a few species have been found at each of the localities Nos. II.—VIII., the plurality of the species is common to them, especially to Shag Point, we may conclude that their flora is to be referred to the same period, being already determined as Eocene.

The strata containing remains of Dicotyledons in New Zealand having been collectively called the "Cretaceo-Tertiary Formation," I have pointed out that some of the strata must be referred only to the Tertiary, and the others only to the Cretaceous formation. Whilst the former have already been taken into consideration in the preceding exposition, I proceed now to explain the results of my investigations of the fossil Flora of the Cretaceous formation.

The Cretaceous Flora of New Zealand has up till now been collected from four localities, as, Pakawau, Grey River, Wangapeka and Reefton. It contains 37 species, distributed into 29 genera and 17 families. Of these species 4 are Cryptogamæ, 8 Coniferæ, 4 Monocotyledons, 13 Apetalæ, and 8 Dialypetalæ. The Gamopetalæ are wanting here. Several species seem to be the ancestors of Tertiary ones, particularly of the genera *Aspidium, Podocarpus, Dacrydium, Quercus, Fagus, Cinnamomum, Dryandroides, Ceratopetalum, Cupanoides,* etc. According to the closer relationship of some of these species to Tertiary ones, we may refer the above-mentioned localities to the Upper Cretaceous formation.

I. Pakawau, Nelson, the richest locality of the four, contains well-preserved fossil plants. Its flora is characterized by species of ferns exhibiting the facies of Cretaceous ferns; by the genera of Coniferæ *Podocarpium* and *Dacrydinium;* by a peculiar genus of Musaceæ, *Haastia,* related to *Musophyllum*; by *Ulmophylon,* a genus comprising the ancestor-species of Tertiary *Ulmus* and *Planera*-species; by a *Dryophyllum* and by a *Grewiopsis*-species analogous to species of the American Cretaceous formation; and by species of *Cinnamomum* and *Dryandroides,* corresponding to European Cretaceous species. There have also been found a *Bambusea,* a *Casuarinites,* a peculiar *Fagus*-species and a *Cupanites.*

II. Gery River, Westland, a locality which offers many but not such well-preserved fossils. There have been disvovered a *Flabellaria,* related to *F. longirhachis,* Ung., from the Cretaceous beds of Muthmannsdorf, Austria; two species of *Quercus,* one species of *Celastrophyllum* and one species of *Palæocassia,* all corresponding to species of the Cretaceous Flora; a *Dalbergiophyllum* reminds us of a *Dalbergia*-species of the same flora. There also have been found, a *Knightiophyllum* and a *Ceratopetalum,* both peculiar to this locality, whilst a *Bambusea,* a *Casuarinites* and a *Cupanites,* which also occur at the former locality, have been collected.

III. Wangapeka, Nelson, showing a flora which agrees with that of the preceding localities, inasmuch as some of its species are common to the latter. Of the several forms of fossil plants peculiar to this locality, the following are worthy of notice: Two genera of Coniferæ, the one intermediate between *Cephalotaxus* and *Torreya,* the other uniting *Ginkgo* with *Phyllocladus*; two *Quercus,* one *Fagus* and one *Ficus*-species, all corresponding to Cretaceous forms; a *Sapindophyllum* analogous to *Sapindus prodromus,* Heer, from the Cretaceous strata of North Greenland; a *Dalbergiophyllum* and a *Poacites.*

IV. Reefton, Nelson.—Only *Casuarinites* Cretaceous has been found here, a species which also occurs at Pakawau and at Grey River.

The collections of Sir Julius von Haast and Prof. Parker also contain numerous fossil plants from localities which I refer to much lower Mesozoic strata. They are Mount Potts, Haast Gully, Malvern Hills II., Mataura and Waikawa. A greater difference of age of these localities is excluded by some common species which they contain. The species mostly are analogous to Triassic ones. I may therefore not be far wrong in supposing that all the last-named localities belong to the Trias formation.

A brief record of their flora follows:—

I. *Mount Potts.* Here have been collected:—*Equisetum microdon,* m., a species corresponding to an European-Triassic one; *Tæniopteris pseudo-vittata,* m., closely allied to *T. vittata* from the European Trias-flora; *Asplenium Hochstetteri,* Ung. sp.; *Palissya podocarpoides,* m., analogous to *P. Braunii,* Endl.; *Baiera australis,* m., also corresponding to an European species of that flora; Phyllodes of *Thinnfeldia australis,* m., and of *Protocladus lingua,* m.

II. At *Haast Gully* (also called "Clent Hills") have been found:—*Sphenopteris amissa,* m., *S. Clentiana,* m., *Pecopteris proxima,* m., *Tæniopteris pseudo-simplex,* m., all more or less related to Triassic species, *Tæniopteris pseudo-vittata, Camptopteris Haastii,* m., *Asplenium Hochstetteri, Equisetum microdon, Palissya podocarpoides,* and *Baiera australis.*

III. *Malvern Hills II.* (not to be confounded with the above-named Tertiary locality Malvern Hills I.). *Pecopteris proxima,* m., *Tæniopteris lomariopsis,* m., both related to Triassic species, *Asplenium palæo-darea,* m., *A. Hochstetteri, Podozamites Malvernicus,* m., and *Protocladus lingua* have been collected there.

IV. *Matura* and V. *Waikawa.* There have been found:- *Sphenopteris Palæopteris,* Ung. sp., *Hymenophyllites australis,* m., *Tæniopteris pseudo-simplex, T. lomariopsis, Asplenium Hochstetteri, Macro-Tæniopteris affinis,* m., *Lycopodites palæo-selaginella,* m., *Nilssonia Zeelandica,* m., *Zamites Mataurensis,* m., *Pterophyllum Dieffenbachi,* m. The fossil plants are well preserved there, and the species bear more or less the facies of those of the Triassic Flora.

In concluding this brief notice, I have to remark that I am unwillingly compelled to disagree with the view expressed by Sir James Hector, and published by him in "New Zealand Court," Catalogue Indian and Colonial Exhibition, London, 1886, p. 60, namely, that there occur Mesozoic plants in New Zealand, as, for instance, species of *Alethopteris, Tæniopteris,* etc., together with leaves of Tertiary Dicotyledons in one and the same strata. I have not seen any trace of such a connexion in the rich material the above-mentioned collections offer. Sir James Hector's statement may be based on some mistake; perhaps, he has taken specimens of *Camptopteris* for leaves of Dicotyledons, an error easily possible when the specimens are not well preserved.

## REVIEWS.

### I.—A Popular Guide to the Geology of the Isle of Wight, with a Note on its Relation to that of the Isle of Purbeck. By Mark W. Norman. 8vo. pp. 240, Map, Sections, and 15 Plates of Fossils. (Ventnor, 1887.)

Mr. MARK NORMAN, who some years ago contributed a paper on the Greensand formation of the Isle of Wight to the Geological Magazine, now presents us with a popular

Geological Guide to the Island. Basing his views upon the excellent works of Mantell, Forbes, Bristow and others, Mr. Norman has incorporated in his volume many descriptive notes and suggestive observations, the result of thirty years' experience and work amongst the Downs and Coast sections of his interesting district. Each geological formation is reviewed in turn, and lists and illustrations of the principal fossils given. Notes on the best collecting grounds, and much information of an instructive and useful kind, both to the collector and visitor, as well as to amateurs and students, will also be found in his pages. After reviewing the various divisions in ascending order, Mr. Norman devotes one chapter to the consideration of "Denudation and Landslips," and another to "The Human Period." In an appendix he discusses "the Relation of the Geology of the Isle of Wight to that of the Isle of Purbeck." Some notes on the Ventnor Museum and a list of the Economic Products of the Island complete the volume.

Although the book is essentially a Geological Guide, Mr. Norman has rendered it useful to other visitors, for he points out the most interesting features in the landscape, and gives much general information touching the antiquities of the Island and other objects.

A map, sections, and fifteen plates of fossils accompany the text, and we must congratulate the author on having so careful a draughtsman as his friend Mr. Ryan, the plates being much superior to those usually seen in Guide-books. Several typographical errors on the plates and others in the text seem to have escaped the notice of the author. The numerous plates and figures together with the low price should recommend this book to all, and it should especially find a place in the equipment of the tourist and the visitor, who is interested in the Geology of the Isle of Wight.

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## II.—PRELIMINARY REPORT ON SOME GRAPTOLITES FROM THE LOWER PALÆOZOIC ROCKS ON THE SOUTH SIDE OF THE ST. LAWRENCE, FROM CAPE ROSIER TO TARTIGO RIVER, FROM THE NORTH SHORE OF THE ISLAND OF ORLEANS, ONE MILE ABOVE CAP ROUGE, AND FROM THE COVE FIELDS, QUEBEC. By Prof. CHAS. LAPWORTH, LL.D., F.G.S. [From the Transactions of the Royal Society of Canada, Section iv. 1886.]

IN his brilliant Memoirs on the Moffat Series and the Girvan Succession, Professor Lapworth completely established the high importance that should be attached to the study of life-zones for the elucidation of the true sequence of fossiliferous rocks. Wherever these rocks are contorted into frequent foldings and their original position disturbed by faults, stratigraphical evidence alone can seldom be relied upon to assign them their place in the series. In such cases the testimony afforded by fossils even of such lowly organization as that of the Graptolites becomes of almost incalculable value.

In complicated areas such as those of the Girvan District, the eastern townships of Lower Canada, and the regions treated of in the Report now before us, a minute and patient investigation of the life-groups, as they occur in each stratum, is the only method open to the geologist who aspires to lay the foundations for an enduring scheme of classification.

The collection of Graptolites treated of in this Report was forwarded to Prof. Lapworth by Dr. A. R. C. Selwyn, F.R.S., Director of the Geological Survey of Canada, the material having been accumulated by various members of the Staff of the Survey at different periods dating from 1876.

The Graptolites were found to belong to several distinct zones, each corresponding with a distinct zone in Great Britain and Western Europe, and ranging from the British Tremadoc Slates to the middle of the Bala or Caradoc Formation of Wales and the West of England.

The Graptolite zones are here briefly described:—

ZONE I.—*Cape Rosier Zone:* Zone of *Dictyonema sociale* and *Bryograptus.*

This is the oldest represented, and it occurs at the Barrasois River, Cape Breton Island, and at Cape Rosier, Gaspé; as well as at other points along the south shore of the St. Lawrence. In Europe it occurs in the Tremadoc of Wales and the Tremadoc and Ceratopyge Beds of Norway (Brögger) and Sweden (Tullberg). It is of Upper Cambrian age.

ZONE II.—*Ste Anne Zone:* Zone of *Phyllograptus Anna;* Graptolites from Rocks three miles above Ste Anne des Monts.

This zone contains the following four species of Graptolites; *Tetragraptus bryonoides*, Hall; *T. fruticosus*, Hall; *Phyllograptus Anna*, Hall; *Didymograptus extensus*, Hall. "These are all well-known Point Levis species, according to the classical monograph of Prof. Hall,[1] and they also occur together upon the corresponding Arenig-Skiddaw horizon in Europe, in the Shelve Arenigs, in the Skiddaw Slates, and in the *Phyllograptus* beds of Norway and Sweden."

The author remarks upon the absence of this Ste Anne Phyllograptus zone in the collection among the fossils eastward of the Ste Anne River, though the lithological characters of these strata point to the persistence of such a zone for great distances.

ZONE III.—*Griffin Point* or *Marsouin River Zone:* Zone of *Cœnograptus gracilis.*

This supplies the largest number of species in the collection.

The most characteristic forms are *Didymograptus sagittarius* (Hall, non Hisinger); *Cœnograptus gracilis*, Hall; *Dicellograptus sextans*, Hall; *Lasiograptus mucronatus*, Hall; *Climacograptus antiquus*, Lapworth; *Diplograptus Whitfieldi*, Hall, "and the presence of a single one of these species is sufficient to settle the age of the rock in Great Britain, and in all likelihood in America." But there are associated with them a few species which enjoy a more extended range in time, such as the well-known Hudson River form, *Dicranograptus ramosus*, Hall.

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[1] Canadian Organic Remains, Decade ii. 1865, "Graptolites of the Quebec Group."

The most important and interesting point in connexion with this Marsouin River zone is its identity with that of the Norman's Kill shales in the Hudson River valley, near Albany, described by Prof. James Hall in the "Palæontology of New York."[1]

The New York geologists have always held that the Norman's Kill beds are of the age of the Hudson River (Lorraine Shales), or of that of the Utica Slate; but Prof. Lapworth observes, "not a shadow of palæontological evidence has yet been adduced to show that these Norman's Kill or Marsouin Rocks are newer than the Trenton." On the whole he regards the Marsouin zone provisionally as coming between the Chazy (holding *Muclurea Logani* and *Ophileta compacta*) and the Trenton Limestone in America, and therefore answering roughly to the *Cænograptus gracilis* zone in Britain, "in age as well as in fossils."

As a result of his analysis of the three Graptolitic zones above detailed, Prof. Lapworth finds that there are two grand faunas represented, viz.:—(A) The so-called Quebec fauna of the Calciferous-Chazy formations of Cape Breton, Cape Rosier, Point Levis and Ste Anne, which answers to the fauna of the British Upper Tremadoc and Arenig rocks and their European equivalents; and (B) the Griffin Cove, Marsouin River, and Norman's Kill fauna, which answers to the fauna of the middle zones of the European Ordovician or Cambro-Silurian rocks.

In each of these grand faunas are found two subfaunas, those of the lower faunas being the more distinctly separable:—

*A*. QUEBEC OR CALCIFEROUS-CHAZY FAUNA.—Subfauna I.—*Cape Rosier and Barrasois River Zone*, of Calciferous age = Tremadoc Rocks of Great Britain and *Ceratopyge* and *Dictyonema* Beds of Norway.

Subfauna II.—*Ste Anne River Zone*, of Point Levis age = typical Arenig of Great Britain; *Phyllograptus* Beds of Scandinavia, etc.

*B*. TRENTONIAN, MARSOUIN RIVER, OR NORMAN'S KILL FAUNA.—Subfauna *A*.—*The Cænograptus Zone of Griffin Cove and the Marsouin River*, answering to the Middle Llandeilo Beds of Great Britain, to the Glenkiln Beds of Scotland, etc.

Subfauna *B*.—*The Cove Fields and Orleans subfauna;* apparently destitute of *Cænograptus gracilis*, and answering to the highest Llandeilo or lowest Caradoc Beds of England.

The last of these subfaunas shows evidence of a transition into the Utica-Lorraine Graptolitic fauna of the Mohawk Valley, New York, and of Lake St. John, Canada."

The author next presents a "Possible Ascending Succession of Strata, on the South Side of the St. Lawrence, from Cape Gaspé to Tartigo River," which includes

PRE-CAMBRIAN.

(*A*). Metamorphic Rocks of the Shickshock Ranges [in the Gaspé Peninsula].

CAMBRIAN.

(*B*). Cambrian Formations.

ORDOVICIAN.

(*C*). Ordovician or Cambro-Silurian Formations.

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[1] Vol. i. 1847.

(1). *Lower or Quebec Group of Logan.*
(2). *Middle Division, or Trenton and Black River Rocks of Hall and Logan.*
(3). *Upper Division, or Hudson River and Lorraine Rocks of Hall and Logan (apparently wanting).*

The lithological characters of these groups are described with much minuteness, and their stratigraphical relations discussed. Into these details our space forbids us to enter, but we cannot refrain from quoting from the paragraph in which Professor Lapworth concludes this interesting and suggestive study of Canadian Graptolites.

"In the careful study of the geographical and geological distribution of the several horizons of these Graptolites in the extensive convoluted rock series of the Eastern Townships, lies the solution of the great geological enigma of the Quebec Group and its puzzling associates. We shall not be able to parallel the eastern and western series, formation for formation, until we know more of the Graptolitic fauna of the Chazy, Black River, Trenton, Utica and Lorraine formations themselves, where they lie flat and undisturbed, and can compare them with those of their European equivalents. This is a work that ought to be at once taken up by American geologists, and carried on, stage by stage, with the study of the equivalent rocks of the convoluted eastern areas. Till this is done, all our correlations of these eastern deposits must be regarded simply as provisional approximations, liable to inevitable modification and improvement in the light of future discovery."

The last few pages of the Report are devoted to a "Provisional list of Fossils [*i.e.* Graptolites], with localities," together with two useful tables; Table A. "Showing the various Horizons, approximate Geological Age, and American and European Equivalents of the several Graptolitic Zones," etc. Table B. "Showing Vertical Range of Graptolites from Rocks between Cape Rosier (Gaspé) and Cap Rouge (Quebec)." A. H. F.

# REPORTS AND PROCEEDINGS.

## I.—The Palæontographical Society of London.

### Report of the Council read and adopted at the Annual General Meeting, held at the Apartments of the Geological Society, Burlington House, 17th June, 1887, Dr. Henry Woodward, F.R.S., Vice-President, in the Chair.

THE Council in presenting their fortieth Annual Report take the opportunity of inviting the attention of Members to the publications of the Society and to the faithful manner in which the wishes and purpose of its founders are being carried into effect.

Since the last meeting was called, a volume has been issued—one every way equal to its predecessors, so far as the valuable scientific information contained in it and the beauty of its illustrations are concerned. This book (the return for the Members' subscriptions due in 1886) contains five distinct subjects, four of which form the commencement of new monographs, and one is the continuation of a Memoir begun twenty years previously. The first on the list, that on the Morphology and Histology of *Stigmaria ficoides*, by Prof. W. C. Williamson, LL.D., F.R.S., is a complete summary of the latest information on the roots and rootlets of the great Carboniferous Sigillaroid trees, and devotes fifteen plates to their aspect, as seen by the aid of the microscope as well as by the unassisted vision. All the plates are examples of high artistic skill, and of excellent lithographic printing.

The second monograph on the list, viz. that on the Fossil Sponges, by Dr. George J. Hinde, F.G.S., deals with a general introduction, and gives much information with regard to the structure and forms of Palæozoic Sponge-spicules. The eight plates accompanying Part I. of this Memoir are fine specimens of careful drawing. In the third work, treating of the Jurassic Gasteropoda, by Wilfrid H. Hudleston, M.A., F.R.S., F.G.S., the variations in the strata of the Inferior Oolite at numerous localities in Dorsetshire and Somersetshire are dwelt upon (the beds themselves being carefully defined), so that when the description of species commences, as will be the case in the next volume, the different horizons can be rigorously indicated. In the fourth Monograph, by S. S. Buckman, F.G.S., the Ammonites of the Inferior Oolite are taken in hand, and five species, illustrated by six admirable plates, are described with much care, an earnest of the nature of the parts that will follow. In the fifth and last work the continuation of the Mammalia of the Pleistocene period, by Professor W. Boyd Dawkins, M.A., F.R.S., F.S.A., F.G.S., the horns of some of the Deer belonging to that era are delineated by seven fine plates.

The cost of this grand volume has exceeded five hundred pounds, and has been more in amount than the sum contributed by the subscribers for the year to which the book relates.

The volume for the year 1887 is with the printer, and will contain the continuation of the Monographs on the Palæozoic Sponges, the Jurassic Gasteropoda, and the Inferior Oolite Ammonites; it will introduce, in addition, a new Monograph on the Palæozoic Phyllopoda, by Prof. T. Rupert Jones, F.R.S., and Dr. H. Woodward, F.R.S.

Dr. H. Woodward has promised, at an early date, a Monograph on the Insects of the Coal-period, for which he has been for some time collecting materials.

Active then as is the Society for the promotion of Palæontological Science, it is a matter of regret, that Geologists in general do not more readily enroll themselves as members. A hundred additional subscribers would materially advance the issue of the Monographs, seeing that several of the latter cannot at the present moment be proceeded with for want of funds. The aim of the Society is essentially national, and is deserving of national support. For forty years the Society has laboured and has outlived all but a very few of its founders and early friends; nevertheless the present year finds it still at work, striving to spread abroad a knowledge of the vast stores of fossil treasures existing in the strata of Great Britain. Since the days that its original promoters met together, many Free-

Libraries, local Geological Societies, and Naturalists' Field-Clubs have risen into being, but the number of these institutions that have joined the Society is very small.

Cannot the lovers of geological science be induced to combine and replenish the void places caused, to so large an extent of late years, by the hand of death in the once long list of members of this useful and important Society, whose work cannot be said to be fulfilled so long as any British fossils remain unfigured and undescribed?

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## II.—GEOLOGICAL SOCIETY OF LONDON.

June 23, 1887.—Professor J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "On Nepheline Rocks in Brazil, with special Reference to the Association of Phonolite and Foyaite." By Orville A. Derby, Esq., F.G.S.

The author refers to the phonolites and associated basalts of Fernando Noronha, a deep-sea island off the north-eastern shoulder of the Continent of South America. Nepheline rocks of a somewhat different character are abundantly developed on the mainland, and under conditions favourable for throwing light on the relations existing between the granitic type, foyaite, and the other members of the group. There are some mountains near Rio de Janeiro composed of these rocks, as is also the peak of Itatiaia, 3000 metres high, the loftiest mountain of eastern South America. A cursory examination of some of these localities having shown an apparent relation between foyaite, phonolite, trachyte and certain types of basalt, Mr. Derby determined to visit the Caldas region, where a railway under construction gave unusual facilities for examining this series. A fine development of foyaite, phonolite and tuff was found, associated with several types that have not yet been met with in the other localities. The existence of a leucite basalt was recognized.

The bulk of the paper was devoted to a detailed description of these railway-sections, and the following deductions are drawn:—

1. The substantial identity, as regards mode of occurrence and geological age, of the Caldas phonolites and foyaites.
2. The connexion of the latter through the phonolites with a typical volcanic series containing both deep-seated and aerial types of deposits.
3. The equal, if not greater antiquity of the leucite rocks as compared with the nepheline rocks, whether felsitic, as phonolite, or granitic as foyaite.
4. The probable Palæozoic age of the whole eruptive series.

2. "Notes on the Metamorphic Rocks of South Devon." By Miss Catherine A. Raisin, B.Sc. Communicated by Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

This communication consisted mainly of detailed observations, supplementary to those published by Prof. Bonney in the Society's Journal for 1884, on the slaty and metamorphic rocks of South

Devon in the neighbourhood of Salcombe estuary. In the first part of the paper details were given of the sections exposed around the estuary, at Hope Cave to the westward, and in several localities to the eastward as far as Hall Sands, all confirmative of Professor Bonney's views, and showing that the slaty beds to the northward do not pass into the mica and chlorite schists to the south, but are separated from the latter by a line of faults.

Descriptions were then given of microscopic slides from various parts of the metamorphic rocks. Some of these showed the action of secondary forces. The effects of lateral pressure in producing cleavage-planes and a kind of jointing were also commented upon.

An attempt was also made to determine the succession of chlorite-mica- and micaceo-chloritic schists around Salcombe estuary. The beds appeared to succeed each other in the following order, commencing from the northward :—

1. (*a*) Interbanded series south of Halwell Wood, etc.
   (*b*) A thick band of chlorite-schist at Scoble, Snapes Point, etc.
2. (*a*) Mica-schist north of the side estuary.
   (*b*) Interbanded series south of the side estuary.
3. Mica-schist of Portlemouth Ferry.
4. Chlorite-schist of Bickerton.

3. "On the Ancient Beach and Boulders near Braunton and Croyde in North Devon." By Prof. T. McKenny Hughes, M.A., F.G.S.

The author observes that amongst the raised beaches of S.W. England we generally find included the sand cliffs of Saunton Down and Middleborough on the coast west of Barnstaple. These deposits possess a further interest owing to the occurrence at their base of large boulders. In 1866 Mr. Spence Bate, in opposition to the prevailing view, concluded that the so-called raised beach is the undestroyed remnant of an extensive district of wind-borne sand similar to that which now exists on Braunton Burrows. The points to which attention was invited are as follows :—

1. Is this deposit on the southern slope of Saunton Down a raised beach?

2. Were the above-mentioned boulders carried to their present position by ice?

The paper was fully illustrated by diagrams, showing the relations of the recent deposit, and by figures showing the mode of occurrence of three of the most remarkable boulders. The conclusions were :—(1) That the ancient beach of Saunton Down and Croyde is not a *raised beach* in the ordinary acceptation of the term. The top is subaerial talus, the middle part is blown sand, the base only marine, and the marine part is not above the reach of the waves of the sea at its present level. (2) The boulders of granite and felsite which occur at the base of the ancient beach were transported to their present position by the waves of the sea. Such as are of local origin could have reached the sea by the ordinary processes of denudation; such as are possibly of northern origin could have been carried down the Irish Channel on bergs, and been thrown up by the sea to their present position at any period subsequent to their transportation southwards by ice; but their presence does not imply any *local* glaciation.

4. "Notes on the Formation of Coal-seams, as suggested by evidence collected chiefly in the Leicestershire and South Derbyshire Coal-field." By W. S. Gresley, Esq., F.G.S.

The author's principal object in this paper was to bring forward evidence in opposition to the view now generally accepted that coal-seams were formed from vegetation growing on the spot.

He showed that during a very extensive experience he had only once or twice detected stems passing into a bed of coal and connected with the Stigmaria-roots in the underclay. If, as was generally stated, the Stigmariæ were the roots of the trees that formed the coal, such instances ought to be common. Not only, however, were they very rare, but the abundance of the Stigmariæ was extremely variable, and these roots, instead of becoming more thickly matted together in the uppermost part of the underclay, as they should be if they were roots of the coal-forests, were generally distributed, as a rule, throughout the clay in a manner that showed them to have been in all probability independent organisms. Stigmarian roots, when found connected with a stem, were more often on the top of the coal-seam than at the bottom.

Other reasons assigned for rejecting the hypothesis that coal-seams were formed of plants that grew upon the spot were the occasional absence of underclays, the sharp division between the coal-seams themselves, and the beds above and below them; the distinct lamination of every seam and its division into layers of different mineral character that are persistent over large areas; the presence of foreign bodies in the underclay, and especially of pebbles and boulders transported from a distance; the presence of similar fish, etc., in the coal itself; and the circumstance that many coal-seams are impregnated with salts, and are associated with beds containing marine fossils.

5. "Note on some Dinosaurian Remains in the Collection of A. Leeds, Esq. Part I. *Ornithopsis Leedsii.* Part II. *Omosaurus*, sp." By J. W. Hulke, Esq., F.R.S., F.G.S.

Part I. *Ornithopsis Leedsii*, nov. sp., from the Kimmeridge Clay of Northamptonshire.

The author described a pelvis, vertebræ and costæ referable to this genus, of a stature far surpassing that represented by the pelvis in the Fox Collection from the Isle of Wight Wealden, which he brought under the notice of the Society a few years since. The ilium has a very long preacetabular process. A rib is three times as large as the largest rib of an elephant of average stature. The trunk vertebræ show the characteristic large chamber opening in the side of the centrum, under the platform supporting the neurapophyses. There is no post-pubis. The pubis and ischium diverge; their close resemblance to those of *Ceteosaurus oxoniensis*, figured by J. Phillips, in the 'Geology of Oxford,' is obvious when each figure is reversed, their true position being misrepresented in that author's diagram, a very excusable error.

Part II. described a sacrum, with ilia, vertebræ, a femur, etc. The neural arches of the sacral vertebræ are synostosed, and so form a continuous roof (simulating the vault of a cranium) of the dilatation of the neural canal, which enclosed the sacral swelling of the spinal cord. The transverse processes are long. The ilia offer a general resemblance to those of *Osmosaurus armatus* (Owen), but differ from those of this species in the relatively greater length and narrowness of the preacetabular process. The similarity of construction of this sacrum to that of *Stegosaurus*, described by O. C. Marsh, and the very close resemblance of their ilia were noticed. The author considered that an extremely close affinity exists between these two genera, and is prepared to find that, upon the acquisition of more materials, their identity may even be established. For the present, he preferred to refer the Peterborough Dinosaur to *Omosaurus*, and proposed for its specific name *durobrivensis*, having reference to that of the old Roman settlement in that locality.

6. "Notes on some Polyzoa from the Lias." By Edwin A. Walford, Esq., F.G.S.

The author briefly reviewed the work of Etheridge, Vine, and others in the tabulating of the British Liassic Polyzoa, and mentioned also the labours of Terquem and Piette, Dumortier, and others in the same direction in France and Germany. He directed attention to a species described by Prof. Tate from the Lias of May, Normandy, under the name *Spiropora liassica*, and described specimens in his own collection from a similar horizon in the Midlands, with which it had been confounded. The English forms have very varying modes of growth; sometimes foliaceous after the fashion of the *Diastopora* proper of Haime, at other times ramose and cylindrical, like *Entalophora*. The latter habit, together with the long, and often partly free, zoœcia, suggest the relationship of the species with the *Tubuliporæ*. The exceptional state of preservation of the specimen is such as to show the cells in a perfect condition, with solid circular calcareous closures within the orifice of the zoœcial tubes, a feature common to both the foliaceous and the cylindrical forms. The surface-pores are unusually well preserved, and appear to be similar to those of the recent Cyclostomatous Polyzoa. The name of *Tubulipora inconstans* is proposed for the species.

Mention was also made of other fragments of Polyzoa of doubtful relationship occurring in the same beds.

7. "On the Superficial Geology of the Southern Portion of the Wealden Area." By J. Vincent Elsden, Esq., B.Sc. Communicated by the President.

The author, after referring to Sir R. Murchison's paper, published more than thirty years ago, on "The Distribution of the Flint Drift of the S.E. of England," proceeded to give in detail his observations on the angular flint-deposits of the Arun, Adur, Ouse, and Cuckmere basins, He also noticed a sandy or loamy deposit containing angular fragments of ironstone, and generally a few small angular flints that occurred on the surface of the Lower Greensand, and to a small extent on the Weald Clay. A block of granite, weighing between 5 and 6 lbs., was found on the chalk escarpment at Kilhurst Hill.

The angular flint-drift occurred mainly on the higher parts of the area, and was wanting in the river-valleys, where, however, river-gravels derived from the denudation of the older deposits were abundantly developed. This distribution of the angular drift was shown to be incompatible with the theory of its origin advocated by Sir R. Murchison and some other geologists, who attributed it to a violent and transitory current. The author showed that not only in the Wealden area, but throughout many of the neighbouring districts, the angular drift consisted of the undenuded remnants of a deposit formed before the present river-valleys were cut, and that many of the river-gravels, though newer than the angular drift, were deposited when the valleys had been less excavated than they now are. This was Mr. Topley's view with respect to the northern portion of the Wealden area. Mr. Searles V. Wood's marine theory of the origin of these gravels was discussed, and shown to be refuted by their mode of occurrence. It was, moreover, contended that the drift, although composed of local materials, was probably of subaqueous origin, and not merely subaerial. The discovery of a granite boulder might, if confirmed by other discoveries, lead to a modification of the views generally held as to the physical character of the area during the Glacial period.

8. "Report on Palæo-botanical Investigations of the Tertiary Flora of Australia." By. Dr. Constantin Baron von Ettingshausen, For.Corr.G.S. (This paper appears in full in this Magazine.)

9. "On some new Features in *Pelanechinus corallinus.*" By T. T. Groom, Esq. Communicated by Prof. T. M'Kenny Hughes, M.A., F.G.S.

The discovery by the author, in the Coral Rag at Calne, of an additional and well-preserved specimen of the Echinoderm originally described by Dr. Wright as a *Hemipedina*, but subsequently made the type of a new genus, *Pelanechinus*, by Mr. Walter Keeping, afforded an opportunity of adding considerably to the known characters of the type. The test proved to be flexible, as in the Echinothuridæ, a point already noted by Mr. Keeping.

A number of details as to the interambulacral and ambulacral areas, the imbricating peristomial plates, pedicellariæ, and teeth were given. Pedicellariæ did not appear to have been previously observed in fossils.

The genus appeared to occupy an intermediate position between the Echinothuridæ, Echinidæ, and Diadematidæ, and must form the type of a distinct subfamily, perhaps referable to the last named. A new description of the species was added.

10. "On Boulders found in Seams of Coal." By John Spencer, Esq., F.G.S.

The discovery of a boulder weighing 6 lbs., and composed of granite, in the Gannister or Mountain-Mine seam of the Rossendale district, at Old Meadows Pit, near Bacup, Lancashire, had led the author to call attention to the occasional occurrence of similar boulders in various parts of Lancashire and Yorkshire. Such boulders were always isolated, and sometimes imbedded in the seam, sometimes in its upper surface. They were always waterworn and rounded, and were composed, so far as had been observed, of granite, gneiss or quartzite foreign to the district.

After considering the various suggestions that had been made as to the means by which such boulders had found their way into the coal, the author gave the preference to the action of floating-ice, both because the presence of fragments from a distance would thus be more readily explained, and because ice-scratched rocks have been found *in situ* in the Millstone Grit within three miles of the place whence the boulder mentioned was obtained.

The next Meeting of the Society will be held on Wednesday, 9th November.

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## III.—Zoological Society of London.

May 17th, 1887.—Prof. W. H. Flower, LL.D., F.R.S., President, in the Chair.—The following communications were read :—

1. "On the Presence of a Canal System, evidently Sensory, in the Shields of Pteraspidian Fishes." By A. Smith Woodward, F.Z.S.

A broken specimen of *Pteraspis Crouchii* in the British Museum adds an interesting fact to our knowledge of the structure of the shield in the Pteraspidian fishes. In his well-known monograph on this ancient group, Prof. Ray Lankester described a number of pits or depressions arranged in rows upon the external surface of certain well-preserved examples, and considered that they were connected with the "lateral line" system of the fish, probably lodging the sensory organs situated in an enveloping soft integument. The same feature was again described in *Holaspis* in 1873 (Geol. Mag. Vol. X. p. 243, Pl. X.) It now appears that these curious depressions are really the openings of a canal system, traversing the middle layer of the shield, and quite comparable to the canals of the lateral line in many ganoids and teleosteans. The branches have the remarkable "feather-barb" arrangement, so well seen in the living Pleuronectidæ.

2. "Note on the 'Lateral Line' of *Squaloraja*." By A. Smith Woodward, F.Z.S.

In his description of the genus *Squaloraja*, recently published, the author had failed to recognise traces of the lateral line. He now showed that these canals were supported by numerous minute, incomplete, calcified rings, exactly similar to those well known in recent and fossil Chimæroids. The fact probably implied that the sensory organs were placed in open grooves, and thus added one more feature to those already noted as connecting the old Liassic Selachian with the Holocephala.

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2. June 23rd, 1887.—Prof. W. H. Flower, LL.D., F.R.S., President, in the chair.—The following communications were read:—

1. "Note on a Fossil Species of *Chlamydoselachus.*" By James W. Davis, F.G.S.

The author showed that some teeth described and figured about ten years ago by R. Lawley ("Nuovi Studi sopra ai Pesci, etc.," Florence, 1876, p. 87, pl. i. figs. 1, *a-c*) were truly referable to the newly-discovered Japanese Shark, *Chlamydoselachus*, Garman. These fossils were obtained from the Pliocene of Orciano, Tuscany, and their original discoverer was naturally perplexed in determining their relationships; he left them *incertæ sedis*, and refrained from proposing a name. Mr. Davis suggested that the new species be known as *C. Lawleyi.*

2. "On the Fossil Teleostean Genus *Rhacolepis*, Agassiz." By A. Smith Woodward, F.Z.S.

This communication contained a detailed description of the Brazilian fossil fish briefly noticed by Agassiz under the name of *Rhacolepis*, and concluded by discussing the systematic position of the genus. The original determination was founded upon a collection of fossils obtained by Mr. G. Gardner, about 1840, from Barra do Jardim, Serra de Araripe, North Brazil, and brief notes were published in the "Edinb. New Phil. Journ." 1841, and the "Comptes Rendus," vol. xviii. p. 1007. An early figure, without name, was also given in the Atlas accompanying Spix and Martius' "Reise in Brasilien," 1823. A large number of specimens now in the British Museum display the principal characters of the skeleton, and also show well-preserved traces of the gills and the lateral muscles of the trunk. The body exhibits but slight lateral compression, and the abdomen is rounded; the snout is acutely pointed, and the roof of the skull flattened. The margin of the upper jaw is formed both by the premaxillæ and maxillæ, and the cleft of the mouth is nearly horizontal; the cheek is covered by the expanded posterior circumorbital bones; there is a narrow preoperculum, a triangular interoperculum, and a relatively large suboperculum. The branchiostegal rays are numerous, about ten, of considerable size, being attached to the epihyal, and an equal number of smaller ones to the ceratohyal. There is a single dorsal fin in the middle of the back; the pelvic fins are abdominal in position, opposite the dorsal, and each consists of about 12 soft rays; the anal is situated half-way between the pelvics and the caudal; and the latter is deeply forked. The scales are cycloid and beautifully marked with delicate radiating rugæ; thin scales also appear upon portions of the dorsal and caudal fins. A distinct "axillary appendage" is observable above the pectoral fin. Three species can be distinguished, and are separated by the form of the body, and the proportions of the operculum and posterior circumorbital bones; they were respectively named by Agassiz, *R. brama*, *R. buccalis*, and *R. latus*, and many of the National fossils bear his MS. labels. The newly-determined characters show that *Rhacolepis* is not a Percoid or Berycoid, as originally supposed, but a truly Physostomous fish. The author concluded that it was an Elopine Clupeoid.

## CORRESPONDENCE.

### NOTES ON CHELONIA.

Sir,—In the interesting "Notes on Chelonia from the Purbeck, Wealden, and London-clay," by Messrs. Lydekker and Boulenger, in the May Number of this Magazine, the authors refer to the generic identity of the plastron named by Prof. Sir R. Owen *Platemys Bullockii*, supposed to have been obtained from the London-clay at Sheppey, and the plastra of the same author's genus *Pleurosternon* from the Purbecks. In regard to which will you allow me to state, that when arranging the fossil Chelonia, some fourteen or fifteen years ago, in the Museum cases at Bloomsbury, I observed that the structural characters of the plastra of *Platemys Bullockii* and of *Pleurosternon* were the same, and that the two genera must be merged into one. This conclusion was further confirmed by a closer examination of the matrix adherent to the former, which proved it to have been derived from the Purbecks, and not as stated from the London clay. The specimen has ever since been exhibited in the Museum cases with the following label attached, "*Pleurosternon* (*Platemys*) *Bullockii*, Owen, Purbeck beds, Swanage."

Though the locality is not positively known, there can be little doubt that the specimen was found in the "Isle" of Purbeck, and in the neighbourhood of Swanage. Prof. Rütimeyer's remarks upon the same subject were, I am sorry to admit, unknown to me until very recently.

Wm. Davies.

### THE LIZARD SERPENTINES.

Sir,—It appeared to me that, in regard to the existence of felspar in the Rill serpentine,[1] lately in dispute between Mr. Teall and myself, the evidence of a chemical analysis of the rock would do much to clear up the question. Through the kindness of Dr. S. Rideal, a partial analysis of this serpentine has been made in the Chemical Laboratory at University College with the following results in two cases:—

| | I. | II. |
|---|---|---|
| $SiO_2$ | 42·70 | 42·63 |
| $Al_2O_3$ | 14·79 | 14·05 |
| $Fe_2O_3$ | 8·77 | 8·55 |
| $CaO$ | 3·05 | 3·22 |
| $MgO$ | 17·08 | 18·68 |
| | 86·39 | 87·13 |

The water, alkalies, etc., were not estimated, as I had said that probably the silica, alumina, and magnesia would suffice for my purpose. At first sight this analysis appears conclusive in favour of Mr. Teall's contention, that there is felspar in the rock. It is the analysis of a picrite, so far as such a variable rock can be said to have a typical analysis. Indeed, the proportion of alumina is large even for a picrite. But I still feel perplexed, for on consideration of the analysis it appears to me to "prove too much." Suppose the alumina all present in the felspar, and that to be anorthite; for

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[1] See Geol. Mag. Feb. 1887, p. 69, and March, 1887, p. 137.

rough calculations take the alumina as 14 per cent., and use the proportions given by Nicol in his Mineralogy: then there will be in anorthite $\frac{43}{37} \times 14$ of silica, and $\frac{20}{37} \times 14$ of lime, i. e. the amounts of silica and of lime in the felspar will be nearly 16·3 and 7·6 respectively. But the amount of CaO in the analyses is only 3·05 or 3·22. Moreover, the total of the constituents in the anorthite would be nearly 37; or more than a third of the rock would be felspar, which is certainly far too much for any slide that I have seen. If the amount be calculated from the lime, 5·5 of the alumina would be needed, and 6·5 of the silica, and the felspar would be 26 per cent. of the rock,—still too much, and there would be 8·5 of the alumina left. In both these cases also there is not magnesia enough for the remaining silica, if, as seems certain, another principal constituent has been olivine. Suppose, however, the felspar be labradorite; then, calculating in the same way, and supposing all the lime to be a constituent of that mineral, we require 8 per cent. of the alumina, leaving 6 per cent., so that the rock should be rather rich in such a mineral as spinel, which it is not. In this case also the proportionate amount of felspar seems considerably in excess of the amount of the mineral which has been claimed. I have made various other trial calculations from the analysis, and in no case can I obtain results which seem to accord with the microscopic structure of the rock, even in matters on which I believe we should be in agreement.

I may indeed add that I have more than once found a similar apparent discrepancy between the microscopic and the chemical analysis of a picrite, and had reason to suspect that the alumina was mainly present as the constituent of a mineral other than felspar. So, notwithstanding the apparently conclusive evidence of the chemical analysis, on which I frankly admit Mr. Teall is entitled to claim a verdict in his favour, I still feel very strongly the difficulties as to the identification of the mineral alleged in my former communication, and am not sure that the question is even yet decided beyond all appeal.

T. G. Bonney.

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## THE BAGSHOT SANDS.

Sir,—I do not think Mr. R. S. Herries (Geol. Mag. April, 1887, p. 192) has found such a 'mare's nest' as he seems to imagine. The note he has quoted from vol. iv. of the Memoirs of the Geological Survey, of a pebble-bed somewhere near Barkham, has long been familiar to me; but I have never succeeded in finding *the* pit to which the description would apply. Short of the identification of the pit, which I have described in my paper in the Geol. Mag. for March last, by the original writer of the note quoted, I cannot admit its application to the case in question. If the author of that note is prepared to vouch for the supposed identification, the inaccuracy of the description will go far to vitiate the evidence of similar notes from the same source. I leave my critics to choose between the horns of this dilemma.

In speaking of an "unmappped outlier," it was simply intended to imply that the beds under consideration *had not been mapped out* *as an outlier.* A portion of them had been mapped, as I knew perfectly well; but, as I think, wrongly. As a matter of fact, they are found to extend half a mile further to the north, than the boundary-line drawn on the map. When Mr. Herries shall have made as complete and close an examination of the locality as I have made, I shall be glad to welcome further criticisms from him on my paper; meanwhile I do not feel quite justified in filling up the pages of the GEOLOGICAL MAGAZINE in recording "glimpses of the obvious." A. IRVING.

WELLINGTON COLLEGE, BERKS.

## OBITUARY.

### ARTHUR CHAMPERNOWNE, M.A., J.P., F.G.S.

BORN MARCH 19TH, 1839; DIED MAY 22ND,[1] 1887.

EVER and anon as we press forward in life's journey we are confronted with the loss of some valued friend and comrade, in whose removal we seem to suffer a far greater hardship than any other we have had to bear. To many of us such a feeling arises when we recall the keen sorrow of a few weeks since at the loss of our fellow-worker in geology, Arthur Champernowne.

He was the eldest son of Henry Champernowne, Esq., of Dartington Hall, Totnes, South Devon, and belonged to one of the oldest families in Devonshire. His father died in 1851, whilst Arthur was only 12 years of age. He was educated at Eton, whence he passed to Trinity College, Oxford, where he graduated as M.A. In 1870 he married Helen, daughter of M. L. Melville, Esq., of Hartfield Grove, Sussex.

Soon after he settled down in Devonshire, he became acquainted with William Pengelly, F.R.S., of Lamorna, and John Edward Lee, F.G.S., of Villa Syracusa, Torquay, the latter of whom was the intimate friend of Prof. John Phillips, of Oxford, whose lectures Arthur Champernowne had attended. The interest these geologists aroused in his mind caused him to look around his own county and try to understand, and finally to map, probably one of the most complex pieces of country in the whole of England.

Mr. Champernowne never enjoyed robust health, but his earnestness and enthusiasm in whatever he undertook carried him through successfully. He was an excellent artist, and when travelling for his health in Italy, he made many sketches; but after he took up geology he only used his pencil to prepare sections and draw fossils, which he executed with great skill and fidelity.

He geologised in Spain, and in order the better to comprehend his native county, he made repeated expeditions to the Devonian rocks of the Eifel, on one occasion with Mr. John Edward Lee, of Torquay,

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[1] The 5th June was by an error the date quoted in the July Number GEOL. MAG.—EDIT.

spending some time at Prüm and Gerolstein. He also geologised at Paffrath and in other parts of Germany and Belgium. His last foreign trip to Belgium was particularly interesting to him, and he was enabled to confirm many of his views as to the geology of South Devon by what he saw in the Meuse Valley. In this visit he was greatly assisted by M. Dupont, the Director of the Geological Survey, who desired M. Alphonse Le Duc to accompany Mr. Champernowne over much of the ground he wished to see and study.

He took the greatest interest in the Devonian Corals, in the working out of which he never seemed to tire. He was the first who discovered the *Calceola* Limestone, and obtained specimens from the cliff-section immediately below Daddy-hole-plain, Torquay—in front of Mr. Lee's house. He also obtained the fine *Homalonotus* from the Devonian of the "New Cut," Torquay (figured in the Geol. Mag. 1881, Pl. XIII. p. 489), and named after him by the writer. So keen was he in the field that wherever he geologised he invariably was the first to discover fossils, and usually the best specimens fell to his own hammer.

During his Devonian researches he discovered in the "Pit-Park Quarry" near the Hall, a vast number of Stromatoporoids, which led him to enter into an earnest correspondence and have frequent interesting conversations with Dr. H. J. Carter, F.R.S., of Budleigh Salterton, Devon, who had taken much interest in this group of organisms. Mr. Champernowne with great diligence extracted large numbers of these fossils from the Limestone, and had numerous sections cut and polished at his own cost to illustrate their internal structure, and he most liberally distributed these to various museums and individuals interested in their examination.

Prof. Nicholson writes, "Mr. Champernowne took a special interest in the Stromatoporoids, and gave me throughout the most unselfish and ungrudging help in the work I had undertaken, namely, to prepare a Monograph on this group of organisms for the Palæontographical Society. He not only placed at my disposal the whole of his splendid collection from the British Devonians, but he freely laid before me the results of his own studies in these difficult fossils; indeed, I owe more than I could easily measure to his friendly criticisms on my work, and his wise suggestions as to the particular lines of research which it would be wise for me to follow. With this feeling, I cannot but recognize in the death of Arthur Champernowne that a heavy loss has befallen the small band of British Palæontologists of which he was so excellent a type. It is not only a gifted scientific observer that has gone from amongst us, but a genuine man and a loyal and true-hearted friend."

With Mr. Horace B. Woodward, Mr. W. A. E. Ussher, of the Geological Survey, and Mr. Frank Rutley, he was in frequent correspondence; and when the former Surveyors were at work in his area, it afforded Mr. Champernowne the keenest pleasure to join them in the field and share his knowledge of the country with them.

The visit paid to Devonshire by Prof. Dr. Ferdinand Roemer, of Breslau (the Geological Historian of the Devonian rocks of the

Eifel) afforded Mr. Champernowne the utmost gratification, as confirming the views which he had arrived at, together with Mr. John Edward Lee, on the Upper Devonian Goniatite Limestone in Devonshire (see GEOL. MAG. 1880, Pl. V. p. 145) and other kindred subjects.

Mr. Champernowne was at the time of his death a Member of the Councils of the Geological and of the Palæontographical Societies, in both of which he took the warmest interest. He was a frequent contributor to the Quarterly Journal of the former Society as well as to the GEOLOGICAL MAGAZINE.

Mr. Horace B. Woodward frequently refers to Mr. Champernowne, and acknowledges his great indebtedness to him for revising the Devonian chapters of his "Geology of England and Wales" (2nd edition just published).

The Director-General of the Geological Survey, Prof. Geikie, told the writer, "When I saw Mr. Arthur Champernowne's detailed geological colouring on the Ordnance Maps of his own area, I was delighted with the beauty and clearness of the work, and after going over the ground with him, I was equally convinced of its careful accuracy.

"When I proposed to him that he should allow me to incorporate his work on the Survey Sheets, he was greatly pleased, but so modest and diffident was he, that after spending years on this area, he expressed his anxiety to go over it all again before allowing me to accept it as quite complete."

It was after attending the Council Meeting of the Geological Society on May 11th, that he hurried down to Dartington intent on setting to work at once upon a revision of his maps, and having gone abroad in unfavourable weather, and suffering from a severe cold, he caught a chill which developed into inflammation of the lungs, under which he gradually sunk.

Mr. Champernowne was connected with every work of benevolence and public usefulness in his own district. As a Magistrate he was most conscientious in the discharge of his duties; as a Landlord he was most generous, and lived upon the best terms with all his tenantry, his constant aim being to promote their welfare. His death was felt as a common sorrow, and his funeral was attended by representatives of all ranks of society each of whom seemed to feel that in the deceased he had lost a personal friend.

Mr. Champernowne leaves a widow and ten children, the eldest, a boy of only fifteen years, to deplore his early loss.

Like shadowy watchers by some misty shore,
  We stretch our arms towards the silent main,
And sigh for those we ne'er shall look on more,
  Whose hand-clasp we may never feel again.

There is no fear that the name of ARTHUR CHAMPERNOWNE will be soon forgotten, either in his home-circle, or in that wider scientific circle of friends, to be associated with whom as a fellow-worker he always esteemed to be his greatest happiness.—H.W.

E. C. Knight lith.
West, Newman & Co imp

Ostracoda from the London Clay.

THE

# GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. IV.

No. IX.—SEPTEMBER, 1887.

## ORIGINAL ARTICLES.

### I.—FURTHER NOTES ON THE TERTIARY ENTOMOSTRACA OF ENGLAND, WITH SPECIAL REFERENCE TO THOSE FROM THE LONDON CLAY.

By Professor T. RUPERT JONES, F.R.S., and C. DAVIES SHERBORN, F.G.S.

(PLATE XI.)

THE Tertiary Entomostraca (Ostracoda) of England, at first treated of in a monograph for the Palæontographical Society in 1856, were revised in the GEOLOGICAL MAGAZINE, 1870, pp. 155–159. The researches of G. O. Sars and G. S. Brady, elucidating the relationships of the genera and species, gave effect in a great degree to that revision; and their continued labours have further helped us.

Since the publication of the Revision, fifteen years ago, besides there being some additional corrections to be noticed, several new species have come to hand, late research in the fossiliferous deposits of Tertiary age having enabled our friends to add to the collections we have made for ourselves, so that the known English Tertiary forms are now nearly eighty in number. The British Post-Tertiary species are still more numerous.[1]

We therefore offer these "Further Notes" as of interest to workers on Fossil Ostracoda.

Besides new species, those requiring some remarks as to new occurrence or corrected nomenclature are noticed in this communication. We especially take this opportunity of drawing attention to the Ostracoda lately found in the London Clay from an excavation in Piccadilly, London; and with them we group in this paper all the species known to occur in that formation, giving illustrations of these London Clay forms in one plate, so as to present their *facies* at a glance,—with the exception of two species which reached us after the plate was finished, but figures of which are given in the text. The order of description is arranged according to the natural grouping of genera adopted by Dr. G. S. Brady in his latest memoirs on recent Ostracoda.

#### CYPRIDEA, BOSQUET, 1852.

This genus is described at large in the Quart. Journ. Geol. Soc. vol. xli. (1885), p. 336. Remarks on the possible alliance existing between *Cypridea* and *Chlamydotheca* have been made by G. S.

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[1] See the "Monogr. Post-Tert. Entom." by Brady, Crosskey, and Robertson, Palæont. Soc. 1874.

Brady, in the 'Proceed. Zool. Soc. Lond.,' 1886, p. 90; and in the 'Journn. Linn. Soc.,' vol. xix. (1886), pp. 200, 201.

### 1. CYPRIDEA SPINIGERA (Sow.).

This is referred to at pp. 316, 333, 334, Quart. Journ. Geol. Soc. vol. xli. as a species common in the upper part of the Weald Clay; and we now find that it occurs in Tertiary beds at Hempstead in the Isle of Wight. Specimens, young or imperfect, from this locality were figured in the "Geological Survey Memoir on the Isle of Wight," 1856, as a sub-reniform Ostracod with a sharp spine on each valve, *Cytherideis unicornis* (Jones). Careful examination of a further series of specimens leaves no doubt that it is the same species as that found in the Wealden beds. The Hempstead specimens are not so well preserved as those in the Wealden Clays, nor are they so abundant; but, with the many individuals that have come under our notice, we have been able to match old and young perfect examples from the Tertiary and Wealden formations.

### 2. CYPRIS INCONGRUENS, Ramdohr.

*Cypris setigera*, Jones, Monogr. Tert. Entom., 1856, p. 12, pl. i. fig. 6.
*Candona compressa* (Koch), GEOL. MAG. 1870, p. 155.

To the localities of Berkshire and Cambridgeshire mentioned in the Monograph, 1856, we have to add the Valley-drift of Fisherton at Salisbury (Dr. Blackmore's Collection), Portland raised beach (Prestwich), and lacustrian bed near Hitchin (W. Hill).

### 3. POTAMOCYPRIS TRIGONALIS (Jones); and var. LÆVIS, nov.

We have two examples of this species from Mr. Clement Reid's Collection,—one from the Norwich Crag at Bramerton,—and one from the Weybourn Crag at East Runton.[1] The latter specimen, being larger and smooth, may be distinguished as var. LÆVIS.

### 4. AGLAIA? CYPRIDOIDES, sp. nov.

The genus *Aglaia*, G. S. Brady (1868), one of the *Cypridida*, has here a fossil form provisionally referred to it on account of the similarity of shape and condition of the valves. The muscle-spot, however, is like that of *Bairdia*. Our example is from the Norwich Crag of Bramerton, and was collected by Mr. Clement Reid, F.G.S. It has the usual curved form, and is delicately pitted. It is too broad in shape for either *A.*? *glacialis*, G. S. Brady, "Post-Tert. Entom.,"

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[1] Mr. Clement Reid, F.G.S., has given a detailed account of the Norfolk Deposits in the "Mem. Geol. Survey; The Geology of the Country around Cromer," 1882. The Weybourn Crag is described at pp. 11—19; and the Entomostraca from that deposit are mentioned at p. 66. See also Prof. Prestwich's Memoir on the Crag Beds of Suffolk and Norfolk; Quart. Journ. Geol. Soc. vol. xxvii. p. 457, 460, etc.; and H. B. Woodward's "Geology of England and Wales," 2nd edit. pp. 465-474, for Bramerton, Weybourn, etc. The Bramerton Crag is also treated of in H. B. Woodward's "Geol. Surv. Mem.; The Geology of the Country around Norwich," 1881, pp. 33-55, 82, etc. The list of Ostracoda from Weybourn referred to above does not agree with our determination in all respects. Thus we have not found *Cythere tuberculata*, Sars, nor *C. pellucida*, Baird, among the specimens we have seen; and probably *C. concinna*, Jones, is represented by the set of the closely allied *C. angulata*, Sars, which we have met with. Other species in our series are not indicated in the printed list referred to.

p. 132, pl. xi. figs. 54–56; or *A.? obtusata*, G. S. Brady, "Report Challenger Ostrac.," p. 35, pl. xxx. fig. 8.

### 5. BYTHOCYPRIS SUBRENIFORMIS, sp. nov.

In the genus *Bythocypris*, determined by G. S. Brady, in "Report Challenger Ostrac.," 1880, the left valve is described as much larger than the right, and overlapping it above and below. In this character, and other features, a specimen from the "Belosepia-bed" at Bracklesham (Science Schools Coll.) coincides. It approaches *Cytherina abbreviata*, Reuss, "Haidinger's Nat. Abh.," vol. iii. p. 52, pl. viii. fig. 10; but it is too short and too high, and is not so reniform. It has the usual kidney-shape, and is also near *B. reniformis*, G. S. Brady, "Report Challenger Ostrac.," p. 46, pl. v. fig. 1; but this figured form is too short, and more incurved on the ventral edge than is our specimen.

### 6. PONTOCYPRIS (?), sp.

A single, small, pitted valve, of uncertain alliance, but approximately like some members of the genus *Pontocypris*, G. O. Sars, occurs in a collection from the Tertiary beds at Colwell Bay.

### 7. BAIRDIA SUBDELTOIDEA (Münster), Jahrbuch für Min. etc. 1830, p. 64; and 1835, p. 446.

(For synonyms see Monogr. Tert. Entom. p. 52.)

As mentioned in the GEOLOGICAL MAGAZINE for 1870, p. 157, the little *Bairdia* from the Crag ('Monogr. Tert. Entom.,' 1856, p. 52, pl. iv. fig. 2) may be *B. fusca*, G. S. Brady, 'Trans. Zool. Soc.' vol. v. p. 364, pl. lvii. fig. 9; and the fine species from the London Clay ('Monogr.' p. 52, pl. vi. fig. 1) is probably *B. subtrigona*, Bornemann, 'Zeitschr. deutsch. geol. Ges.,' vol. vii. p. 357, pl. xx. fig. 4.

We have now from the Bracklesham Belosepia-bed (Science Schools Coll.), a very fine example of the real *subdeltoidea*, which we have compared with authentic specimens from Osnabrück, sent by Count Münster to London many years ago.

With the Bracklesham specimen is a smaller individual, relatively thicker and rounder; it may belong to a different species, but for the present we leave it as a variety.

### 8. *Bairdia subtrigona,* Bornemann. Pl. XI. Fig. 1.

*B. subdeltoidea*, Jones, Monogr. Tert. Entom., 1856, p. 52, pl. vi. fig. 1.

This specimen from the London Clay is re-figured from the abovementioned Monograph. As mentioned in our description of *B. subdeltoidea*, we now refer this species to Bornemann's *B. subtrigona.*

### 9. BAIRDIA LONDINIENSIS, sp. nov. Pl. XI. Fig. 2.

This is a small neat *Bairdia*, of a not unusual form, but not exactly matching in shape any species known to us; it is moreover denticulated at the end margins, and punctate all over with very distinct, roundish, close-set pits. This valve is stained with numerous bright orange-irony spots, which possibly may be traces of the original colouring of the shell.

From the London Clay, Piccadilly; collected by Messrs. Sherborn and Chapman.[1]

### 10. BAIRDIA RHOMBOIDEA, sp. nov.

A stiff-looking *Bairdia;* broadly angular in front; nearly parallel above and below; narrow behind, with a curve on the ventral, and a slope on the dorsal edge of this end. The antero-ventral margin is suddenly constricted, leaving a projection behind the antero-ventral slope. The surface is very delicately punctate.

From the White (*Coralline*) Crag of Sutton, Suffolk.

### 11. BAIRDIA OVOIDEA, sp. nov. Pl. XI. Fig. 3.

A very small roundish *Bairdia,* pitted, rosetted at the muscle-spot, of a rather unusual pattern. It is like fig. 2, pl. iv., Monog. Tert. Entom., but much less of a subdeltoidal shape, being well rounded before, and slopingly curved behind, with the greatest fullness in the front moiety; hence, though both ends are somewhat obliquely rounded, the anterior half of the valve is broader than the hinder portion.

From the London Clay, Piccadilly. Collected by Sherborn and Chapman.

### CYTHERE, Müller, 1875.

Valves unequal (left valve usually somewhat larger than the other), oblong-ovate to quadrate in shape, smooth or rough, mostly highest in front; hinge with teeth and sockets at anterior and posterior angles, variously developed.

The quadrate and rough forms have been classed as *Cythereis* ('Monogr. Cretac. Entom.,' 1849, p. 14); and, although this group will not hold its own as a true genus, Dr. G. S. Brady having shown that the animals do not differ from other *Cytheræ,* yet it is a very convenient grouping for palæontologists, who have to study the valves only of these small fossil Crustacea.

### 12. CYTHERE RECURATA,[2] sp. nov.

Oblong-reniform, nearly equal at the ends in the outline, but thickest posteriorly, as seen in edge view. Approximating to fig. 7*g*, of G. S. Brady's *C. demissa,* in pl. xii. of the "Report Challenger Ostracoda," but more even in outline. Coarsely punctate; the pits somewhat in lines, but with a tendency to assume a concentric arrangement on the front half of the valve. Others are of the same outline, but differ in the ornament.

From the "Norwich Crag" of Southwold.

### 13. CYTHERE VENUSTULA, sp. nov.

Oblong, rounded at the ends, broadly oblique in front, semi-circular behind; straight on the ventral margin, oblique dorsally by the

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[1] In the 'Journ. R. Micros. Soc.' ser. 2, vol. vi. p. 740, this specimen was doubtfully collated with Sowerby's *Cypris barbata* ('Trans. Geol. Soc.,' ser. 2, vol. v. 1834, p. 131, pl. ix. fig. 1), but this was probably a *Cythere.*

[2] "Finished in a workman-like manner."

swelling of the anterior hinge-joint. Depressed on the front half, but more convex behind. Surface ornamented with a neat open network of delicate meshes, lying obliquely from the postero-dorsal to the antero-ventral region.

From the Belosepia-bed at Bracklesham. (Science Schools Coll.)

### 14. CYTHERE REIDII, sp. nov.

Valves sub-oblong, obliquely rounded at the ends, broader in front than behind, straight on the back, slightly sinuous below, nearly flat; rising into a median knob in the anterior third. Surface with rather coarse punctation, making a rough reticulation. Named after Mr. Clement Reid, F.G.S., who collected this and many other undescribed Ostracoda from the Crag beds of Norfolk. From the Weybourn Crag of East Runton. (Museum of Practical Geology.)

### 15. CYTHERE RETIFASTIGIATA, Jones.

Mr. Clement Reid has met with a good example, with less prominent ridges than in the figure in the 'Monograph,' 1856 (pl. iii. fig. 7), and with a smaller, neater, and closer punctation. Weybourn Crag. (Mus. Pract. Geol.)

### 16. CYTHERE LACRYMALIS, sp. nov.

One of the sub-oblong punctate *Cytheræ*, of a not uncommon shape, but rather more oblique anteriorly than usual. Surface slightly convex, swelling at the anterior third, and posteriorly bearing two separate, short ridges, which rise near the middle of the valve, and end each in a strong knob at the posterior border, thus forming two long tear-shaped eminences, instead of the more usual pair of posterior swellings, such as we see in *C. bidentata*, Bosquet, Tert. Entom., 1852, p. 72, pl. iii. f. 9, and several other Tertiary *Cytheræ*. From the Norwich Crag, Bramerton, collected by Clement Reid, F.G.S. (Mus. Pract. Geol.)

### 17. CYTHERE DICTYOSIGMA, Jones.

This was not figured in the 'Monogr. Tert. Entom.,' 1856, p. 33; but we hope to figure it shortly. We may remark that some of Dr. G. S. Brady's illustrations of his *Cythere mutabilis*, 'Trans. Zool. Soc.,' 1866, p. 377, pl. lix. fig. 14 (*C. tuberculata*, G. O. Sars, Brady, etc., Post-Tert. Entom., p. 164), approach very near to *C. dictyosigma*.

### 18. CYTHERE ANGULATA (G. O. Sars), var.

*Cythere angulata*, G. S. Brady, Trans. Linn. Soc. vol. xxvi. p. 409, pl. 26, figs. 39-42.

In some of their more important characters our little specimens agree with Dr. G. S. Brady's definition of *C. angulata*; but in them we also see a strong affinity to *C. limicola*, Norman; *C. globulifera*, Brady, and *C. concinna*, Jones, as described in full by G. S. Brady, are also near allies.

Our specimens were obtained by Mr. C. Reid from the Norwich Crag of Bramerton, and the Weybourn Crag of East Runton; and are in the Mus. Pract. Geology.

### 19. Cythere Charlesworthiana, sp. nov.

A neat small *Cythere*, oblong, with front end rather obliquely rounded, and the posterior nearly square. Ventral edge slightly incurved, dorsal faintly arched. Broadest at the anterior third near the front hinge-joint. Surface ornamented with very delicate elongate pits, arranged in lines lengthwise, but curving in front, parallel with the margin. The anterior margin is neatly denticulate, especially on its dorsal third. This differs from our *Cythere recurata* in being truncated posteriorly and denticulated in front, and also in its ornament. The form nearest to this that we know of is *C. tenera*, G. S. Brady, Trans. Linn. Soc., vol. xxvi. p. 399, pl. 28, fig. 29–32; but in shape and ornament it differs.

From the Weybourn Crag of East Runton, collected by Mr. Clement Reid. (Mus. Pract. Geol.)

In memory of his early researches in the Crag, we name this species after Mr. E. Charlesworth.

### 20. Cythere villosa, Sars. B. C. and R., Monogr. Post-Tert. Entom. 1874, p. 157, pl. iii. figs. 7-13.

Subtriangular, straight on the ventral, and obliquely arched on the dorsal and front edges, but somewhat truncate behind. Surface bearing a concentric reticulation of coarse angular pittings. Three tubercular swellings affect the valve just within its thickened rim, two behind, such as are frequent in this group of *Cytheræ*, and one in the antero-ventral third. The greatest convexity of the valves is central, making the edge-view acute-oval.

From the Weybourn Crag of East Runton. Collected by Mr. Clement Reid. (Mus. Pract. Geol.)

With this species we connect a variety from the "Norwich Crag" of Southwold, in which the tubercles are not so definitely marked. The places of the two near the ventral margin are occupied by irregular swellings, and the postero-dorsal tubercle is ill-defined.

### 21. Cythere læsa, sp. nov.

Ovate-oblong, straighter on the ventral than on the dorsal edge. Close to the ventral margin is a broad, longitudinal, somewhat sinuous ridge, widened, or rather doubled, with an oval interspace at its posterior third, and irregular at the anterior third. In one specimen the surface is coarsely reticulate with angular meshes; in the other, the ornament consists of a smaller mesh-work. In this latter individual the edge-view is less convex than in the other.

Norwich Crag, Bramerton. Collected by Mr. Clement Reid. (Mus. Pract. Geol.)

### 22. Cythere Woodwardiana, sp. nov.

Sub-trigonal; obliquely rounded in front, nearly semicircular behind; broad across the anterior third by the projection of the hinge-joint. Surface slightly convex; ventral surface somewhat flattened. Superficial ornament a coarse irregular pitting.

We name this species after Dr. Samuel Woodward, one of the earliest workers in these late Tertiary deposits.

From the Weybourn Crag, East Runton. Mr. C. Reid. (Mus. Pract. Geol.)

### 23. Cythere arenosa, Bosquet. Pl. XI. Fig. 4.

This is one of the papulated forms of *Cythere*, the surface having low, tubercular, and obscure meshes, which in other instances form strong tubercles. In some cases these become ragged warts (*C. scabra*, Münster; see Bosquet, Entom. Tert., p. 103, pl. v. fig. 7); in others they pass into spines (*C. ericea*, *C. irpex*, and others; G. S. Brady. "Challenger Ostrac.," pl. xvii. and xviii.); we have also a passage-form. The above and two following forms have a subovate edge-view. They were found in the London Clay of Piccadilly, London, by Messrs. Sherborn and Chapman.

### 24. Cythere scabropapulosa, Jones. Pl. XI. Fig. 5.

This specimen from the London Clay of Piccadilly is more uniformly convex and more rounded posteriorly than the Bracklesham specimen figured in the Monograph, 1856, pl. v. fig. 16. Moreover, the anterior margin is strongly denticulated, but the dorsal edge is not quite so roughly tuberculate as seen in the valve from Bracklesham.

Dr. G. S. Brady's "*C. scabropapulosa*" from the Antwerp Crag (Trans. Zool. Soc. vol. x. p. 393, pl. lxvi. fig. 2), being much rougher and more warty, is nearer to *C. scabra*, Münster, and might be regarded as *C. scabropapulosa*, var. *rudis*.

### 25. Cythere scabropapulosa, Jones, var. aculeata, nov. Pl. XI. Fig. 6.

This is a well-grown valve of *C. scabropapulosa* becoming hispid, by the tubercles ending with a sharp prickle or spine. A further development of this spinose condition is seen in *C. irpex*, Brady, as above mentioned. This also is from the London Clay of Piccadilly.

### 26. Cythere gyriplicata, sp. nov.

Narrow-suboval in outline, hinge-line slightly convex, but distinct. Ends rounded; narrow behind, somewhat oblique in front. Surface sculptured with delicate longitudinal ridges, arranged concentrically towards the margins, and united by smaller transverse ridges.

From the *Belosepia*-bed of Bracklesham. T. R. Jones' Collection.

The nearest species we know of is Bosquet's *C. multicostata*, Entom. Tert., p. 59, pl. ii. fig. 12; but this is very much coarser and broader, and without any sign of reticulation.

### 27. Cythere delirata,[1] sp. nov.

A *Cythere* of the not uncommon sub-oblong form, but with the rare ornament of slight furrows diverging up and down from the median line of the posterior region, and becoming more or less concentric or confused anteriorly. Edge view long-oval.

From the Fluvio-marine beds of Headon Hill, Isle of Wight. (Fred. Edwards' Collection in the British Museum.)

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[1] Ploughed with divergent furrows.

## EXPLANATION OF PLATE XI.

(Ostracoda from the London Clay.[1])

Fig.
1. *Bairdia subtrigona*, Bornemann.
2. ,, *Londiniensis*, sp. nov.
3. ,, *ovoidea*, sp. nov.
4. *Cythere arenosa*, Bosquet.
5. ,, *scabropapulosa.*
6. ,, ,, var. *aculeata*, nov.
7. ,, *scalaris*, sp. nov.
8. ,, *scrobiculoplicata*, Jones.
9. *Cythereis Bowerbankiana*, Jones.
10, *a*, *b*. ,, *aranea*, sp. nov.; *b*, ventral aspect.
11, *a*, *b*. ,, *Prestwichiana*, sp. nov.; *b*, transverse section.
12. *Cytheridea perforata* (Roem.), var. *insignis*, Jones.
13. ,, *glabra*, Jones.
14, *a*, *b*. *Krithe Londiniensis*, sp. nov.
15, *a*, *b*. ,, *glacialis*, B. C. and R.
16. *Cytheropteron triangulare* (Reuss).
17. *Cytherella fabacea*, Bornemann.
18. ,, *Beyrichi* (Reuss).
19. ,, *compressa* (Münster).

(*To be continued.*)

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## II.—On some Belgian Fossil Reptiles.

By Louis Dollo, C.E.,
Assistant Naturalist in the Royal Museum of Natural History of Belgium, Brussels.

I HAVE read with much interest the two articles which Messrs. G. A. Boulenger and R. Lydekker have recently published in the Geological Magazine,[2] and I should be very much obliged if you would permit me to make an addition, which appears to me useful, and which I should be glad to see published.

I. Pseudotrionyx.[3]—1. I have remarked with satisfaction that it has been possible for the above-named naturalists to refer to *P. Delheidi*, a Tortoise of the London-clay. This discovery is doubly interesting, in the first place because it shows the existence of the Belgian fossil in England, in the second place, because it establishes the existence of the Bruxellian (Middle Eocene) Chelonian in the Ypresian epoch (Lower Eocene).

2. I do not, however, believe that the absence of the horny scutes in *Pseudotrionyx* would be sufficient to create a new family.[4] In fact, I think, for reasons which I shall explain elsewhere,[5] that the *Thecophora*[6] without horny scutes (Gymnoderms) proceeded from types which possessed them (Lepidoderms). I believe also that

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[1] See also woodcuts in the text.

[2] R. Lydekker and G. A. Boulenger, 'On Chelonia from the Purbeck, Wealden and London Clay,' Geol. Mag. June, 1887, p. 270. R. Lydekker, 'Notes on Hordwell and other Crocodilians,' Geol. Mag. July, 1887, p. 307.

[3] L. Dollo, 'Première Note sur les Chéloniens du Bruxellien (Eocène moyen) de la Belgique,' Bull. Mus. Roy. Hist. Nat. Belg. 1886, t. iv. p. 75.

[4] R. Lydekker and G. A. Boulenger, 'Chelonia,' etc. p. 274.

[5] L. Dollo, 'Première Note sur les Chéloniens oligocènes et néogènes de la Belgique,' Bull. Mus. Roy. Hist. Nat. Belg. 1887, t. v. (*in the press*).

[6] L. Dollo, 'Chéloniens du Bruxellien,' etc., p. 79.

the disappearance of the scutes has taken place by a progressive diminution of their rigidity, a diminution in consequence of which the skin has been gradually moulded upon the subjacent bone, taking exactly its reliefs and hollows. At this stage it must have already possessed a vermiculated external surface of the carapace (as happens with the *Thecophora*, which have a soft skin, *Trionyx* for example), but the dorsal tegument was always divided into distinct areas, leaving their trace upon the above-mentioned external face. Such is perhaps *Anostira*,[1] and probably *Chelonia Suyckerbuyki*. Afterwards, these different areas have disappeared, and with them their lines of demarcation on the skeleton: take *Trionyx* and *Pseudotrionyx* as examples. We may then find, by future researches, all the passages between the gymnoderm and lepidoderm *Thecophora*, and I do not understand, consequently, how the presence or the absence of horny scutes could suffice alone to characterize a family.

II. PACHYRHYNCHUS.[2]—1. As Messrs. Boulenger and Lydekker have pointed out,[3] this name has already been employed; it will therefore be necessary to change it. In a paper at present in the press[4] I have proposed to substitute for it *Erquelinnesia*, to recall the locality in which the curious Chelonian has been discovered, and where it is so common.[5]

2. As Messrs. Boulenger and Lydekker admit,[6] and contrary to the statement of Mr. E. D. Cope,[7] my *Pachyrhynchinæ*[8] are quite distinct from the *Propleuridæ*[9] of the celebrated Professor of Philadelphia, since the latter have nine pairs of costal plates, whereas the Chelonian of Erquelinnes has only eight.

3. Mr. Cope, notwithstanding the assertion to the contrary of Messrs. Boulenger and Lydekker,[10] does not refer, at least in the paper mentioned by them,[11] any of the species of Sir R. Owen to *Puppigerus*.[12] Besides, as I have said in a former paper,[13] *Erquelinnesia* is, without any doubt, generically different from the American type, since the latter has the xiphiplastrons united by

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[1] J. Leidy, 'Contributions to the extinct Vertebrate Fauna of the Western Territories,' Rep. U. S. Geol. Surv. Territories (F. V. Hayden), Washington, 1873, p. 174 and 175, pl. xvi. fig. 1 and 2. E. D. Cope, 'The Vertebrata of the Tertiary Formations of the West' (book i.), Rep. U. S. Geol. Surv. Territories (F. V. Hayden), Washington, 1883, p. 112. L. Dollo, 'Chéloniens du Bruxèllien,' etc. p. 95.

[2] L. Dollo, 'Première Note sur les Chéloniens landéniens (Eocène inférieur) de la Belgique,' Bull. Mus. Roy. Hist. Nat. Belg. 1886, t. iv. p. 129.

[3] R. Lydekker and G. A. Boulenger, 'Chelonia,' etc., p. 270.

[4] L. Dollo, 'Chéloniens oligocènes et néogènes,' etc. (v. *supra*).

[5] L. Dollo, 'Chéloniens landéniens,' etc., p. 129.

[6] R. Lydekker and G. A. Bouleger, 'Chelonia,' etc., p. 271.

[7] E. D. Cope, 'Dollo on Extinct Tortoises,' American Naturalist, November, 1886, p. 968.

[8] L. Dollo, Chéloniens landéniens,' etc., p. 139.

[9] E. D. Cope, 'Tertiary Vertebrata,' etc., p. 111.

[10] R. Lydekker and G. A. Boulenger, 'Chelonia,' etc., p. 271.

[11] E. D. Cope, 'Dollo on Extinct Tortoises' (v. *supra*).

[12] E. D. Cope, 'Tertiary Vertebrata,' etc., p. 112.

[13] L. Dollo, 'Chéloniens landéniens,' etc., p. 131.

sutures. The Turtle of the New World, which the Belgian reptile resembles most, appears to me, as well as to Mr. Cope, to be *Euclastes.*[1] But I shall return to this subject on another occasion.

III. PELTOCHELYS.[2]—Whatever may be the position of this form in classification, I do not believe that it can be identified with *Tretosternum*, as Messrs. Boulenger and Lydekker think.[3] In fact, with regard to *Tretosternum*, according to the naturalists just named, "the plastron is essentially of the *Dactylosternine* type of Cope."[4] Now I can assert that I have not seen the least trace of "more or less open digitations"[5] in the plastron of *Peltochelys*.

IV. BERNISSARTIA.[6]—According to Mr. Lydekker,[7] with whom Mr. Boulenger agrees,[8] *Bernissartia* = *Hylæochampsa*,[9] for there would exist in the latter an orbito-latero-temporal notch.

1. In the first place, I beg leave to point out to these naturalists that Sir Richard Owen says plainly: "The orbits in *Hylæochampsa* are circular and better defined by the postfrontal from the lateral outlets of the temporal fossæ than in *Crocodilus*, and herein they more resemble the orbits in *Teleosaurus*,"[10] which agrees with the figure given by the celebrated palæontologist.[11] And, on the other hand, I can assert that, in *Bernissartia*, the orbito-latero-temporal notch is as clearly marked as in any living Crocodilian. The difference which I have pointed out is therefore quite real, although perhaps less strongly marked than I have stated.

2. In the second place, I will add that a naturalist peculiarly competent in the question under consideration, and who has also seen the type of *Hylæochampsa*, Mr. A. S. Woodward, is inclined[12] to consider it rather as a Teleosaurian, which supports what I have just said, and removes the English Crocodilian from *Bernissartia*.

3. However this may be, and until I shall have described in a more complete manner (and with numerous figures) the Crocodilians of Bernissart, I may add, to the character which I have already indicated, the following differences between *Bernissartia* and *Hylæochampsa*.

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[1] E. D. Cope, 'Synopsis of the Extinct Batrachia, Reptilia and Aves of North America,' Trans. Amer. Philos. Soc. Philadelphia, 1871, p. 147 and pl. vi.

[2] L. Dollo, 'Première Note sur les Chéloniens de Bernissart,' Bull. Mus. Roy. Hist. Nat. Belg. 1884, t. iii. p. 76.

[3] R. Lydekker and G. A. Boulenger, 'Chelonia,' etc., p. 273.

[4] R. Lydekker and G. A. Boulenger, 'Chelonia,' etc., p. 273.

[5] E. D. Cope, 'Tertiary Vertebrata,' etc., p. 111.

[6] L. Dollo, 'Première Note sur les Crocodiliens de Bernissart,' Bull. Mus. Roy. Hist. Nat. Belg. 1883, t. ii. p. 309.

[7] R. Lydekker, 'Crocodilians,' etc., p. 310.

[8] R. Lydekker, 'Crocodilians,' etc., p. 310.

[9] R. Owen, 'Monograph on the Fossil Reptilia of the Wealden and Purbeck Formations,' Supplement, No. VI. Crocodilia (Hylæochampsa), Wealden, Palæontographical Society, London, 1873.

[10] R. Owen, 'Hylæochampsa,' etc., p. 3.

[11] R. Owen, 'Hylæochampsa,' etc., pl. ii., fig. 24.

[12] A. S. Woodward, 'On British Fossil Crocodilia,' GEOL. MAG. Nov. 1887, p. 504. A. S. Woodward, 'The History of Fossil Crocodiles,' Proc. Geol. Assoc. Feb. 1886, p. 318.

| CHARACTERS. | HYLÆOCHAMPSA.[1] | BERNISSARTIA. |
|---|---|---|
| 1.<br>*Ornamentation of the cranium.* | "The outer surface of the cranial bones shows a different pattern of sculpture from that in *Goniopholis*; instead of small circular pits, there are short irregular ridges, which, at some parts, the post-frontal, for example, have a tendency to diverge from a reticulate centre; a number of short ridges and clefts radiate from the raised part of the border of the temporal outlet; but all these accentuations of the surface are rather feeble" (pp. 1 and 2). | Ornamentation very accentuated and consisting in small circular pits. |
| 2.<br>*Orbits.* | A. "Circular" (p. 3).<br>B. Antero-posterior diameter shorter than the corresponding one of the supratemporal fossæ; transverse diameter longer than the corresponding one of the supratemporal fossæ.<br>C. Orbits neither horizontal, nor vertical, but intermediate between the two. | A. No; having the form of the figure 8 of which the anterior circle has a much smaller diameter than the posterior one, but being equally well accentuated.<br>B. Antero-posterior and transverse diameters much greater than the corresponding ones of the supratemporal fossæ.<br>C. Orbits horizontal. |
| 3.<br>*Interorbital space.* | Forming very distinctly, in its narrowest part, more than the half of the transverse diameter of an orbit. | Forming, in its narrowest part, very distinctly less than the half of the transverse diameter of an orbit. |
| 4.<br>*Supratemporal fossæ.* | Form very elongated, "teleosauroid" (p. 3). | Form more rounded. |
| 5.<br>*Intersupratemporal space.* | At the narrowest part, at least a third inferior to the transverse maximum diameter of a supratemporal fossa. | Perceptibly equal, in its narrowest part, to the transverse maximum diameter of a supratemporal fossa. |
| 6.<br>*Posterior border of the superior surface of the cranium seen from above.* | With three notches of which one is median. | With two symmetrical notches and a point on the median line. |
| 7.<br>*Pterygo-palatine vacuities.* | Slight, very narrow and elongate. | Enormous and much broader in proportion to their length. |
| 8.<br>*Interpterygo-palatine septum.* | Much thicker, at its narrowest part, than the transverse diameter of one of the pterygo-palatine vacuities. | Much thinner, at its narrowest part, than the transverse diameter of one of the pterygo-palatine vacuities. |
| 9.<br>*Choanes.* | A. Rounded.<br>B. Situated very distinctly nearer the occipital condyle. | A. Elongated in the direction of the longitudinal axis of the cranium.<br>B. Placed very perceptibly more anteriorly. |
| 10.<br>*Size.* | At least $\frac{1}{3}$, if not $\frac{1}{2}$, greater than that of our greatest specimen of *Bernissartia*. | The entire cranium of our largest specimen of *Bernissartia* is not greater than the preserved portion of that of *Hylæochampsa*. |

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[1] The figures between brackets, in this column, indicate the pages of the Monograph of Sir R. Owen.

To conclude, from the preceding remarks, I think that *Bernissartia* cannot be considered as a synonym of *Hylæochampsa*, and, that consequently, the name of the Crocodilian of Bernissart ought to be retained, instead of placing it in a list of synonyms.

## III.—On *Ammonites serpentinus*, Reinecke, *Am. falcifer*, Sowb., *Am. elegans*, Sowb., *Am. elegans*, Young, etc.

By S. S. Buckman, F.G.S.

I HAVE had occasion lately to thoroughly investigate these and other allied Ammonites, partly because it has been important to me that I should know the true affinities of these species, partly because my attention was directed to certain still obscure points with regard to their identification, and partly on account of the statement by the late Dr. Wright that *Am. serpentinus* and *Am. falcifer* were the same species. In pursuing my investigations I have received a great deal of assistance from Dr. E. Haug's Beiträge zu einer Monographie der Ammoniten-gattung Harpoceras,[1] which I am pleased to acknowledge, although I do not find myself able to agree with him in one or two small points which I will presently mention. Meanwhile, by the aid of a few references to well-known works, I will indicate the Ammonites so that they may be understood.

### Hildoceras ? serpentinum (Reinecke).

1818. *Argonauta serpentinus*, Reinecke, Maris protog., p. 89, fig. 74–75.
? 1822. *Ammonites Strangewaysi*, Sowerby, Min. Conch. t. 254, fig. 1 and 3.
Non *Am. serpentinus*, D'Orb. (figure reduced), Wright, Bayle, etc.

This Ammonite seems to be extremely scarce. What has been called by D'Orbigny, Wright, and others, *Am. serpentinus*, and is so labelled in museums and private collections, is the *Ammonites falcifer* of Sowerby, which has been erroneously supposed to be the young state of *Am. serpentinus* (Reinecke). Oppel, in his Juraformation, p. 243, noticed that this was not so, and keeps both species distinct; and Dr. E. Haug, in his Beiträge Monog. draws pointed attention to the fact of *falcifer* having been generally figured for *serpentinus*. Dr. Haug corrects this error, and separates the *Am. serpentinus* totally from *Am. falcifer*, placing *Am. serpentinus* in the group of *Am. bifrons*, and consequently in Hyatt's genus *Hildoceras*. The form of the inner margin, the general outline of the ribs, obscure, it would seem, on the inner part of the whorl, seem to warrant this; but at the same time it lacks the furrows on each side of the keel present in *Hild. bifrons*. Of its suture-line I can say nothing, but the suture-line of *Hild. bifrons* is very distinctive. To whatever genus the true *Am. serpentinus* belongs, I feel convinced it does not belong to the same genus as *Am. falcifer*; and that *Am. falcifer* does not belong to the genus *Hildoceras* is very clear, on account of the suture-line, the shape of the inner margin, etc., but especially on a distinctive structural difference in the keel. The keel of *Hildoceras bifrons* is filled by the mould, and is the same shape in reference to the ventral

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[1] Neues Jahrbuch für Mineral. Beil. Bd. iii. 1885.

area when the test is present or absent; but the keel of *Am. falcifer* is separated from the mould by an inner layer of shell; and the two sides of the keel and this layer form a triangle inclosing a hollow space, which has become filled with mud. Where, therefore, the test is absent, the mould of *Am. falcifer* becomes rounded on the ventral area. This kind of keel is well shown by Dr. Haug, Beiträge Monogr. Harpoceras, plate xi. fig. 1, for *Am. variabilis*; and it is to be seen in the genera *Hammatoceras, Sonninia*, etc.; but this structure of the keel is not shown in the genera *Hildoceras, Ludwigia, Lioceras*, etc. It therefore seems right to separate *Am. falcifer* generically, and since Dr. Haug has proposed to restrict Waagen's genus *Harpoceras* to a small group of which *Am. falcifer* is the type, we desire to follow such a good suggestion.

### Genus Harpoceras, Waagen, emend. Haug.

Ribs sickle-shaped, much produced on ventral area. Keel distinct and hollow, separable from the mould; ventral area of mould rounded when keel absent, no furrows on either sides of the keel, inner margin square; large accessory lobe in siphonal saddle; large and much branched superior lateral lobe; inferior lateral and auxiliaries retracted.[1]

### Harpoceras falciferum (Sowerby).

1822. *Ammonites falcifer*, Sowerby, Min. Conch. t. 254, fig. 2.
1846. ——— *serpentinus*, D'Orbigny (non Reinecke), Pal. fr. t. 55.
1878. *Lioceras serpentinum*, Bayle, Explic. carte géol. iv. t. 87, figs. 2-3.
1882. *Harpoceras serpentinum*, Wright, Lias Am. t. 58.

The above list of references will at once show how this Ammonite has been misunderstood. D'Orbigny, Wright, and other authors have extinguished Sowerby's names of *Strangewaysi* and *falcifer*, considering them to be the same and also equivalent to Reinecke's *serpentinus*. In this they were perhaps right as far as *Am. Strangewaysi* is concerned, which is very near to Reinecke's *Am. serpentinus*; but Sowerby was certainly correct when, having the two specimens in front of him, and putting them for comparison on the same plate, he made them two different species; and it is singular that D'Orbigny, Wright, etc., should have figured as Reinecke's *serpentinus* what is really *Am. falcifer*, for a comparison of the inner edges of the whorls should have shown this to be a mistake. Sowerby distinctly says of *Am. Strangewaysi*, "inner edges of the whorls obliquely flattened," and of *Am. falcifer* that it differs from *Am. Strangewaysi* by "wanting the flat surface of the inner margin of the whorl," and Reinecke distinctly shows the section of his *serpentinus* (fig. 75) with the inner margin obliquely flattened. Again, the coiling is very different. In Reinecke's *serpentinus* it is regular throughout; in Wright's figure it is irregular, that is, the inclusion becomes less with every whorl. Reinecke's *serpentinus*, which is

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[1] Compare genus *Hildoceras*. Mould showing shape of keel; ventral area flattened or furrowed; inner margin subconcave, sloping. Very broad siphonal saddle, small accessory lobe, superior lateral lobe little branched, inferior lateral and auxiliaries produced.

3 inches 4 lines in diameter, has four whorls at least. Wright's *serpentinus* at the same diameter has barely three. Taking the diameter of Reinecke's figure as = 100, the breadth of the outer whorl is 29·6, whilst taking the same diameter on Wright's figure (3 inches 4 lines), we find the breadth of the outer whorl at that size is 40·7. I think it is therefore clear that Sowerby's *Am. falcifer* is not Reinecke's *Am. serpentinus*.

### HARPOCERAS ELEGANS (Sowerby).

1815. *Ammonites elegans*, Sowerby, Mineral Conch. vol. i. table 94, upper figure.
1884. *Harpoceras bicarinatum*, Wright (non Zieten), Lias Ammonites, Pal. Soc. 1884, plate 82, figs. 9 and 10 (non 11).
Non *Am. elegans*, Young and Bird, non *Harpoceras elegans*, Wright.

Sowerby describes his species in the following terms:—

"*Spec. Char.* Involute, much depressed, acutely keeled; volutions about three, inner ones about two-thirds concealed; radii twice curved, numerous, equal; keel distinct, entire; aperture acutely triangular; internal angles truncate.

"A delicate species with a thin shell; thickness about one-sixth of the largest diameter; it gradually lessens towards the edge, which is rather obtuse, with a sharp keel placed upon it. The septa are tolerably close with their sinuous margins much plaited: the siphuncle slender within the keel."

Sowerby's type-specimen is not in the British Museum collection, and so unfortunately we cannot refer to it; but although the species has been much misunderstood, I think that if the figure and the description be accurately studied, we shall be able to arrive at definite conclusions about it. One thing is perfectly certain, that the *Am. elegans* of Young and Bird is not Sowerby's *elegans*. Dr. Wright has figured on plate 63, *Harpoceras elegans, Sowerby*, but has corrected this in his text, page 447, to *Young*, and he further states: "Some authors refer this species to *Am. elegans*, Sowerby, but none of the specimens I have examined correspond with Sowerby's figure, which does not appear to be a Lias shell at all." However, on p. 462 he places *Am. elegans* of Sowerby as a synonym of *Harp. bicarinatum*, and in this matter I think he was so far correct that I think his *Harp. bicarinatum*, plate 82, figs. 9, 10, are really Sowerby's *Am. elegans*, and certainly not *Am. bicarinatus* of Zieten, plate 15, fig. 9, which has a far smaller centre.

Dr. Haug, on page 680 of his Beiträge Monog. Harpoceras, is mistaken in supposing Dr. Wright to have figured Sowerby's *Am. elegans* on plate 63, and Dr. Wright himself corrects this. Sowerby's *Am. elegans* does not belong to the group of *Am. opalinus* as Dr. Haug has placed it, though undoubtedly *Am. elegans*, Wright, does. Therefore we have this position:—The *Am. elegans*, Sowerby, I consider to have been figured again by Wright as *Am. bicarinatus*, and not to be Zieten's *Am. bicarinatus*, and that it is also a distinct species in itself. Further, that it belongs to the restricted group of *Am. falcifer*, which is now erected into a genus, and therefore must be called *Harpoceras elegans*, Sowerby. On the other hand, the name of *Am. elegans*, Young, ought in reality to be cancelled; but we know from Young that it has a concave inner margin, and Wright has given a very good figure of a shell of this kind, which agrees with Young's description, and as this shell of Wright's would belong to a different genus, and possesses no other name, perhaps it is as well to retain this one. Also, since it belongs to the genus *Lioceras*, it would be correctly stated as *Lioceras elegans* (Young, or Wright), and would be well distinguished from *Harpoceras elegans* (Sowerby).

There is one point about this latter species, namely, that Sowerby states that the siphuncle is within the keel. As *Harpoceras* in its restricted definition is distinctly not so, we think he may have mistaken the hollowness for the siphuncle, as he did in his figure of *Am. Sowerbyi*, pl. 213.

### HARPOCERAS EXARATUM, Wright.

1822. *Ammonites exaratus*, Young and Bird, Geol. Surv. Yorks. p. 266.
1882. *Harpoceras exaratum*, Wright, Lias Am. Pal. Soc. pl. 62, fig. 1.

As Young does not give any figure of his species, we cannot say what it may be, and therefore accept Wright's figure as the type of the species. It seems, judging from the figure, to belong to the genus *Harpoceras*. It is certainly not, as Wright has mentioned in his synonyms, *Am. complanatus* of D'Orbigny, which has a very different sectional view and smaller centre. This species has the same sized umbilicus as *Harp. elegans* (Sow.), but differs in the sectional view, the sides being less sloped towards the ventral area. If there are no other differences, I should be inclined to regard this shell as merely a variety of Sowerby's *H. elegans*.

### HARPOCERAS SUBPLANATUM (Oppel).

1844. *Ammonites complanatus*, D'Orb., Terr. Jur. p. 353, pl. 114, figs. 1–2.
1856. ——— *subplanatus*, Oppel, Juraf. p. 244.

Dr. Wright has given *Am. complanatus*, D'Orb., as a synonym of *Harp. exaratum*; but I think that a comparison of the centres and the section of D'Orbigny's and Wright's figures will show this to be a mistake, and Dr. Haug (p. 619) has wisely separated the two species. Dr. Haug has included both of these species in the group of *Am. falcifer*, and also *Am. discoides*; but I am inclined to think that *Am. discoides* should be separated. It has a likeness in regard to its ribbing, but it has in reality no keel, only the ventral area sharpened, and, judging from the suture-line, I consider that it does not belong to *Harpoceras* at all, but should be classed in proximity with *Oppelia*. *Harp. subplanatum* occurs in England; by the kindness of Mr. B. Thompson, F.G.S., I have been able to examine a specimen from Northamptonshire.

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We have, therefore, in the genus *Harpoceras*, *Harp. falciferum*, Sow., *Harp. elegans*, Sow., *Harp. exaratum* (Young), Wright, and *Harp. subplanatum*, Oppel; whilst *Am. serpentinus*, Reinecke, perhaps belongs to the genus *Hildoceras*, and as the species was not figured by Wright in his Monograph, a good figure of it in its various stages would be an advantage.[1]

Besides these species, we have *Am. elegans*, Young, which belongs to the genus *Lioceras*, and we have *Am. bicarinatus*, Zieten, which is distinct from any we have mentioned on account of its smaller centre and furrows on the ventral area, and in all probability belongs to another genus. I do not know if it has really occurred in England.

It may be interesting to notice the sizes of umbilicus in these various species taken from the figures given. The diameter = 100, the umbilicus of *Harp. falciferum* is, youth (Sowerby) 31·9; adult (Wright) 40·5, showing the decrease of inclusion I have mentioned. *Harp. exaratum* (Wright's figure) 20·5 and *Harp. elegans* (Sow. figure) 20·7. (These two have a different sectional view.) *Harp. subplanatum* (D'Orb. pl. 114) 16·76, *Am. bicarinatus* (Zieten's figure) 12·2. Whilst Wright's *Am. bicarinatus*, pl. 82, fig. 9, which I contend is Sowerby's *Am. elegans*, has, umbilicus 19·00, which is almost exactly the same as Sowerby's figure at the *same* diameter. I have given these measures exactly from the figures. Of course in ordinary work care would have to be taken as to the amount of body-chamber present, and the size of the specimen; but if allowance is made in the present instance for these, it will not account for the variation in the umbilicus in these species.

P.S.—If Sowerby's *Am. Strangewaysi* be really Reinecke's *Am. serpentinus*, I should much doubt, from the indications of suture-lines given by Sowerby, if it be correct to class it in the genus *Hildoceras*. Etymologically, as Dr. Haug wrote to me when making his suggestion, *Harpoceras* is very aptly applied to the true *Falciferi*. It is an important matter to assign a correct place to Waagen's genus which had been partly forestalled by Hyatt's genera *Tropidoceras*, *Hildoceras*, *Lioceras*, *Grammoceras*, *Hammatoceras*, and to another section of which Bayle gave the name *Ludwigia*. In accordance with these genera the restriction of *Harpoceras* becomes a necessity.

## IV.—On Explosive Slickensides.

By Aubrey Strahan, M.A., F.G.S.

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

During a recent examination of the lead-mines of Derbyshire, I was interested in some accounts of explosions which had taken place, which were not due either to any material used by the workmen or to fire-damp. Though at first inclined to believe that the accounts were exaggerated, I soon found that not only was the evidence of such explosions having constituted a real danger to the men overwhelming, but that accidents are still liable to occur from this cause. The explosions are connected with the structure known as slickenside in the veins. The vein-stuff, consisting generally of galena, calc-spar, heavy spar (sulphate of baryta), and fluor-spar, is divided by the planes of slickenside into more or less vertical sheets

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[1] Wherever Dr. Wright has mentioned the zone of *Harp. serpentinum*, it must probably be taken to indicate the zone of *Am. falcifer*.

or slabs. Such sheets, when bared in the mining operations, fly to fragments with explosive violence on being struck, or even scratched by a miner's pick. The following extracts from old authors, and from communications on the subject that I have received, will serve to illustrate the nature of the explosions and the manner in which the danger was met by the men. The accounts relate chiefly to the mines near Eyam, but explosions occurred also in the Odin Mine near Castleton.

The earliest reference to the subject which I have met with is by Dr. Short:—

"On the North Side of this Mountain [Hucklow Edge, near Eyam] . . . is a Mine which cannot be wrought; for in picking or striking the Ore, the sudden shaking of the Metal gives such a violent Motion to the Sulphur, that it makes an Explosion like fired Gunpowder, or a Blast in a Rock, so as great Lumps rise up and fly about along with a Kind of *Terræ Motus*, or Earthquake."[1]

Pilkington,[2] writing fifty years later, remarks that "the crackling and explosions caused by scraping these slickensides with a pick-axe are well known, but hitherto not satisfactorily accounted for. They are said to lose the above property very soon after they are taken out of the mine. In regard to their external appearance, their smooth side greatly resembles black lead very thinly spread over the surface of any smooth body. But the rough side looks very much like to common limestone."

But the most detailed account is furnished by John Whitehurst,[3] and is, I think, of sufficient interest to be reproduced here in full:—

"I purpose giving some account of an extraordinary phenomenon which has frequently happened in Haycliff and Ladywash Mines at Eyam, and in Oden Mine at Castleton: the former are thus circumstanced.

"1. The minerals are contained in the fissures of the limestone, covered by a *stratum* of shale and grit, which retain their full thickness of sixty fathoms each.

"2. The minerals contained in the above mines are blended together so as to produce the appearance of white Italian marble clouded with black, and are so extremely hard and compact as to require blasting with gunpowder, to separate them from the general mass.

"3. Those in the Ladywash veins are divided in two equal parts parallel to the sides of the fissure. They may be compared to two slabs of marble, whose polished surfaces are absolutely in contact with each other without the least degree of cohesion.

"4. These naturally polished surfaces are not truly flat, but in some degree waved, as if formed by a carpenter's plane, consisting of various members.

"5. The two surfaces are generally coloured with lead ore, thinly

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[1] The History of the Mineral Waters of Derbyshire, Lincolnshire, and Yorkshire, by Thomas Short, M.D., 4to., London, 1734, p. 96.

[2] A View of the Present State of Derbyshire, 1789, vol. i. p. 195.

[3] An Inquiry into the Original State and Formation of the Earth, by John Whitehurst, 3rd edition, 1792, London, p. 218, *et seq.*, plate i.

laid on, as if only rubbed over with black lead, though sometimes thicker.

"6. The vein in Haycliff Mine contains two of the above seams, and therefore may be compared to three slabs of marble, the middle one polished on both sides and in contact with the other two.

"Thus are the above veins circumstanced. Now what is yet more remarkable is this: if a sharp pointed pick is drawn down the vein with a small degree of force, the minerals begin to crackle, as sulphur excited to become electrical by rubbing; after this in the space of two or three minutes, the solid mass of the minerals explodes with much violence, and the fragments fly out, as if blasted with gunpowder. These effects have frequently happened, by which many workmen have been wounded, but none killed, both in the Eyam Mines, and in that called Oden, at Castleton.

"In the year 1738 a prodigious explosion happened in the mine called Haycliff. The quantity of two hundred barrels of the above minerals were blown out at one blast; each barrel, I presume, contained no less than three or four hundredweight. At the same time a man was blown twelve fathoms perpendicular, and lodged upon a floor, or bunding, as the miners call it, in one of the shafts.

"When the above explosion happened, the barrel, or tub, in which the minerals, etc., are raised to the surface, happened to hang over the engine shaft, which is nearly seven feet in diameter, and 448 yards distant from the forefield, or part, where the explosion happened; this barrel, though of considerable weight, was lifted up in the hook on which it was suspended; and the people on the surface felt the ground shake, as by an earthquake.

"Such are the effects which have frequently been produced in all the above mines; but from what cause they proceed, I have not yet been able to discover, nor even the least traces towards it. The substance having been analized, is found to consist of fluor and the ore of lead, but the cause of explosion still remains equally mysterious, though some attempts have been made to obtain a knowledge of this curious phenomenon.

"These curious observations I received from Mr. Mettam, of Eyam, overseer of the mines, who also addressed the following account of them to Mr. George Tissington, of Winster, principal agent of the works.

"Eyam, 2 July, 1768. Sir,—I send you by the bearer, two specimens of our *slickensides*, containing all the variety of minerals where the explosions happen; they fly out in such *slappits*,[1] smooth on one side. The explosions are sometimes heard to the surface, and felt like an earthquake; they frequently blow out all the candles in the mine, and split the *stemples*[2] into splinters as small as the twigs of a birch besom, to the distance of thirty or forty yards from the *forefield*;[3] others are broke, and some of them become too short

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[1] *Slappits*, fragments of the minerals burst out of the vein.

[2] *Stemples*, joists laid across fissures, when the minerals are cut out, by way of making a floor, on which rubbish is deposited, to save the expense of raising it to the surface.

[3] *Forefield*, that part of the vein under workmanship.

and drop out. The smooth sides lie face to face, and have the appearance of being shot with a plane, consisting of various members. There is generally two of these divisions in our forefield at Haycliff, about eight or ten inches asunder, and a seam of white *kebble*[1] in the middle of that space, half an inch thick, in which the miners rake down a sharp pointed pick until the crackling ceases; then they run away, knowing that the explosion will follow in a minute or two. Sometimes a noise is heard like the beating of a church clock, after which the greatest explosions happen.—I am, yours, etc., William Mettam.—To Mr. George Tissington, Winster."

John Mawe also writes in 1802 that in the Odin Mine "is found that singular variety of lead ore, called *slickenside.* This galena presents a smooth surface, as if plated. Sometimes it forms the sides of cavities, and on being pierced with the miner's tool, rends with violence, and explodes with a crackling noise. The cause of this phenomenon has not been fully explained. I have seen a man, when he came out of the mine, only a few minutes after the explosion, who, regardless of the danger, had pierced the sides of this substance, and was much hurt, and cut violently, as if stabbed about the neck and other places with a chisel, whence he was unable to return to the mines for two weeks."[2]

"Sometimes the vein-stuff is found perfectly divided vertically, throughout, and the surfaces polished; and these are called *Slickensides* or Cracking-whole, which usually are ribbed or slightly fluted, horizontally: the appearances are very similar to those of faults, but extraneous matters do not usually accompany them, the sides being mostly in very close contact; and often, after one side is removed, so as to give room, especially if the surface be pecked or broken, large Slapits, Spels, or fragments fly off, sometimes with loud explosions, and continue so to do for some days or longer, until the gate or passage in such vein is greatly enlarged thereby: this is the case in Gang Mine, in Cromford, where the hard 1st Toadstone also, in the gates and shafts, thus spels off, until they want timbering often, to support the roof and sides. I could not learn, that the Slickensides in the Mines about Eyam explode now, on mere scratching, as they were said to do in the late Mr. Whitehurst's time."[3]

"In Gang Mine, where a *Slickenside* runs through the Vein, the Miner avails himself of a curious property attending such Veins, by drawing laces, stoops, or nicks, at about six inches apart and four inches deep, with the point of his Pick, from top to bottom of his face of work, when he then leaves for several hours, and on his return, finds all the Vein-stuff so furrowed, spelled, or slappeted off, and laying on the sole ready got to his hands."[4]

"When their edges occur in the face of the vein, on the miner striking his pick into the vein they separate, in some districts without,

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[1] *Kebble*, a white opaque spar, calcareous, but not apt to break into rhomboidal forms.

[2] The Mineralogy of Derbyshire, by John Mawe, 8vo. London, 1802, p. 48.

[3] General View of the Agriculture and Minerals of Derbyshire, by John Farey, 8vo. London, 1811, vol. i. p. 250.

[4] *Ib.* p. 367.

in others with a slight report; and in some of the mines in the neighbourhood of Eyam, in Derbyshire, with *loud* reports, particularly in Cracking-hole vein, in Haycliffe title . . . . where in the centre of the vein, termed a shack vein, was a small white impalpable (not effervescing) powder, called a mallion, a quarter of an inch thick, which on being scratched, a loud explosion immediately ensued, before which explosion a singing kind of noise was heard. By setting a blast in the vein at a short distance from the mallion, after the blast was fired, in a few minutes an explosion took place, when a large quantity of the vein fell down. In the year 1790, a loud explosion took place from a slide joint of Slickensides going across, but not into the cheeks of the vein containing the mallion, which caused on its being stirred the loudest explosion and the largest quantity of vein materials to come down. . . . . The last great explosion was in the year 1805. It has sometimes happened that persons have been maimed or even killed by this phenomenon; which, however, has not been noticed from Slickensides *where no shale is incumbent.*"[1]

In writing of the mines on Hucklow Edge, William Wood refers to the Hay Cliff, as "a mine distinguished for having contained in great abundance, that extraordinary phenomenon in the mineral world, provincially called Slickensides. . . . The effects of this mineral are terrific: a blow with a hammer, a stroke or scratch with a miner's pick is sufficient to blast asunder the massive rocks to which it is found attached. . . . A person named Higginbotham once narrowly escaped with life, by incautiously striking this substance in the above mine. Experienced miners can, however, work where it greatly abounds without much danger. It is also known by the name of Cracking-whole."[2]

The phenomenon is referred to by W. Adam also, who supposes that the slickenside has been produced by the rubbing of the rocks against one another. "The intense heat generated by the motion of such vast masses (expanding the air in its pores) may account for its exploding when broken into, similar to lumps of glass when suddenly cooled, which explode on being scratched or slightly broken."[3]

"To avoid the danger attendant on working in its immediate contiguity, the miners use the precaution of merely making a small incision or aperture, with the point of the pick, and then retire to a place of safety, awaiting the result. In case of an explosion, it generally takes place in ten or fifteen minutes, and by the force attendant on which, considerable masses of ore, and even stuff, are detached."[4]

Sir Charles Lyell, referring to this subject in the 6th edition of

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[1] An Account of the Explosion of Slickensides, by W. Watson, Edin. Journ. Sci. new ser. vol. ii. p. 186, 1829.

[2] The History and Antiquities of Eyam; with a minute account of the Great Plague, which desolated that village in the year 1666, by William Wood, 8vo., London and Derby, 2nd ed. 1852; 3rd ed. date not stated.

[3] The Gem of the Peak; or, Matlock Bath and its Vicinity, etc., by W. Adam, London, 1845, p. 419, footnote.

[4] Mining Almanack for 1850, by W. English, London, p. 220.

his Elements of Geology in 1865, remarked, "these phenomena and their causes (probably connected with electrical action) seem scarcely to have attracted the attention they deserve." In subsequent editions this suggestion of a connection with electrical action was omitted.

Mr. Leonard Maltby, of the Mill Dam Mine, Great Hucklow, informs me[1] that he has had experience of the explosion of slickensides. The explosions take place at the present time in the vein at the Cockersfield Shaft; pieces of mineral burst from the face with a loud noise and with great force, so as to necessitate great care on the part of the men when working. There are also several other places in the Mill Dam Mine where slickensides of an explosive tendency have occurred, as well as in the Silence Mine on the same vein, and in a vein near Eyam, called the Brookhead Vein. At the Lady Wash Mine also, on the eastern range of the vein worked at Mill Dam, the miners noted the same phenomenon. Its prevalence in this neighbourhood leads Mr. Maltby to infer that slickensides will explode more or less, while being cut, wherever they occur. He remarks further that where slickensides occur, the vein is always as hard and fast as it is possible to be, and seems to be under great pressure. "When we work with a pick, cutting one side of the vein, as soon as we have made a little opening, it seems then that the air gets in, and the mineral swells and bursts off with loud noises, and where the vein is hardest and most nipped, the explosions are strongest. It always bursts off just as far as the opening is made." He considers both the slickenside and the explosions to be the result of pressure.

Though some of the veins in which explosions have occurred contain much fluor-spar, yet the phenomenon has been more frequently observed in the hard and tight veins which contain calc-spar, heavy spar (sulphate of baryta) and galena. Fluor-spar, as Mr. Maltby informs me,[2] occurs more commonly in soft veins, such as that at the Dusty Pits, near Eyam, where it was very abundant. In this vein no slickenside was seen and explosions were unknown.

The late Mr. J. A. Phillips, F.R.S., F.G.S., etc., informed me that he had known of several instances of the flying off of fragments of mineral from the slickensided face of a vein, with a sharp report. In one case a fragment was thrown off with sufficient force to break the leg of a man who was passing. The explosions occurred after a portion of the vein had been undercut. Mr. Phillips suggested that the removal of one side of a vein would leave the remaining side in a condition of strain, resembling that of a strung bow, with a tendency to bulge outwards into the workings. The undercutting would free, so to speak, one end of the bow.

Mr. W. Bowman, of Alport, writes[3] that he has seen pieces of limestone in the Ecton Mine fly off with a sharp small crack, some short time after it has been broken by blasting. In one instance, in 1885, two miners were drilling a hole by hand in the Clayton Adit-level, when a piece of rock burst from the face with a loud report,

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[1] In a letter dated 22nd October, 1886.

[2] In a letter dated 23rd November, 1886.

[3] In a letter dated 15th October, 1886.

throwing the men to the ground, and bruising them considerably; the thickness of the fragment was equal to the depth of the drill-hole, namely, ten or twelve inches. The toadstone also has been known by Mr. Bowman to break off with a little noise soon after it has been relieved of pressure by excavation. Ecton Mountain is composed of the upper beds of the Carboniferous Limestone, sharply contorted and crushed.

I may refer here also to the description by Mr. W. H. Niles,[1] of the movements of rocks resulting from lateral pressure, and exhibited in quarries. It was found at Monson that the rock has been brought into a compressed condition by a powerful lateral pressure acting in a north and south direction, and that, when opportunity is presented, the compressed rock expands with great energy, often bending, folding, and fracturing the beds, and sometimes producing sudden and violent explosions, and occasionally throwing stones into the air. The expansion became apparent on cutting trenches in the rock in an east and west direction.

At Lemont, Illinois, the bed of rock forming the floor of a quarry was gradually bent up into the form of an anticlinal, trending east and west, and running for about 800 feet with an elevation of six to eight inches. The elevation had taken place in consequence of the removal of the overlying rock, and had been attended by explosive sounds, and sometimes fragments of the rock had been thrown into the air. In the same quarry it was observed that drill-holes bored through two layers of stone became displaced, the upper parts of the holes being no longer vertically over the lower parts. The effects of this force have been noticed at five different localities, ranging over five and a half degrees of longitude.

Mr. Niles refers also to explosions which have sometimes occurred in making railway-tunnels and other excavations, and which could not be accounted for as the results of any artificial power.

The tradition among miners that knockings may be heard underground, where ore exists, is well known, and has often led to the expenditure of much money. That subterranean noises are not uncommon has been proved beyond doubt, and the following account by a working miner is not without interest.[2]

"I have heard some Miners say that it is a Knocking they hear, Striking much like as when one in Boreing, not constantly but resting by Fits, and always seem to be at a distance from him. . . . I once Worked in a Groove not many Years ago, where two more Men wrought, they worked by yards at a deeper Level than I wrought at . . . One day I having some leasure at Work, it struck into my Head to go down to them, . . . but coming there I found no Body, which I did much Wonder at, since I well knew that no Body else wrought within my hearing. Next Day I told the Men how I was mistaken; see you there says one of them to the other, it is what

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[1] The Geological Agency of Lateral Pressure exhibited by certain Movements of Rocks, Proc. Boston Soc. Nat. Hist. vol. xviii. p. 272 (1876); see also *ib.* vol. xiv. and Proc. American Assoc. for the Advancement of Science, vol. viii. p. 285, and vol. xxii. part ii.

[2] The Miner's Dictionary, by William Hooson, 8vo. Wrexham, 1747 (under the head Knocker).

we are used to hear; after some little Discourse, they told me that they had heard it very often, and (says they) not long before you came here, we was both at Work and heard a Noise, and we concluded it could be nothing but somebody coming down the Shaft, and in a little while, about the time they might be got to our first Sump-head, we presently heard as we thought, them throwing the Corves down the Sump; we heard 'em rattle so plain against the hard Sides, and amazed at such folly we came in hast up, where we found all things as we had left them when we came down without the least alteration, as we could discerne. Thus the Men.

"One Instance more may be of the same kind, where I have been acquainted, and 'tis this: I with others wrought in a certain Work about eighty Yards deep, the Shaft was Sunk in a great and loose Shack of Chirts, which sunk down to the Soles and much further for any thing we know, being exceeding loose, and not any openess seen throughout the whole Work, but the ways that were cut; the looseness of this Work was all the care to keep it up; yet what I Remark is, that the Workmen themselves, but more especially the Labourers, at the Sump-heads and in the Gates, have been often affrighted with such a Noise and dismal Rattle, as if sometimes the Shaft had run in, and at other times the Gates or Sumps; I have heard it my self, and have thought by the Noise, we had been all made fast, but by God's Blessing, never found one Stick of Timber disordered or out of its Place; one would think that the Noise might be caused by something running in some openness, or great Shack, but there was never any such seen in the whole Work; for altho' there were large and wild shaken Places, yet they were all full of loose small Chirts to the Day; . . . what these Noises are, we miners know not, but must leave them to the Disquisition of such learn'd Men as deal in those profound Matters; I mention it because Miners say that the Knocking is some Being, that Inhabits in the Concaves and Hollows of the Earth; and that it is thus kind to some Men of suitable Tempers, and directs them to the Ore by such its knocking, etc."

In some of the mines near Eyam, which have been referred to above, explosions of fire-damp have occurred from time to time, especially in those which were sunk through the Yoredale Shale into the Carboniferous Limestone, and in the water-levels which were driven long distances through the Millstone Grit and Yoredale Shale to drain the mines. References to such explosions occur in most of the authors quoted above, and in such terms as to show that they were clearly recognized as distinct from the explosions due to slickensides. I am therefore disposed to believe that the great explosion described by Whitehurst as having occurred in 1738 was due to slickensides, but that in the fifty years which had elapsed before Whitehurst wrote, the account of the effects had become considerably exaggerated, or more probably confused with the account of some explosion due to fire-damp.

It is difficult to understand the lifting of the barrel in the shaft, and the blowing of a man twelve fathoms perpendicularly, except by an explosion of violent expansive power. It will be noticed that the cause of the great explosion of 1790 is distinctly stated by Mr. W. Watson, though writing nearly forty years after the event, to have been a slide joint of slickensides going across a vein.

By the kindness of Mr. Maltby I have been supplied with some specimens of the explosive ore from the Cockersfield Shaft of the Milldam Mine at Great Hucklow, near Eyam. The specimens consist of sulphate of baryta and galena arranged in more or less vertical but irregular ribs. The planes of slickenside are beautifully polished, so much so in places as to possess the reflective power of a looking-glass, but they show also the usual ribbing or striation which so strongly conveys the idea of slickenside having been produced by the rubbing of two surfaces together. The planes of slickenside were clearly formed after the filling in of the vein by the minerals mentioned above. They cut through the galena and baryta impartially, nor in any of the specimens in my possession is there any appearance of a rearrangement of the minerals having resulted from the existence of the plane of slickenside, except that the slickenside surfaces are slightly stained by iron oxide, or coated by a microscopically thin film of galena.

The spar in these specimens has the granular appearance of white lump sugar, and readily crumbles into a gritty powder. Whether this granular structure is the result of the explosions by which the specimens were detached, there is no evidence to show. The specimens themselves average from half an inch to three inches across, and are of all shapes. Attempts have been made to prepare microscopic sections across the planes of slickenside, but up to the present without success.

The first explanation that suggested itself to me was that the mass of rock, separating two planes of slickenside, was comparable to a huge sheet of very brittle glass, placed on its edge; a slight blow on the lower part of which might bring down the whole mass in fragments. This, however, provides no explanation of the explosive power, which is so clearly brought out in the above quotations.

Secondly, it will be familiar to all who have been in mines, that newly bared shale swells and crumbles on exposure to air and moisture. This is probably due in many cases to chemical processes set up in the mass of the rock, principally no doubt in connection with the salts of iron. It seemed conceivable that such processes, taking place within a brittle rock, might place it in a condition of strain, under which it would fly to pieces with a mere touch. But there is no sign of any chemical alteration having taken place in these explosive spars.

The explanation, which perhaps best satisfies the requirements of the problem, appears to be that the spars are in a state of molecular strain, resembling that of the Rupert's Drop, or of toughened glass, and that this condition of strain is the result of the earth-movements, which produced the slickensides.

## V.—WOODWARDIAN MUSEUM NOTES: ON SOME ANGLESEY DYKES. I.

By ALFRED HARKER, M.A., F.G.S.,
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IN the Woodwardian Museum is a collection of nearly a thousand rock-specimens made by Professor Henslow to illustrate his "Geological Description of Anglesea" (1821, Trans. Camb. Phil. Soc. vol. i. pp. 359–452, plates xv.–xxi.). Specimens of the principal dykes were submitted to the examination of Professor Cordier, and his remarks on them are quoted in Henslow's paper. As Cordier's determinations date from a time when thin slices of rocks were unknown, and but little attention has since been given to the dykes of Anglesey, it is believed that brief notices of some of the typical rocks from localities easily identified may have an interest for British geologists. As regards the mode of occurrence of the dykes and their effects upon the adjacent strata, little can be added to the accurate descriptions of Henslow, written at a time when the igneous origin of dykes was a proposition to be proved. The specimens are referred to by number in the memoir, and these numbers will be cited below in brackets [ ].

We begin with a few specimens from the numerous dykes exposed on the shores of the Menai Straits. In spite of some interesting variations, these rocks possess many characters in common. They strike usually in directions varying from S.E. to E.S.E., and often coincide with lines of faulting, which are at right angles to the general strike of the strata. The only direct evidence of their date of intrusion is that they sometimes cut through Carboniferous beds; but if it is allowable to correlate these dykes with others having a similar direction in the Anglesey Coal-field, we may infer from Sir A. Ramsay's reasoning that the whole are of pre-Permian age (Geology of North Wales, 2nd ed. p. 264).

Beginning near Beaumaris, we find in the green contorted schists between Gallows Point and Garth Ferry an enormous number of small dykes of generally compact appearance. The majority of them are not more than a foot or two in breadth, but some attain to about twenty feet. They frequently ramify, but show on the whole a parallel arrangement with an average bearing about S.E. by E. In some cases a certain relative movement of the rocks on opposite sides of a dyke can be verified. Making allowance for the varying sizes of the dykes and the modifications due to more rapid cooling near the edges, the rocks present a general community of megascopic characters; only two of Henslow's specimens have been selected for closer examination.

### *Dykes between Gallows Point and Garth Ferry.*

[640.] Augite-andesite.—The hand-specimen shows a black, compact ground-mass containing numerous clear felspars in the form of parallelograms. These crystals are very flat, and have a marked parallel arrangement, as noticed by Cordier and Henslow. Under the microscope they are seen in cross-sections of elongated shape, 0·1 to 0·15 inch in length, and their fluxional arrangement is very evident. The faces which give the felspars their tabular habit are the brachypinacoids, while the other forms present may be the macropinacoid and basal planes. The usual albite-twinning is seen, combined with the Carlsbad type: the extinction-angles seem to indicate labradorite. The crystals are often bent and partially fractured, but I have not observed any relation between these disturbances and the twin-lamellation. Besides the felspars are abundant crystals of magnetite; and the ground-mass is composed of felspar microlites, magnetite, and rounded granules of augite decomposing into a pale-green substance. In both the ground-mass and the larger constituents, the magnetite seems to be of rather earlier formation than the felspar.

[642.] Augite-andesite.—Henslow mentions this rock as "more remarkably fine-grained and tough than any other which I have met with in Anglesea." It is a contact specimen with a fragment of the green schist firmly adhering to it. Here the scattered felspars are smaller and occur more sparsely; they show little of the tabular habit and parallel disposition so striking in the preceding slide. The ground-mass too is a little finer; but with these exceptions the same description will suffice.

To illustrate the modifications of texture in different parts of one dyke, two specimens collected by Prof. Hughes have been sliced, They are from a dyke just south-west of Gallows Point.

Augite-andesite from marginal portion of dyke.—This is intermediate in texture between [640] and [642], and has the same general characteristics. The scattered felspars, however, have inclusions of magnetite, disposed chiefly along the twin-planes.

Dolerite from central part of the same dyke.—The slide exhibits rectangular sections of felspar, mostly lath-shaped and about 0·1 inch in length, magnetite in crystals giving quadrangular sections and in rods, and decomposed augite in ophitic plates. There is no ground-mass. The felspars show twinning by different laws. In some cases a crystal is divided by a line which may represent Carlsbad twinning into two halves, of which one shows lamellation on the albite and the other on the pericline type. The lamellæ are often interrupted.

Another of Prof. Hughes' specimens, from a dyke north-east of Garth Ferry House, may be styled a porphyritic dolerite.—This rock bears a close resemblance to the preceding, but differs from it in the fact that the magnetite occurs in imperfect crystals of later formation than the felspar. Besides the rectangular felspars there are a few of larger dimensions giving squarish sections. This rock shows more advanced decomposition than the others mentioned above. The augite, which appears to have formed ophitic plates, is entirely destroyed and replaced by the usual pale-green substance with confused scaly structure, and polarizing in low tints of grey and indigo. Patches of this 'viridite' inclose crystalline grains of calcite. Grains of secondary quartz are also plentiful, as well as magnetite dust and ferruginous specks. The felspars are almost opaque.

Cordier pronounced some specimens from this part of the Straits to be "dolerite. The pyroxene very evident, with *fer titané*." In the slides examined, however, the iron-ores never show forms characteristic of ilmenite, and no leucoxene occurs. The compact rocks are named "basaltic lava."

*Cadnant dyke.*—Between Garth Ferry and Menai Bridge we meet with the first large dyke, which occurs on the right bank of the little stream at Cadnant. This dyke is not marked on the Maps of the Geological Survey, but Henslow traced its course among the schists for some distance inland. He also found it on the Carnarvonshire shore, where it cuts Carboniferous strata. In the latter place the rock is less compact in texture than on the Anglesey side, and Henslow states that "none of the dykes which intersect the limestone and shale attain to so great a degree of compactness as the generality of those which are found among the schist." Three dykes having a similar strike to that at Cadnant are marked on the Survey Map south of Bangor Station, and a slide from one of these, at Glan Adda, has been examined. Cordier identified the Cadnant rock as "a true dolerite, having the ingredients, pyroxene, *fer titané*, and felspar well characterized."

[545.] Dolerite; a typical specimen from Cadnant.—To the eye the rock shows a moderately coarse-grained aggregate, in which the augites are conspicuous, moulding elongated crystals of felspar. Under a low objective the structure is seen to be holocrystalline and ophitic. The felspars occur in mostly elongated sections, showing a rather fine albite-twinning, combined with a concentric zonary banding, and sometimes twinning on the pericline law. From the extinction-angles they should be andesine or oligoclase. This rock exemplifies a character found in most other similar dykes in North Wales; the felspars appear to be of two generations, of which one is older, and the other newer than the bulk of the magnetite. The later felspars are distinguished by their imperfectly defined outline and more equal dimensions, their more marked zonary banding, and their greater clearness: their twin-lamellæ are usually very narrow and rather wide apart. A few prisms of apatite are seen. The magnetite in this slide is plentiful, and builds crystals of intricate branching shapes. The augite has the pale-brown tint common to that mineral in almost all North Welsh rocks. It moulds the other constituents, and never shows crystal boundaries. The prismatic cleavages are strongly marked, and there are ill-defined interpositions arranged in branching lines or planes. The chief secondary product is a yellowish-green, doubly refracting mineral, which pseudomorphs augite: secondary granular magnetite accompanies it in places. The dominant felspar is often almost opaque owing to alteration-products.

Porphyritic dolerite: Glan Adda, south of Bangor Station.—This dyke occurs on the same line as that at Cadnant, and may be briefly referred to for comparison. Here the earlier felspars have lath-shaped sections: the later ones are more equi-dimensional, and show the zones of different chemical composition very distinctly. The augite moulds the older felspars, but is of earlier formation than the second generation, and sometimes shows crystal-outlines, the prism and pinacoidal planes. Iron-ores are abundant, chiefly magnetite; fine needles of apatite occur in the felspars; small scattered flakes of biotite are sparsely present. The latter mineral is met with in the Cadnant dyke [525], "a circumstance of rare occurrence in the dykes of Anglesea," (at least in those of the Menai Straits). The Glan Adda dyke has pink porphyritic felspars, which under the microscope show large squarish sections, much decomposed.

It will be noticed that all these dolerites correspond in character more closely to the andesitic than to the basaltic family: olivine I have not yet observed in the above rocks, though it may possibly be lost among the decomposition-products. This mineral occurs, however, in the Plas Newydd dyke described below.

[546.] Dolerite: near Four Crosses, on the north-western prolongation of the Cadnant dyke.—This specimen, to illustrate the more compact type of rock, is taken from the outer portion of the dyke, though not from the actual contact, where the andesitic *habitus* prevails. The magnetite is mostly older, but partly newer, than the felspar; it occurs in crystals showing the cube or octahedron, and in complex shapes related to those forms. The minuter grains often appear in star-like aggregates with sections exhibiting three bilobate rays: these are sometimes surrounded by a ring of finely granular magnetite. The felspars give elongated rectangular sections: the larger ones are often simple or once twinned, but fine twin-lamellation is also found. The pale-brown augite, in ophitic plates of varying extent, is mostly destroyed. As secondary products occur the usual "viridite," finely granular calcite, and clear quartz.

The dykes in the neighbourhood of Menai Bridge have not been sliced. They are dolerite, often with porphyritic felspars. They appear to be much decomposed, and contain a considerable amount of calcite and pyrites.

*Plas Newydd dyke.*—The largest dyke in this part of the island cuts through the lower beds of the Carboniferous Limestone series a little south of Plas Newydd, the seat of the Marquis of Anglesey. This dyke, 134 feet wide, occupies a probable line of fault bearing in a south-easterly direction: it is met with again on the opposite side of the Straits. In the nomenclature of Cordier's day the rock was described as "indubitable basalt, consisting of felspar and pyroxene," but the normal type is holocrystalline and granular.

[485.] Olivine-Dolerite; typical rock of the Plas Newydd dyke; a rather coarse-grained dolerite with marked ophitic structure.—The microscope reveals olivine in abundant rounded grains included in the augite. There is much secondary magnetite dust resulting from its decomposition. Magnetite occurs also in crystals, usually imperfect cubes; this and the olivine are the earliest formed constituents. The chief felspars are in elongated crystals showing finely repeated twinning and often concentric zoning; the extinction angles are moderately high, and would agree with labradorite. There is some slight bending of the crystals, which may perhaps affect the twin-lamellation. Sometimes cross-twinning, presumably on the pericline law, is observed. There is also, as in the Cadnant dyke, a later generation of felspars, shapeless, but broader than the others. They are simple or once twinned, and between crossed Nicols show strong zonary shading: as usual they are clearer than the earlier felspars. The augite is in light-brown plates, moulding the dominant felspars: it shows branching layers of interpositions. The chief secondary products in this slide are a yellowish-green structureless substance and a ferruginous staining; both seem related to the augite.

[486.] Dolerite; the more compact portion of the dyke; a fine-grained ophitic rock with abundant magnetite, closely resembling [546] from the Cadnant dyke. The felspar is in elongated prisms, with mostly repeated albite-twinning and fairly wide extinction-angles. It is clear except for some granular calcite and fine viridite strings, following for the most part, the basal cleavage-cracks. Magnetite is plentiful in crystals, skeletons, and rods; and is slightly posterior to the felspar. The apparent rods, which are probably sections of plates, have a parallel disposition, and are arranged transversely to felspar crystals which they surround. A similar relation of magnetite to olivine is described by Reusch from the basalts of Jan Mayen.[1] The present rock contains also minute rings (spherical shells) of magnetite dust surrounding nuclei of the same. The augite, always allotriomorphic, has the same characters as in the preceding slide. Chloritic decomposition-products and clear secondary quartz occur.

The metamorphic effects of the Plas Newydd dyke upon the adjacent Carboniferous strata, as described by Henslow, possess considerable interest. On the south-west side a bed of calcareous shale, abutting upon the dyke, is converted into a kind of lydianite, containing calcite and clusters of garnet and analcime crystals. Henslow's specimens [511 to 523] show the development of these last-named minerals in every stage from mere whitish concretionary spots in the hardened shale to perfectly formed crystals. These are closely clustered together along particular bedding-planes, and sometimes the valve of a *Productus*, converted into crystalline calcite, is seen to be studded over and penetrated by globules or crystals of analcime.

The garnet occurs in crystals up to 0·7 inch in diameter, showing the faces of the rhombic dodecahedron (110), sometimes truncated by narrow planes belonging to the form (211): they have often a marked concentric zonary structure. They vary from yellowish-green to olive-brown, with a resinous lustre. "Their specific gravity is 3·353," and their hardness under 7. These characters indicate a variety approaching *grossularia*; Lyell[2] gives the percentage of lime as 20. A slice (cut from a specimen in the Sedgwick collection) shows a number of crystals in various stages of development, closely packed together, and the interstices filled with crystalline calcite. The crystals are not all isotropic: they contain a large amount of foreign material. The readiness with which garnets of considerable

[1] Cf. also Prof. Judd's basalt from Mull, Q.J.G.S. vol. xlii. pl. vi. fig. 7, 1886.

[2] Student's Elements of Geology, 3rd ed. p. 515.

size are formed by contact alteration is evidently connected with this capacity of the mineral for including in its crystals a large quantity of foreign matter. The same remark applies to disthene and chiastolite.

The analcime crystals, where they are best developed, show the faces of the trapezohedron (211), and have a concentric zonary structure. The specimens were analyzed by Cumming, who pronounced them to be "analcime with excess of iron." His figures, however, differ widely from published analyses of the mineral in question, and can only be reconciled by supposing the analcime to be partially changed into prehnite, a mode of alteration known to take place occasionally.[1] Assuming the iron to be present as ferric oxide, and replacing it by alumina, Cumming's analysis is represented by column I. below. The second column gives the composition of analcime calculated from the formula $H_4\,Na_2\,Al_2\,Si_4\,O_{14}$; the third prehnite from the formula $H_2\,Ca_2\,Al_2\,Si_3\,O_{12}$. Column IV. is the mean of II. and III.

| | I. | II. | III. | IV. |
|---|---|---|---|---|
| Silica | 49 | 54·4 | 43·6 | 49·00 |
| Alumina | 24 | 23·4 | 24·9 | 24·15 |
| Lime | 12 | — | 27·1 | 13·55 |
| Soda | 9 | 14·1 | — | 7·05 |
| Water | 5 | 8·1 | 4·3 | 6·20 |
| | 99 | 100·0 | 99·9 | 99·95 |

It will be seen that the Plas Newydd mineral agrees fairly well with the composition of analcime half-converted into prehnite. That such a mineral as analcime should be formed as a true contact-alteration product appears at first very improbable, but the whole process of development can be seen in the specimens, and is precisely similar to that of the garnets.

*Moel-y-don and Plas-Coch dykes.*—Several dykes, one forty feet in width, were noted by Henslow at Moel-y-don, opposite what is now Port Dinorwic. These are not marked by the Geological Survey, and I have failed to find any exposures on the shore. Others occur inland on about the same line, near Plas-Coch.

[563.] Amygdaloidal dolerite from one of the minor dykes, south of Moel-y-don: a medium-grained ophitic dolerite, with numerous spherical cavities, averaging 0·1 inch in diameter, filled with secondary minerals, and others larger and more irregular in shape. Under the microscope the dominant felspars are seen in elongated sections with ragged ends due to some of the twin-lamellæ projecting beyond others. Between crossed Nicols they show for the most part finely repeated albite-twinning, and some zonary shading. Some sections perpendicular to the twin-plane give extinction-angles up to about 38°, indicating anorthite. The smallest crystals are once twinned, and in several places have a radiate arrangement about a centre. Besides these earlier-formed felspars, there is a second generation, less abundant and, judging roughly from their

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[1] Blum., "Pseudomorphosen," p. 100, etc.

extinctions, of a more acidic species. These are untwinned, and show the zones of growth very clearly. They are without crystal boundaries, and sometimes include little crystals of the older generation. Magnetite occurs in small cubes of later formation than the first set of felspars: it is not very abundant. The augite in pale-brown patches moulds or completely includes the felspars of the earlier generation. In some places it is crowded with short black rods, probably of magnetite, disposed parallel to two definite directions: this appears to be a secondary phenomenon connected with the decay of the augite. The usual feebly polarizing 'viridite' patches replace this mineral, and there is some calcite dust in the slide. The infilling of the vesicles has taken place in several distinct stages. First a zeolitic mineral has been deposited at points on the wall, in fan-like bundles of imperfect crystals. The interior of the cavity, thus reduced in size, has been stained by a greenish-yellow substance, and then lined with chalcedony in the usual mamillary coating. The remainder of the vesicle has finally been filled with calcite, not in one mass, but as a mosaic of distinct crystalline grains, mostly untwinned. In some cases a little clear quartz occurs with the calcite.

*Llanddwyn dykes.*—Henslow collected specimens from two dykes in the island or peninsula of Llanddwyn, westward of the opening of the Menai Straits. They do not agree in position with those marked on the Survey Map. The rock is much decomposed, and only one slide has been prepared.

[684.] Porphyritic dolerite from Llanddwyn.—This is a fine-grained, much-weathered rock inclosing liver-coloured felspars more than an inch in diameter. One of these is shattered, but the parts still remain in proximity to one another. The microscope shows abundant cubes of magnetite, small felspar prisms much altered, and augite replaced by the characteristic pale-green product with some calcite. There is a small vesicle filled by a deposit of quartz followed by calcite with polysynthetic twinning. The large porphyritic felspars are deeply affected by an apparently saussuritic alteration. In some places, however, they are clear enough for their finely repeated twinning to be made out, and the extinction-angles are such as would be given by labradorite. Similar felspars occur in the Glan Adda dyke already mentioned.

All the dykes of the Menai Straits, with perhaps the exception of the olivine-bearing rock of Plas Newydd, are intermediate rather than basic in their affinities. The characters of the augite are in accordance with this; so also the frequent cross-twinning in the larger felspars and their very pronounced zones of growth, the abundance of magnetite to the exclusion of ilmenite, and the nature of the ground-mass where it occurs. The rocks are all 'porphyritic' in the sense of Rosenbusch, since they contain felspars of more than one generation. When the later felspars occur as microlites forming part of a ground-mass, I have used the name *augite-andesite*. Rocks of more holocrystalline type, in which the two sets of felspars are of about equal size, have been called *dolerites*, as distinguished from *diabases,* which are characteristic of larger intrusive masses, and exhibit the 'granular' structure of Rosenbusch. The term *porphyritic dolerites* has been applied to those containing larger scattered felspars, making in all three generations.

The dykes of the central and northern portions of Anglesey and of Holyhead Island differ widely from those described above, and may furnish the subject of further notes.

## REVIEWS.

### I.—The Fossil Fishes of the Chalk of Mount Lebanon, in Syria. By James W. Davis, F.G.S., F.L.S., etc. Scientific Trans. Royal Dublin Soc., series 2, vol. iii. pp. 457–636, pls. xiv.–xxxviii. (April, 1887.)

AGAIN we have to welcome from the pen of Mr. James W. Davis an important contribution to our knowledge of the palæontology of Fishes. Nearly four years ago (Geol. Mag. Nov. 1883) we received an exhaustive monograph upon the fossil fish-remains of the Carboniferous Limestone of Britain, in which were figured and described a number of teeth and spines, indicative of types previously unknown to science; and on the present occasion, a still more substantial contribution is made in the form of figures and descriptions of a large series of the most perfectly preserved fossil fishes that have hitherto been discovered. The author treats of the palichthyology of the Upper Cretaceous rocks of the Lebanon, as revealed by the researches of the Rev. Prof. E. R. Lewis, formerly of the Syrian Protestant College, Beyrout, whose magnificent collection was acquired some years ago by Mr. R. Damon, of Weymouth, and a large portion of which has now been purchased by the British Museum. This memoir, like the previous one, was communicated by the late Earl of Enniskillen to the Royal Dublin Society, and is printed and published in the excellent style for which that Society's Transactions are so well known.

On glancing over the pages, we are led to admire the industry and untiring energy of the author, who succeeds, in the midst of business avocations and at so great a distance from works of reference, in turning hours of leisure to such profitable account. Nearly all the more important memoirs bearing upon the subject have been consulted and are referred to, and, in addition to notes upon forms already known, no less than ten genera and sixty-six species are described as new to science. At the same time, the pursuit of scientific study under such conditions must necessarily render one liable to errors arising out of the very difficulties surrounding work requiring so much research as the present; and to this cause must probably be ascribed certain misapprehensions that will doubtless be criticized adversely by ichthyologists more favourably situated for interpreting these remains.

Mr. Davis prefaces his work with a concise and appropriate introductory section, historical and geological. This is mainly based upon the *resumé* already published by Pictet and Humbert, with the addition of a notice of works that have subsequently appeared. By some singular mishap, however, there is no reference to Prof. Lewis's own interesting account of the geology of the Lebanon, which appeared in the GEOLOGICAL MAGAZINE in 1878; and the omission is all the more unfortunate, since the observations contained in this paper were made while collecting the fossils which chiefly form the subject of the memoir before us.[1]

Proceeding to the systematic portion of the work, the author wisely decides to follow some definite published classification, and selects that of Dr. Günther employed in the well-known "Study of Fishes." We can scarcely agree with Mr. Davis, however, when he states that this system "embraces the most recent work of modern embryologists and anatomists;" and we venture to think that some of the new facts revealed by the Lebanon fishes themselves will combine with other recent discoveries to demonstrate the illogical nature of the arrangement.

The descriptions of the Selachian fishes occupy 24 pages and seven plates, and relate to a magnificent series of specimens representing 9 genera and 16 species, of which 2 genera and 12 species are considered to be new. A very fine nearly complete example of *Notidanus* is made known under the name of *N. gracilis*. Two new Scylliidæ are referred to *Thyellina*. Of the Spinacidæ, there are remarks upon *Spinax primævus*, and the description of a novelty, *Centrophoroides latidens*, closely related to *Centrophorus*; but the author unfortunately fails to appreciate the essential characters of this family, and includes a remarkable new genus, *Rhinognathus*, which is described as possessing a distinct anal fin. The teeth of the latter, if found isolated, would have been unhesitatingly referred to *Lamna*, and the discovery of the complete fish to which they belong is thus of especial interest. Among Rays, the Rhinobatidæ are believed to be represented by six species of *Rhinobatus*, of which five are new and most beautifully preserved; a large *Cyclobatis* is described as *C. major;* and a diminutive fossil from Sahel Alma is doubtfully assigned to *Raja*. The Chalk of Mount Lebanon has thus yielded one of the most important series of Sharks and Rays ever discovered in a single formation, and the accession of new forms is unusually great. On reading the letterpress, however, accompanying the plates, we cannot but regret the want of scientific precision in regard to anatomical points. The branchial arches, for example, are continually described as "branchiostegal rays"; the basal pterygia of the pectoral fins are referred to as part of the scapular arch, being, in *Rhinobatus*, "divaricating osseous plates," and in one case "protecting the gills"; the shagreen is regarded as a "cuticular" covering; and in the description of the fine skull of *Rhinobatus tenuirostris* on p. 488, the most evident features are overlooked.

Some interesting novelties are made known among the Ganoids, which comprise two species of the Pycnodont *Palæobalistum*, and

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[1] See The Fossil Fish Localities of the Lebanon by the Rev. Prof. E. R. Lewis, M.A., F.G.S., 1878, Decade II. Vol. V. pp. 214-220.

two forms perhaps having some affinity with *Amia*. In the determination of *Palæobalistum Goedelii*, Heckel, the author has apparently followed Mr. William Davies' labelling of the National fossils without consulting Heckel's original description; for there is no reference to the latter, and it is wrongly assumed (p. 496) that the species was not at first described from the Lebanon. With the exception of certain head bones, almost the complete skeleton of this fish is shown in the new specimens; and there is also good evidence of a second species, which Mr. Davis names *P. ventralis*. The two remaining Ganoids are known only by portions of the caudal region, and so cannot be satisfactorily placed; they are described as *Spathiurus dorsalis* and *Amphilaphurus major*. With the same order are also associated a decidedly Teleostean caudal fin, curiously determined to be "*Chondrosteus ?*" and another small fish "*Microdon ? pulchellus*," which does not appear even remotely connected with the Pycnodonts.

Passing to the Teleosteans, there are some brief remarks upon the Sparoid genus, *Pagellus*, and then follows a most interesting account of the Berycidæ. One new species of *Beryx*, two of *Pseudoberyx*, two of *Hoplopteryx*, and one doubtful species of *Homonotus*, are described; and the author adds some appropriate remarks upon the mixture of extinct fishes originally referred to the first of these genera. He shows (so far as we are aware, for the first time) that the so-called *Beryx Zippei*, *B. superbus*, and *B. syriacus*, ought all to be placed in the genus *Hoplopteryx*; and this is an important advance towards the philosophical arrangement of the extinct members of the family.

The only representatives of the Carangidæ are referred to *Platax*, and of this genus two species are distinguished, the one named *P. minor* by Pictet and Humbert, and the other new, described as *P. brevis*. Some family-headings, however, have been accidentally omitted from the text, and *Petalopteryx*, *Cheirothrix*, and *Sphyræna*, thus fall under the section Carangidæ. Of the first of these, Mr. Davis has only observed a single specimen, referable to a new species; but of the second, some five examples are described. The latter are said to have no less than fifty vertebræ, and other features combine to render their association with the Gobioids somewhat problematical. *Sphyræna Amici*, Agassiz, is rightly dismissed as founded upon uncertain evidence.

Of the Fistulariidæ, a fine specimen of "*Solenognathus*" *lineolatus*, Pict. et Humb., is figured; but the author omits to substitute a new generic name for the one it bears, so long pre-occupied. Next succeeds a lengthy account of the characteristic Lebanon Cretaceous genus, *Pycnosterinx*. Mr. Davis agrees with Pictet and Humbert in placing this form with the Chromides, and recognizes five species in addition to the six already known. These are mostly described in detail; but it would have been interesting to have further information regarding the fish named *P. latus* (pl. xxvii. fig. 2), which appears to possess a remarkably primitive tail. In the same family is also placed *Imogaster auratus*, Costa, of which a beautiful new species is made known; and another example of the Italian Professor's *Omosoma Sahel-Almæ* is referred to the Stromateidæ.

The Physostomous fishes are placed in the families of Siluridæ, Scombresocidæ, Esocidæ, Halecidæ, Hoplopleuridæ, and Muræenidæ. The first of these becomes a convenient "refuge" for two remarkable genera, whose characters appear to be unique. *Coccodus* has already been so determined by Pictet, and the new materials described by Mr. Davis add very materially to our knowledge of the skeleton of the fish. There is an anteriorly directed spine upon the top of the head; the body seems to have been scale-less; and the notochord persistent. Another fish, known only by a single specimen, destitute of the head, is named *Xenopholis carinatus*, and presents very different characters. The body is covered with imbricating bony scutes; the dorsal and anal fins are long and opposite, and the latter possesses two small robust spines in front; while the pelvic fins are abdominal, consisting of 12 or 13 rays, all soft.

Of the Scombresocidæ, a small flying fish is described under the new generic name of *Exocœtoides*, and considered to be closely allied to the living *Exocœtus*. Beautiful specimens are figured, showing all the more characteristic features of the genus. Another interesting novelty is a well-preserved example of *Istiæus* from Sahel Alma, —a form hitherto only discovered in the Upper Cretaceous of Westphalia. This is named *I. lebanonensis*, and Mr. Davis follows Agassiz and W. von der Marck in assigning the genus to the Esocidæ.

The great families of Salmonidæ and Clupeidæ are next treated together under Agassiz's convenient name of Halecidæ. Six new species of *Osmeroides* are determined; one of *Sardinius*; one of *Opistopteryx*; five of *Clupea*; and one doubtful species of *Engraulis*. There are also two new forms of *Spaniodon*. The section upon *Osmeroides* commences with a general notice of the genus, particularly referring to the important researches of W. von der Marck, but unfortunately omitting a reference to Laube's recent remarks upon the skeletal anatomy of the first (Denkschr. Akad. Sci. Wien). The species are then carefully described in detail, with numerous illustrative figures; and two specimens are interesting as showing well-preserved ova, though the author does not appear to have recognized these, merely noting them as "masses of rounded granular substance spread over the abdominal region." *Sardinius crassapinna* is another important new member of the Lebanon Chalk fauna; and the type specimen of *Opistopteryx curtus* exhibits the skeleton of the latter genus in an unusually perfect state. Proceeding to the long series of species of *Clupea*, we hardly feel convinced of the propriety of assigning some of the forms described to this genus; *C. Lewisii*, for example, has a remarkably Elopine aspect, and there are others whose connection with *Clupea* does not, at first sight, seem well established. Closely related to these is *Leptosomus*, of which Mr. Davis has found nothing to add to the original descriptions. Some notes on *Chirocentrites* follow, and then an interesting detailed account of the species of *Spaniodon*, and of a nearly allied fish believed to represent a new genus, *Lewisia*.

The remainder of the Halecidæ are referred to this group with more hesitation. The author removes to this position the remarkable genus *Eurypholis*, from its more usual place in the Hoplopleuridæ, adding one new species, and showing that Pictet's *E. longidens* must be regarded, at least in part, as representing a hitherto unrecognized genus, for which he proposes the name of *Eurygnathus*. This is a fish of extreme interest, as are also two others referred to new genera, *Pantopholis* and *Phylactocephalus*. These forms belong to a type apparently well represented in Cretaceous seas, and are suggestive of some interesting considerations in regard to the affinities of the primitive Teleosteans of later Mesozoic times, to which, it is to be hoped, the author will return in greater detail on some future occasion. We would wish to know something further, for example, concerning the obvious connection between *Eurygnathus* and *Enchodus*—especially as Prof. Cope, so long ago as 1875, showed that the latter was a truly Physostomous fish, having no affinities with the Trichiuridæ, as previously supposed, and is still erroneously maintained in the monograph before us.

A large number of fine specimens of *Rhinellus* are described, indicating no less than six new species, and the author then proceeds to consider an equally unique series of *Leptotrachelus*, representing the family of Hoplopleuridæ. These fossils are preserved in the British Museum, and reveal almost all the hard parts of the fish. *L. triqueter* is described in great detail, and Mr. Davis makes known a new variety of this form, in addition to another, which is considered specifically distinct. He also gives reasons for concluding that no true *Dercetis* has been found in the Lebanon Chalk, and that Pictet's *D. linguifer* was probably founded upon a fragment of *Leptotrachelus triqueter*. A figure of *Aspidopleurus cataphractus* is likewise added, and this genus included in the same family.

In conclusion, Mr. Davis makes an important contribution to philosophical ichthyology by bringing forward the first evidence hitherto discovered of a Mesozoic eel. Two species, referred to *Anguilla*, are figured and described, the one from Hakel and the other from Sahel Alma; and the specimens are fortunately sufficiently complete to leave not the slightest doubt as to their family relationships.

As will be gathered from this brief *resumé*, the author is to be congratulated on having contributed to fossil Ichthyology one of the most extensive works of recent years; and its value is doubly enhanced by the careful drawings of Miss E. C. Woodward, who has executed the fine series of illustrative plates. A. S. W.

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II.—SUNLIGHT. By the Author of "THE INTERIOR OF THE EARTH." Second Edition. pp. 180. (London, Trübner and Co., 1887.)

IN this little work the author (Mr. H. P. Malet) asks for the "serious consideration" of his "simple suggestion, that light was the first cause of the creation of this earth, acting on a nebulous mass that held in it gases or material sensitive to, absorptive, and retentive of that light." "In other words, a nebulous, chaotic mass was converted into air, water, and solids by the action of sunlight on gases sensitive to that force." He finds that there is actually no proof of heat in the sun, nor that this earth was ever hot; but that the "solids contracted and subsided in their necessary gravitation, and the waters certainly subsided with the bed they rested on. As the entire solid body could not possibly sink into a smaller space than it occupied, it followed that the water sank into the lower levels of its bed, and left ridges and islands all round the sphere to form the dry land." This sinking of the ocean-bed is one of the main contentions of the author: "the process has been going on ever since organic life began; therefore we find the relics in our quarries, mines, and on our mountain tops." It is needless to criticize these statements, for although made by one who has read or consulted some standard geological works, he has evidently failed to grasp the principles and philosophy of the science. We can only lament the publication of books of the class to which "Sunlight" belongs, for they are calculated to do much harm to those who cannot discern fact from fiction. The author, quoting remarks of Mr. Froude, asks, "How many times must we outsiders learn our science and then unlearn it? Each generation of philosophers laughs at the conclusions of its predecessors." In questions relating to Cosmogony science is naturally speculative, and the most eminent men differ on many points; but it is curious to find the author quoting from that "lover of truth," Dr. Kinns, and criticizing some of his statements about the early history of the earth.

We do not find so much fault with the author for his quotations to show how various geologists "ancient and modern" differ one from the other on speculative matters; we find most fault with his own geological (?) teachings. The following quotations will suffice to justify our lamentations. "It is asserted that rocks are scratched, grooved, and polished by ice-friction." And the author proceeds as follows, "I have examined many of these places, and take a type in Lucerne. The polishing was all done by running water; the small scratches and the larger grooves were all done first by sand and water; then as they increased in size gravel and pebbles made them into grooves. Some of these follow bends in the rock, which ice could not have done." Again, in reference to Caverns, the author remarks, "To prevent any confusion, I divide caves into three heads —First, those that have been excavated by man or beast; secondly, those that have been washed out by water; thirdly, those that have been built on a centre or nucleus." In reference to the third cause for caves he goes on to say, "They are built as a nucleus on a centre support, and are similar in history, but not in extent, to those coal-fields which have ocean deposits over each seam." While, however, we take exception to these and many other statements, we entirely sympathize with one sentence in the work before us, "We require correct data to start from, before puzzling students of natural history by one thing to-day and another to-morrow, thus throwing cosmogony into chaos, and making scientific teaching untrustworthy."

# REPORTS AND PROCEEDINGS.

## VISIT OF THE GEOLOGISTS' ASSOCIATION TO THE HISTORICAL AND TYPE COLLECTIONS IN THE GEOLOGICAL DEPARTMENT, BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, S.W.

ON Saturday afternoon, the 12th of March, 1887, the Members of the Association, accompanied by their President, F. W. Rudler, Esq., F.G.S., their Secretaries Dr. J. Foulerton, F.G.S., and B. B. Woodward, Esq., F.G.S., assembled in the Central Hall of the Natural History Museum, Cromwell Road, whence they proceeded, under the guidance of Dr. Henry Woodward, F.R.S., the Keeper of the Department of Geology, to visit a newly-opened Gallery (No. 11), in which had been arranged, in seventeen cases, a series of nine Collections of historical and palæontological interest, bearing upon the early history of the British Museum and the study of Geology and Palæontology in this country. Dr. Woodward addressed the members as follows:—

Taking the exhibition cases in *chronological order*, the earliest is the "Sloane Collection." This is the most ancient portion of the Geological Collection, having formed a part of the Museum of Sir Hans Sloane, Bart., F.R.S., acquired by purchase for the Nation in 1753.

The geological specimens are stated to have consisted "in what by way of distinction are called *extraneous fossils*, comprehending petrified bodies, as Trees or parts of them; Herbaceous plants; Animal substances," etc., and reported to be "the most extensive and most curious that ever was seen of its kind." Until 1857 the Fossils and Minerals formed one collection, so that a large part of the "Sloane Collection" consisted probably of mineral bodies and *not organic*, but in any case only about 100 specimens of invertebrate[1] fossils can now be identified with certainty as forming part of the original Sloane Museum. Each specimen in the Sloane Collection had originally a number attached to it, corresponding to a carefully prepared Manuscript Catalogue, still preserved, which contains many curious entries concerning the various objects in the Museum. In the course of more than 130 years, many of these numbers have been detached from the objects or obliterated by cleaning. But as all fossils at this early date were looked upon *merely as curiosities*, but little attention was paid to the formation or locality whence they were derived. Historically, the collection has immense interest to us, marking the rapid strides which the science of Geology has made of late years, especially as regards its more careful and systematic methods of study.

The next Collection in chronological order is the "Brander Collection," and is the earliest one in which types of named and described species have been preserved.

This Collection was formed by Gustavus Brander, F.R.S., F.S.A., in the earlier half of the last century, and an account of the same, with eight quarto plates, was published in 1766, entitled, "Fossilia

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[1] And some few vertebrate fossils which have not been separated from the General Collection.

Hantoniensia Collecta, et in Musæo Britannico deposita." The descriptions of the species given in the work were written by Dr. Solander, one of the Officers of the British Museum. They were "collected in the County of Hampshire, out of the cliffs by the sea-coast between Christchurch and Lymington, but more especially about the cliffs by the village of Hordwell, nearly midway betwixt the two former places" (*op. cit.* p. 111).

Only a small number out of the original 120 figured specimens, are now capable of being identified, the rest having become, in the course of 120 years, commingled with the far more numerous and later Eocene Tertiary acquisitions, and so have lost their connection with this admirable Memoir. The engravings of the shells are equal to any modern published work descriptive of the fossils of the Eocene formation; but the names given by Dr. Solander are in many instances incorrect, according to our present knowledge of the genera of Mollusca.

The next series to which I would direct your attention is the Collection of William Smith, LL.D. This Collection, which was commenced about the year 1787, was purchased by the Trustees in 1816, a supplemental Collection being added by Dr. Smith in 1818.

It is remarkable as the first attempt made to identify the various strata forming the solid crust of England and Wales by means of their fossil remains. There had been other and earlier Collections of fossils, but to William Smith is due the credit of being the first to show that each bed of Chalk or Sandstone, Limestone or Clay, is marked by its own special organisms and that these can be relied upon as characteristic of such stratum, wherever it is met with, over very wide areas of country.

The fossils contained in this Cabinet were gathered together by William Smith in his journeys over all parts of England during thirty years, whilst occupied in his business as a Land Surveyor and Engineer, and were used to illustrate his works, "Strata Identified by Organized Fossils," with coloured plates quarto (1816; four parts only published): and his "Stratigraphical System of Organized Fossils" (quarto, 1817).

A coloured copy of his large Geological Map, the first Geological Map of England and Wales, with a part of Scotland, commenced in 1812 and published in 1815—size 8 feet 9 inches by 6 feet 2 inches wide, engraved by John Cary—is exhibited in the last Wall-case on the right hand side of this Gallery, at the north end. It is well worthy of careful inspection.

William Smith was born at Churchill, a village of Oxfordshire, in 1769; he was the son of a small farmer and mechanic of the same name, but his father died when he was only eight years old, leaving him to the care of his uncle, who acted as his guardian, William's uncle did not approve of the boy's habit of collecting stones ("pundibs" = *Terebratulæ*, and "quoit-stones" = *Clypeus sinuatus*); but seeing that his nephew was studious, he gave him a little money to buy books. By means of these he taught himself the rudiments of geometry and land-surveying, and at the age of eighteen he obtained employment as a land surveyor in Oxfordshire, Gloucestershire, and other parts, and had already begun carefully and systematically to collect fossils and to observe the structure of the rocks. In 1793 he was appointed to survey the course of the intended Somersetshire Coal-Canal, near Bath. For six years he was the resident engineer of the canal, and, applying his previously-acquired knowledge, he was enabled to prove that the strata from the New Red Marl (Trias) upwards followed each other in a regular and orderly succession, each bed being marked by its own characteristic fossils, and having a general tendency or 'dip' to the south-east.

To verify his theory he travelled in subsequent years over the greater part of England and Wales, and made careful observations of the geological succession of the rocks, proving also, by the fossils obtained, the identity of the strata over very wide areas along their outcrops.

His knowledge of fossils advanced even further, for he discovered that those *in situ* retained their sharpness, whereas the same specimens derived from the drifts or gravel-deposits were usually rounded and water-worn, and had reached their present site by subsequent erosion of the parent-rock.

In 1799 William Smith circulated in MS. the order of succession of the strata and imbedded organic remains found in the vicinity of Bath.

His large Geological Map of England and Wales is dated 1815.

On June 1, 1816, he published his "Strata identified by Organized Fossils," with illustrations of the most characteristic specimens in each stratum (4to.).

In 1817 he printed "A Stratigraphical System of Organized Fossils," compiled from the original geological collection deposited in the British Museum (4to.).

In 1819, he published a reduction of his great Geological Map, together with several sections across England.

These have just been presented to the Museum by Wm. Topley, Esq., F.G.S.

Mr. Smith received the award of the *first* Wollaston Medal and fund in 1831, from the hands of Prof. Sedgwick, the President of the Geological Society.—"As a great original discoverer in English geology, and especially for his having been the first, in this country, to discover and teach the identification of strata, and to determine their succession by means of their imbedded fossils."

In June, 1832, the Government of H.M. King William the Fourth awarded Mr. Smith a pension of £100 a year, but he only enjoyed it for seven years, as he died 28 Aug. 1839.

In 1835 the degree of LL.D. was conferred upon Mr. Smith by the Provost and Fellows of Trinity College, Dublin.

Perhaps the highest compliment paid him was that by Sedgwick, who rightly named him "the Father of English Geology."

The bust above the case which contains William Smith's collection is a copy of that by Chantry surmounting the tablet to his memory in the beautiful antique church of All Saints at Northampton, where his remains lie buried.

We come next to a collection, the very name of which betrays the antiquity of its origin. It is known as "Sowerby's Mineral Conchology."

This Collection was begun by Mr. James Sowerby, prior to 1812, and continued by his son, Mr. James de Carle Sowerby, F.L.S., during the preparation of their great work entitled, "The Mineral Conchology of Great Britain," which appeared in parts, between June, 1812, and December 1845, and forms six volumes octavo, illustrated with 648 plates.

The value of the work consists in the fidelity and accuracy of the figures given, and also that most of the specimens drawn are here named and described for the first time. They comprise fossils from all parts of England and from every Geological formation.

The small green labels mark the specimens actually figured in the work. The Collection was purchased by the Trustees from Mr. J. de Carle Sowerby, January, 1861.

It may be interesting to record that many of the latter parts were illustrated by plates drawn by the late Mr. J. W. Salter, A.L.S., F.G.S., for so many years palæontologist to the Geological Survey. When a youth, Salter was apprenticed to Mr. J. de Carle Sowerby, F.L.S., who was at that time both a naturalist and an engraver. The youthful apprentice afterwards married his master's daughter, and became, as is well known, one of the most brilliant palæontologists in this country.

Another curious, but small series represents the 'types' or 'figured specimens' of "König's *Icones Fossilium Sectiles.*"

This illustrated work, on miscellaneous fossils in the British Museum, was prepared by Mr. Charles König, the first Keeper of the Mineralogical and Geological Department, after its separation from the general Natural History Collections in 1825.

The engravings are rough, but characteristic, and the first "Century" (or 100 figures of fossils), is accompanied by descriptions; the plates of the second "Century" have names only, but no descriptions are published with them.

A far more important Collection is that known as "The Gilbertson Collection."

In 1836 Prof. John Phillips published Vol. II. of his "Illustrations of the Geology of Yorkshire," which is devoted to the "Mountain Limestone District." In the Introduction he writes as follows:—"My greatest obligation is to Mr. Wm. Gilbertson of Preston, a naturalist of high acquirements, who has for many years explored with exceeding diligence a region of mountain limestone, remarkably rich in organic remains. The collection which he has amassed from the small district of Bolland is at this moment unrivalled, and he has done for me, without solicitation, what is seldom granted to the most urgent entreaty; he has sent me for deliberate examination, at convenient intervals, THE WHOLE OF HIS MAGNIFICENT COLLECTION, accompanied by remarks dictated by long experience and a sound judgment." He (Gilbertson) had proposed to publish on the *Crinoidea* himself, but his sketches as well as his specimens were all placed at Prof. Phillips's disposal. Phillips adds—"An attentive examination of this rich collection rendered it unnecessary to study minutely the less extensive series preserved in other cabinets . . . . *most of the figures of fossils are taken from specimens* in Mr. Gilbertson's Collection, because these were generally the best that could be found."

The Gilbertson Collection was purchased for the British Museum in 1841.

The collections which follow mark a distinct era in the annals of Geological Science.

Some forty-seven years ago a little society was founded by a few London geologists, namely—Dr. J. Scott Bowerbank, F.R.S., Searles V. Wood, F.G.S., Prof. John Morris, F.G.S., Alfred White, F.L.S., Nathaniel T. Wetherell, F.G.S., James de Carle Sowerby, F.L.S., and Frederick E. Edwards, F.G.S., for the purpose of illustrating the Eocene Mollusca, and entitled the "London-Clay-Club."

They met at stated periods at each other's houses, and after a time they said, "Why should we not illustrate all the fossils of the British Islands, and from every formation?" No sooner proposed than a society was founded, called the Palæontographical Society, in the year 1847 (just forty years ago). The first volume, issued in that year, was "The Crag Mollusca, Part I., Univalves," by Mr. Searles V. Wood, F.G.S. (with 21 plates).

You have here before you the actual "Searles Wood Crag Collection." This collection was commenced in 1826, and occupied about 30 years in its formation. It represents the Molluscan fauna of the Red and Coralline Crags of the neighbourhood of Woodbridge, and from Aldborough, Chillesford, Sudbourn, Orford, Butley, Sutton, Ramsholt, Felixstow, and many other localities in Suffolk, also from Walton-on-the-Naze in Essex. The specimens so collected were employed by Mr. Searles Wood in the preparation of his Monograph on the Crag Mollusca, published by the Palæontographical Society (1848–1861); with supplements in 1871, 1873, and 1879, illustrated by seventy-one quarto plates. Each figured specimen is indicated by having a small green label affixed to it.

A geological description of the Crag formation by Mr. S. V. Wood, jun., F.G.S., and Mr. F. W. Harmer, was issued by the Palæontographical Society in 1871 and 1873.

The collection was presented by Mr. S. V. Wood to the British Museum, January, 1856, and a supplementary collection was given by Mrs. Searles V. Wood in 1885.

The next "Palæontographical Collection" is of nearly equal antiquity and fully of equal merit. It is the Eocene Molluscan Collection formed by the late Frederick E. Edwards, F.G.S., about the year 1835, and was continually being added to, until a few years before his death, which happened in 1875. It was acquired for the nation by purchase in 1873.

Originally intended to illustrate the fossils of the London Clay, Mr. Edwards extended his researches over the Eocene strata of Sussex, Hampshire and the Isle of Wight, where, assisted by Mr.

Henry Keeping, he made the most complete collection ever attempted by any geologist, and it still remains unrivalled.

Mr. Edwards contributed six Memoirs to the Palæontographical Society, 1848-1856, also separate papers to the "London Geological Magazine," 1846, the "Geologist," 1860, and the "Geological Magazine," 1865, descriptive of the Eocene Mollusca in his collection.

Mr. S. V. Wood continued the work for Mr. Edwards, describing and figuring the "Eocene Bivalves" in the annual volumes of the Palæontographical Society for 1859, 1862, 1870, and 1877. Each specimen which has been figured is specially marked.

About 500 species have been described and figured, but the collection is very rich in new and undescribed forms.

The last Collection is that of a Naturalist who devoted his entire life to the study and illustration of a single class of organisms, namely, the Brachiopoda. It was formed by the late Mr. Thomas Davidson, LL.D., F.R.S., F.G.S., V.P. Pal. Soc., etc., (formerly of 9, Salisbury Road, West Brighton, and Muir-house, Midlothian); between the years 1837 and 1886, with the object of illustrating his great work on the "British Fossil Brachiopoda," published by the Palæontographical Society, in six large quarto volumes, between the years 1850 and 1886, comprising 2290 pages of text, and 234 plates, with 9329 figures, and descriptions of 969 species.

Dr. Davidson was also the author of the Report on the recent Brachiopoda collected by H.M.S. "Challenger" (vol. i. 1880); of the article "Brachiopoda," in the Encyclopædia Britannica, Ninth Edition, 1875; of a Monograph of Recent "Brachiopoda" (Trans. Linnæan Society, 1886 and 1887), and of more than fifty other separate Memoirs mostly bearing upon Brachiopoda both Recent and Fossil, printed in the Transactions and Journals of the various learned Societies, etc.

His collection, both of Recent and Fossil Brachiopoda, together with all Dr. Davidson's original drawings, his numerous books and pamphlets were presented by him to the British Museum through his son William Davidson, Esq., February, 1886. By his direction the entire collection of recent and fossil species *are to be kept together in one series*, for the convenience of reference of all men of science who may wish to consult the same.

At the conclusion of Dr. Woodward's remarks Mr. William Topley, F.G.S., kindly added some valuable information with reference to William Smith's maps and sections and his geological work in various parts of England.

The President then returned thanks to Dr. Woodward, and expressed the interest which, he said, he and all the members present felt in this very important addition made to the exhibition-series of the Galleries devoted to Geology and Palæontology. After a further examination of the Collections the Members separated, well pleased with their visit to this deservedly popular Museum.

# CORRESPONDENCE

## RECENT DISCOVERIES IN THE SALT RANGE OF THE PUNJAB.

SIR,—Having already trespassed upon your space with regard to this subject, I beg leave to add a few necessary words, because the discoveries already noticed (GEOL. MAG. March and May, 1886) have since extended to further recognition, by Dr. Warth and Mr. R. D. Oldham, of the continuation of the boulder beds of the original "Olive Group" westwards—these being identified by their *Conularia*-containing pebble layer in a position entirely different from that which my own acquaintance with the Range would have led me to expect.

My contention has been that the boulder beds with the *Conularia* layer in the east of the Range, occupying a position immediately beneath the Eocene limestone, occupied a different horizon from that of other boulder beds of somewhat similar and somewhat different character, in the west of the Range, which had their place with the lowest members of the series amongst Silurian or other old Palæozoic rocks.

The recent discovery of the same *Conularia*-layer underlying a group of sandstones, next below the Carboniferous Limestone, must modify my previous views, and I feel the more inclined to abandon the contention above stated, were it even to involve identification of the eastern and western boulder-beds as upon one and the same horizon, in consequence of the probability that a coincident unconformity, till quite lately undetected, intervenes between these boulder beds and the older groups of the Range, its place being traceable by means of the boulder-beds with *Conularia* pebbles.

Without the evidence of the subsequently-discovered fossiliferous layer, or that of the associated discordance, the extension of a part of the original "Olive Group" westwards at the higher level appears to have been taken by me as representative of the whole, there being another dark-coloured zone amongst the lower groups, to which soft dark rocks could be referred when low down in the series.

The correction which it is expected will now be applied to previous classifications of the Salt Range rocks is of great interest in connexion with the geology of the Punjab, and I refer to it, so far as my own published views to the contrary are concerned, gladly accepting new light thrown upon the subject from reliable sources, but as far as possible refraining from forestalling the full announcement of details to be looked for from those who have added these important discoveries to our knowledge of the Salt Range series, a series of such complexity that additional facts of detail cropping up here or there might almost have been anticipated. A. B. WYNNE.

*June 10th*, 1887.

P.S.—Since writing the above I have seen Dr. Warth's account of his discovery alluded to (Records Geol. Surv. Ind. vol. xx. pt. 2, p. 117), and find therein much with which I can agree.

## THE PALÆONTOGRAPHICAL SOCIETY.

Sir,—By the publication of the Council's Report in your last Number, the attention of your readers is once more drawn to the Palæontographical Society, and its need of a larger number of members in order to find the necessary funds for carrying on its excellent work.

I think I shall be doing the Society a service if I briefly point out some facts which may partly account for the falling off in the number of its members. The Council regret that "geologists in general" do not more readily enroll themselves as members, and they remark that since the formation of the Society, many free libraries, local geological societies, and field clubs have been established, "but that the number of these institutions that have joined the Society is very small."

I venture to think that one reason of this backwardness may be a feeling that the subjects of the Monographs issued by the Society are not always of general geological interest, and that many of them are not such as would be practically useful to the members of local societies.

It is said that a guinea a year is very little to pay for such a splendid series of books, and so it is; but if the intending subscriber feels that half the contents of the volumes are not likely to be of use to him (or to the society he represents), he is apt to think that the money could be more usefully spent in other ways, or perhaps he purchases second-hand copies of those monographs which he does find are frequently wanted, such as Davidson's Brachiopoda, Wright's Echinoderms and Ammonites, Wood's Crag Mollusca, etc., etc.

I feel a difficulty in expressing my meaning more plainly without appearing to depreciate the value of many excellent and valuable monographs which have been published by the Society; but every one admits that there are certain classes of fossils which are of great practical use to the geologist, and that there are others which are of much less geological importance, though biologically they may be equally interesting. In the first category we place the *Mollusca*, *Brachiopoda*, *Echinodermata*, *Corals*, and certain orders of *Crustacea*; among the less useful we must class *Plants*, *Sponges*, *Cirripeds*, *Entomostraca*, *Polyzoa*, *Insects*, *Fishes*, *Reptiles*, *Birds*, and *Mammals*. This being so, it is surely desirable that prominence should be given to the more important groups, and until these have been fully described and figured, very little space should be given to those of less general value; particularly should the delineation of large Vertebrate remains be postponed in favour of the Invertebrate fossils, which occupy so much less space, and a knowledge of which is so much more generally useful.

I know that there are difficulties in the way of applying these principles, and probably the Council would not consider themselves justified in refusing an offered monograph because it deals with one of the less geologically important classes, but I think they should have regard to the effect which the publication of such monographs may have on intending subscribers. Let us consider the monographs in the recently issued volume for 1886. I imagine there are very few *general geologists* who desire to possess 15 plates of one species of plant, however curious and interesting that plant may be. Again, the appearance of seven plates devoted to the horns of Deer is not likely to be welcomed by any but a few experts. These 22 plates would have illustrated 50 or 100 species of Mollusca, and there are many hundreds of such fossils awaiting illustration.

Why are the Mollusca so neglected? It is true that in this volume we have the first parts of two memoirs on Jurassic Mollusca, but one of these parts is wholly taken up with stratigraphical details which, though unquestionably useful, might perhaps have been condensed or printed elsewhere; this, however is a minor point, and every one will welcome Mr. Hudleston's Monograph. Cannot the Council induce other palæontologists to prepare similar monographs on the *Cephalopoda*, *Gasteropoda*, and *Pelecypoda* of the Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Cretaceous, Eocene, and Oligocene formations?

I can testify that the synonomy of some of the commonest Chalk fossils is in the utmost confusion; and that Monographs of the Cretaceous Mollusca would be welcomed by many amateur and professional geologists. When will Mr. Wiltshire give us his promised contribution? I feel sure that if this and other Molluscan Monographs were produced, and if those relating to fossil plants and bones were deferred, the publications of the Society would be used by a much larger number of persons, and consequently that many more geologists and local institutions would decide to become subscribers.

HARWELL, BERKS, *August* 5. A. J. JUKES-BROWNE.

## THE GLACIAL DEPOSITS OF SUDBURY, SUFFOLK.

SIR,—I owe an apology to Mr. Jukes-Browne for having omitted any reference to the action of coast-ice in my paper upon the Glacial Deposits of Sudbury in the June Number of the MAGAZINE (pp. 262-270). In considering the suggestions made to account for the contortion of drift deposits, I should have mentioned the grounding of true or false icebergs, *or of coast-ice*. Nevertheless, it seems to me that the arguments I brought forward against the contortion having been produced by icebergs apply equally to the case of coast-ice.

Unless we are prepared to admit that the drifts were actually frozen into the coast-ice at the time that the contortion was produced in them (and I fail to see how such could be the case, considering the uniformity of succession and characters of the drift over a considerable area), we must suppose that they were deposited on the sea-floor before the exertion of pressure by this ice. If so, it is difficult to see why the drifts were not frozen as well as the underlying Tertiary rocks, for these drifts are of some thickness, and considerable time must have elapsed during their formation. If they were so frozen, the Tertiary beds ought to be affected in the same manner as the drifts, which is not the case.

If the drifts were not frozen, I cannot understand the production in them of overfolds of considerable horizontal extent (such as that shown at the south end of Mr. Green's pit), without any obliteration of the planes of deposition.

Mr. Jukes-Browne speaks of the drifts as being pushed along in a 'partially-frozen state.' Even if contortion can be produced by coast-ice in deposits under such conditions, I cannot conceive that the order of succession of the deposits should be so constant as it is in the Sudbury area, upon this hypothesis. Surely the incoherent portions of the drift would become churned up, so that we should find masses of boulder-clay, gravel, and loam mingled together, and having their divisional planes obliterated. I have seen no signs of such in the area under consideration.

In asserting that contortions occur "in the accumulations which lie on the summits of ridges," I used the term 'summits' not for the highest points, but for the upper portions of the major ridges, and I referred to Mr. Green's pit and the pits near the cemetery. These pits are situated at the upper parts of major ridges, and the contortions are seen in Mr. Green's pit to lie *against* a minor ridge. At the same time I do not wish to assert that all the contortions were caused by the inequalities close to which they now lie.

I regret that my summing up should appear biassed in favour of one explanation. I visited the Sudbury area with little practical knowledge of the East Anglian drifts. Having read much of the literature bearing upon these drifts, including Mr. Jukes-Browne's lucid papers, I started my examination with a strong bias in favour of their marine origin. As I was gradually led to abandon this view, I considered it worth while to state the evidence which weighed with me, but brought forward my reasons as an advocate, and not as a judge. I should certainly not venture to make a charge to a jury with the evidence derived from so limited an area.

I take this opportunity of calling attention to one or two inaccuracies in Fig. 1 of my paper. The Crag mass C′ should be separated from the filled-in ground D by a little gravel; the junction of the Thanet sand and chalk in the isolated patch at the south end of the pit should be in the same straight line with that of the main portion, and the top and base of the Thanet sand layer are much more even than represented in the diagram. John E. Marr.

St. John's Coll., Cambridge.
*Aug.* 6, 1887.

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## THE CORTLAND ROCKS.

Sir,—Dr. Callaway, in combating the 'metamorphic' origin of the rocks of the 'Cortland Series,' does not appear to be aware that Prof. Dana has materially modified his earlier opinion on this point. After examining some new railway cuttings, he was convinced that the hornblendic and augitic rocks are of true *eruptive* origin, and although he does not find that the new sections throw any light on the origin of the 'soda-granite,' his former line of argument is evidently much weakened (Amer. Journ. Sci. 3, vol. xxviii. p. 384, 1884). Mr. G. H. Williams, who is publishing a series of petrological studies on the whole of the rocks in question, reserves to the last any general conclusions concerning their origin; but he states that the area "is quite sharply separated from the gneisses, mica-schists and limestones which surround it, showing none of the gradual transitions into these rocks which Hermann Credner, in his description of this district written in 1865, supposed to exist." (*Ibid.* 3, xxxi. p. 27, 1886.) ALFRED HARKER.

ST. JOHN'S COLLEGE, CAMBRIDGE, *Aug. 5th*, 1887.

## OBITUARY.

### SIR J. F. JULIUS VON HAAST.

SIR JOHN FRANCIS JULIUS VON HAAST, K.C.M.G., Ph.D., F.R.S., F.L.S., F.G.S., Ord. Fr. Jos., Ord. Coron. Ferr. Austr. Coron. Ital., etc., etc., Director of the Museum, and Professor of Geology in Canterbury College, New Zealand.

It is with deep regret that we learn, through a Reuter's telegram from Wellington, that our friend and fellow-geologist, Sir Julius von Haast, died suddenly of heart disease, on the 15th August. It seems but yesterday that he was here with us, and although complaining of rheumatic gout, which he attributed to the severe work and endless engagements arising out of the duties he was called upon to fulfil last year, as Commissioner in charge of the New Zealand exhibits at the Colonial and Indian Exhibition, he appeared to have many more years of good work lying before him.

Sir Julius von Haast has done excellent service to science in New Zealand, not only in connection with its Geology, in which he took an active part, but also in the discovery and collection of remains of the great extinct Wingless Birds of those Islands with which the Museum of Christchurch (N.Z.), and those of nearly all the principal European and American Museums, have been enriched.

Sir Julius received the honour of Knighthood in recognition of his services in connection with the Colonial and Indian Exhibition; but so far back as 1867, he had been elected a Fellow of the Royal Society in recognition of his services to science. Upwards of thirty memoirs are credited to him in the Royal Society's list of scientific papers, mostly on the Geology and Extinct Birds of New Zealand. His loss will be keenly felt in the Colony where he has laboured so long and diligently.—H. W.

### PROFESSOR LAURENT-GUILLAUME DE KONINCK.

Prof. C. Malaise informs us of the recent death (on 16 July last) of our venerable friend, Prof. de Koninck, For. Memb, Geol. Soc. Lond., late Professor of Chemistry and Palæontology in the University of Liége, Belgium. Prof. de Koninck's labours on the Fauna of the Carboniferous rocks of Belgium, England, Australia, etc., are well known. We hope to give a notice of his life in a later Number.—EDIT. GEOL. MAG.

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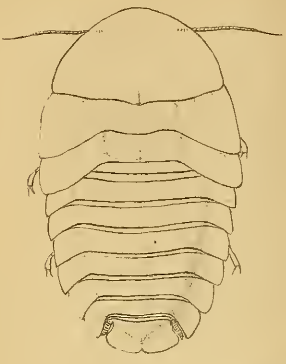

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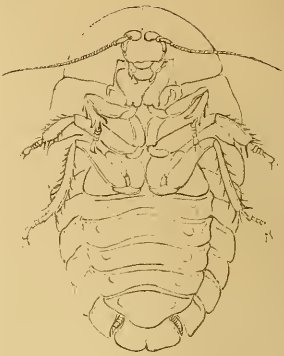

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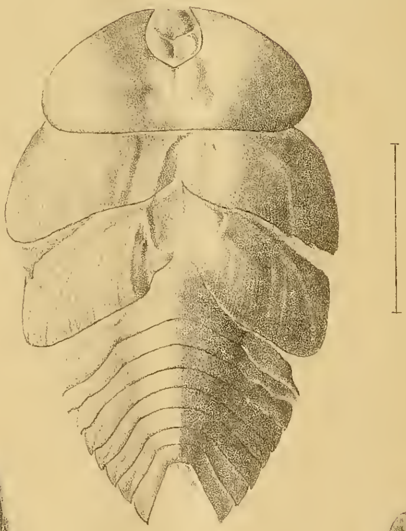

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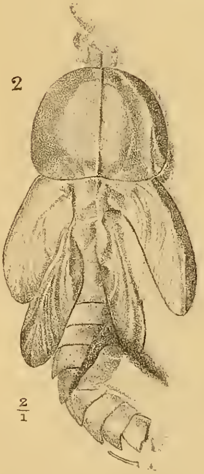

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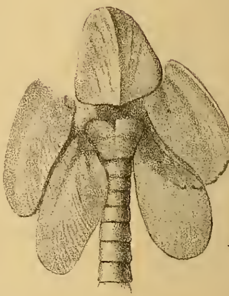

$\frac{2}{1}$

G. M. Woodward del. et lith.

West, Newman & Co. imp.

Carboniferous Cockroaches.

# ERRATA.

P. 435, line 5 from below, *for* fine *read* free.
,, 438, ,, 9 ,, ,, ,, *‘these’* ,, *‘there.’*

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. IV.

No. X.—OCTOBER, 1887.

## ORIGINAL ARTICLES.

### I.—ON THE DISCOVERY OF THE LARVAL STAGE OF A COCKROACH, *ETOBLATTINA PEACHII*, H. WOODW., FROM THE COAL-MEASURES OF KILMAURS, AYRSHIRE.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.,
British Museum (Natural History).

(PLATE XII.)

BY the kindness of Mr. B. N. Peach, F.R.S.E., F.G.S., of the Geological Survey of Scotland, I have been permitted to examine a very interesting insect-remain enclosed in a light-brown nodule of Clay-Ironstone, obtained fram Kilmaurs, Ayrshire.

In February last[1] I had the pleasure to describe three new forms of British Carboniferous Cockroaches, viz.:—

1. *Etoblattina Johnsoni*, H. Woodw., Coal-Measures, Coseley, near Dudley.
2. *Leptoblattina exilis*, H. Woodw. do. do.
3. *Lithomylacris Kirkbyi*, H. Woodw., U. Coal-Measures, Meithil, Fife.

Mr. S. H. Scudder, of Boston, has described no fewer than 30 species from the Coal-Measures of N. America, whilst 41 species have been described by Goldenberg, Heer, Germar, Scudder, and others from the Coal-Measures of Europe, so that this group of Orthopterous insects was perhaps almost as well represented in the Coal-period as at the present day, and nearly as widely distributed geographically.

The present example from the Coal-Measures of Kilmaurs makes us acquainted with another entirely new form, measuring 23 millimètres in length, by 14 mm. in breadth, and exhibiting the minute head sunk in the rounded pronotum, a pair of rudimentary wing-covers, and a pair of rudimentary wings, which, as in other fossil cockroaches, are not differentiated from one another as they are in the modern Blattariæ.

The abdomen exhibits nine segments with broadly-expanded free-edges to their terga remarkably unlike the abdomen of most modern cockroaches.

The 8th and 9th segments are as large in proportion as those preceding them, thus differing markedly from living species, in which the terga of these segments are very narrow and are greatly overlapped by the 7th segment.

The 10th abdominal segment cannot be made out, but was probably present between the free-edges of the terga of the 9th segment.

Save the wings, no appendages are preserved.

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[1] See GEOL. MAG. 1887, Decade III. Vol. IV. pp. 49—58.

*Detailed description.*—The *pronotum* is nearly semicircular in outline, its anterior border being rounded and its posterior border straight. It is twice as broad as it is long.

The *head* is seen occupying a small rounded indentation in the centre of the anterior border of the pronotal shield. The epicranial plate is divided longitudinally down the centre; there is also a transverse furrow probably indicating the ocular and genal divisions.

Behind this notch in which the head lies, the pronotum is ornamented with two small slightly-raised prominences, and two small rounded depressions. Breadth of pronotum, 12 millimètres, length 5 mm. The *wing-covers* and *wings*, which are nearly alike in form and size, are each about 10 mm. in length, and about 5 mm. in greatest breadth. The mediastinal vein is seen in all 4 wings, also the veins of the Anal and the Internomedian area. The wings appear to conceal the whole of the mesonotum and the greater part of the metanotum. The length of the mesonotum and metanotum together is 6 mm.

The abdomen is 12 mm. in length by 10 mm. in breadth at its broadest anterior part. The segments 9 in number diminish in breadth rapidly, being only about 3½ mm. in breadth at the posterior border. Fully half the breadth of the segments consists of the free-edges (epimera) of the terga, the body itself being not more than 5 mm. in breadth at the widest part, the terga making up the remaining 5 mm.

Compared with other fossil Cockroaches, the wings in this fossil Blatta have a close resemblance to those of *Blattina insignis*,[1] Gold. (Pl. XII. Fig. 3), from the Coal-Measures of Saarbrück (Rhenish Prussia); also to *Leptoblattina exilis*, H. Woodw., from the Coal-Measures of Coseley, near Dudley (Pl. XII. Fig. 2).[2]

I mention in my description of *L. exilis* (*op. cit.* p. 57) that "there is evidence of epimeral pieces to 3 of the segments," which would have greatly increased their width.

Compared with recent Cockroaches, there seemed at first but small hope of finding any form amongst living Blattinæ which would serve for comparison with this remarkable fossil; but through the kind assistance of Mr. W. F. Kirby, of the Zoological Department (British Museum of Natural History), I was referred to the figures and description of Blattariæ given by Brunner de Wattenwyl,[3] from the West Indies and Brazil, and particularly to one named *Blabera atropos*, by Stoll. This form, of which Brunner figures the male and female, and also the larva, presents in its larval stage[4] a close approach to our fossil example, not only in the rudi-

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[1] "Fauna Sarepontana Fossils," Die fossilen Thiere aus der Steinkohlenformation von Saarbrucken von Dr. Frederick Goldenberg; Saarbruck, 1873. 4to. 1st Heft, mit 2 Tafelen (Taf. ii. fig. 14).

[2] See "Some New British Carboniferous Cockroaches," by Henry Woodward, Geol. Mag. 1887, Dec. III. Vol. IV. Pl. II. Figs. 2 and 3, pp. 56—58.

[3] Noveau Système des Blattaires, par Charles Brunner de Wattenwyl, Vienna, 1865, p. 375–6 and tab. xii. 55, A—G.

[4] *Op. cit.* tab. xii. 55, F.

mentary wings, but also in the great development of the free-edges (epimera) of the terga of the abdominal segments, so marked a feature in the fossil before us. (Compare Figs. 1 and 4, Plate XII.)

The Kilmaurs specimen, however, differs from the larva of *Blabera atropos* (Stoll), in the presence of the anterior notch of the pronotum in which the head is visible; in the larger size of its wings and the ornaments on the segments of the abdomen in the living form and the difference in the ornament on the pronotum.

In the character of the neuration of the wings in the adult of *Blabera atropos* one cannot but be struck with its resemblance to the neuration of *Etoblattina* amongst Coal-measure forms of Blattariæ.

Seeing that there can be little doubt that we are here dealing with a larval form, it may be well to place it provisionally under the genus *Etoblattina*, and I cannot think of a more suitable specific name to propose for it than that of the geologist from whose hands I received it. I therefore name it *Etoblattina Peachii*, after that most able naturalist and geologist, Mr. B. N. Peach.

### EXPLANATION OF PLATE XII.

Fig. 1. *Etoblattina Peachii*, H. Woodward, sp. nov. (enlarged three times), Coal-Measures, Kilmaurs, Ayrshire.
,, 2. *Leptoblattina exilis*, H. Woodward, Coal-Measures, Coseley, near Dudley.
,, 3. *Blattina insignis*, Goldenberg, Coal-Measures, Saarbrück, R. Prussia.
,, 4. Larva of *Blabera atropos*, Stoll, Brazil, view of upper side.
,, 5. The same larva seen from beneath.

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## II.—On the Organic Origin of the Chert in the Carboniferous Limestone Series of Ireland, and its Similarity to that in the Corresponding Strata in North Wales and Yorkshire.

By George Jennings Hinde, Ph.D., F.G.S., etc.[1]

THE first references in any detail to the nature of the Chert in Carboniferous rocks appeared in 1878,[2] when Messrs. Hull and Hardman published a joint paper on the subject, treating more particularly of the Chert in the Upper Carboniferous Limestone of Ireland. Prof. Hull gave a general description of the distribution and mode of occurrence of the Chert, and a detailed notice of its microscopic structure, as shown in fifteen thin sections of the rock from various localities in Ireland. The author reached the conclusion that the Chert is essentially a pseudomorphic rock, consisting of gelatinous silica replacing limestone of organic origin, chiefly foraminiferal, crinoidal, and coralline; the replacement was believed to have taken place before the shales overlying it were deposited, whilst the limestone was in a more or less plastic condition, admitting the fine percolation of water holding silica in solution. The sea was believed to have been largely charged with silica in solution,

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[1] Paper read before the British Association at Manchester.

[2] Scientific Transactions of the Royal Dublin Society, vol. i. n.s. 1878, pp. 71–94, pl. iii.

and the chemical process was accelerated by the warm surface waters of a shallow sea. The origin of the Chert from the siliceous skeletons of Diatomaceæ, Polycystinæ, and the spicules of sponges is distinctly denied, and it is affirmed that it can only be considered as a secondary product due to the replacement of lime-carbonate by silica.

Mr. Hardman gave, in his part of the paper, the results of numerous analyses of the rock, showing that it consisted principally of anhydrous silica, reaching up to 95·5 per cent., with a varying admixture of carbonate of lime, iron, and a few other minerals. Judging from its chemical constitution, Mr. Hardman considered that the formation of Chert can only be accounted for by a process of pseudomorphism in limestone, and "supposing that the ocean in which the limestone was being formed contained an unusually large percentage of silica, it is but natural to suppose that the water would elect to dissolve small portions of the more easily soluble carbonate of lime and in their place to deposit equivalent portions of the less soluble silica in the gelatinous state" (*op. cit.* p. 92).

Shortly after the appearance of the paper just referred to, M. Alphonse Renard, of Brussels, published, in a paper entitled[1] "Recherches lithologiques sur les Phthanites du Calcaire Carbonifère de Belgique," the results of an examination of the same kind of rock in the Carboniferous Limestones of Belgium. This author very carefully studied the macroscopic and physical characters of the Chert, and he reached nearly the same conclusion respecting its origin as that of Messrs. Hull and Hardman, viz. that the phthanites (as the Chert beds are technically termed) have been formed by the silicification of the organic and inorganic calcareous elements which composed the limestones, and that this more or less complete pseudomorphosis has taken place at an epoch when the sediments, although retaining a certain amount of plasticity, already possessed the structure which may be seen in the normal Carboniferous Limestone. The author further adds, that it is impossible to explain the formation of phthanites by the accumulation of organisms with siliceous skeletons, and there[2] was nothing to prove that the silica which had infiltrated into the limestone was derived from the decomposition of the spicules of sponges or the frustules of diatoms.

I may just remark that the observations of M. Renard on the characters of the Chert or phthanites appear to have been very carefully and thoroughly worked out, and it is not to these but to the theoretical conclusions as to the inorganic origin of the silica of the Chert that I venture to take objection.

Since 1878, no special memoir on the nature of the Carboniferous Chert has appeared, but a curious commentary on the statement of Prof. Hull that this Chert was not derived from siliceous organisms such as the spicules of sponges, was afforded by the discovery by Prof. Sollas,[3] that some of the very sections described and figured in Prof. Hull's paper were so constituted of sponge-spicules that

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[1] Bulletin de l'Académie Royale de Belgique, 2 s. t. 46, pp. 471–498, pl. i.

[2] *Op. cit.* p. 498.

[3] Ann. and Mag. Nat. Hist. vol. vii. (1881) p. 141.

they made up the larger part of the Chert. Another fact, also bearing on the probable organic character of the Irish Carboniferous Chert, was the discovery by Messrs. Wright and Stewart of Belfast of beds of siliceous clay, apparently resulting from decayed Chert, which were described by Mr. H. J. Carter, F.R.S.,[1] as in some parts nearly entirely composed of sponge-spicules.

In a paper[2] showing the derivation of the Chert in the Lower and Upper Greensand of the South of England from the remains of siliceous sponges published in the Phil. Trans. for 1885, I ventured to suggest that the facts above stated justified the conclusion that the Carboniferous Chert of Ireland would be found to be likewise of organic origin, and that therefore Messrs. Hull and Hardman were probably wrong in regarding it as of inorganic derivation. This suggestion has been warmly combated by Messrs. Hull and Hardman in two short papers brought before the Royal Society,[3] and lately published in its Proceedings. Prof. Hull states, in the paper referred to, that there is absolutely no evidence that the silica of the Irish Carboniferous Chert has been derived from sponge-spicules; that there is only a fanciful analogy between the Carboniferous Chert-beds and the sponge-beds of the Cretaceous formation; that as sponges were rare in the Carboniferous rocks, it is clear that they could have taken no important part in the formation of the Chert-bands in the Carboniferous Limestone; and the assertion I made is therefore unfounded, and I must have mistaken sections of crinoid stems for sponge-spicules. Prof. Hull still maintains and reasserts his original proposition, that the beds and nodules of siliceous material in the Carboniferous Limestones of Ireland have been formed by a direct replacement of the original calcareous substance of the limestone itself by silica held in solution in the sea-water, without the intervention of siliceous organisms.

It is somewhat remarkable that neither Prof. Hull nor Mr. Hardman make any mention whatever in these papers of the fact, published by Prof. Sollas, that in at least two of the specimens of Chert in Prof. Hull's own possession, sponge-spicules make up the larger part of its substance. This fact alone is quite sufficient foundation for the assertion I made, and Prof. Hull was in duty bound to give some explanation of it, before accusing me of making a statement on absolutely no evidence. It is manifest that[4] Prof.

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[1] Ann. and Mag. Nat. Hist. s. 5, vol. vi. (1880) p. 213.

[2] On Beds of Sponge-Remains in the Lower and Upper Greensand of the South of England, Phil. Trans. pt. ii. 1885, pp. 405-453, pls. 40-45.

[3] Proc. Royal Soc. vol. xlii. p. 304, et seq.

[4] I regret to have to make another serious complaint against Prof. Hull of having misquoted a passage from my published paper in the Phil. Trans., leaving out words essential to its meaning, and then stating that he has quoted the entire passage to avoid the possibility of misinterpretation, and that it is altogether unintelligible! The passage in question, at the bottom of page 432 in my paper, is as follows, "Thus Dr. Bowerbank held that the sponges imbedded in the Chert of the Greensand possessed horny and not siliceous skeletons, and that the silica of the Chert in which they were imbedded was attracted from the exterior medium by the animal matter and not secreted therefrom by the living sponge." In Prof. Hull's quotation the last paragraph runs thus, "The silica in the Chert in which they were imbedded was

Hull had clear evidence in his own possession; that its nature had been publicly pointed out by Prof. Sollas; and that he has entirely ignored it in his reply to my statement.

As I have been engaged during this last year in an investigation of the character of the Carboniferous Chert of Yorkshire and North Wales, which proves to be unequivocally of the same organic nature as the Chert in the Cretaceous strata of the South of England, this emphatic denial of the organic origin of the Carboniferous Chert in Ireland by the Director of the Irish Geological Survey made me desirous of examining for myself the character of the rock in question, and with this end in view, I visited during this last July the various localities in Ireland in which, according to Prof. Hull, the Chert in the Carboniferous series is best developed, and I propose now to give a short notice of the observations I made in the field, and also of a microscopic examination of the specimens I collected. Time has not allowed me to work out fully the results of my studies of the English and Welsh Carboniferous Chert, and I shall only make a brief reference to these rocks at present; but the specimens I have brought will enable any one to see how close is the resemblance in general characters between the same rock from the different countries.

Before starting on my search, I called at the Office of the Geological Survey in Dublin, and through the courtesy of Prof. Hull, for which I tender him my best thanks, I was allowed to examine under the microscope the series of sections of Carboniferous Chert prepared for his original description of the rock, including the two, in which, according to Prof. Sollas, sponge-spicules make up the larger part of the Chert. I can fully substantiate this statement of Prof. Sollas, not only as regards the specimens which he examined, but in others as well; the sponge-spicules in the slides are mostly shown in transverse section and their characters are unmistakeable.

It is somewhat strange that with specimens filled with sponge-spicules before him Prof. Hull should not in his paper have made a single mention of these structures beyond denying that they had anything to do with the structure of the rock. If we compare the original specimens with the descriptions given of them, the mistake made by Prof. Hull is at once apparent. Thus, for example, the section of the brownish and banded Chert from Ballymote, County Sligo, represented on fig. 4 of the plate, is stated to contain "circular disks of crinoids, sometimes with dark central nuclei,

attracted from the exterior medium by the animal matter, and not secreted from the living sponge." In the original I distinctly state that the living sponge secreted the silica now forming the Chert from the exterior medium (*i.e.* the sea-water). In the quotation, Prof. Hull omits the important words '*these*' and '*by*,' and then accuses me of not stating that the silica was originally derived from the sea-water!

Again, Prof. Hull on page 305 of his paper gives as a quotation from my paper, between inverted commas, the following passage, "The beds and irregular masses of Chert have been derived solely from the silica of the sponge-remains, instead of from that held in solution by the sea-waters themselves." This passage, quoted as a verbatim extract, does *not* occur in my paper, and is not even a fair representation of my meaning, which will be seen by turning to pages 432, 3, to be, that the silica of the Chert was not derived *directly* from that held in solution in the sea-water.

obscure forms of foraminifers in section, coralline structures? and bivalves (brachiopods) with crystalline silica in interiors," etc. In the original of the figure, however, sections of crinoid stems do not appear, and it is evident that the forms described as "circular disks of crinoids with dark central nuclei" are really transverse sections of sponge-spicules, and the central nuclei are sections of their axial canals! These are abundant enough in the section. A similar mistake vitiates the descriptions of the other sections, and the supposed Crinoidal stems are, in most instances, the spicules of sponges! When a chance section of the ossicle of a Crinoid does occur in Prof. Hull's slides, the distinction between it and a sponge-spicule is readily apparent, for not only is the Crinoid fragment much larger, but it also exhibits the minute cribriform structure peculiar to Echinodermal organisms, which is so well known to every tyro in the microscopical study of organic rocks, and serves to mark them off from sponge-remains. Prof. Hull has charged me, and erroneously, with mistaking sections of Crinoids for sponge-spicules, but it is evident that he was himself really committing the converse mistake of describing the sponge-remains in his own specimens as portions of Crinoids!

As Prof. Hull's specimens were selected without any reference to their composition, and as they have been brought forward as evidence of the inorganic origin of the silica of the Chert, the fact that some are found filled with siliceous spicules may fairly be taken as a strong argument from a perfectly independent source that the Carboniferous Chert is really derived from the silica of sponge remains.

The Chert in the Irish Carboniferous Limestone is mainly developed in the Upper Division or Upper Limestone, which[1] Prof. Hull regards as the equivalent of the upper portion of the Carboniferous Limestone in England, the shale beds intervening between this Upper Limestone and the Millstone Grit being considered by him as the representatives of the Yoredale beds of Yorkshire. As a fact, however, the Yoredale series in its typical region mainly consists of beds of limestone associated with beds of Chert, often of considerable thickness; these limestone and chert beds are of a similar character to those of the so-called Upper Limestones of the Irish series, and it is therefore reasonable to conclude that these Chert-bearing Upper Limestones are the equivalents in the geological scale of the Chert-bearing limestones in the Yoredale series of Yorkshire and North Wales.

According to the reports of the Irish Geological Survey, beds of Chert are very generally distributed in the Upper Limestones of the south-western districts of Tipperary, Limerick, Kerry, and Cork, but I had no opportunity of visiting these counties, and my observations were limited to the Chert in the Limestones in Queen's County and Kilkenny to the south, and in the Counties of Fermanagh and Sligo to the north-west of Ireland, from whence Prof. Hull obtained the specimens on which he has founded his

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[1] *loc. cit.* p. 73.

theory of its inorganic origin. I also examined the Chert in the Carboniferous Limestones in the vicinity of Dublin, which, though coloured in some of the Geological Survey Maps as belonging to the Upper Limestone series, forms part, as I was informed by Prof. Hull, of the Middle division, or Calp series.

The mode of occurrence and the physical characters of the Chert are in the main similar both in the south and in the north-west of Ireland. It is usually exposed on the flanks and summits of some of the principal hills which have partially escaped the severe glacial erosion to which the country has been subjected, and their preservation may, in part at least, be attributed to the compact resistant nature of the Chert and Cherty-limestones of which they are composed. The Chert often occurs as nodular masses of irregular form, inclosed in beds of hard bluish Limestones, and following the planes of bedding, much in the same way as the flints in the Upper Chalk; but unlike the flints, these nodular masses are not sharply delimited from the Limestones in which they are interbedded, but there is a gradual passage from the Chert to the Limestone.

More frequently, however, the Chert exists in definite beds, from one to five inches (·025–·12m.) in thickness, which intervene at irregular intervals between beds of Limestone. These beds sometimes occur also as well-marked layers in the central portions of beds of Limestone. Both the nodular aggregations and the horizontally-bedded Chert usually occur in the same series of rocks; the particular mode of deposition probably depends on the extent to which the sponge-remains (of which it will be shown the Chert consists) are present in the respective areas.

Owing to this irregular mode of deposition, it is difficult to arrive at an estimate of the total thickness of the Irish Carboniferous Chert. Nowhere have I seen a continuous series of beds like those in North Wales and Yorkshire; the Chert in Ireland was more interrupted by the deposition of Limestones, but its aggregate thickness may not fall much short of the beds in Yorkshire.

On the sides of the hill of Knock-na-Rea, near Sligo, Chert occurs at frequent intervals, both in beds and nodular masses throughout the series of Limestone, about 800 feet (240m.) in thickness, forming the upper portion of the hill, and at Ben Bulben to the North of Sligo Bay, the Limestones, in the higher slopes, about 600 feet (180m.) in thickness, also contain an abundance of Chert. I should estimate the Chert to vary from one-tenth to one-fifth of the total thickness of these beds. On the sides and summit of the hill of Benachlan, Florence Court, near Enniskillen,[1] Prof. Hull estimates that the Chert-bands in the Upper Limestone series may have a thickness of 150 feet (45m.) out of a total thickness of 400 feet, but from my own observation I should judge that this estimate is considerably too high. In the South of Ireland the upper portion of the Upper Limestone series consists, according to the reports of the Geological Survey,[2] nearly entirely of a mass of Chert from

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[1] Proc. Royal Soc. vol. xlii. p. 306.

[2] Explanation of Sheet 128 (1859), p. 11.

30 to 50 feet (9 to 15m.) in thickness. As the total thickness of the Upper Limestone series, in which the Chert is mainly developed, is from 600 to 800 feet, there is probably an aggregate thickness of 100 to 150 feet of Chert (30–45m.), and in addition to this there is a considerable thickness of Chert in the Middle or Calp series of Limestone.

There is considerable uniformity in the character of the Chert in the Carboniferous series of Ireland. It is, for the most part, a compact, dark rock, it breaks with a conchoidal or splintery fracture, is too hard to be scratched with a knife, and, as a rule, gives no action with acid. The fractured surfaces are usually dull, sometimes with a faint lustre, resembling the so-called Lydian Stone. Horizontal lines of banding are not often shown in it. The beds are sometimes traversed by minute thread-like fissures, now infilled with quartz. The upper and under surfaces of the beds weather into a light grey or whitish siliceous crust, in some cases nearly an inch (20mm.) in thickness, of a porous granular material, harsh to the feel, and adhesive to the tongue, which strikingly contrasts with the black compact Chert of the central portion of the beds. In cases of extreme weathering, the entire mass of the Chert is converted into this porous rock, it then has a pumice-like aspect, and is relatively very light.

In the case of cherty limestones, in which the shells of Brachiopods, Crinoid stems and other calcareous organisms have been imbedded, the calcareous structures are entirely removed by weathering, and the impressions of the fossils are distinctly shown in the siliceous matrix.

In some cases the Chert has a light brownish tint; it is equally as hard as the black Chert, and weathers out in a similar manner. In Queen's County and Kilkenny some of the nodular masses, and beds of Chert as well, are of a grey or bluish grey tint, the beds are much jointed, and thin films of calcite have formed in the joint-planes. Occasionally the siliceous rock occurs in the granular porous condition in the limestones, it does not appear to have reached the stage of compact Chert. When treated with acid or when weathered out naturally, the siliceous portions stand out from the limestone in the same way as the porous crust on the solid Chert.

I have not had any chemical analysis of the Chert prepared, those carried out by the late Mr. Hardman[1] being sufficient to show its mineral composition. In several of these analyses the proportion of insoluble silica varied from 90 to 95 per cent., the residue consisting of carbonate of lime, iron, alumina and magnesia. In less pure Chert the proportion of silica diminished, whilst that of carbonate of lime increased, and some of the rocks analyzed were rather limestones than Chert. Prof. Hull states from his microscopic observations that the silica of Chert occurs in a gelatinous or colloid condition.[2] The chemical analyses of Mr. Hardman[3]

[1] Scient. Trans. Royal Dublin Soc. vol. i. 1878, pp. 86-91.

[2] Op. cit. p. 84.

[3] Op. cit. p. 92.

show, however, that in all cases the silica present is in the insoluble form, and he seems to have been puzzled to reconcile this fact with the preconceived notion that it was in the amorphous or soluble condition. The sections of the Irish Chert which I have examined between crossed Nicols all show the optical characters of chalcedony and quartz, and thus substantiate the accuracy of Mr. Hardman's analyses; it is therefore probable that Prof. Hull's statement that the silica is now in a colloid condition is founded on some mistake.

In order fairly to ascertain the microscopic structure of the Chert I had sections prepared, from specimens obtained from every locality I visited, including Dublin. The localities comprised Dunamase, near Maryborough, in Queen's Co.; Bonnet's Rath, near Kilkenny; Keishcorran, near Ballymote; Knock-na-Rea, and Ben Bulben in the County of Sligo, and also Benachlan, Florence Court, near Enniskillen.

Nearly all the sections were prepared from the prevalent dark Chert. This, when viewed by reflected light under the microscope, showed a diffused, cloudy, bluish-white reticulation on a dark ground. By transmitted light the bluish portion becomes translucent, and when the section is very thin, transparent. It is resolved into microscopic sponge-spicules, confusedly intermingled together, whose individual outlines can be traced with varying degrees of clearness. In transverse section the spicules appear as well-defined circles, with, in many cases, a central spot indicating the axial canal of the spicule. In longitudinal section, the larger spicules exhibit two parallel lines with a clear space between them, but viewed in this direction the individual forms are much less distinct than when seen transversely. In most of the sections under examination, sponge-spicules are the only organisms visible, in some there is a slight admixture of specimens of the genus *Fenestella* and other Polyzoa, the cells of which are now filled with either chalcedony or quartz, rarely also there are fragments of minute Brachiopod or Entomostracan shells, and one or two microscopic ossicles of Crinoids, but I have not recognized Foraminifera in my sections.

The dark material in the Chert is for the most part disposed in wavy bands, following the plane of bedding. Some of it consists of very minute opaque crystals, but for the most part it has a cloudy appearance. It appears to me to be partly of a carbonaceous and partly of a ferruginous character. As already mentioned, this dark material disappears in the weathered outer crust of the Chert, and even the *central* portion of black Chert beds becomes bleached after exposure.

Sections of the light-brown Chert from Benachlan contain, in addition to spicules, numerous well-defined microscopic cubic and rhombic crystals, either entirely or partially transparent or opaque; they vary from ·02 to ·075 mm. in diameter; similar crystals are also present in the dark Chert, but in fewer numbers. In this brown Chert the spicules have a brownish cloudy aspect in transmitted light; their outlines are extremely jagged, showing that solvent action has reduced them to mere skeletons of their original forms.

In all the sections of Chert which I had prepared sponge-spicules are present; in some their traces are indistinct and objection might be raised that the few forms visible are insufficient to justify the conclusion that the rock has been derived from these organisms. In other slides of precisely the same kind of rock in outer appearance, the spicules are so abundant that it must be conceded that, as Prof. Sollas remarked of some of Prof. Hull's specimens, they make up the larger part of the Chert. But even in the best-preserved specimens of the Irish Chert, the spicules have suffered from the influences of fossilization, and many are passing into various stages of dissolution, and there are good grounds for supposing that in the specimens which only show the spicules faintly, they have become nearly obliterated through subsequent changes in the rock.

I have discovered evidence strongly confirmatory of this view, in the nature of the porous crust, which, as already mentioned, results from weathering action on the surfaces of beds of Chert. In most cases, this crust appears to consist only of minute siliceous grains, but under favourable conditions of preservation, it is seen to be composed of innumerable minute rod-like sponge-spicules, intercrossing, and as it were felted together irregularly in the plane of the bedding of the rock. Also the layers of porous siliceous rock, which, as already noticed, in some cases appears to take the place of the compact Chert in the limestone, are likewise seen to consist of matted masses of minute spicules.

In the cases just mentioned, the evidence in favour of the view that the silica of the Chert is derived from the accumulation of the skeletal elements of siliceous sponges, and not as a *direct* deposit of this mineral from solution in sea-water, is demonstrable and conclusive. We can see in these instances that the silica of the Chert is distinctly of organic origin; the sponges have by vital action secreted the silica to form their spicules, and whilst some of these still retain their forms, others have been partially or completely destroyed to form the siliceous matrix. These spicular crusts also prove the presence of these bodies in the central mass of the beds of Chert, even when they cannot be distinguished in microscopic sections.

The preservation of the sponge-remains in the Irish Carboniferous Chert is much less favourable than in the corresponding Chert-beds of the Yoredale series in Yorkshire and North Wales; the spicules are far more eroded, and consequently it is more difficult to determine their characters. They appear to be nearly entirely minute acerate and cylindrical spicules varying from ·3 to ·9 mm. in length, and from ·017 to ·12 mm. in thickness. Most of these spicules probably belong to the Monactinellidæ, though some of the larger forms may be those of Tetractinellid sponges. Occasionally slender filiform spicules are present which attain a length of 2 mm., though only ·05 mm. in thickness.

Not a single entire sponge has, as yet, been discovered in any of the Chert-beds referred to, and though masses of rock reaching, as we have seen, an estimated thickness of 100 to 150 feet (30–45 m.)

are built up by these organisms, the portions preserved do not suffice to determine satisfactorily a single species. The sponges, like those in the Cretaceous rocks, have lived for successive generations on the areas of these Chert-beds, and after the death of the animal and the decay of the soft structures, the microscopic spicules of their skeletons have gently fallen and intermingled together on the sea-floor. When the sponges have existed continuously and nearly exclusively in the same area for long periods, massive beds of Chert have been produced by the accumulation and partial solution of their spicules; where, however, the sponges have grown in association with Crinoids and Polyzoa, then the Chert is in nodular aggregates, or the interspaces between the Crinoidal and other calcareous structures have been filled up by the silica resulting from the partial solution of the sponge-remains producing Cherty limestones.

Under certain conditions, however, when the calcareous portions of the rock much exceed the sponge-remains, these latter are frequently partially or entirely dissolved and replaced by calcite. This substitution has taken place in some of the dark limestones of the Calp series near Dublin, in which by the aid of a simple lens numerous spicules can be detected, but on treating the rock with acid, the spicules are dissolved away equally with the limestone matrix, leaving only a few small hollow fragments in the residue. The spicules in this limestone are considerably larger than those in the Chert-beds, and appear to belong mostly to Tetractinellid sponges.

It is not my intention to enter now into a detailed comparison of the Irish Carboniferous Chert with that in the Yoredale series of Yorkshire and North Wales; it will suffice to state that in all essential features the rocks from these different localities are very similar, so that in many cases it would be impossible to distinguish hand-specimens of the Irish from the Welsh Chert. The organic nature of the English and Welsh Carboniferous Chert, as produced from sponge-remains, is far more distinctly shown than in the case of the Irish beds, for the spicules are much better preserved, and the beds have been less altered by fossilization. Sponge-life also has been more continuous in the Yorkshire and North Wales areas, or, at all events, these organisms have been less intermingled with Crinoids and other animals possessing skeletons of carbonate of lime, so that their remains form continuous series of Chert-beds. In some of the Yorkshire areas there are beds of Chert 18 feet (5·4m.) in thickness without a break, and in North Wales there is a continuous series 350 feet (105m.) in thickness, without the intervention of Limestones. I hope shortly to give a detailed notice of these remarkable and hitherto unequalled sponge-beds, which, alike with those in the Irish Carboniferous rocks, conclusively show that in the interval between the Carboniferous Limestone proper and the Millstone Grit, siliceous sponges existed in greater force and played a more important part as rock-builders, than at any subsequent geological period.

The organic nature of these Carboniferous Chert and siliceous rocks, though strenuously denied by some geologists, has been frequently suspected by others, but no satisfactory proof has been heretofore brought forward to decide the question. I think, however, that the evidence which I have now collected from so many quarters will be found sufficiently conclusive to set at rest all objections to their organic origin.

I am not in a position to discuss how far the British Cherts correspond with the phthanites of the Carboniferous strata of Belgium, but judging from the careful description given of the latter by M. Renard, the resemblance is very close, and in my opinion the phthanites will be found to have the same origin as our Cherts. I have some grounds for this belief from the fact that in sections of a hand specimen of phthanite from the Carboniferous rocks at Namur, which was kindly sent to me by Dr. C. Barrois, there are abundant remains of sponge-spicules, and in transverse sections they correspond closely with those figured by M. Renard in illustration of his paper. Most of these spicules, however, are now so fragmentary and altered, that they would not be recognized as such by any one unfamiliar with the changes produced in them by fossilization.

I wish in conclusion shortly to notice some of the arguments brought forward by Messrs. Hull and Hardman and by M. Renard in favour of what may be called the chemical theory of Chert, which is that the silica of which it is composed is a direct deposit from the stores of this mineral held in solution in the sea-water, without the intervention of organic life. According to the explanation given by M. Renard,[1] at certain intervals the waters of the Carboniferous sea, holding in solution carbonic acid, a solvent of calcite, attacked the calcareous material, the silicic acid being infiltrated into it, and taking its place in proportion as it was decomposed. Prof. Hull distinctly states that the Chert is essentially a pseudomorphic rock consisting of gelatinous silica replacing limestone of organic origin.

I am unable to recognize the evidence for the statement that the silica of the Carboniferous Chert is a pseudomorph after limestone. In the beds of pure Chert, that is, when there is scarcely any admixture of carbonate of lime, hardly any traces of organisms other than sponge-spicules can be distinguished. According to the transmutation theory these Chert-beds were originally organic limestones, and should now show in silica the forms of their original structures; but, unfortunately for the theory, there are scarcely any present in them. In the Cherty limestones, calcareous organic structures are plentiful, but curiously enough, even here, there has been little replacement. Silica has indeed infilled the vacant spaces in the cells of the Polyzoa and the stems of the Crinoids, but it has not, as a rule, replaced the calcareous structures themselves. This is clearly shown when the Cherty limestones are exposed to atmospheric influences by which the calcareous structures in them are dissolved away and removed, leaving perfect moulds of their forms in the siliceous matrix, which is now in the form of rottenstone. If they

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[1] Bullet. de l'Acad. Roy. de Belgique, 2me s. t. 46 (1878), p. 497.

had been replaced by silica on the transmutation theory, they would not thus be dissolved out. I fully admit that the substitution of silica for calcite is of common occurrence, but in the case of these Carboniferous Cherty limestones it does not seem to have taken place to any great extent.

The main argument brought forward by Prof. Hull,[1] in his lately published paper, against the derivation of the Chert from sponge-remains, is stated to be "based on the fact that the development of sponge-life in the Carboniferous period was insignificant, and quite inadequate to account for the existence of bands and masses of Chert, sometimes constituting almost a half or third of the entire mass of the Upper Limestone."

But in what manner did Prof. Hull set himself to ascertain the fact that the Sponge-life in the Carboniferous seas was insignificant? With great pains he compiles lists of the numbers of species and genera of sponges and calcareous organisms in the Carboniferous and Cretaceous formations respectively, and he finds an "enormous proportion of siliceous sponges in the Cretaceous as compared with those in the Carboniferous period." Further, in the Carboniferous period, "the species of siliceous sponges might almost be counted on the fingers of the two hands; both in genera, species and individuals they are quite unimportant as compared with the calcareous organisms of that period, and totally inadequate to supply materials for the formation of such beds of Chert as are formed in the Carboniferous Limestone formation."

It seemed to me, however, that this method was rather an unsafe one to determine a question of this character, and that even in the hands of a Director of the Geological Survey, in his own field of investigation, a satisfactory result would not be obtained by figuring up lists of species, and then doing a rule-of-three sum with the totals. I ventured to think that it would be more satisfactory to ask the question whether sponge-life was insignificant in the Carboniferous period, of Nature herself, and so, with the limited time and resources at my disposal, I went to the rocks in Ireland and collected the evidence which has been brought forward in this paper. I leave it to the reader to determine whether my plan, or that of the Director of the Irish Survey, is most to be relied on, and whether, as Prof. Hull states, there is absolutely no evidence beyond a fanciful analogy for the organic origin of the Carboniferous Chert of Ireland.

## III.—THE GROWTH OF CEPHALOPOD SHELLS.

By F. A. BATHER, B.A., F.G.S.,
of the British Museum (Natural History).

THE shells of Cephalopods form an evolutionary series, traceable to an ancestor unknown, but nearly related to not yet coiled forms of the Cambrian. In all descendants from this common stock homologous parts are discerned. Hence facts regarding the growth of any one form may be applied to all. Of Cephalopods with chambered shells only *Nautilus*, *Spirula*, and *Sepia* exist. *Spirula* is

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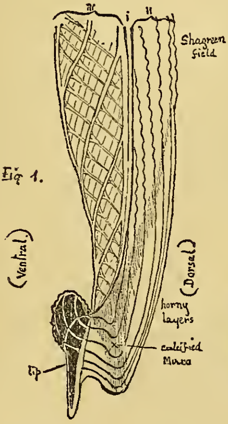
[1] Proc. Royal Soc. 1887, vol. 42, p. 306.

so rare and its shell so retrograde that no theory has yet been built on it. Examination of *Nautilus* gave rise to the Secretion-hypothesis, shortly stated as follows:—As the animal grows, the adherent muscles and the cincture gradually advance, the siphuncle lengthening in proportion; thus a cavity is formed between the last septum and the surface of the visceral hump: this latter then deposits calcareous matter, beginning at the sides of the shell and proceeding towards the siphuncle round which it is continued backward. During the advance of the animal the anterior portion of the mantle secretes calcareous matter, which it deposits in successive layers on the margin of the aperture (Edwards and Wood).

Microscopical examination of the fresh Sepion has led Dr. E. Riefstahl to propose what may be called the Intussusception-hypothesis:—That each new septum is absolutely developed from the preceding, and is removed therefrom by growth of the intervening zone of the outer shell wall; which growth is effected, not by apposition, but by intussusception (The Sepion and its relations to Belemnites, Palæontographica, Bd. 32, 1886). Startling though this be, the minuteness of the investigation demands attention. His paper consists of (*a*) description of minute structure of the Sepion; ($\beta$) conclusions as to its mode of growth; ($\gamma$) establishment of homologies with the Belemnite, thus bringing those conclusions to bear on external shells.



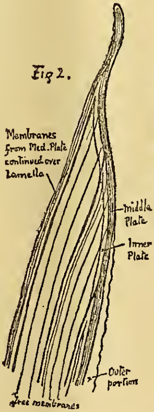


FIG. 3.

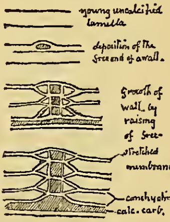


FIG. 1. Sagittal section, posterior end of young Sepia shell. Diagram after Riefstahl.
FIG. 2. Sagittal section, anterior margin of Sepia shell: the partitions not shown.
FIG. 3. Development of sinuous partitions. Diagram after Riefstahl. The thickness of the free membranes is exaggerated.

(*a*) The Sepion is a complex of conchyolin membranes, impregnated with lime in varying degrees: in accordance with the extent and mode of calcification three parts are distinguished (Fig. 1.)—i. Middle plate; calcification slight and not extended to the margin; ii. Outer portion, dorsal; membranes parallel and overlapping, stiffened in definite tracts by calcareous discs to form an anterior "shagreen field" and a posterior "mucro"; iii. Inner portion, ventral; chiefly consists of the so-called "spongioid tissue"; in sagittal section the organic membranes forming this are seen to be in groups; in each group the ventral membranes lie close together and are supported by a calcareous lamina of prismatic structure, thus forming a "lamella"; the remaining membranes are stretched freely at regular intervals; between the lamellæ, at right angles to them, are calcareous "sinuous partitions," which radiate towards the margin; through these the free membranes pass, and are by them supported: decalcification shows that all the membranes are continuous with those of the Middle plate (Fig. 2).

(β) The Outer portion is secreted by the mantle; its form is determined by that of the Inner portion. Secretion does not explain the growth of the Inner portion: the last formed lamellæ lie more closely on one another than do those of earlier age; the spaces between the freely-stretched membranes are not smaller, but the number of those membranes is less, they are absent from at least the hinder edge of the last formed lamella; hence the partitions are shorter, and the space between the insertion-lines of the two last lamellæ is less than in other parts of the shell (Fig. 2); each partition is bifid ventrally, this end is the first to appear. It follows that the membranes are separated from the lamellæ, not secreted by the mantle; and the calcium carbonate is only deposited on the inner, *i.e.* dorsal, side of the conchyolin (Fig. 3): the subsequent sundering of the lamellæ is accounted for by intussusceptional growth of the shell.

(γ) The Outer portion equals the Belemnite guard; the Inner portion the phragmocone, the lamellæ being septa; the Middle plate was represented by an *epicuticula* of the phragmocone: this is confirmed by fresh details. Hence in all chambered shells the hinder end of the body is in continuous contact with the youngest septum, and the subsequent sundering of the septa is effected by the growth of those zones of the shell-wall that lie between the sutures.

Thus far Riefstahl.

Undeniably there are objections to the Secretion-hypothesis, such as the complex structure of nacre, especially when freely-stretched membranes are present. But neither alternate secretions of lime and gas or, as in *Sepia*, liquid, nor alternate deposition of lamellæ and partitions are so absurd as Riefstahl maintains. Despite their regularity, due to advance of structure and function, we need not think the septa of Cephalopods originally different from those of some Gasteropods. Still the chambers of a *Nautilus* have, thanks to the siphuncle, a vitality denied to the septate portion of a *Bulimus*; here Riefstahl's conclusions harmonize with those of F. Müller on shell formation in Lamellibranchs: "The shell is no product of secretion, but has independent life, and grows by intussusception" (Zool. Beitr. Breslau, 1885, p. 206). Yet the avascular nature of the shell renders it hard to credit elaboration of lime in parts removed from the animal, nor is it to be thought that the latter is wholly idle;

in *Sepia* the inner surface of the mantle covering the lamellæ is formed of columnar cells, which at the anterior margin, where growth is most vigorous, are extremely long; removing this, there are seen on the ventral side of the last-formed septum, especially at the margin, developing sinuous partitions, over which I have been unable to demonstrate any such conchyolin membranes as are shown in Fig. 2. Further, this hypothesis requires subsequent growth of the septum as well as of the wall.

In the adult *Nautilus*, *Ammonites*, and *Spirula* the last septum is always nearer the penultimate septum than the regular increase in the depth of the chambers would lead one to expect; this also obtains in *Belemnites* so far as our fragmentary specimens allow one to judge, and, as Riefstahl has shown, in Sepia. The Intussusception-hypothesis demands (i) that this should be also the case in the young; (ii) that, in any one species, the body-chamber should at all ages be of the same depth in proportion to the length of the whorl. Riefstahl and his reviewer in Naturforscher (April 30, 1887) assume these facts and adduce them as arguments. But in smaller and presumably younger specimens of *Sepia* the last-formed lamella does not always seem to be nearer the penultimate, while the spaces between the insertion-lines are regular: it is easy to be deceived by the fact that all the lamellæ approach one another at their posterior borders. In *Nautilus* sections through undoubtedly young shells show that the last-formed chamber is actually larger than the preceding. In such young shells a distinct nacreous ring often indicates the first formation of a fresh septum. Had it been completed, the chamber enclosed by this septum would, without any interstitial growth, have been of increased size: the ratio of the body-chamber to the whorl, as compared with other specimens, is less or greater according as this half-formed chamber is counted in or not. The evidence from *Ammonites* is often vitiated by fracture; granting that the last chamber in small specimens is sometimes of relatively little depth, it is not so always, and in adults there may be seen, though rarely, a small air-chamber between two of normal size. In *Nautili* the 8th chamber is always less deep than those preceding, for the increased breadth and height of the cone makes up for loss of depth: examination of shells with only 8 or 9 chambers would therefore be deceptive. Riefstahl says that his fixed point is the hinder end of the animal's body: this does not explain the lines of advance so clearly seen in the muscle-scars.

So far facts do not confirm the Intussusception-hypothesis, some of those here brought forward favour the old view. Still Dr. Riefstahl deserves our gratitude for re-opening an interesting question, which is not likely to be settled without further investigation.[1]

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[1] As bearing upon the subject of this Article, see a paper "On the Structure of Camerated Shells" by Henry Woodward, Popular Science Review, 1872, vol. xi. pp. 113–120, pl. lxxxii.

## IV.—Further Notes on the Tertiary Entomostraca of England, with Special Reference to those from the London Clay.

By Professor T. Rupert Jones, F.R.S., and C. Davies Sherborn, F.G.S.[1]

(*Continued from p.* 392.)

### 28. Cythere costellata (Roemer), var. triangulata, nov.

The specimen under notice is relatively shorter, broader (higher), more triangular, and with sharper ridges than the figure in the 'Monograph,' 1856, pl. vii. f. 21. The anterior hinge is more prominent, and the front margin rather oblique. It is also narrower behind, ending with three small spines or denticles. The edge view is acute-ovate. From the Belosepia-bed, Bracklesham. T. R. Jones' Collection.

This variety of *C. costellata* is figured and described in the 'Monogr. Post-Tert. Entom.' 1874, p. 152, pl. xvi. figs. 13-15, from Selsey, and there recognized as being probably of Tertiary date, though found in the superficial mud.

### 29. Cythere plicata, Münster.

We have a narrow and compressed carapace, contracted posteriorly, from the Belosepia-bed, Bracklesham. T. R. Jones's Collection. This species is noticed in the Geol. Mag. 1874, p. 479, as having been found in the London Clay of Copenhagen Fields, with two species of *Chara*.

### 30. Cythere latimarginata, Speyer.

*Cythere latimarginata*, Speyer, Tert. Ostrac. Casell., 1863, p. 22, pl. iii. fig. 3.
*Cythere abyssicola*, G. O. Sars, Overs. Norg. Mar. Ostrac., 1865, p. 163.
*Cythere latimarginata*, Brady, Crosskey, and Robertson, Monogr. Post-Tert. Entom., 1874, p. 163, pl. xvi. fig. 6.
*Cythere latimarginata*, G. S. Brady, Trans. Zool. Soc., vol. x. p. 389, pl. lxiv. fig. 8.

Following Dr. Brady's determination of this species in the papers above mentioned, we refer this specimen to Speyer's species. The figure in the "Monogr. Post-Tert. Entom." comes nearest to our form, but is furthest from Speyer's original figure, to which the figures of the Antwerp-Crag specimens in 'Trans. Zool. Soc.' nearly approximate.

One valve; White (Coralline) Crag. T. R. Jones's Collection.

### 31. Cythere angulatopora (Reuss).

*Cypridina angulatopora*, Reuss, Haidinger's Nat. Abth. vol. iii. 1854, p. 86, pl. x. fig. 32.

An oblong valve, with parallel dorsal and ventral margins, and rounded ends. Surface with numerous small, more or less angular pits, arranged in parallel rows. A series of pits independently of the other ornament, follows the semicircular outline of the anterior end, just within the margin. The hinder margin is toothed. A single valve, associated with *Nummulites elegans*, in a bed regarded as at the top of the Bracklesham series, Hunting Bridge, New Forest. Collected by Mr. Keeping. T. R. Jones' Collection.

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[1] For Plate XI. see September Number Geol. Mag. facing p. 385.

The specimens figured and described as *C. angulatopora*, in the "Monogr. Tert. Entom.," 1856, p. 34, are not referable to that species. Figs. 17 and 18 of plate iv. correspond with the form (No. 33) to which we have here given the name *C. scalaris*; and fig. 18, pl. vi. figured by Bosquet (we think, erroneously) as *C. angulatopora* of Reuss, we now regard also as a new species, and have named it C. BOSQUETIANA (No. 32).

### 32. CYTHERE BOSQUETIANA, sp. nov.

*Cythere angulatopora* (not Reuss), Bosquet, Entom. Tert. 1852, p. 68, pl. iii. fig. 5.
*Cythere angulatopora* (not Reuss), Jones, Monogr. Tert. Entom., 1856, p. 34, pl. vi. fig. 18.

One of the oblong species of *Cythere*, with rounded ends, well-marked hinges, and convex valves, ornamented with a strong reticulation, the longitudinal meshes of which are stronger than the transverse. Just in front of the centre of the valve the meshes show an inclination to assume a concentric arrangement. This is strongly marked in fig. 18, pl. vi. of the Monogr. 1856.

One valve, occurring with *Nummulites elegans*, in the "uppermost bed" of the Bracklesham Series, at Hunting Bridge, New Forest. Collected by Mr. Keeping. T. R. Jones' Coll.

### 33. CYTHERE SCALARIS, sp. nov. Pl. XI. fig. 7.

*Cythere angulatopora* (not Reuss), Jones, Monogr. Tert. Entom., 1856, p. 34, pl. iv. figs. 17, 18.

Another oblong *Cythere* with nearly equal ends, but the front margin, sloping to the strongly marked anterior hinge, is more oblique than the other. The surface has longitudinal ridges, which on the hinder moiety of the valve are connected by transverse riblets, making irregular square meshes. The disposition of the ridges vary as to their parallelism.

A fine series of allied forms, from Gaas, near Dax, have been described and figured by Reuss ('Sitz. k. Ak. Wiss. Wien,' vol. lvii. 1868, pp. 38–40, pl. vi. figs. 3, 4, 5, and 7); but the differences are sufficiently apparent.

Two or three examples, London Clay; Islington. T. R. Jones' Coll.

### 34. CYTHERE POLYPTYCHA (REUSS), var.

Somewhat trigonal-obovate; the antero-ventral angle and the opposite hinge both well developed. Anterior border nearly semicircular; the posterior somewhat contracted. Surface puckered with nearly parallel, but irregular, longitudinal ridges, with intermediate rough, but obscure reticulation. The central region swollen into a round boss. Except that this specimen is less quadrate, possesses a boss, and is less distinctly reticulate, it closely resembles Reuss' original figure, Haidinger's 'Nat. Abth.,' vol. iii. 1854, p. 83, pl. x. fig. 22, from the Tertiary of Bohemia.

This *Cythere* belongs to a group of which *C. pusilla*, Bosquet, Entom. Tert., p. 85, pl. iv. fig, 7, may be taken as a type; possibly embracing the species referred by G. S. Brady, Trans. Zool. Soc., vol. v. 1866, p. 376, pl. lix. fig. 10, to Reuss' *C. clathrata* (which does not appear to us to be at all identical), and also *C. pumila,* G. S. B., *op. cit.*, p. 378, pl. lx. fig. 7. The latter, though near to our specimen, has far more irregular ridges.

One valve, from the "Norwich Crag" of Southwold. T. R. Jones' Collection.

### 35. CYTHERE SCROBICULO-PLICATA, Jones. Pl. XI. Fig. 8.

A figure of this species is reproduced from "Monograph Tert. Entom.," 1856 (p. 33, pl. vi. figs. 4 and 6), as one of the forms belonging to the London Clay of Finchley and Copenhagen Fields; the species also belongs to the Barton Clay, in which deposit it occurs in greater abundance than in the London Clay.

### 36. CYTHERE HARRISIANA, Jones. Woodcut Fig. 1.

*Cythereis interrupta*, Jones. Monogr. Cretac. Entom., 1849, p. 16, pl. ii. f. 6.
*Cythere Harrisiana*, Jones. GEOL. MAG., 1870, pp. 75, 76.

This form was found with *C. spinosissima*, hereafter described, while looking over for a second time some washings of London Clay. We have only this one valve, which agrees so closely in every particular with valves from the Gault, presenting the same isolated prickles and the pursed-up posterior end with its flattened margin, that we cannot separate them.


FIG. 1.—*Cythere Harrisiana*, Jones.

Sherborn and Chapman Collection; from Piccadilly, London.

### 37. CYTHERE FORBESII, sp. nov.

A subquadrate form, approaching the more definitely squared *Cytheræ*, for which we conveniently keep the subgeneric name of *Cythereis*. The valves are well-rounded in front and behind, with nearly straight lower and upper margins, the latter marked with well-defined hinges. The posterior margin is usually denticulate. The surface bears 6 or 7 crenulate and fenestrate ridges; those on the ventral region being more continuous than those on the dorsal. The interspaces of the ridges are deeply reticulated. This distinct and well-defined species we dedicate to the late Edward Forbes, whose investigations into the fossil fauna of the Isle of Wight Tertiaries will ever be gratefully remembered.

Specimens numerous, from the Fluvio-marine beds of Headon, Isle of Wight. F. Edwards' Collection in the British Museum.

### 38. CYTHEREIS BOWERBANKIANA, Jones. Pl. XI. Fig. 9.

Monogr. Tert. Entom. 1856, p. 38, pl. vi. figs. 7 and 8.

A figure of this quadrate species, characteristic of the London Clay, is here reproduced in illustration of the group. It has been found at Copenhagen Fields and Wimbledon Common (Jones), and at Whitecliff Bay (Sherborn).

### 39. CYTHEREIS SPINOSSISSIMA, sp. nov. Woodcut, Fig. 2.

A right and left valve of this form were lately found, with *C. Harrisiana*, in some washings of the London Clay from Piccadilly. They are oblong, with the front margin broader and more semicircular than the hinder. Surface coarsely reticulate; the reticulations becoming more shallow and indistinct as they reach the central area. Many of the ridges of the meshes are pinched up at their junctions, and in most cases thus form bluntly-pointed spines; these spinous prolongations are partly the cause of the confusion of the reticulation in the central area. Approaching the margins, the spines become longer and more defined; and the anterior area bears, in addition to its marginal row of spines, a second row just within the other. In this form, related to *C. Bowerbankiana*, on the one hand, and to *C. horrescens* on the other, we note that the characteristic ventral ridge of spines, which is present in both these forms, is absent, being merely represented by scattered spines, not arranged in a definite order except on the anterior area. The reticulation is also much more distinct,—a marked feature in the new form.

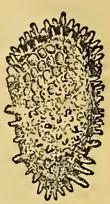
Fig. 2.—*Cythereis spinossissima*, sp. nov.

To this same group belongs a rather common recent and Post-Tertiary species, namely, *Cythereis Dunelmensis*, Norman (the references are given in full in the "Monogr. Post-Tert. Entom." 1874, p. 168). The chief differences between this and the older form from the London Clay are in the shape of the posterior margin, which is elliptically rounded in the latter instead of being square, and a more definitely spinose, instead of foliaceous, condition of the ornament, especially towards the margins.

Two valves only: from Piccadilly. Sherborn and Chapman Collection.

### 40. Cythereis aranea, sp. nov. Pl. XI. Fig. 10*a*, 10*b*.

Oblong, with the front margin broader and rounder than the hinder, both more or less denticulate. The surface ornamented with a delicate raised network of irregular meshes, which extend over the flat ventral area. Two ridges, over which the network is traceable, are present. One, shorter than the other, occupies the median line from about the centre to the edge of the posterior slope, which makes a strong depression at the hind margin. The other and longer ridge commences in a curve inside the front margin, rises as it borders the ventral region, and dies out at the posterior slope, like the other. The ventral aspect of the carapace is cuneiform or almost sagittate. *C. Haidingeri*, Bosquet, 'Tert. Entom.,' p. 125, pl. vi. fig. 10, is near to this species in general characters; but its more angular shape, and more symmetrical network distinguish it. So also *C. Edwardsii* (Roemer), Reuss, 'Haidinger's Nat. Abth.' vol. iii. p. 84, pl. x. fig. 24, is like it to some extent; but its ridges extend the whole length of the valve, joining fore and aft, and, as figured by Bosquet, 'Entom. Tert.' p. 94, pl. iv. fig. 14, it appears still coarser or stronger, and with still more marked features.

Several specimens from the London Clay; Piccadilly, London. Sherborn and Chapman Collection.

### 41. Cythereis Prestwichiana, sp. nov. Pl. XI. Figs. 11*a*, 11*b*.

A very small neat *Cythereis*, with well-developed marginal rim in front, which, passing along the ventral region, gradually rises higher, and ends in a sharp rectangle. A similar, but lower, ridge follows the dorsal edge. Both are more or less crenulated. There is a central boss, and a short ridge behind it, ending, like the others, at the sudden posterior slope, which terminates in a narrow, produced, flat, and toothed edge. The surface of the valve is somewhat depressed, and is covered with a distinct lace-like reticulation. Edge-view, subsagittate.

This form is clearly related to that figured in the "Monogr. Cretaceous Entom.," 1849, pl. v. fig. 13*b*., which we propose to remove from *C. ornatissima* (Geol. Mag., 1870, p. 75). We now have closely allied forms from the Chalk of other localities of the British Islands, and the distinctness of this new species, named after Prof. Prestwich, becomes more and more apparent.

Two valves from the London Clay of Whitecliff Bay, Isle of Wight. Collected by C. D. Sherborn.

### 42. Cythereis Hoernesi, Speyer.

*Cytherella Hoernesi*, Speyer. Ostrac. Cassel. Tertiär., 1863, p. 32, pl. iii. fig. 7; pl. iv. fig. 1.

Oblong; swollen into a distinct boss in the centre; ends round, the front margin semicircular and deeply fenestrated, the hind margin depressed and slightly toothed. Surface reticulated, ornamented with two prominent ridges, the dorsal and most striking of which, strong, fenestrated, and somewhat convex, partly obscures the hinge-line, and curves forwards and downwards below the front hinge. The ventral ridge is not so strong; both are sharply angular posteriorly.

The only marked difference between our specimen and that figured by Dr. Speyer is—that the dorsal ridge in the former is much better developed, being higher, thinner, fenestrate, more delicate, and ending posteriorly in a much sharper angle.

A single valve from the White (Coralline) Crag. T. R. Jones' Collection.

### 43. Cythereis corrugata (Reuss), var.

This valve is rugosely reticulate, with the longitudinal meshes stronger and more persistent than the transverse. Several allies of this form are figured in plates xxi. and xxii. of the "Report Challenger Ostracod.," 1880. Of the previously published forms we find that *C. corrugata*, Reuss, Haidinger's Nat. Abth. vol. iii. p. 79, pl. x. fig. 14, is the nearest to ours, although it varies in being squarer, stronger, swollen at centre, and strongly rimmed on the front margin.

One specimen, collected by the late F. Edwards from the Fluviomarine beds, Headon, Isle of Wight. British Museum.

### 44. Cythereis cornuta (Roemer).

Three or four specimens of this form from Bracklesham, of which one is here figured, differ individually from those previously figured in the Monogr. 1856, and elsewhere, in their narrowness, the parallelism of their upper and lower margins, and in the replacement of the curved dorsal ridge by a uniform marginal rim. The very faint markings seen along the ventral ridge, in the figures in the Monograph of 1856, are more distinct in the specimens now under consideration, and are evidently due to alternate thick and thin rod-like divisions, forming minute, light and dark, squarish areas. The slight transverse dorsal notch in fig. 19 is also traceable in our present specimens, when carefully illuminated and strongly magnified.

Bracklesham. T. R. Jones' Collection.

### 45. Cytheridea perforata (Roemer).

This specimen is like figure 14*a*, pl. iv. in the 'Monogr.' 1856, but is rather less triangular, much more coarsely punctate and strongly marked at the front hinge.

It was found with numerous normal valves in some washings from the clay at Barton.

T. R. Jones' Collection.

### 46. Cytheridea perforata, var. insignis. Pl. XI. Fig. 12.

Monogr. Tert. Entom., 1856, p. 46, pl. vi. fig. 3.

This fine variety is reproduced in the accompanying Plate from the original monograph. It was found in the London Clay of Copenhagen Fields.

### 47. Cytheridea glabra, Jones. Pl. XI. Fig. 13.

*Cytheridea perforata*, var. *glabra*, Jones. Monogr. Tert. Entom., 1856, p. 46, pl. v. fig. 24.

This angular and smooth form, related to *C. perforata*, should now, we think, be regarded as a species. It came from the London Clay of Copenhagen Fields.

### 48. Cytheridea punctillata, Brady.

One damaged valve we refer to this species, which has been described and figured in full in the 'Monogr. Post-Tertiary Entom.,' 1874, p. 177, pl. vi. figs. 1–11. Our specimen, however, approaches most closely to another figure of the same species in Dr. G. S. Brady's paper, 'Trans. Linn. Soc.,' vol. xxvi. (1868), p. 424, pl. xxvi. fig. 36.

From the "Norwich Crag" at Southwold. T. R. Jones' Collection.

### 49. Cytheridea pinguis, Jones.

We have this species from the Weybourn Crag; collected by Mr. Clement Reid at East Runton. Dr. G. S. Brady figures it from the Antwerp Crag, 'Trans. Zool. Soc.,' vol. x. p. 397, pl. lxii. fig. 3.

### 50. Cytheridea debilis, Jones.

We have seen a right valve (opposite to that figured in the Monograph, 1856), apparently belonging to this species from the Belosepia-Bed, Bracklesham. Science Schools Collection.

### 51. CYTHERIDEA ELONGATA, Brady.

*C. elongata*, G. S. Brady. Monogr. Recent Brit. Ostrac., Trans. Linn. Soc. 1868, vol. xxvi. p. 421, pl. xxviii. figs. 13–16; pl. xl. fig. 6; Monogr. Post-Tert. Entom., 1874, p. 181, pl. ix. figs. 10–13.

Numerous specimens from the Weybourn Crag of East Runton, varying slightly in individuality of growth and sex, are referable to Brady's *Cytheridea elongata.* Collected by Mr. Clement Reid, F.G.S. We have it also, not rare, in the Crag of Southwold (Norwich Crag).

### 52. KRITHE GLACIALIS, B. C. and R. Pl. XI. Fig. 15*a*, 15*b*.

B. C. and R. 'Monogr. Post-Tertiary Entom.,' Pal. Soc., 1874, p. 184, pl. vi. figs. 21–24.

A smooth specimen of *Krithe* from the London Clay of Piccadilly is so extremely close in every feature to *K. glacialis* from Scotland and Norway, except in the apparent pitting of the latter, that we cannot separate it from this later form. Sherborn and Chapman Coll.

### 53. KRITHE LONDINENSIS, sp. nov. Pl. XI. Fig. 14*a*, 14*b*.

Carapace narrow obovate, not quite semicircular in front, subacute posteriorly. In edge-view the anterior third is compressed and wedge-shaped, the middle is swollen, and the posterior third is compressed, and ends in the usual notch formed by the produced ends of the two valves. Surface smooth and shining. In this last feature it resembles other forms of this genus, but in its outlines it differs from any we know. From the London Clay of Piccadilly. Sherborn and Chapman Collection. Bornemann's *Bairdia pernoides* (Zeitschr. D. g. Ges. vol. vii. 1855, p. 358, pl. 20, fig. 7) is a somewhat similar *Krithe* of this geological age.

### 54. XESTOLEBERIS AURANTIA (Baird), 1835; var.

*Xestoleberis aurantia*, Brady, Crosskey and Robertson, 'Monogr. Post-Tert. Entom.,' Pal. Soc. 1874, p. 191, pl. xvi. figs. 32, 33. (Full synonymy is here given.)

Except in being minutely punctate, and not distinctly papillose, this specimen (from Headon) closely resembles the recent *X. aurantia*, above quoted. From the Fluvio-marine deposits of Headon Hill, Isle of Wight. Collected by the late F. E. Edwards, and now in the British Museum.

### 55, XESTOLEBERIS COLWELLENSIS, sp. nov.

Carapace ovate in outline, and subovate in edge-view, with spinulose surface. This is near *X. aurantia* (Baird), but blunter anteriorly.

From the Tertiary of Colwell Bay. T. R. Jones' Collection.

### 56. CYTHERURA PRESTWICHIANA, sp. nov.

This belongs to the same type as *Cytherura nigrescens*, B. C. and R., 'Post-Tert. Entom.,' p. 192, pl. xi. f. 28–32, but differs in its greater compression anteriorly, and in being less strongly notched behind. Allied forms are known to us from several Jurassic strata. From the Belosepia-bed, Bracklesham. T. Rupert Jones's Collection.

Named after Professor Prestwich, of Oxford, who has so greatly advanced our knowledge of the Tertiary deposits.

### 57. CYTHERURA CLATHRATA, G. O. Sars.

*Cytherura clathrata*, G. O. Sars. Brady, Trans. Linn. Soc., vol. xxvi. 1868, p. 446, pl. xxix. figs. 43-46; B. C. and R., Post-Tert. Entom., Pal. Soc. 1874, p. 204, pl. xi. figs. 1–4.

In this small and interesting form, the oval carapace is somewhat sharper behind than before, and more compressed in front than behind. It has the surface ornamented with a strong median ridge, branching freely off towards the margin. The main branches in our specimen keep their entirety, but Dr. G. S. Brady figures individuals in which the branches lose themselves in a rough general reticulation over the surface. From the Weybourn Crag of East Runton; collected by Mr. Clement Reid, F.G.S.

### 58. CYTHEROPTERON TRIANGULARE (Reuss). Pl. XI. Fig. 16.

*Cythere triangularis*, Reuss, Zeitschr. Deutsch. geol. Ges. vol. vii. 1855, p. 279, pl. x. fig. 3.
„ ,, Jones, Monogr. Tert. Entom. 1856, p. 25, pl. vii. fig. 5.
„ *tenuicristata*, Reuss, Sitzungsb. k. Ak. Wiss. Wien, vol. lii. 1865, p. [23] plate, fig. 12.

This well-marked form has already been well described, as also have several allies, namely, *Cytheropteron mucronalatum*, Brady, "Challenger," 1880, p. 140, pl. xxxiii. fig. 8; *C. fenestratum*, Brady, *Ibid.* p. 139, pl. xxxiv. fig. 6; and *C. sphenoides* (Reuss), Denkschr. k. Ak. Wiss. Wien, vol. vii. p. 141, pl. xxvii. fig. 2.

From the London Clay of Piccadilly; Sherborn and Chapman Coll.

### 59. CYTHERIDEIS GRACILIS (Reuss).

*Cytherina gracilis*, Reuss, Haidinger's Nat. Abh. vol. iii. 1850, p. 52, pl. liii. fig. 3.
*Cytherideis gracilis*, Brady, Trans. Zool. Soc., vol. v. 1866, p. 367, pl. lviii. f. 1*a–d*.

To this neat form, already described by Reuss and others, the following are more or less allied:—*C. arcuata* (Bosq.), Tert. Entom., 1852, p. 32, pl. i. fig. 14; *C. lithodomoides* (Bosq.), *Ibid.*, p. 36, pl. ii. fig. 3; *C. Bairdia difficilis* (Reuss), Sitzungsb. k. Ak. Wiss. Wien, vol. lvii. 1868, p. 35, pl. v. fig. 7.

The figure given in the "Fonds de la Mer" (8vo. Paris, 1867–71), livr. 4, 1868, p. 94, pl. xii. figs. 1, 2, of Brady's *Aglaia pulchella* reminds us of this form.

We have one small specimen from a Tertiary bed at Colwell Bay. In the closed carapace the right valve is the smallest; it is faintly toothed on the anterior margin. The longitudinal lines on the ventral surface are distinct, though faint.

### CYTHERELLA, Jones (sub-genus), 1849.

The members of this genus are separable with difficulty as to their probable specific identities (Monogr. Carbonif. Entom., Part I. No. 2, Pal. Soc., 1884, pp. 57-69). For the recognition of the Tertiary forms, with which we are at present concerned, we propose to keep certain types in view, referring our specimens to one or the other of the several groups.

Group I.—Typified by *Cytherella compressa* (Münster), as figured by Egger, 'Ostrak. Ortenburg,' Neues Jahrb., 1858, p. 404, pl. ii. fig. 2, with its wedge-like ends and flat parallel sides. To this we must relegate *C. Londiniensis*, Jones, 'Monogr. Tert. Entom.' p. 54, pl. v. figs. 20 [reproduced here, Pl. XI. Fig. 19] and 22, besides, "*C. compressa*, var. 2," Fig. 19 of the same Plate.

Group II. *Cytherella Muensteri* (Roemer). These carapaces have their greatest convexity near the middle or towards the hinder part of the valves. One of our specimens from Bracklesham belongs to this group; but we know of none exactly like it, in its symmetrical, broad, and oblong outline, with nearly equally rounded ends, median convexity toward the ventral edge, and broadly ovate edge-view. We call it *C. Rœmeri*. Another is near Roemer's original figure, 'Neues Jahrbuch, für Min. etc.' 1838, p. 516, pl. vi. fig. 13, in shape, though not so strongly punctate. In the 'Monogr. Tert. Entom.,' p. 56, pl. v. fig. 13, is a smooth variety; but fig. 12 is even more strongly pitted than is Roemer's fig. 13, and was termed var. *rectipunctata* in the Geol. Mag., 1870, p. 157. Some allied forms, smooth and having the convexity more definitely in the hinder third of the valves, are remarkably ovate in outline, and lanceolate in edge-view. These may be regarded as belonging to a new species to be called *C. Reussii*, after the eminent micrologist of Prague and Vienna. In the 'Monogr. Tert. Entom.,' p. 54, pl. v. figs. 21 [reproduced in our Pl. XI. Fig. 17] and 23 are also smooth, and belong to this group: but they are obovate in outline, like Bornemann's *C. fabacea*, 'Zeitschr. Deutsch. geol. Ges.,' vol. vii. 1855, p. 355, pl. xx. fig. 2, to which they must be referred, as in Geol. Mag. 1870, p. 157. Another of our Tertiary *Cytherellæ* is ovate-oblong, lanceolate in edge view, with acute-ovate end-view. This also we believe to be new, and name it *C. Dixoni*, in memory of one of the most enthusiastic workers on the geology and fossils of Bracklesham, whence all but one of the *Cytherellæ* described as new in this paper have been obtained.

A very small *Cytherella*, smooth, subovate, and with lanceolate edge-view, belongs apparently to Group II. It was found by Mr. Clement Reid in the Weybourn Crag of East Runton.

Group III. The type is *Cytherella Beyrichi* (Reuss).

*Cytherina Beyrichi*, Reuss, Zeitschr. Deutsch. geol. Ges., vol. iii. 1851, p. 89, pl. vii. fig. 65.
*Cytherella Beyrichi*, Bornemann. *Ibid.* vii. 1855, p. 354, pl. xx. fig. 1.
,, *compressa*, var. 1, Jones. Monogr. Tert. Entom. 1856, p. 55, pl. v. fig. 18. [Reproduced here, Pl. XI. Fig. 18.]
,, *Beyrichi*, Speyer, Ostrac. Cassell. Tertiär., 1863, p. 54, pl. i. fig. 1.
,, *Beyrichi*, Brady, Trans. Zool. Soc., vol. v. 1866, p. 362, pl. lvii. fig. 3.
,, ,, Jones, Geol. Mag. 1870, Vol. VII. p. 157.

In this group the carapaces vary from round-ended oblong to ovate-oblong, with a partial flattening of the anterior portion, giving a compressed wedge-shaped edge-view. In most cases the posterior end is full and truncate, herein also differing from the members of Group II. Generally the surface is pitted, but we have a smooth example of this form. The last may be termed *C. Beyrichi*, var. *lævis*; but we consider that the others do not offer differences sufficient to separate them from the type as named varieties.

Referring especially to the specimens from the London Clay, we conclude that they should stand as follows:—

60. CYTHERELLA FÁBACEA, Bornemann. Pl. XI. Fig. 17.

*Cytherella compressa*, Jones (not Münster), Monogr. Tert. Entom. p. 54, pl. 5, fig. 21.

61. CYTHERELLA BEYRICHI, Bornem. Pl. XI. Fig. 18.

*Cytherella Beyrichi* (?), Jones, Monogr. Tert. Entom. p. 55, pl. v. fig. 18.

62. CYTHERELLA COMPRESSA (Münster). Pl. XI. Fig. 19.

*Cytherella Londiniensis*, Jones, Mon. Tert. Entom. p. 55, pl. v. fig. 20.
*C. compressa*, var. 2, Jones, *ibid.* fig. 19.

The last is very near to the other, but is rather more oblong and is somewhat punctate.

63. In Mr. Clement Reid's Collection we have seen the following Freshwater Ostracoda from the uppermost Pliocene Formations.

MUNDESLEY UNIO-BED.[1]

*Cypris reptans* (Baird).
,, *gibba*, Ramdohr.
*Candona candida* (Müller).
*Cypridopsis obesa*, B. & R.
*Darwinula Stevensoni*, B. & R.
*Cythere concinna*, Jones, var.

SIDESTRAND UNIO-BED.

*Cypris reptans* (Baird).
,, *Browniana* (?), Jones.[2]
,, *gibba*, Ramdohr.
*Candona candida* (Müller).
*Cypridopsis obesa*, B. & R.

64. Mr. C. Reid, F.G.S., has lately sent from the Isle of Wight:—

1. *Candona Forbesii*, Jones, from the Hempstead beds of Parkhurst Forest (Bore-hole, No. 32).

2. *Cytheridea Muelleri* and its variety, *torosa*, Jones; from Bore-hole No. 5, east bank of the Medina, one mile north of Newport.

65. In his notice of some of the Post-Tertiary deposits, associated with the Raised Beach at Portland (see Q.J.G.S. vol. xxxi. 1875, p. 39) Prof. Prestwich mentions two species (*Cypris Browniana* and *Candona candida*) as occurring there. We can now add *Cypris gibba*, Ramd., and *C. incongruens*, Ramd., besides an undetermined species.

66. We here add a list of some Post-Tertiary Entomostraca, which we find in a Chara-deposit from near Hitchin.

Collection of W. Hill, Esq., jun., F.G.S.

*Cypris Browniana*, Jones.
,, *incongruens*, Ramdohr.
*Cypris reptans* (Baird).
*Candona candida* (Müller).

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The following are Lists of the species of Ostracoda treated of in the foregoing Memoir:—

WEYBOURN CRAG.

3. *Potamocypris trigonalis*, Jones, and var. *lævis*, nov.
14. *Cythere Reidii*, sp. nov.
15. ,, *retifastigiata*, Jones.
18. ,, *angulata*, Sars, var.
19. ,, *Charlesworthiana*, sp. nov.
20. *Cythere villosa*, Sars.
22. ,, *Woodwardiana*, sp. nov.
49. *Cytheridea pinguis*, Jones.
51. ,, *elongata*, Brady.
57. *Cytherura clathrata*, Sars.
*Cytherella*, sp.

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[1] See also Trans. Norf. Norw. Nat. Soc. vol. iii. p. 631.

[2] Dr. G. S. Brady informs us that he has lately received *C. Browniana* from Loch Fadd, near Rothesay, and that it will be described and figured in a forthcoming Report of the Scottish Fisheries Commission.

## Southwold Crag.

12. *Cythere recurata*, sp. nov.
20. ,, *villosa*, Sars.
34. ,, *polyptycha*, Rss., var. nov.
48. *Cytheridea punctillata*, Brady.
51. ,, *elongata*, Brady.

## Bramerton Crag.

4. *Aglaia ? cypridioides*, sp. nov.
16. *Cythere lacrymalis*, sp. nov.
18. *Cythere angulata*, Sars, var.
21. ,, *læsa*, sp. nov.

## Suffolk Crag.

10. *Bairdia rhomboidea*, sp. nov.
17. *Cythere dictyosigma*, Jones.
30. *Cythere latimarginata*, Speyer.
42. *Cythereis Hoernesi*, Speyer.

## Hempstead, Isle of Wight.

1. *Cypridea spinigera* (Sow.).

## Headon Hill, Isle of Wight.

27. *Cythere delirata*, sp. nov.
37. ,, *Forbesii*, sp. nov.
43. *Cythere corrugata*, Rss., var.
54. *Xestoleberis aurantia* (Baird).

## Colwell Bay.

6. *Pontocypris* (?) sp.
55. *Xestoleberis Colwellensis*, sp. nov.
59. *Cytherideis gracilis* (Reuss).

## Hunting Bridge.

31. *Cythere angulatopora* (Rss.).
32. *Cythere Bosquetiana*, sp. nov.

## Barton.

45. *Cytheridea perforata* (Roemer).

## Bracklesham.

5. *Bythocypris subreniformis*, sp. nov.
7. *Bairdia subdeltoidea* (Münster).
13. *Cythere venustula*, sp. nov.
26. ,, *gyriplicata*, sp. nov.
28. ,, *costellata*, Roem., var. *triangulata*, nov.
29. ,, *plicata*, Münst.
44. *Cythereis cornuta* (Roem.)
50. *Cytheridea debilis*, Jones.
56. *Cytherura Prestwichiana*, sp. nov.
*Cytherella Muensteri* (Roem.).
,, *Beyrichi* (Rss.) var. *lævis*, n.
,, ,, 3 varr.
,, *Rœmeri*, sp. nov.
,, *Reussii*, sp. nov.
,, *Dixoni*, sp. nov.

## London Clay. (Figured and described in this paper.)

8. *Bairdia subtrigona*, Bornem.
9. ,, *Londinensis*, sp. nov.
11. ,, *ovoidea*, sp. nov.
23. *Cythere arenosa*, Bosq.
24. ,, *scabropapulosa*, Jones.
25. ,, ,, var. *aculeata*, nov.
33. ,, *scalaris*, sp. nov.
35. ,, *scrobiculoplicata*, Jones.
36. ,, *Harrisiana*, Jones.
38. *Cythereis Bowerbankiana*, Jones.
39. ,, *spinosissima*, sp. nov.
40. *Cythereis aranea*, sp. nov.
41. ,, *Prestwichiana*, sp. nov.
46. *Cytheridea perforata* (Roem.), var. *insignis*, Jones.
47. ,, *glabra*, Jones.
52. *Krithe glacialis*, B. C. & R.
53. ,, *Londiniensis*, sp. nov.
58. *Cytheropteron triangulare* (Rss.)
60. *Cytherella fabacea*, Bornem.
61. ,, *Beyrichi* (Rss.)
62. ,, *compressa* (Münster).

Appendix.—It is advisable to make the following emendations in the paper in the Geol. Mag. 1870:—Page 155, *for* No. 9 *read* No. 19, *and transfer the paragraph* to p. 156. Pages 157 and 159 for *Ilyobates* read *Krithe*. Page 158, 2* var. *tumida*, should come under 2 *Cypris Browniana*.

For later alterations in generic and specific names, see the present paper.

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## V.—THE GNEISSOSE ROCKS OF THE HIMALAYA.

By R. D. OLDHAM, A.R.S.M., F.G.S.,
of the Geological Survey of India.

IT had not been my intention to publish anything on this subject at present, as I have in preparation a review of the present state of our knowledge of Himalayan geology; but as Col. McMahon has started the subject, and his paper is not exhaustive, I trust the following outline of that part which relates to the gneissose rocks may prove of interest.

The gneissose or granitoid rocks of the Himalayas may be divided into three groups:—

(1) The fundamental or "Central" gneiss of Dr. Stoliczka.
(2) The orthoclase, usually porphyritic and gneissose, granites.
(3) The oligoclase granite.

The last of these appears to be distinct from and of later date than the first two, and will not be further referred to here.

The fundamental, or, to use the term under which it was first described, the central, gneiss consists of a great thickness of crystalline rocks. In the little disturbed sections of the Upper Pábar Valley in Bissahir it is seen to unconformably underlie rocks which I have little doubt are the equivalents of Dr. Stoliczka's Babeh series of Silurian age. Both by lithological structure and mode of occurrence, these beds are shown to be of metamorphic, as opposed to intrusive origin; they contain beds varying from almost pure felspar to almost pure quartzite or mica-schist, but felspar is seldom altogether absent; some of the beds are *augen gneiss*, the eyes being lenticular in form, lying in accord with the planes of foliation, and, as regards their internal structure, consisting of a single twinned crystal of orthoclase.

On the section over the Babeh Pass, that first examined by Dr. Stoliczka, the beds are more disturbed and more metamorphosed. Highly foliated beds are rare, and the rock is for the most part a more or less fine-grained granitoid gneiss: some beds are *augen gneiss*, in which the eyes still maintain their lenticular form, though, as a rule, they have more or less acquired an outline in conformity with their crystalline structure; these crystals, however, still lie along the planes of foliation or very slightly oblique to them.

There can be little doubt that it is from the fusion of these beds that the gneissose granite was derived. Typically this rock consists of a somewhat fine-grained, slightly-foliated matrix, through which porphyritic crystals of orthoclase are scattered; the crystals exhibiting no definite orientation, but being scattered about with their axes pointing in every direction, as described by Col. McMahon. It occurs in large intrusive masses, or in veins of various thickness, usually intruded parallel to the bedding planes; the former usually show very slight signs of foliation, except near their boundaries, while the latter are almost, if not quite, invariably distinctly foliated. As the veins are traced away from their parent masses, the larger crystals of felspar appear to be left behind, and the rock gradually ceases to be porphyritic, and sometimes contains merely a small proportion of felspathic material. How complete is the assumption of a gneissose and loss of the granitic structure may be judged from the fact that specimens from one exposure, which can be shown to be intrusive, have been examined by Col. McMahon, and declared by him to be a true gneiss showing no signs of intrusive origin.[1]

Col. McMahon has shown that the microscopic structure of this rock, as well as the inclusions of mica-schist, prove its intrusive nature. I may add that the same is shown by its mode of occurrence, by the manner in which it cuts across the bedding of the rocks among which it occurs, and by the invariable occurrence of contact metamorphism in the neighbourhood of any large mass of it. The intrusion, in many cases, does not seem either to have caused or been accompanied by any considerable disturbance, but to have taken place by a fusion (or solution) and absorption of the rocks which it has replaced. These often continue with a perfectly steady, low dip right up to a large mass of the gneissose granite, and end abruptly there; yet the intrusive nature of the granite is shown by the presence of included masses of these very rocks. The same thing is indicated by a study of the intrusive sheets; they constantly thin out and thicken without any disturbance of the bordering beds, which simply run up to the edge of the gneissose granite, and stop there abruptly; the granite itself too becomes more micaceous or more quartzose (according to the prevailing type of rock it has passed through) and less felspathic the further it is traced from its source, indicating a gradual increase of impurity. But the most conclusive proof I know of is exhibited by the sections on the eastern side of the Chor Mountain. The southern sections show a considerable thickness of volcanic beds, altered to more or less schistose hornblende rock; while on the northern sections these hornblende rocks are absent, but the granite has become so highly hornblendic that the ground-mass is of a dark green colour, throwing up the porphyritic crystals of white orthoclase in a most conspicuous manner.

Before passing on, it will be well to explain how these two distinct rocks came to be confused with each other. In the Sutlej Valley, between Simla and the Wangtu bridge, there are extensive exposures of gneissose rocks; these are almost all the gneissose granite, but owing to similarity of lithological appearance and absolute continuity of outcrop, they were (erroneously) confounded by Dr. Stoliczka with the granitoid gneiss which is exposed almost to the exclusion of intrusive granite on the ascent from the Wangtu bridge to the Bábeh pass. In 1877 Col. McMahon published a paper on the "Central gneiss" of the Simla Himalayas, in which he (correctly) identified the rock of the Chor and the gneissose granite intrusions south of the Sutlej with the rock of the Sutlej Valley. In 1883 he showed that while the rock of the Dhaoladhar, which he had identified with that of the Chor, could not in a single case be

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[1] Rec. Geol. Surv. India, vol. xvii. p. 60; vol. xix. p. 86.

shown to be a true gneiss, it presented all the characters of an igneous rock. In this paper he dropped the term granitoid gneiss in favour of gneissose granite, and added that "it is for consideration whether the term 'central gneiss,' introduced by the late lamented Dr. Stoliczka, and since used to denote the 'granitoid gneiss' of the North-West Himalayas, should not be discontinued in future." Consideration is entirely in favour of this proposition, but against the total abandonment of the term "central gneiss," which may still be conveniently used for the fundamental gneiss, the oldest rock, in the Himalayas.

The separation of these two rocks in the field will often be a matter of difficulty, and not always possible, except where the gneissose or the intrusive characters are well developed; the microscope will not aid in this, for, as I have remarked above, in one case it has declared what can be shown to be an intrusive rock to be a metamorphic gneiss, while some of the more granitoid forms of the central gneiss show so little foliation and are so granitoid as seen in a hand specimen, that I doubt whether even microscopic examination would give a decided answer as to whether they are granite or gneiss. The general result then is the satisfactory one (for it is always more satisfactory to confirm than to refute a previous observer) that Dr. Stoliczka was correct in describing the oldest rock he observed as a *gneiss*, while Col. McMahon is equally correct in maintaining that the rocks of the Sutlej Valley and the Dhaoladhar are *granite*. I may now pass on to consider the cause of the foliation of this granite.

In considering this question, it is necessary to distinguish between the large, slightly foliated masses and the distinctly foliated sheets. In the former case the obscure foliation is probably in the main a form of fluxion structure, but the well-developed foliation of the thin sheets, which are occasionally sufficiently fissile to be used as flags or roofing slates, cannot be solely due to this cause.

When we find intrusive sheets of a few feet, or even a few tens of feet, in thickness, extending for miles without more than mere local variations of thickness, it must be evident that their fluidity cannot have been in any great degree due to excess of temperature; in the case of the thinner sheets I do not think that it can have been in any degree due to this cause, but rather to a difference of composition which enabled the granite to maintain some degree of fluidity, while the rocks into which it was intruded remained solid. Whatever this temperature may have been, it was sufficient to metamorphose the sedimentary beds which have always been converted into more or less perfect schists, that do not exhibit any marked increase of metamorphism near the sheets of gneissose granite intruded into them.[1]

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[1] Contact metamorphism is only conspicuous in the case of large intrusive masses. The statement in the text may seem inconsistent with that of Col. McMahon regarding the slightly metamorphosed condition of the slates in contact with the outer band of gneissose granite in the Dalhousie region; but the particular slates referred to are everywhere characterized by a much greater power of resisting metamorphism than those above and below them. I have more than once observed the total absence of metamorphism, or the mere development of a micaceous glaze on the bedding-planes, where associated beds were converted into distinct schists.

The exact causes productive of foliation are not thoroughly understood, but it appears to be in some way related to the parallel structure due to stratification or cleavage, as the case may be. In the case of an intrusive sheet of granite, there would be neither stratification nor cleavage; but friction against the sides of the channel it flowed in would be sufficient to produce a slight parallel structure in a viscid mass; while it is not inconceivable that the very fact of the minerals, in the rock on either side, arranging themselves in a laminated structure, would induce similar rearrangement of the minerals in the gradually cooling granite. In short, I believe that the very slight foliation of the larger masses is principally a fluxion structure, while the more developed structure of the thinner bands, and near the margins of the larger masses, was produced in the solid but still heated granite by the same causes—whatever they be—that led to the foliation of the adjacent sedimentary beds.[1]

Before leaving this subject, there is one point that may be referred to with advantage. In Mr. Lydekker's memoir on the geology of Cashmir it is stated, both on the map and in the text, that part of the gneiss of that region consists of metamorphosed Silurian strata; this statement will not, I fear, be borne out by a more detailed examination of the ground. I have had a tolerably extensive, if fragmentary experience of the Himalayas, during which I have never seen a case of beds, which occur elsewhere as slates, having been converted into gneiss; but I have seen sections, similar to those described by Mr. Lydekker, where there appears to be a gradual passage from slate to gneiss. It appears not to be uncommon that near the boundary of a crystalline area there should be sections showing a considerable thickness of gneissic rocks, with small intercalations of non-gneissic beds, which can occasionally be recognized as belonging to some definite horizon in the slaty series. The sections, at first sight, seem to indicate an extreme metamorphism of the beds, a few of which have so far escaped metamorphism as still to be recognizable. Apart, however, from the fact that the gneiss exhibits those features especially characteristic of the gneissose granite, where I have been able to trace the horizontal extension of the rocks into unaltered slates, the change has not been by a gradual diminution in the metamorphism of the rocks as a whole, but by a gradual diminution of the gneissose beds, those which remain being as distinctly crystalline as before, till, where they have diminished in thickness and the schistose beds prevail, they can be distinctly recognized as intrusive gneissose granite. The sections indicate, not an extreme degree of metamorphism of the slaty rocks, but their more or less complete obliteration by gneissose granite.

In Western Garhwál there is a considerable development of arkose beds which have become foliated, but are still recognizable as foliated arkose. It is quite conceivable that similar beds might be so metamorphosed as to be undistinguishable from gneiss, but with this

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[1] In 1884 Colonel McMahon seems to have held an opinion somewhat similar to this (see Records Geol. Surv. India, vol. xvii. p. 72), but so far as I can understand his paper in the May Number of this Magazine, he has now abandoned it.

exception (which could not be called a true metamorphic gneiss as the felspar was provided ready made), I do not think that any beds belonging to the slaty series of the Himalaya have been converted into gneiss; whether they could be is a matter to be decided by chemical analysis.

## NOTICES OF MEMOIRS.

### I.—British Association for the Advancement of Science. Fifty-seventh Meeting, Manchester, 1887.

### Section C.—Geology.

*President*: Henry Woodward, LL.D., F.R.S., F.G.S.

Titles of Papers Read September 1st to 7th, 1887.

1. Address by the President.
2. *Prof. W. Boyd Dawkins.*—On the Geography of the British Isles in the Carboniferous Period.
3. *Prof. W. Boyd Dawkins.*—On the Structure of the Millstone Grit of the Pennine Chain.
4. *Mark Stirrup.*—Foreign Boulders from Coal Seams.
5. *Dr. G. J. Hinde.*—On the Organic Origin of the Chert in the Carboniferous Limestone Series of Ireland, and its similarity to that in the corresponding strata of North Wales and Yorkshire.
6. *Robert Law and James Horsfall.*—On the Discovery of Carboniferous Fossils in a Conglomerate at Moughton Fell, near Settle, Yorkshire.
7. *Dr. H. Crosskey.*—Report on the Erratic Blocks of England, Wales, and Ireland.
8. *Prof. E. Hull.*—Note on a few of the many remarkable Boulder Stones to be found along the Eastern Margin of the Wicklow Mountains.
9. *Prof. H. Carvill Lewis.*—The Terminal Moraines of the great Glaciers of England.
10. *Prof. H. C. Lewis.*—On some important Extra-Morainic Lakes in England, North America, and elsewhere, during the period of Maximum Glaciation; and on the Origin of Extra-Morainic Boulder Clay.
11. *Hugh Miller.*—A comparative study of the Boulder Clay in the Glaciated Districts of Europe—Britain, Norway, Switzerland, Low Germany, and the Pyrenees.
12. *Dr. H. Hicks.*—Report on the Cae Gwyn Cave, North Wales.
13. *J. W. Davis.*—On an Ancient Sea-Beach near Bridlington, containing Mammalian Remains.
14. *Dr. H. Woodward.*—On the Discovery of a Larval Cockroach, *Etoblattina Peachii* (H. Woodw.), from the Coal-Measures of Kilmaurs, Ayrshire.
15. *Dr. H. Woodward.*—On a new form of *Eurypterus* from the Lower Carboniferous Shales, Glencartholme, Eskdale, Scotland.

16. *Dr. H. Woodward.*—On a new Trilobite (*Conocoryphe*) from the Upper Green Slates, Penrhyn Quarry, near Bangor.
17. *Prof. T. Rupert Jones.*—Report on the Fossil Phyllopoda of the Palæozoic Rocks.
18. *Prof. H. G. Seeley.*—Evidence on the Mode of Development of the young of *Plesiosaurus*.
19. *Prof. H. G. Seeley.*—On the reputed Clavicles and Inter-Clavicles of *Iguanodon*.
20. *Prof. H. G. Seeley.*—On *Cumnoria*, an Iguanodont Genus founded on *Iguanodon Prestwichi*, Hulke.
21. *Prof. H. G. Seeley.*—The Classification of the Dinosauria.
22. *Prof. Vilanova.*—Sur la calcedoine enhydrique et la roche dans laquelle se trouve à Salto Oriental (Uruguay) avec exhibition de l'echantillon.
23. *Prof. W. Boyd Dawkins.*—On the Schists of the Isle of Man.
24. *Prof. G. A. Lebour.*—On Thinolite and Jarrowite.
25. *W. W. Watts.*—A Shropshire Picrite.
26. *Vaughan Cornish and Percy F. Kendall.*—On the Mineralogical Constitution of Calcareous Organisms.
27. *Sir J. William Dawson.*—On New Facts relating to *Eozoon Canadense*.
28. *Dr. T. Sterry Hunt.*—Gastaldi on Italian Geology and the Crystalline Rocks.
29. *Dr. T. Sterry Hunt.*—Elements of Primary Geology.
30. *Prof. T. G. Bonney.*—Preliminary Note on Traverses of the Western and of the Eastern Alps, made during the summer of 1887.
31. *J. E. Marr.*—Some effects of Pressure on the Sedimentary Rocks of North Devon.
32. *Prof. J. F. Blake.*—Report on the Microscopic Structure of the Older Rocks of Anglesea.
33. *Dr. C. Callaway.*—Notes on the Origin of the Older Archæan Rocks of Malvern and Anglesea.
34. *J. J. H. Teall.*—The Origin of Banded Gneisses.
35. *Howard Fox and Alex. Somervail.*—On the occurrence of Porphyritic Structure in some rocks of the Lizard district.
36. *Prof. W. J. Sollas.*—Some Preliminary Observations on the Geology of Wicklow and Wexford.
37. *G. H. Kinahan.*—On Archæan Rocks.
38. *W. Pengelly.*—Recent Researches in Bench Cavern, Brixham, Devon.
39. *Prof. J. W. Judd.*—The Natural History of Lavas, as illustrated by the materials ejected from Krakatoa.
40. *Dr. H. J. Johnstone-Lavis.*—Report on the Volcanic Phenomena of Vesuvius and its neighbourhood.
41. *Prof. J. Milne.*—Report on the Volcanic Phenomena of Japan.
42. *Dr. T. Sterry Hunt and James Douglas.*—The Sonora Earthquake of May 3, 1887.
43. *Thos. Ward.*—The History and Cause of the Subsidences at Northwich and its neighbourhood in the Salt Districts of Cheshire.

44. *Prof. J. H. Panton.*—Places of Geological Interest on the Banks of the Saskatchewan.
45. *Rev. E. Hill.*—The Disaster at Zug, on July 5, 1887.
46. *Dr. A. Fritsch.*—On the Permian Fauna of Bohemia.
47. *Prof. W. C. Williamson.*—Report on the Carboniferous Flora of Halifax.
48. *A. Smith Woodward.*—On the Affinities of the so-called Torpedo (*Cyclobatis*, Egerton) from the Cretaceous of Mount Lebanon.
49. *Prof. J. F. Blake.*—Description of a New Star Fish from the Yorkshire Lias.
50. *C. E. De Rance.*—Report on the Underground Waters in the Permeable Formations of England.
51. *Prof. Vilanova.*—Notice du *Dinotherium,* deux especes, trouvées en Espagne.
52. *A. H. Foord.*—On the Genus *Piloceras,* Salter, as elucidated by examples lately discovered in N. America, and in Scotland.
53. *J. S. Gardner.*—Report on the Fossil Plants of the Tertiary and Secondary Beds of the United Kingdom.
54. *A. Bell.*—Report on the "Manure" Gravels of Wexford.
55. *R. G. Bell.*—The Pliocene Beds of St. Erth, Cornwall.
56. *J. S. Gardner.*—Report on the Higher Eocene Beds of the Isle of Wight.
57. *W. A. E. Ussher.*—The Triassic Rocks of West Somerset.
58. *W. A. E. Ussher.*—The Devonian Rocks of West Somerset on the Borders of the Trias.
59. *Prof. H. Carvill Lewis.*—The Matrix of the Diamond.
60. *Prof. T. G. Bonney.*—Observations on the Rounding of Pebbles by Alpine Rivers, with a Note on their Bearing upon the Origin of the Bunter Conglomerate.
61. *Prof. W. Boyd Dawkins.*—The Present State of the Channel Tunnel, and the Boring at Shakespeare's Cliff, near Dover.
62. *Prof. Otto Torell.*—On the Extension of the Scandinavian Ice to Eastern England in the Glacial period.
63. *Prof. H. Carvill Lewis.*—On the Terminal Moraine of the Irish-Sea Glacier, near Manchester.
64. *E. P. Quinn.*—Upon a Simple Method of Projecting Microscopic Rock Sections upon the Screen, both by ordinary and by polarized light.

### List of Papers bearing upon Geology read in other Sections.

### SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

*Prof. E. Hull.*—On the Effect of Continental Lands in Altering the Level of Adjoining Oceans.

*H. C. Russell.*—On some Variations in the Level of the Water in Lake George, New South Wales.

*E. Douglas Archibald.*—The Direction of the Upper Currents over the Equator in connexion with the Krakatoa Smoke-Stream.

### SECTION B.—CHEMICAL SCIENCE.

*F. W. Clarke.*—The Chemical Structure of Natural Silicates.

### SECTION D.—BIOLOGY.

Discussion on the arrangement of Museums (in conjunction with Section C), Opened by Dr. H. Woodward, F.R.S., F.G.S.

### SECTION E.—GEOGRAPHY.

*W. Brindley.*—A Visit to the Porphyry Quarries of Gebel Dukhan.

Second Report of a Committee for inquiring into the depth of the permanently frozen soil in the Polar Regions.

*Prof. Boyd Dawkins.*—The beginning of the Geography of Great Britain.

*G. Skelton Streeter.*—The Ruby Mines of Burma.

*Josiah Pierce, jun.*—On the United States Geographical and Geological Survey.

### SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

*W. Topley.*—On the Future Production of the Precious Metals (at a Joint Meeting with Section C).

### SECTION G.—MECHANICAL SCIENCE.

*Jeremiah Head.*—The Iron Mines of Bilbao.

*F. Ransome.*—Portland Cement Manufacture.

*T. A. Walker.*—Severn Tunnel.

### SECTION H.—ANTHROPOLOGY.

*Sydney B. J. Skertchly.*—On the Occurrence of Stone Mortars in the Ancient (Pliocene?) River Gravels of Butte County, California.

Report of the Committee on the Pre-historic Inhabitants of the British Isles.

*Dr. Henry Hicks.*—The Migrations of Pre-glacial Man.

*Dr. H. Colley Marsh.*—The Early Neolithic Floor of East Lancashire.

*W. Pengelly.*—On Recent Researches in Bench Cavern, Brixham, Devon.

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Papers Read at the Meeting of the British Association, Manchester, in Section (C), Geology.

## II.—THE PLIOCENE BEDS OF ST. ERTH, CORNWALL. By ROBERT GEORGE BELL, F.G.S.

SINCE the publication of the paper read before the Geological Society of London in February, 1886, a good deal of work relating to the geological surroundings and to the special fauna of the deposit has been undertaken. Considerable excavations were made, and much examination given to the sands and clays, with the result that the section given on p. 202, "Quarterly Journal of Geological Society," for May, 1886, was completely verified.

The clay deposit is not, however, uniformly fossiliferous, nor is it uniform in the distribution of its fossil contents as a rule. *Cerithia* are found in great numbers at the base of the blue clay, while the larger *Nassæ* and *Turritellæ* are generally distributed in that bed. A great feature of interest is the large number of the smaller species of mollusca, especially of Gasteropods, which embrace more than three-fourths of the total amount.

Of these small shells the genera *Rissoa* and *Odostomia* are the most plentiful, in species and numbers; about twenty species of the former (including the Hydrobias) and eighteen of the latter genus are present, some being living inhabitants of the British and Mediterranean seas, while others appear new to science, and will have to be described. The *Trochi* are nearly all extinct, three only being Crag and living forms. Of *Nassa* about eight species are present, *Nassa serrata* being by far the most common, and is nearly identical with the general form of *Nassa reticosa*, Sowerby, so plentiful in the coprolite pits of the Boyton district in Suffolk; there are also other well-known Crag species of this family.

The carnivorous Gasteropods are, however, not otherwise plentiful; one should be noticed, a large fragment of *Buccinum undatum*, but no traces of *Fusus antiquus* or *F. gracilis*; all the *Pleurotomas* are scarce except *P. brachystoma*, and there are two species of *Pisania* or *Lachesis*; all these last are southern forms.

Of the bivalves not much can be said; few species were obtained, and these mostly in a fragmentary condition. It is still a difficulty to afford an adequate explanation of this fact, for while the deposit of clay is so well calculated to preserve the shells, as shown by the perfect state of the univalves, the bivalves (if we except the oysters and some minute species) have universally suffered. Some explanation other than that of the physical character of the deposit must be sought for, and none has yet appeared sufficiently satisfying.

The opinion expressed in the earlier reports upon this deposit, as to the southern facies of its fauna, has been amply justified by fresh researches; a large quantity of the fossiliferous clay has been carefully washed and examined, and no trace of northern forms, except *Buccinum undatum*, and the two small species noticed in the paper previously referred to, has been found, while greatly increased evidence confirming what has been already said is present. Had there been any connection with northern seas or colder waters, it would be difficult to understand the entire absence of those forms of *Pleurotoma* (*Bela*) so abundant in the Boreal seas of the Crag period and the present age, as well as the equally characteristic bivalves, *Astarte* and *Cyprina*.

Some conflict of opinion exists upon the depth of water in which the St. Erth clays were deposited.

In a letter to "Nature," of August 12, 1886, a very competent authority on Pliocene phenomena, Mr. Clement Reid, F.G.S., gave it as at least forty or fifty fathoms, founding his view on the evident fact of its deposition in still water, which he maintains could not be found in a district exposed to Atlantic swells at less depth. To this the writer must take serious exception. Undoubtedly the clays exhibit an entire absence of such a disturbing cause as the influence of great wave action, but it remains to be proved that such a great depression as Mr. Reid describes did occur at the western end of Cornwall, and as far as I have been able to observe there is little indication of such a fact. Some depression, of course, must have happened, sufficient to submerge the low-lying land near St. Erth, causing a strait or gulf, dividing the Land's End from the main eastern portion of the county.

In this shallow strait the clays and sands were deposited, and just such an assemblage of mollusca is found as will bear out this view. Scarcely any of the shells which are of living species are known to inhabit such deep water as Mr. Reid indicates, while the majority show the presence of a laminarian zone, extending to not more than fifteen fathoms. This bathymetrical range is the chosen habitat of the *Rissoæ*, who are all vegetable feeders, and of the *Nassæ*, which are predatory and always plentiful just below low-water mark; and what appears still more conclusive is the number of *Hydrobiæ*, which have a close connection with *Littorina* and indicate shallow depth and close proximity to shore.

It is hoped that a more detailed examination of the mullusca fauna may soon be completed, and the whole series added to the National Collection.

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## III.—PRELIMINARY NOTE ON TRAVERSES OF THE WESTERN AND OF THE EASTERN ALPS MADE DURING THE SUMMER OF 1887. By Prof. T. G. BONNEY, D.Sc., LL.D., F.R.S., F.G.S.

THE first traverse was made along the line of the Romanche from near Grenoble to the Col du Lautaret, and thence by Briançon over the Mont Genèvre and the Col de Sestrières to Pinerolo at the edge of the Italian plain. The second went from Lienz, across the central range of the Tyrol to Kitzbühel, and the rocks of this range were also investigated at other places, During both traverses the author had the advantage of the assistance of the Rev. E. Hill, who had accompanied him on a similar journey in 1885.

The results of their examination fully confirm the views already expressed by the author as to the nature and succession of the crystalline rocks of the Alps.

(1.) The lowest group consists partly of modified igneous rocks (which indeed occur at all horizons), partly of gneisses of a very ancient (Laurentian) aspect.

(2.) The next group, up to which there seems a gradual passage, consists mainly of more friable gneisses and moderately coarse mica-schists (Lepontine type). This group is commonly less fully developed in the above districts than in the Central Alps, having probably been removed by very ancient denudation.

(3.) The third group has an enormous development. It forms a large part of the Cottian and Graian Alps, and it flanks the central axis of the Eastern Alps on both sides, often passing beneath the ranges of Secondary strata, which here form the northern and southern ranges. It has been traced almost without interruption from east to west for more than fifty miles on the southern, and eighty on the northern side of the central range. It has a very close resemblance in all respects to the uppermost group of schists in the Central Alps, found to some extent in the Lepontine and yet more largely in the Pennine Alps, and the author fully agrees with the Swiss and Austrian geologists in regarding it as in the main a prolongation of the same series. It is characterized especially by rather dark-coloured mica-schists, often calcareous, sometimes passing into fine-grained crystalline limestones, with occasional intercalated chloritic schists, especially in the lowest part, and with (rarely) quartz schists.

(4.) The Carboniferous and Secondary strata infolded or overlying in the Western Alps section, and the Palæozoic (? Silurian) and Secondary strata succeeding the metamorphic rocks in the Eastern Alps, are comparatively little altered, and are each readily to be distinguished from the above.

(5.) The succession of strata in the third group is inexplicable, unless it be due to stratification; in the second this explanation appears highly probable, and in the first not more difficult than any other.

(6.) As groups of rocks with marked lithological characters occur in like succession over a mountain chain measuring above 400 miles along the curve, and sometimes at distances of 40 miles across it; as these groups correspond with rocks recognized as Archæan elsewhere, which exhibit like characters and sometimes a like order of succession, the author thinks a classification of the Archæan rocks by their lithological characters (using the phrase in a wide sense), may ultimately prove to be possible.

(7.) The views already expressed by the author as to the distinctness of cleavage-foliation and stratification-foliation have been fully confirmed by the examination of the above districts. He believes that the failure to recognize this distinction is the cause of the contradictory statements with regard to the relation of foliation and bedding which have been made by so many excellent observers, and lies at the root of much of the confusion which exists on the subject of the so-called metamorphic rocks.

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## IV.—SECOND REPORT OF THE COMMITTEE, CONSISTING OF PROFESSOR T. McK. HUGHES, DR. H. HICKS, DR. H. WOODWARD, AND MESSRS. E. B. LUXMOORE, P. P. PENNANT, EDWIN MORGAN, AND G. H. MORTON, APPOINTED FOR THE PURPOSE OF EXPLORING THE CAE GWYN CAVE, NORTH WALES. DRAWN UP BY DR. H. HICKS, SECRETARY.

THE main object that the Committee had in view this year was to extend the excavation which had been made in front of the new entrance to the cavern, discovered last year, so that a clear section of the deposits which covered that entrance might be exposed.

Work was commenced on June 6, and continued to the 18th, when it was decided that sufficient excavation had been made, and work was for the time suspended. It was deemed advisable to postpone the shoring up of the sides and any filling in that may be required until August, so that an opportunity may be given to any one interested in the exploration to examine the section exposed. The excavation was visited daily by some members of the Committee, and all, excepting Dr. H. Woodward, were able to be present on several occasions. The section has also been examined by Prof. Boyd Dawkins, F.R.S., Messrs. C. E. De Rance, F.G.S., R. H. Tiddeman, F.G.S., Clement Reid, F.G.S., A. O. Walker, F.L.S., H. C. Beasley, and others.

It was found necessary to remove much of the timber placed last year to support the face in front of the entrance, so that the section might be clearly exposed, and the cutting was widened here sufficiently to show a vertical face of undisturbed deposits. The timber supporting the north-east face of the cutting was allowed to remain, as that portion had been well exposed last year, and it was thought that the excavation in front and to the south-west would yield all necessary evidence without incurring that additional trouble and expense. The cutting was carried in a south-south-west direction from the mouth of the cavern, and beyond the dip in the field supposed to indicate the line of an old fence; the length from the timber on the north-east face to the commencement of the dip in the field being about 30 feet and the width varying from 5 to 10 feet; the narrowest part being at the furthest point from the cavern. In the face exposed in front of the entrance, and for a distance in the cutting from there of about 25 feet, the soil varied in depth from 18 inches to 2 feet, but at the slope supposed to indicate the line of the old fence it thickened considerably. Underlying this throughout the whole length of the cutting and in the field beyond this point, a boulder clay of reddish-brown colour was exposed. This boulder-clay contained thin seams of sand, which were traceable generally at the same horizon along the whole section.

At a depth of about 7 feet from the surface, in a continuous band of reddish sandy clay, numerous fragments of marine shells and some perfect ones were met with, and these have been recognized by Mrs. McKenny Hughes to belong to the following species, viz. *Ostrea sp., Mytilus sp., Nucula nucleus, Cardium echinatum, C. edule, Cyprina islandica, Astarte borealis, Artemis exoleta, Venus gallina? Tellina balthica, Psammobia ferröensis, Donax? Mya truncata, Littorina sp., Turritella terebra, Buccinum undatum.* Below the boulder-clay at a depth of about 9 feet from the surface, there was exposed some sandy gravel and fine banded sand with a total thickness of over 6 feet, and under the latter a well-defined band of finely laminated reddish clay.

Below the laminated clay the brecciated bone earth was found to extend as far as the cutting was made in front of the entrance, and also for a distance of 7 feet in a southerly direction from the entrance. This year only a few fragments of bone and bits of stalagmite were obtained from this earth, though it will be remembered that last year it yielded many teeth as well as the flint flake which was discovered near the entrance. The limestone floor under the bone earth was found to rise gradually outwards from the mouth of the cavern for some distance, forming a shallow basin-shaped space in front of the entrance. In the bone earth in this space there were several large angular blocks of limestone.

It was not thought necessary to dig down to the floor along the whole length of the cutting, but it was traced for 7 feet in that direction by the side of the cliff against which the deposits abutted. Beyond that point the cutting was made deep enough to reach the sandy gravel under the boulder-clay, and at different parts test-holes were sunk still deeper into the gravel and sand. One hole was also sunk in the field in front of the cutting at a distance of over 35 feet from the entrance to the cavern. The deposits here were found to be similar to those in the cutting and in front of the cavern, but the depth of the soil over the boulder-clay was only from one foot to 18 inches. A very large number of smoothed and ice-scratched boulders were found, many of considerable size; the majority being fragments of Wenlock shale from the neighbourhood, and Lower Silurian rocks from the Snowdonian area. Amongst them also were fragments of granite, gneiss, quartzites, flint, diorites, basalts, Carboniferous rocks, etc.

## V.—THE DISASTER AT ZUG ON JULY 5, 1887. BY THE REV. E. HILL, M.A., F.G.S., OF ST. JOHN'S COLLEGE, CAMBRIDGE.

ON July 5, 1887, at the town of Zug, in Switzerland, a portion of the shore gave way and sank into the lake. About three hours later another much larger adjacent area also suddenly subsided, so that in all an area considerably over two acres, with half of one of the principal streets, was submerged to a depth of about 20 feet. It can be seen that the subsoil consists of coarse gravel and sand, followed after a few feet by soft wet sand and fine mud. According to Professor Heim, this fine mud or sludge reaches to a depth of nearly 200 feet, and the disaster is shown to be due to a flowing out into the lake of this mobile sludge from under the superincumbent weight of buildings and firmer ground. The buildings collapsed as they sank. The catastrophe must have been long impending; the exact cause which precipitated it is indeterminate, but a low level of the lake and tremors from pile-driving for new quays are suggested as contributories. On the English coast the incessant changes of pressure from tides probably render impossible such instability of equilibrium.

## REVIEWS.

### THE MAMMOTH AND THE FLOOD. AN ATTEMPT TO CONFRONT THE THEORY OF UNIFORMITY WITH THE FACTS OF RECENT GEOLOGY. By HENRY H. HOWORTH, M.P., F.S.A., M.R.A.S. 8vo. pp. xxxii. 464. (London, 1887, Sampson Low, Marston, Searle, and Rivington.)

THE desire to find harmony between the Geological record and the first chapter of Genesis, laudable enough when Science was in its infancy, has ceased now-a-days to cause much anxiety. Geological chronology, like human history, can only be separated into epochs that are marked by local breaks or "landmarks" in the continuity of events; so that no system of subdivision that applies to one tract of the earth's surface will be equally applicable in all countries.

Even when such terms as Silurian, Jurassic, and Cretaceous are employed in all quarters of the globe, it must not be inferred that the periods embraced can be limited in the same way as they are in this country. With the later epochs of Pleistocene and Recent, it is possible, however, to speak more confidently, though in a general way, of contemporaneous forms of life.

Mr. Howorth candidly dismisses the first chapter of Genesis as "absolutely valueless in geological discussion"; but, granting this to be the case, he adds, "there is no reason whatever why subsequent chapters which profess to report, not how things arose before man appeared, but the traditions of man himself, should be discarded." Thus approaching his subject, the author continues, "To speak more definitely, the Flood, as reported in the Bible, is undoubtedly a very old tradition, it is in correspondence with similar traditions among widely separated peoples, *between whom there has been no intercourse, so far as we know*, at least since the first dawn of history. These traditions generally agree in placing a great catastrophe, involving widespread destruction to animal life, at the verge of human memory. Such widespread and continuous traditions need explanation." At the outset we are disposed to question the value of the traditional evidence, so far as it suggests "a deluge apparently unparalleled in extent and completeness in any other geological period"; for the words we have placed in *italics* indicate a flaw in that evidence, as the ideas held by the various peoples may have been transmitted from one independent source, and not have originated simultaneously all the world over. Be this as it may, the main object of the work before us is to bring forward facts to prove that a very great cataclysm or catastrophe occurred at the close of the Mammoth period, by which that animal with its companions, were overwhelmed over a very large part of the Earth's surface; that this catastrophe constitutes the gap which is almost universally admitted to exist in Northern Europe between so-called Palæolithic and Neolithic man; and that while this flood was exceedingly widespread, considerable areas escaped, and from these insular areas man, animals, and plants spread out again and reoccupied those districts which had been desolated.

We may pass over those portions of the work that deal with the etymology of the word Mammoth and its identity with Behemoth; or that review the old records of fabulous beasts and giants, based on the discoveries of huge bones. These accounts, together with the speculations on the origin of the bones, furnish a good deal of interesting matter.

The author is evidently quite "at home" with "the Mammoth in Siberia," and he gives full and instructive accounts of the discoveries of bones and frozen carcases ("Mammoth Mummies"); of the trade in fossil ivory; and of the physical features of the land. The larger portion of Northern Siberia, as is well known, consists of flat tracts, known as *tundras*, upon which few if any trees will grow. The areas are covered with moss, and they are swept by icy winds. The ground is in parts frozen to a depth estimated at 630 feet, although in the summer season it may be thawed to a depth of three feet. In several cases Mammoth carcases have been found standing upright in the ground, as if they had sunk down and been frozen in that position; in other cases remains of various animals are commingled in the frozen soil and must have been drifted some distance, before being embedded in the black earth, sand, or icy clay. There is evidence also of much drift wood, as well as of large tree-stems, to indicate that the climate formerly was more favourable to vegetation than it now is. The animals represented by the frozen carcases, must have been overwhelmed and have been rapidly enveloped in mud and gravel, and the ground must have become frozen, and remained so until the present day. There appears no escape from this conclusion, though it is difficult to say in what way the animals were overwhelmed and how long they have been embedded. As Mr. Howorth remarks, no Russian naturalist holds the view that the Mammoth lived on to Recent times in Siberia.

The facts pointed out by our author are opposed to the view that the Mammoth and other animals were, as a rule, drifted far from the south, for the remains are found not only on the banks of the long rivers, but also abundantly on the borders of the very short ones, and in nearly all parts of the tundra. Mr. Howorth concludes that the Mammoth and his companions lived for the most part where their remains occur in northern as well as in southern Siberia, but under different climatal conditions. He says (p. 96), "We cannot postulate a separate climatic cataclysm for each individual case and each individual locality, but we are forced to the conclusion that the now permanently frozen zone in Asia became frozen at the same time from the same causes." While we feel with the author that diluvial agents may reasonably be inferred in order to account for the remarkable entombment of many organic remains, yet we are not prepared to go so far as he does, and to regard the phenomena generally as "the result of one of Nature's hecatombs on a grand and wide-spread scale, when a vast fauna perished simultaneously."

The fact is, our author would lead us all round the world, and taking the Pleistocene fauna, which we admit in a general way to be contemporaneous, he would have us believe that the bulk of the animal remains were smothered up at one time in "the Great Flood." Not only were the remains of Mammoth and Rhinoceros found in brickearth and gravel and in Cave-earth, over the north of Europe, entombed by this cataclysm; but the bulk of the Pleistocene remains in North and South America, in Australia, Tasmania, and New Zealand were covered up at one and the same time! In other words the Mastodon and Elephant, the *Megatherium*, the *Diprotodon* and *Nototherium*, and the Moa also, perished in one general catastrophe!

The author bases his views partly on the general mode of occurrence of the fossil animal remains, their abundance in certain places, and the commingling of various genera; but as he observes the present volume only deals with one-half of the problem, namely, that illustrated by palæontology and archæology. In interpreting this or any other geological record, the stratigraphical evidence is of the highest importance, but that is not now put before us, the author hoping to treat the geological side of the case fully and completely in a subsequent volume, when he will discuss the cause of the catastrophe and its extent. In the meantime he observes that "This vast effort seems from inexorable evidence to have been due to the exertion of some cataclysmic force by which the Earth's crust was greatly disturbed, not merely locally, but over a large part of its surface. It was in consequence of this dislocation that the loose watery envelope which covers a large portion of the world was set in motion, and sweeping over the land drowned and then buried deep in gravel, loam and clay, hecatombs of living beings."

All this is of course very vague and hypothetical. The relations of the Mammoth and its companions to the Glacial period form an exceedingly important subject, but the questions that Mr. Howorth raises concerning them cannot be discussed until his second volume comes to light. He however so far anticipates himself as to speak of the Mammoth age as the true Glacial epoch, and to remark that he is "completely opposed to the extreme views urged in recent years by Agassiz, Croll, James Geikie," and others, whose views he regards as a "glacial nightmare."

Nevertheless, whatever opinions be held with regard to the relative influence of land-ice, coast-ice, and icebergs, there can be no reasonable doubt that all agents have acted a part in the history of the Glacial period. Moreover, that epoch must have lasted thousands of years. The records of tumultuous deposits are interwoven with those of quiescent deposits, and in a broad and general—we might say *poetic*—way it would not be very rash to speak of this period as Catastrophic. Compared with what is now going on in this country, no doubt the Glacial period was decidedly catastrophic, and we feel convinced that excessive denudation and deposition must have taken place far and wide over the surface of our land. Indeed, we believe with Mr. Howorth, that the Glacial period coincides generally with that of Palæolithic man; and it is not unreasonable to suppose, as Mr. Tiddeman has suggested, that extensive floods in those days gave rise to the tradition of a Universal Deluge. More than this we are not prepared to admit, nor can we agree with the author when he says that "over much the largest portion of the earth's surface which is covered and protected by herbage or forest, denudation is not going on at all, but on the contrary *humus* is being deposited in a more or less slow fashion." This is a very misleading statement, inasmuch as the author entirely neglects the effects of subterranean denudation: for we need only point to the solid matter carried away in solution and suspension by springs and rivers, much of which sedimentary matter is derived from lands covered and protected by herbage. There can be no doubt that the level of the land is in places gradually lowered without the general surface contour being visibly affected.

Another point on which the author places considerable stress, is that remains of animals are not now-a-days preserved to the extent they were during "the Great Flood." The facts that "in Spitzbergen it is easier to find vertebræ of a gigantic Lizard of the Trias than bones of a self-dead Seal, Walrus, or Bird," or that in the forests of Ceylon remains of Elephant are rarely if ever found, simply show that conditions for the preservation of the bones did not locally exist. At Lyme Regis it would be easier to find Saurian remains in the Lias, than Mammoth bones in the old gravels of the neighbouring valleys, or than remains of Bear, Wolf, and species of animals still existing, in the more recent Alluvial deposits. We should be surprised rather than otherwise to find bones preserved on the surface "in subaerial layers," excepting those bones which have been buried, and it is far from strange "that the plough, in cutting through virgin soil," seldom meets with them. Throughout the history of all our stratified rocks fossils are more abundant at particular spots even in the same stratum, just as we find recent shells abundantly on our beaches at some localities, while they are absent at others. Mr. Howorth might visit many a section in our older Thames Valley deposits and return home without any osteological reward; and he might meet with similar experience in searching for bones in the Norwich Crag, or even in the Cromer Forest Bed.

In other instances bones are locally very abundant, and sometimes represent animals in various stages of growth. This again is quite natural, for land-animals that die of old age would, as a rule, perish in situations where their bones would not be preserved. We are, however, quite disposed to agree with the author when he maintains that "The occurrence of immense caches in which the remains of many species of wild animals are incongruously mixed together pell-mell, often on high ground, seems unaccountable, save on the theory that they were driven to take shelter together on some point of vantage, in view of an advancing flood of water, a position which is paralleled by the great floods which occur occasionally in the tropics, where we find the tiger and its victims all collecting together on some dry place, and reduced to a common condition of timidity and helplessness by a flood which has overwhelmed the flat country."

Most of the Pleistocene Mammalia found in this country have been obtained in deposits that occur in caverns or in the drainage areas of modern rivers; and we dispute the statement, that in many places in this country, "we find the caches of bones in positions entirely out of the reach of any possible rivers or river-floods." Nor is it generally the case that the beds in which Palæolithic implements occur are found in situations where no river flows, and where no river that we can postulate as possible ever could have flowed.

These dogmatic statements are certainly inconsistent with the general tenor of the author's remarks, and we hope in his second volume he will not be led to quote exceptional and disputed cases in support of his particular views.

From the facts brought before us in this volume, we cannot discern any immediate connection between the accumulations formed by the direct agency of ice, such as the widespread deposits of Boulder-clay and the entombment of the various Pleistocene mammalia. And this view is in concord with Mr. Howorth's statement (p. 100) that "Speaking roughly, remains of the Mammoth are absent or exceedingly scarce in the area bounded on the east by Lakes Onega and Ladoga, an area where the Boulder-drift prevails." That floods of considerable magnitude may have taken place, again and again during the Glacial period, is more than likely; but the stratigraphical and physical evidence in support of the Great Flood, as pictured by Mr. Howorth, has yet to be made known.

Mr. Howorth has given lists of the Pleistocene Mammalia from various parts of the world, a task which we can readily admit has given him a great deal of patient labour. Nor was his task at all lightened by the uncouth names so profusely applied to the genera and species. On this subject he seeks to comfort his troubled mind by remarking, "Surely we are nearing a time when the man who coins a new species without abundant excuse will be deemed a scientific criminal, and when the ambition to flood text-books with lists of names of one's own invention will cease to be called science, and be treated as mere child's play."

In addition to the Mammalia, other organic remains, including the Plants of Pleistocene times, are more or less fully recorded.

The author loses no opportunities of entering and repeating his protests against "the creed of English Uniformitarians." In this respect he is not alone, we think, in somewhat needlessly spending a good deal of energy; his views, after all, as he points out, coincide with those advanced by Prof. Huxley more than eighteen years ago in an address to the Geological Society of London. Moreover, the elementary facts to which Mr. Howorth alludes (p. xv), such as the sudden creation and rapid disappearance of the submarine island near Santorin, are clearly not opposed to the teachings enunciated by Lyell, and they do not "strain the theory of Uniformity to the breaking point." Geologists do not argue "that the present forces which are busy with the Earth's crust are the measure of what they have always been," but they do hesitate to introduce "abnormal" causes, or tools that are not known to exist in Nature's workshop, to explain phenomena that can be accounted for by known agents.

Notwithstanding our objections to the very sweeping conclusions drawn by Mr. Howorth, his work will be of great value as a storehouse of facts on the fauna and flora of Pleistocene times. The book is well printed on thick paper and neatly bound. Its value, however, as a work of reference is seriously damaged by the lack of an index: but perhaps the author can remedy this when he brings out his second volume.

## CORRESPONDENCE.

### NAMES OF BONES REVISED.

Sir,—In "The Ornithosauria," 1870, pl. xii. figs. 12, 13, I gave two views of a fragment of bone, which is described as follows: "Undetermined [? pterygoid end of palatine bone]." This fragment I now know to be the radial crest of an Ornithosaurian humerus.

In the Quarterly Journal of the Geological Society, 1877, vol. xxxii. p. 716, is an account of *Pliosaurus Evansi.* A bone in that paper, which is described and figured as a left ischium (pp. 721–3, figs. 7–9) is the left coracoid.

In the Geological Magazine, February, 1887, p. 84, the humerus of *Pelorosaurus* is referred to *Cetiosaurus*. I had previously, in the Quarterly Journal of the Geological Society, 1882, vol. xxxviii. p. 371, regarded the same bone as referable to *Ornithopsis*, and to that determination I adhere. *Cetiosaurus* is well known to be allied to *Ornithopsis*, but I am aware of no evidence of the presence of *Cetiosaurus* in the Wealden deposits, in which the type is represented by species of *Ornithopsis*. H. G. Seeley.

*24th August*, 1887.

## PARALLEL STRUCTURE IN IGNEOUS ROCKS.

Sir,—I am obliged to Mr. Harker for the information given in his letter in your August Number. I do not see the American Journal of Science, and was not aware that Prof. Dana had partially modified his views, or that Mr. G. H. Williams had by observations on the ground come to the conclusion that the igneous rocks of Cortland were sharply separable from the adjacent crystalline schists. It need hardly be pointed out that this coincidence of opinion between Mr. Williams and myself is of considerable evidential value. Ch. Callaway.

Wellington, Shropshire, *September 17th*, 1887.

## OBITUARY.

### EDWIN WITCHELL, F.G.S.,

Treasurer of the Cotteswold Naturalists' Field Club.

It is with deep regret that we have to announce the sudden death, on the 20th August last, of Mr. Edwin Witchell, solicitor, of Stroud, at the age of sixty-four. Mr. Witchell was a son of Mr. Edward Witchell, of Nymphsfield, a well-known and highly-respected yeoman, and was born in June, 1823. His tastes from early boyhood led him more to the study of books than to the cultivation of the soil; at the early age of thirteen years he was placed in the office of Mr. Paris, of Stroud, the chief local solicitor of those days. Later on he was articled to that gentleman, and ultimately succeeded to his practice in 1847. He was at one time very fond of hunting, and used frequently to accompany the late Mr. Paul Hawkins Fisher in some of the most memorable runs of the adjacent packs of foxhounds. This exhilarating sport doubtless contributed to his then robust health; but as years crept on, Mr. Witchell gave up his hunter and applied himself assiduously to rambles in pursuit of his favourite science of Geology. About five years ago, when climbing in a dangerous part of the cliffs at Lyme Regis, heart trouble set in, and for three or four years he has suffered from angina pectoris, but had not been incapacitated from business, nor deterred from carrying on his geological work. And it was while engaged in collecting fossils from the Inferior Oolite at Swift's Hill, near Stroud, that Mr. Witchell overtaxed his strength, and fell amidst the rocks to which he had devoted so much study. In the neighbourhood of Stroud the loss will be long felt, for Mr. Witchell was much esteemed; a man of kindly, genial nature, he was essentially a peacemaker, and was never known to say a harsh or unkind word of any one.

Mr. Witchell no doubt owed his early love of geological study to his long association with the late Mr. George Poulett Scrope, for many years M.P. for Stroud. Mr. Witchell was for a long period the trusted agent and friend of Mr. Scrope. In 1861 he was elected a Fellow of the Geological Society, and had since contributed papers to its Quarterly Journal. The last of these, on "The Basement Beds of the Inferior Oolite of Gloucestershire," was read for him on the 24th of February last year, his health at that time rendering a journey to London undesirable. Mr. Witchell was for many years an active member of the Cotteswold Naturalists' Field Club, and contributed many valuable papers to its Proceedings. For several years he was treasurer to the Club, and this year was elected one of its vice-presidents. No geological discussion at the meetings of the Club was considered complete until Mr. Witchell had taken part in it, when his stores of geological knowledge would be given out with his characteristic enthusiasm and ability. His last contribution to the Cotteswold Proceedings, on the "Genus *Nerinæa*," appears in the part last issued, and was illustrated by his own hand with a series of beautiful and accurate drawings. Mr. Witchell took an active part in all matters pertaining to scientific education in Stroud, and helped to support the various institutions that succeeded the first Mechanics' Institution more than thirty-five years ago. He read papers, gave lectures, and not seldom took parties of members for Geological field-work on the neighbouring Cotteswolds. He was always most anxious to see a local museum formed in Stroud, and his own large and complete collection of local fossils was a great attraction to all geologists visiting the district. It will be remembered that last Whitsuntide the members of the Geologists' Association visited Stroud, when Mr. Witchell conducted them to Rodborough and Minchinhampton, an excursion which will long be a pleasant recollection to them. The following is a list of the principal papers contributed by Mr. Witchell to the Proceedings of the Cotteswold Club:

1. "Sections of the Lias and Sands exposed in the Sewage Works."
2. "A Deposit on Stroud Hill containing Flint Implements, Land and Freshwater Shells."
3. "On a Section of the Lias and Recent deposits in the Valley of the River Frome at Stroud."
4. "On the Denudation of the Cotteswolds."
5. "On a Bed of Fullers' Earth at Whiteshill, near Stroud."
6. "On the Angular Gravel of the Cotteswolds."
7. "On a Section of Stroud Hill, and the Upper Ragstone Beds of the Cotteswolds."
8. "On the Pisolite and Basement Beds of the Inferior Oolite of the Cotteswolds."
9. "On the Genus *Nerinæa* and its Stratigraphical Distribution in the Cotteswolds."

In 1882 Mr. Witchell published an excellent work on "The Geology of Stroud," which contains a large amount of original information; and at the time of his death he was collecting materials for the publication of another work.—*Stroud News*, Aug. 16, 1887.

E. C. Woodward del. et lith.
West, Newman & Co. imp.

Eurypterus scabrosus, H. Woodw., L. Carboniferous, Eskdale, Scotland.

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## ORIGINAL ARTICLES.

### I.—On a new Species of *Eurypterus* from the Lower Carboniferous Shales of Glencartholm, Eskdale, Scotland.

By Henry Woodward, LL.D., F.R.S.

(PLATE XIII.)

SOME time since, in the summer of 1884, Mr. Jex, a collector of fossils employed by Mr. Robert Damon, F.G.S., of Weymouth, obtained from the Lower Carboniferous Shales of Eskdale, a new and most interesting form of Merostomatous Crustacean belonging to the genus *Eurypterus*. It has been secured for the Geological Department of the British Museum (Natural History), and I now propose to submit a brief description of this very interesting specimen.

In my Monograph of the order Merostomata (Part IV. 1872, pp. 133—139, pls. xxv.—xxvii. see also p. 180) I described the only previously-known British *Eurypterus* from the Carboniferous Limestone series, Kirkton, near Bathgate, West Lothian, named *Eurypterus Scouleri*; a specimen doubtfully referred to the same having been since discovered at Cape Breton. Another species not determined was noticed by Salter from the Carboniferous of Nova Scotia. A form doubtfully referred to *E. Scouleri* from the Upper Devonian of Kiltorcan, Ireland, and one named by Salter *E. pulicaris* from the same horizon, St. John's, New Brunswick, and two from the Lower Devonian of Arbroath, namely *E. Brewsteri* and *E. pygmæus*, complete the Carboniferous and Devonian series.

But in the Upper Ludlow beds (U. Silurian) no fewer than 17 species have been described, 10 being from Russia and N. America, and seven from Ludlow, Kendal, and Lanarkshire; but the most perfectly preserved are those from New York and the Island of Oesel in the Baltic.

*Description of the Specimen.*—The specimen is preserved with its dorsal aspect exposed upon the surface of a much-jointed bluish-grey mudstone; owing to shrinkage and the want of tenacity between the matrix and the fossil, much of the black and glistening organic surface of the carapace and segments has been lost in transit. The counterpart however of a portion of the fossil is preserved, and assists us in the interpretation of the appendages, etc.

The head, which is semicircular in outline, is very tumid, and strongly and irregularly tuberculated; the general surface being coarsely squamose and scabrous. The eyes are not visible; but this I believe to be owing to an unfortunate series of fractures, which intersect the middle of the carapace just where in other specimens these organs are usually situated. There is a distinct and rather wide and smooth margin to the head-shield, which can be traced for about three-fourths of its circumference, but it is broken away upon the right side by the protruding appendages.

Three almost entire jointed appendages, furnished with numerous spines at their articulations and with smaller spinelets along their edges, are preserved *in situ* on the right side of the head. A portion of a fourth is seen on the right anterior border of the carapace; and portions of the corresponding limbs are shown on the left side of the head. The appendages where best preserved show six articulations, the 1st or coxal joint (making 7 articuli) being hidden beneath the carapace. The two body-segments which follow next after the head-shield are unusually large, being one-third as deep as they are broad, and very strongly squamose, the squamæ lying very close to one another and becoming more elongated near the margins of the segments; the posterior angles of each segment were slightly produced, the points being directed backwards. Portions of five other segments following the 1st and 2nd are seen in place on the right side of the specimen, three of which are also partly preserved on the left side.

These show that the 3rd, 4th, 5th, 6th, and 7th segments were much narrower than the preceding two, their depth being only one-seventh of their breadth; the surface-ornamentation too undergoes a considerable change, being sparingly covered with small irregular tubercles.

Scattered irregularly over the somites may be seen a number of small circular disc-like bodies, having a radiating fibrous structure, which I at first mistook for some small polyzoon or other minute sessile parasite, fixed to the surface of the Crustacean. A more careful investigation—in which Dr. G. J. Hinde was so kind as to give me his valuable assistance—showed me that these bodies were actually enclosed within the chitinous substance of the terga, and are in fact deposits of calcite forming part of the crust of the segments themselves.

Under the description of *Anthrapalæmon Parki* (Peach), from the Carboniferous series of Langholm, Dumfriesshire, Mr. B. N. Peach writes as follows[1]:—

"The test is very thin, and probably contained very little calcium carbonate, as it is apt to be filled with *calculi*,[2] such as that now found in the common shrimp. Where the test is thin these are mere scales; but in the spines and thickened portions they are semi-globular, the rounded part being mammilated. In every case, however, they have a central nucleus from which radiations proceed.

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[1] See Trans. Roy. Soc. Edinburgh, 1880, vol. xxx. pt. 1, p. 80; see pl. ix. figs. 4*g*, 4*h*.

[2] "Globular calcite." Prof. Huxley informs me that he has noticed this deposit as constantly present within the chitinous test of every *Palæmon* and *Crangon* which he has examined.—H. W.

The above remarks are equally applicable to all the Crustacea described in the present paper. Sometimes these calculi are sporadic, at other times they fill the whole tests of the creatures, forming an irregular polygonal net-work, which destroys the character of the test and gives it a granulated appearance. Even in this case the nucleus and radiations are observable." These calcareous deposits are most carefully figured by Mr. Peach in plate ix. of his memoir, figs. 4*g* and 4*h*. They agree exactly with those observed in the specimen of *Eurypterus* now under description.

In a detached piece, obtained with and forming a part of this same specimen, is preserved the left margin of four other body-segments which must have been parts of the 8th, 9th, 10th, and 11th segments, so that we only need evidence of the 12th segment and the telson to complete our knowledge of this specimen.

These posterior segments give clear evidence of becoming narrower and deeper as they recede from the head—the 9th being about five times as broad as deep; the 10th being about four and a half times as broad as deep; the 11th being about twice as broad as it is deep. There is the mould of a raised longitudinal subcentral ridge, one evidently of a pair of ridges no doubt present on each of the posterior body-segments as seen in *Eurypterus remipes* (De Kay) from North America.

The fifth pair of broad spatulate swimming-feet answering to the maxillæ, or to the maxillipeds of the higher Crustacea, are not preserved in this fossil; but as they have been found with nearly all the species of *Eurypterus* hitherto described, there is little doubt that this form also possessed them when entire. Certainly the other appendages reproduce with only slight modification in their style of ornamentation those of the Russian, the American, and the Lanarkshire *Eurypteri* already described and figured by Hall, Schmidt, and myself. Certain delicate brown leaf-like bodies can be observed lying on the left side of the head. There can be no question that these are the remains of the branchiæ, such as I have figured from Lanarkshire, and such as are frequently found lying detached on pieces of shale from Eskdale, and which have been considered by Mr. Peach to have belonged to some form of Arachnide?

Prof. Geikie indeed states that "Mr. Peach's researches go to show that the Carboniferous *Eurypterus* was almost certainly a gigantic Arachnid and not a Crustacean. Some splendid specimens of its scorpion-like combs and feet have been obtained from the Lower Carboniferous rocks of the South of Scotland" (Geikie's Text-Book of Geology, p. 724, Second Edition, p. 723.)

The scorpion-like combs I have not seen, but I cannot for a moment doubt that the feet of this specimen are those of a true Eurypterid, and although the pair of swimming-feet are not preserved, the form of the body-segments and their squamate ornamentation proves that this was a true aquatic form, and that the fragmentary leaf-organs lying beside it were remains of its branchial lamellæ.

Of course—if the *branchiated* aquatic forms of the Merostomata, are to be relegated to the same division as the terrestrial *tracheated* forms of the Arachnida, there is no need to offer any further evidence; but at present I deny, with other Carcinologists, that Professor Ray Lankester has proved his position, or that such an arrangement is consistent with sound zoological classification.

It is extremely interesting to record the fact that in 1881 Mr. J. F. Mansfeld communicated an account, with a woodcut, of a fine fossil *Eurypterus* found by him in the shale immediately beneath the Darlington Cannel Coal-bed, Lower Productive Coal Measures, Darlington, Pennsylvania, U.S.A. (See Amer. Phil. Soc. Proc. vol. xix. p. 152, April 1st, 1881.)

The figure I have seen, being only a sketch, and roughly executed —without scale—does not admit of accurate comparison; but so far as I am able to judge, this American *Eurypterus* must have been extremely closely related to our Eskdale species.

As it is convenient to have a name for a new form, I propose to designate this our second Scottish *Eurypterus* from the Carboniferous series as *E. scabrosus.*

*Dimensions of Specimen.*—Head $5\frac{3}{4}$ inches broad, by $4\frac{1}{2}$ inches in length. Length of body (including head to seventh segment) 10 inches, perfect appendage 8 inches in length, widest part at third segment of body $6\frac{1}{2}$ inches broad. Total length estimated at about 20 inches, including the telson.

### EXPLANATION OF PLATE XIII.

*Eurypterus scabrosus*, sp. nov.

Fig. 1. Larger slab containing the head with three of the gnathopodites in place on the right side; and the 1st to the 7th somites more or less perfectly preserved. Fragments of the branchial leaves (*br.*) are seen on the left side of the head. Prof. Huxley (who kindly looked at the original specimen) has suggested that the portion of an appendage, with a row of small tubercles along its border near the small figure 2, on the right side of the head, may possibly have been a part of a chelate appendage; but it is very obscure. Other fragments are seen on the left side of the head (near 5) similarly ornamented.

Fig. 2. A fragment of same specimen showing portions of the 8th to the 10th somites.

## II.—On the Origin of certain Banded Gneisses.

By J. J. H. Teall, M.A., F.G.S.

(PLATE XIV.)

THE term gneiss as generally used by geological writers signifies a rock of granitic composition in which a parallel structure in the arrangement of the constituents is more or less apparent. For our present purpose it is important to note that other plutonic rocks besides granite (*e.g.* diorite, gabbro, and peridotite) have their gneissose equivalents, so that, if we use the term gneiss in a structural rather than in a mineralogical sense, we may speak of diorite-gneiss, gabbro-gneiss, and so on.[1] Now the parallel structure of gneissose

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[1] Roth has recently (Sitz. d. k. preuss. Akad. d. Wissen. Ueber den Zobtenit, vol. xxxii. 1887, p. 611) proposed that Leopold von Buch's term Zobtenfels should be revived under the form Zobtenite for those gabbros which are associated with crystalline schists and are often foliated.

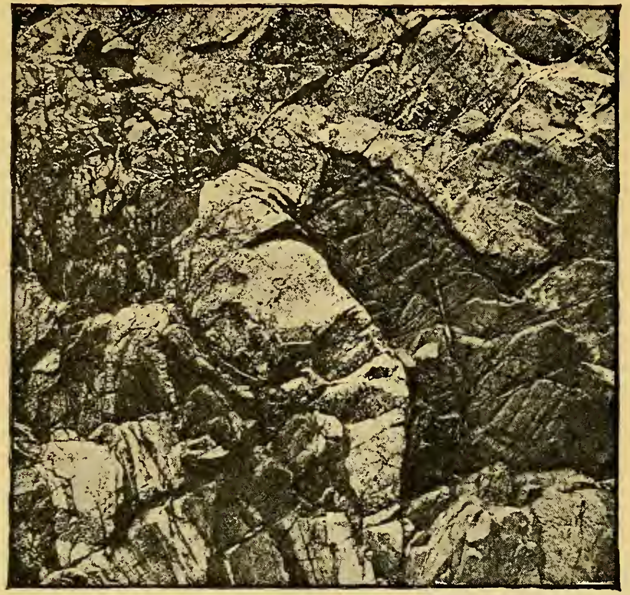

Fig. 1.—Granite veins in diorite, Pen Voose, the Lizard.

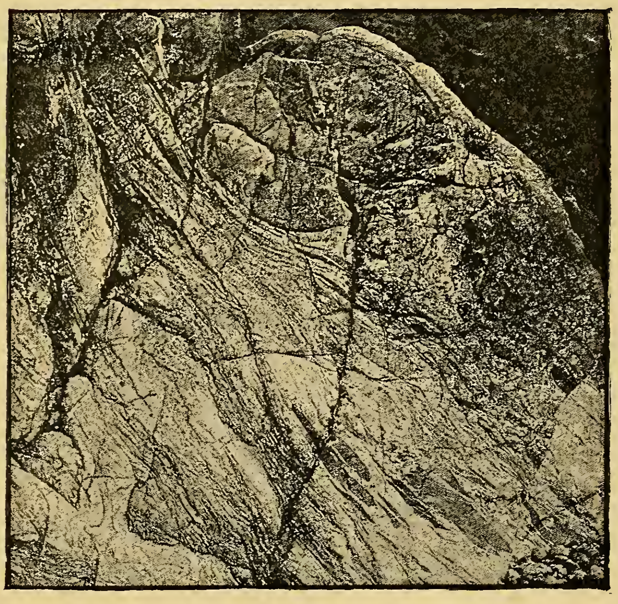

Fig. 2.—The "Granulitic Series," Pen Voose, the Lizard.

To illustrate Mr. J. J. H. Teall's paper on Banded Gneisses.

rocks is of two kinds. It may consist (1) of a parallel arrangement of certain constituents (*e.g.* mica plates or porphyritic felspars), or (2) of an alternation of bands of varying chemical and mineralogical composition. It is agreed on all hands that a parallel structure of the first kind may be due either to the deformation of a mass of half-consolidated plutonic rock at the time of intrusion, in which case it is strictly analogous to the flow structure in many volcanic rocks, or to deformation produced by earth-stresses operating on the mass after consolidation. As regards the origin of the second kind of parallel structure there is no such general agreement, and many writers regard it as due to some process akin to sedimentary deposition. The object of the present paper is to show that just as the first kind of parallel structure may be and in certain cases actually is due to the plastic deformation of what may be termed homogeneous[1] plutonic masses, so the second kind of parallel structure (banded structure) may be and in certain cases actually is due to the deformation of heterogeneous plutonic masses.

In the first place let us inquire what kind of deformation is necessary in order to produce parallel banding in a heterogeneous mass. A moment's consideration will show that if any heterogeneous mass of fairly uniform dimensions in the different directions be deformed into a flat sheet or narrow ribbon, then the individual portions will be similarly deformed and the mass as a whole will show a banded structure. This was clearly realized by Mr. Poulett-Scrope in 1824, who not only explained in this way the parallel banding of the Ponza liparites, but also suggested that the similar appearances in gneiss and schist might be due to the same cause.[2] A very simple experiment will serve to illustrate the important fact just referred to. Take pieces of differently coloured clays (say ordinary potter's clay and clay which has been intimately mixed with the blue used by laundresses); bring them together in any way you please so as to make one lump and deform the lump into a thin sheet or narrow band by squeezing or rolling. Then fold the sheet or ribbon on itself two or three times and, if you like, repeat the process of rolling it out. In this way the most perfect parallel banding may be produced and by varying the conditions in ways which readily suggest themselves (as for example by using clays of different degrees of plasticity and inserting fresh pieces after the deformation has progressed to a certain extent) it is easy to produce many of the peculiar structures seen in banded gneisses.

It is important to note that the result will differ according as the mass is deformed into a flat sheet or narrow strip. In the former case the strain-ellipsoid will be an ellipsoid of revolution with its short axis in the direction in which the stress was applied, in the latter case the strain-ellipsoid will possess three unequal axes, the least axis lying approximately as in the former case, and the greatest axis lying at right angles to this and in the direction of

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[1] Not homogeneous in the strict sense of the term, but homogeneous in the sense that the different mineralogical constituents are uniformly mixed throughout the mass.

[2] Geology of the Ponza Isles, Trans. Geol. Soc. London, 2nd ser. vol. ii. p. 228.

the length of the strip, *i.e.* in the direction of stretching. The idea of a strain ellipsoid is of course only applicable to those masses or portions of a mass which have been subjected to a uniform strain.[1] If the different coloured clays yield differently to the deforming stresses the phenomena will be highly complex.

Now before we are justified in looking favourably on the theory I am endeavouring to illustrate, it is necessary to show, (1) that banded gneisses are on the whole identical with plutonic rocks in composition, (2) that masses of plutonic rocks are often heterogeneous, and (3) that heterogeneous masses, if such exist, may be deformed in the manner required to produce banded structures.

To establish the first point it is only necessary to refer to Roth's elaborate collection of rock analyses.[2] No one who has studied these analyses can doubt for a moment that the banded gneisses are essentially identical with plutonic rocks so far as chemical composition is concerned. The resemblance, however, is not limited to chemical composition, it extends to mineralogical composition and in a certain sense even to structure. Each plutonic rock has its equivalent in the banded gneisses.

We pass on now to consider the second point. When large masses of plutonic rock are examined they are often found to vary considerably in composition. They frequently contain patches which differ from the main mass. These have been investigated by Mr. Philiips, so far as the granites are concerned, and have been shown by him to be in general more basic in composition than the rock in which they occur. Again, every one is familiar with the phenomena of contemporaneous or segregation veins. These appear to be in general more acid than the rock in which they occur. Sometimes two or more varieties of plutonic rocks interlace in the most intricate manner. Cases of this kind have been described by Prof. Judd[3] as occurring in the Isle of Rum, where basic and ultra-basic rocks are concerned; by Messrs. Peach and Horne[4] as occurring in the Shetland Isles, where granite and diorite are concerned; and by Herr Lossen[5] in the Hartz, where granite (granitite) and gabbro are concerned. The last-mentioned observer states that both granitite and gabbro occur in the same dyke, and that the acid rock either surrounds or penetrates masses of the basic rock in the form of veins—the relations of the two rocks being such as to suggest that the two magmas were intruded simultaneously (or nearly so) rather than that the fluid granite-magma was injected into solid gabbro.

Diorite and granite may be seen in intimate relation in the ridge

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[1] A mass is said to have been strained uniformly when every portion has been strained alike.

[2] Beiträge zur Petrographie, etc. Abh. d. k. preuss. Akad. d. Wissen. für 1869, 1873, 1879, and 1884.

[3] On the Tertiary and older Peridotites of the West of Scotland," Q. J. G. S. vol. xli. p. 358.

[4] The Old Red Volcanic Rocks of Shetland, Trans. Royal Soc. Edinburgh, vol. xxxii. part ii. p. 373.

[5] On the Eruptive Rocks of the Hartz, Jahr. d. preuss. Geol. Landesanstalt für 1882, p. xxi.

of crystalline rocks running E. and W. a few miles south of Haverfordwest, in Pembrokeshire, and similar rocks show similar relations in the Lizard peninsula. The last-mentioned case will shortly be described at greater length.

We have now to consider the question of deformation. No one will doubt that deformation necessary to produce banded structures in heterogeneous plutonic magmas may take place in connexion with intrusion. The only question that can arise is whether many banded gneisses have originated in this way. At present I have no definite opinion on this point. There is, however, another way in which the necessary deformation may be produced, viz. by the operation of the earth-stresses of which we have such striking evidence in mountain-regions. With reference to this mode of deformation I will content myself by referring to the work of Heim and Baltzer in the Alps, of Reusch in the Bergen peninsula, of Lehmann in the granulitic region of Saxony, and of Lapworth and the Geological Survey (Messrs. Peach and Horne) in the north-west of Scotland. It will not be doubted by any one who has studied the writings of these authors, and is at all familiar with the phenomena they describe, that large masses of country have been profoundly modified by the earth-stresses. It may be a long time before we become acquainted with the precise nature of the movements and deformations, but that they are adequate to convert a heterogeneous plutonic mass into a banded gneissic series is to say the least highly probable. It must of course be remembered that sedimentary rocks may also be involved in the movements, so that the occasional presence in a gneissic series of bands having the composition of sedimentary rocks is no proof that the whole series is of sedimentary origin.

Having by these general remarks established, as I believe, the *a priori* probability of the theory I am endeavouring to illustrate, I will now refer to what appears to me to be a case in point. In the Lizard district of Cornwall we find two or three rock-types occurring as portions of an igneous complex and as portions of a banded gneissic series. Where they exhibit the relations of igneous rocks (Fig. 1, Plate XIV.), they may be termed granite, diorite and gabbro; where they occur as portions of a banded gneissic series they possess the same specific gravity, but usually show a more or less marked parallel structure and in certain cases differ in mineralogical composition. Consider first of all the petrographical characters of the different rock-types.

*Granite.*—This rock never occurs in large independent masses, but only as comparatively small veins and dykes. It is found in gabbro (north of Pen Voose), serpentine (Kynance) and diorite (Pen Voose). It is present also, in a somewhat modified form, in the banded gneissic series—the "granulitic series" of Prof. Bonney.[1] The least modified rock is a fine-grained granular aggregate of quartz, felspar and dark mica. The felspar is mostly unstriated, but a striated variety also occurs. Both felspar and quartz are

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[1] Quart. Journ. Geol. Soc. vol. xxxix. (1883), p. 1.

present for the most part in irregular grains. Sometimes, however, we find more or less rounded grains of quartz inclosed in the felspar, so that the quartz was not always the last mineral to form. The mica is deeply coloured. It occurs in detached scales and also in aggregates composed of several individuals. Sections parallel to the vertical axis appear a pale yellowish-brown when viewed with rays vibrating at right angles to the cleavage cracks, and opaque or a deep reddish brown when viewed with rays vibrating parallel to these cracks. The mineral is biaxial with a very small optic axial angle. It evidently contains a considerable amount of iron, for the rock in which it is abundant often assumes a deep red colour by weathering. The mica of the weathered rocks has been replaced by chlorite with which iron-oxides are associated.

The more modified rocks, and these are by far the most abundant, are characterized by the presence of a fine-grained granulitic aggregate of quartz and felspar and a more or less marked parallel structure. The granulation of the quartz and felspar is, I believe, a secondary phenomenon due to the dynamic metamorphism which has operated upon the district. It may be developed merely at the margin of the original grains, in which case we have the mortar-structure of Tornebohm[1]—the relics of the original grains then lie in a fine-grained granulitic paste like stones in mortar—or it may replace entirely, or almost entirely, the original quartz and felspar. The development of white mica does not appear to be a common feature. It may, however, be observed in what I am inclined to regard as a schistose granite from Porthalla, where it occurs along the planes of schistosity. In this rock the secondary granulitic aggregate forms a large portion of the mass.

A very interesting variety of gneissose rock occurs in the serpentine near Kynance. It forms only a thin band, and is, I believe, a granitic vein which has been profoundly modified by the regional metamorphism. Sections at right angles to the foliation show a magnificent micro-flaser structure. The secondary aggregate of quartz and felspar winds in and out amongst the relics of the original grains, and possesses in some places a crypto- rather than a micro-crystalline structure. The rock does not possess any very definite schistosity and white mica is absent. It appears as if the development of white mica were connected with movement along definite planes—where the mass has been deformed in a plastic manner white mica is absent.

The specific gravity of the rocks of the granitic type lies between 2·6 and 2·7

*Diorite.*—This rock, like the granite, never occurs in large independent masses. It is generally veined by the granite or intimately banded with it in the gneissic series. It may also be found in the gabbro. The rocks to which I here apply the term diorite vary in composition and specific gravity. Some belong to the intermediate, others to the basic series. At the one end of the series we have a

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[1] Naagra ord om granit och gneiss. Geol. Fören. i Stockholm Förhandl. 1881, pp. 166 u. 233.

rock which may be termed a mica-diorite, with a specific gravity of about 2·75; at the other end of the series we have a rock which may be termed hornblende-diorite (basic diorite, or possibly an epidiorite) with a specific gravity of 2·99; between the two extremes we find intermediate forms which may be termed mica-hornblende-diorites. The specific gravity of one of these is 2·83.

The more important minerals of the dioritic group of rocks are felspar (mostly striated in the least modified rocks), dark mica, green hornblende, sphene, iron-ores, and apatite. The felspar of the least modified rocks is often somewhat turbid, and the turbid portion frequently forms a kind of kernel in the centre of a comparatively unaltered individual. This points to an original zonal structure. Some of the diorites are porphyritic, and traces of the forms of the porphyritic crystals (felspars) are preserved even in the foliated rocks.

The mica is similar to that of the granite. It occasionally contains minute granular inclusions (probably zircon) which are surrounded by very dark borders. The sphene is a very interesting and important constituent of the diorites. It occurs in perfect crystals and also as grains. The grains in certain rocks form a border to the opaque iron-ores. This is a feature which may be observed in some of the gneissic rocks of Sutherland and the Malvern Hills. Iron-ores are comparatively rare in the mica-diorites, but they become abundant in the basic diorites. Apatite is very common in some of the mica-hornblende-diorites.

The felspars of the diorites show the same tendency to granulation as those of the granite and the individual grains in the granulitic aggregates are mostly untwinned. In the foliated diorites of the banded gneissic series striated felspar is comparatively rare.

*Gabbro.*—As this rock and the modifications which it undergoes when subjected to regional metamorphism were described at the last meeting of the British Association,[1] it will be unnecessary for me to enter into details on the present occasion. Suffice it to say that every gradation from a massive rock to a gabbro-schist may be observed in the district. Unaltered gabbros are, however, very rare, just as unaltered granites and diorites are rare. Since my last paper was read I have isolated the felspar and augite of the unaltered gabbro from Coverack, and Mr. Player has kindly analyzed them for me in my laboratory; the former is a somewhat basic labradorite; the latter possesses ·6 °/₀ of chromic oxide, and is therefore a chrome-diopside. The hornblende of the gabbro-schist from Pen Voose has also been analyzed by Mr. Player. It possesses over 10 °/₀ of alumina and differs from the augite also in containing more magnesia than lime. It contains, however, decided traces of chromium. The analyses, therefore, so far as they go, point to the conclusion that the hornblende differs from the augite or diallage in composition, so that the disappearance of the pyroxene and the development of hornblende cannot be ascribed to simple paramorphism. The specific gravity of the chrome-diopside is about 3·22, that of the hornblende

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[1] Geol. Mag. Decade III. Vol. III. p. 48.

is about 3·05. With regard to the so-called saussurite, I am able to state that malacolite, felspar, and minute granules of sphene often occur as constituents. The malacolite has been isolated and analyzed by myself, so that no doubt exists as to its identification, though it often occurs only in minute grains without form or cleavages. The doubtful substance which appears white by reflected and brown by transmitted light and which is a constant feature in the Lizard saussurite has not been identified.

Fig. 3.

We have now to consider the mutual relations of the different rocks above described. At Kennack Cove and at Pen Voose, near Landewednack, granite may be seen veining diorite, often in the most intricate manner (see Fig. 1, Plate XIV.). At Pen Voose, veins of both granite and diorite occur in the gabbro, Fig. 4. The three rocks are therefore of igneous origin. They exhibit the relations of igneous rocks, and they possess the composition of igneous rocks; moreover, it is possible to find here and there portions which have escaped the influence of the dynamic metamorphism, and which show the normal structure of igneous rocks. But the same rock types occur as integral portions of a banded gneissic series in the same localities. The bands are in some places as regular as layers of sediment in a stratified rock-mass, in other places they are crumpled and contorted (Fig. 3); in others we observe "eyes" and lenticles of diorite surrounded by streaks and bands of a granitic rock (see Fig. 2, Plate XIV.)

As a rule the banded gneissic series is formed only of granitic and dioritic rocks, but we occasionally find eyes and streaks of gabbro and gabbro-schist. One large specimen, to which I wish to direct special attention, shows a crumpled band of gabbro-schist in mica-diorite.

Another mass much too large to carry away showed the appearance represented in Fig. 5. It consisted of parallel bands and narrow lenticles of foliated gabbro, granite and diorite. Fig. 6 represents the relations of granite, diorite, and gabbro in a mass which exhibited no parallel structure. In Figs. 5 and 6 the space left clear represents granite, or at any rate a rock of granitic composition; the dotted portions represent diorite, and the portions indicated by fine lines gabbro or gabbro-schist. Fig. 5 represents a mass four feet and Fig. 6 one three feet in height.

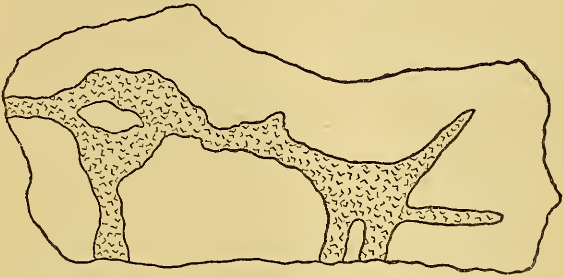


Fig. 4. Granite in Gabbro, Pen Voose. Block 6 feet long.

I submit, therefore, that the rocks of the Lizard District referred to in this communication, and which constitute the greater portion of Prof. Bonney's granulitic series, are of igneous origin and that the parallel structure which characterizes many of them has nothing to do with stratification in the ordinary sense of the word, but is a consequence of the deformation to which the original rock-masses have been subjected. It is undoubtedly true, as Prof. Bonney has pointed out, that many of the rocks are largely composed of broken crystals, and may be said therefore to possess a clastic structure if we use the term clastic in its etymological sense. But this is no proof that the fragments have been deposited as such. The original minerals may have been broken during the deformation of the rock-masses. This I believe is what has actually taken place.

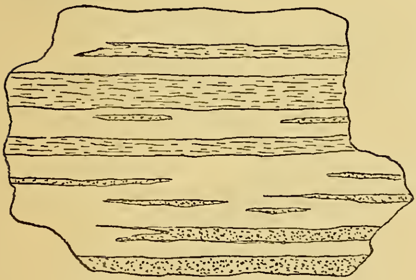


Fig. 5.

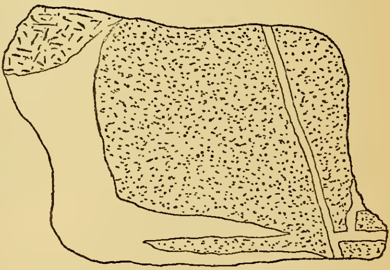
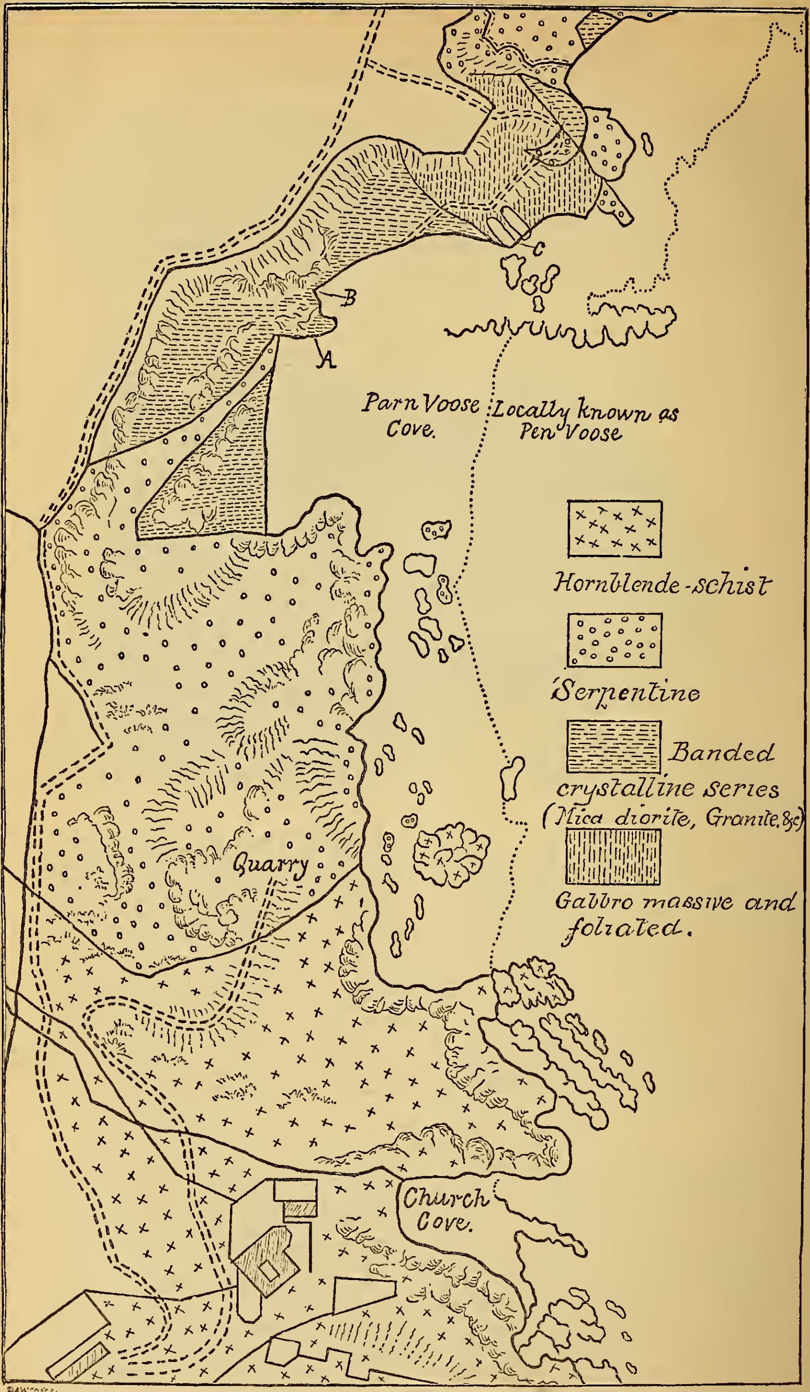


Fig. 6.



Geological Map of Coast near Landewednack. Scale 25 inches to the mile.
To illustrate Mr. J. J. H. Teall's paper.

The structures are of the kind for which Prof. Kjerulf[1] has proposed the term cataclastic.

I doubt whether any true clastic (epiclastic[2]) rocks occur in the Lizard District south of St. Keverne.

## EXPLANATION OF ILLUSTRATIONS.

The map is merely intended to enable readers to form some idea of the relations of the rocks in the district especially referred to in the latter part of the paper, and to fix the exact localities from which the illustrations are taken. The actual phenomena are too complicated to be accurately represented even on the 25 inch scale At the point marked A an "eye" of gabbro foliated at the margin and measuring about five or six feet in length may be seen in the "granulitic" series. Figs. 2 and 3 are reproductions from photographs taken at B. Fig. 5 represents a portion of the cliff face about nine feet in height; Fig. 6 another portion about four feet. The crumpling of the bands is well seen in the negative, but has not been very successfully reproduced in the figure. Fig. 1 is from a photograph taken at C, where the banded gneissic series and the gabbros are seen in juxtaposition. It represents a portion of the cliff about 8 feet in height. The line representing the boundary between the gneissic series and the gabbro should have been brought to the point C. This figure illustrates very well the manner in which the light-coloured granitic rock veins the dark-coloured diorite. It must be remembered that Figures 1, 2, and 3 represent portions of the same rock mass. If the rocks are igneous at C as seems to be proved by Figure 1, they must also be igneous at A and B. The point C is the point where a granite vein is indicated on the geological map of the district.

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## III.—ELEMENTS OF PRIMARY GEOLOGY.[3]

By T. STERRY HUNT, M.A., D.Sc., LL.D., F.R.S.

1. UNDER the general terms of Primary and Original, given by Werner and others, to the early crystalline rocks, have been included various mineral aggregates which may be classed under three heads: 1. The great stratiform masses of aqueous origin, essentially granitic, and formed by slow deposition at the earth's surface, which I have called Indigenous rocks. 2. Those lesser crystalline masses which were formed under similar conditions to the last, but within veins or fissures in pre-existing rocks, and may therefore be called Endogenous. 3. Rocks resembling the last in their geognostic relations, and often confounded with them, but distinguished by the fact that they have come into their present positions not by deposition from solution, but by displacement in a more or less fluid or plastic state. These Exotic or erupted masses, whether ancient or modern, are in a sense Primary, since they sustain, in one way or another, intimate relations to the more ancient rocks to which this name was first given.

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[1] Grundfjeldspsrofilet ved Mjφsens sydende, Nyt Magazin, 1885, p. 215.

[2] Some modification in the use of the term clastic is rendered necessary by recent discoveries. I venture to suggest that it should be applied to all rocks which consist largely of mineral fragments and that we should distinguish between the three types of clastic rocks at present recognized by using the terms epiclastic, cataclastic, and pyroclastic. *Epiclastic*—Rocks formed of fragments resulting from the breaking up of older rocks occurring *upon* the earth's surface. *Cataclastic*—Rocks largely composed of fragments produced during the deformation of older rocks by the earth-stresses. *Pyroclastic*—Fragmental rocks of volcanic origin. The same terms may be applied to the structures which characterize the rocks in question.

[3] Paper read before Geological Section, British Association, Manchester, 1887.

2. The history of the origin of all these rocks is one of evolution through successive differentiations. The transformations of the primitive igneous material of the earth's crust, through the action of air and water, aided by internal heat, present a mineralogical evolution not less regular, constant and definite in its results than the evolution apparent in the organic kingdoms. The nature of this very complex operation, and its various stages, the writer has elsewhere endeavoured to set forth at length, and the object of the present note is to state concisely, and in an elementary form, some conclusions and generalizations reached after forty years of study; referring the reader for details to his recently published volume entitled *Mineral Physiology and Physiography.* It may, however, be said in a few words that the protoplasmic mineral matter—which we may define as the superficial portion of a cooling globe solidifying from its centre—was, so soon as its surface became sufficiently refrigerated, the subject of a double series of processes. These included (1) the removal from its mass by solution, through permeating waters, of the elements of the Neptunian, or as I have elsewhere named them, the Crenitic, crystalline and colloidal or porodic aggregates; (2) the modification of the residue by this watery lixiviation, removing silica, alumina and potash, and when sea-water intervened, bringing in lime, magnesia and soda in exchange; and farther by the crystallization and partial differentiation through the influence of gravity, and by eliquation, of more or less altered portions of this primitive mass, resulting in the production of various types of properly igneous or plutonic rocks.

3. The continued removal therefrom of the elements of the great succession of crenitic rocks, which were laid down upon its surface alike as indigenous and endogenous masses, caused a progressive diminution in volume in this water-impregnated primitive plutonic stratum; which must not only have produced a profound corrugation of its earliest crenitic envelope, but through the succeeding ages of the duration of this operation, have given rise to that generally folded and inclined attitude, with frequent discordances, which characterizes the Primary stratified rocks, while it is only occasional and accidental in Secondary strata. With the decline of crenitic action the weight of accumulated strata apparently brought about the plutonic and pseudoplutonic eruptions; which appear to have been rare in the earlier periods, but in later times to have replaced the previously continuous upward transfer of matter from the primitive plutonic substratum by the process of aqueous solution. In thus indicating what must have been in early periods a potent agent in producing corrugation and disturbance of strata in the crenitic rocks, it must not be forgotten that from the beginning to the present time the contraction of the terrestrial anhydrous nucleus from secular refrigeration has also doubtless been a factor therein not to be overlooked.

4. The crenitic masses present in successive ages marked variations in mineral type, which furnish the basis of a chronological classification having regard especially to the relative proportions of silica,

alumina and alkalies in the masses. In the study of these rocks as members of great succeeding groups, it is however necessary to take account of the products, alike soluble and insoluble, of the subaerial decay of previously exposed masses, both crenitic and plutonic, of the frequent intervention of sea-water bringing magnesian salts, and also of the direct and indirect intervention of products of organic life; all of which have caused at different periods variations in the constitution of the rock-masses generated. From these considerations it will be apparent that no series of deposits subsequent to the ancient granitoid gneisses can ever have possessed the same degree of uniformity and of universality as they. Variations from causes already assigned appear also in the constitution of the plutonic rocks of successive ages.

5. Types of silico-aluminous crenitic rocks which are rare at a given period become more abundant in a later time, and subsequently disappear. The earlier types recur locally and less well characterized in later ages. From this it results that in the mineral as in the organic world, generalizations as to chronological classification must be based upon the mineral characters of the group considered as a whole, and not on those of individual varieties. Rocks not including aluminous silicates,—such as quartz, carbonate of lime, iron-oxyds and protoxyd silicates,—recur with slight variations at very widely separated periods in geologic time.

6. The operations of solution and deposition, and those of subaerial decay and disintegration during the earlier ages went on under geographic conditions not very much unlike those of later periods, so that in the great series of crenitic rocks certain groups are often absent; in some cases from non-deposition, and in others from subsequent erosion connected with movements of elevation and depression. From these causes, as well as from the universal contraction of the underlying plutonic stratum, due to the crenitic process, stratigraphical breaks and discordances exist among the crenitic strata as among the sedimentary rocks of later ages. All such phenomena in stratigraphy, at whatever period recurring, are however but local and accidental interruptions of the normal order of mineralogical development.

7. The great groups of stratiform crystalline rocks, which everywhere appear as the substratum of the uncrystalline sediments, are essentially neptunian or crenitic in origin, and the few plutonic masses of pre-Palæozoic age have no other significance in the lithological history of these groups than that which comes from the fact that portions of these plutonic masses, or the results of their subaerial decay, occasionally intervene in the formation of the crenitic rocks. Their importance as factors in primary geology is so small that their exclusion therefrom by Werner and his school was an error much less grave than those of the endoplutonic and exoplutonic schools, and especially of the latter; which, in its extreme and logical form, assigns an eruptive origin to the whole category of crenitic rocks, including gneisses, norites, steatites and serpentines, and even quartzite, iron-oxyds and limestones.

8. If we restrict the term eruptive to such rocks as have evidently come in a fused or plastic condition into their position among and above previously formed masses, we may on mineralogical grounds divide them into two classes.

I. Rocks consisting essentially of basic silicates, including much alumina, lime, magnesia, and ferrous oxyd, of which dolerite is the type. These we regard as portions of the primitive plutonic mass, which however, as already explained (§ 2), has, through successive ages, become more or less modified alike by additions and subtractions through the crenitic process, and by crystallization and partial eliquation, thereby giving rise to the considerable variations in composition met with in these basic rocks in different areas and in different periods. The stratiform arrangement of the elements of these, due to movements of flow, occasionally met with in such masses, simulates, as is well known, the structure of stratified crenitic masses. This has led some theorists to assign to these plutonic rocks an aqueous and so-called metamorphic origin; while the same resemblance has been, alike by endoplutonists and exoplutonists, made an argument for maintaining a plutonic origin for all stratiform crystalline rocks.

II. Besides the basic eruptive rocks, which are to be regarded as truly plutonic, are those mineralogically very unlike masses which resemble in composition the predominant type of the earlier crenitic rocks, and are often confounded with them. Such are the trachytes and the clearly eruptive granites, which, it is maintained, are but softened and displaced portions of older crenitic masses, and may be designated pseudoplutonic rocks.

9. Besides these masses of once softened and plastic material —whether plutonic, or pseudoplutonic and of crenitic origin— which have been erupted after the manner of lavas, there are two other kinds of rock-masses, which, from their geognostic relations, are frequently regarded as eruptive. Of these the first is the veinstones or endogenous rocks—alike quartzose, calcareous and granitic—already mentioned (§ 1), themselves of crenitic origin, and formed, although in fissures or cavities, under chemical conditions not unlike those which gave rise to the greater masses of non-plutonic primary rocks. As regards the second kind of masses above referred to, it often happens that disrupted portions of crenitic rocks have, without softening or change of state, been forced, as the result of local movements, among softer and more yielding strata. Such intrusions of rigid amongst plastic masses have in many cases caused the former to be regarded as rocks erupted after the manner of lavas.

10. In the case of crystalline or colloidal rocks evidently posterior to the enclosing material, the question will therefore arise whether a given mass may be (1) a truly plutonic rock; (2) a crenitic deposit *in situ*, as a granitic veinstone; (3) a crenitic mass from a lower horizon, which by softening and displacement has assumed a pseudoplutonic form; or (4) a portion of rock, either crenitic or plutonic in origin, which, without having itself been softened, has been forced among soft and yielding materials, displacing these.

These various cases, it is evident, introduced certain apparent perturbations into the normal order of crenitic rocks, and should be carefully borne in mind. The many evidences of the displacement of previously formed crenitic rocks, alike in rigid masses, and in a softened and plastic condition, are especially worthy of a critical study. A more careful investigation than has generally been made alike of the chemical, mineralogical, and geognostical history of the various silicated rocks, keeping in view all of the above considerations, will, it is believed, serve to correct some of the extreme views of certain geologists of the metamorphic school, as well as those of the plutonists.

11. The process of mineral evolution seen in the succession of the earlier and later indigenous crenitic rocks, and in the veinstones or endogenous rocks of still later periods, has continued, though with progressively diminished activity, through Palæozoic and still later ages down to the present time, as evidenced by the indigenous silicates sometimes found in Palæozoic rocks, and even in the deep-sea ooze and the deposits of certain thermal waters. The transition from the earliest fundamental granite to the predominantly uncrystalline sediments of the Palæozoic age is marked by gradations, so that it is not easy to define the respective limits of what were originally designated Primary, Transition, and Secondary rocks. The terms Azoic, Eozoic, and Palæozoic, are for a different reason equally vague. While organic life undoubtedly existed long before what is called Palæozoic time, we have no evidence that it had appeared when the fundamental granite, that is to say, the basal granitoid gneiss, was laid down; although it is apparent that the formation of certain crystalline silicates was still active in later Transition times, contemporaneous with organic life.

A failure to grasp this conception has led geologists of the Huttonian school to an undiscriminating use of the vague and ill-defined term metamorphism, which, in the interest of a more exact science, it would be well to banish from the language of geology. The extremists of that school have maintained, and still maintain, that the chemical and mineralogical constitution of the crenitic silico-aluminous rock-masses has no constant and definite relation to their age, and that large areas of Secondary sediments have, by a subsequent metasomatic change, been converted into mineral masses undistinguishable from the crystalline strata of the earlier Primary periods. Without referring to the fact that recent and careful geognostical studies have at every point shown the fallacy of the stratigraphical evidences adduced in favour of this assumption, it may be remarked that the whole metamorphic hypothesis is an attempt to substitute a constant intervention of miracle for the orderly and systematic evolution which appears in the mineralogical history of the earth's crust.

The transition above referred to introduces a difficulty into our terminology, since among the crenitic indigenous masses are included both Eozoic rocks and others which are apparently pre-Eozoic. Both the Primary and the Transition of Werner are also included therein.

For this reason the often used word Archæan, from its very vagueness and indefiniteness, is perhaps, in the present state of our knowledge, the most convenient term to designate the more or less completely crystalline or colloidal rocks which preceded the essentially detrital rocks of Secondary time, and by their decay and disintegration furnished the chief part of the material of these.

12. As a result of all these considerations, the author has been led to attempt a subdivision of the Archæan indigenous rocks into several chronological groups, which he has often described elsewhere, and which, in his *Mineral Physiology and Physiography*, are concisely treated in a chapter entitled A History of Pre-Cambrian Rocks. It will therefore be sufficient for the present purpose to recall briefly the great subdivisions there advocated.

I. Under the name of Laurentian are comprised the gneissic rocks of the Laurentides, the Adirondacks, the Highlands of the Hudson, and much of the Rocky Mountains in North America. These rocks are divided, so far as known, into a lower granitoid series, often but obscurely stratified, and without included limestones or quartzites (the Ottawa gneiss) and an apparently unconformable series of gneisses, much resembling the last, but with interbedded quartzites, limestones and iron-oxyds (the Grenville series). The name of Laurentian was originally (in 1854) made to include both of these, without regard to the subdivisions; which were, however, pointed out in 1847, and which we may provisionally designate as Lower and Upper Laurentian. The latter term, afterwards applied by Logan to a succeeding series, otherwise called Labradorian, having been superseded by Norian, the name of Middle Laurentian, which some have erroneously applied to the Grenville series, or upper division of the Laurentian, becomes meaningless.[1]

II. The Norian series, in which stratiform crystalline rocks, granitoid in structure, nearly or quite free from quartz, and composed essentially of basic feldspars, of which labradorite is the type, constituting the rocks known as norite, is our next great division. It, however, includes also occasionally quartzose and gneissic rocks, together with crystalline limestones, and iron-oxyds, generally titaniferous. From the resemblance of these gneisses to those of the Laurentian, and from the few contacts observed, this Norian division is assigned the second place in the succession. The characteristic rocks of this series are often called gabbro, but are widely distinct from the euphotide of the Huronian or Pietre-verdi series, to which this name was first applied.

III. At the base of the Huronian appears in many regions a great series essentially composed of petrosilex, often becoming a quartziferous porphyry, and occasionally interstratified with an indigenous

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[1] Inasmuch as these distinctions were first devised and announced by the Canadian Geological Survey, it may here be said that its earliest printed reports on the ancient rocks of the country (those for 1845 and 1846, published in 1847) were prepared from the notes and collections of Logan and Murray, by the present writer after his connection with that Geological Survey in February, 1847, and that all subsequent matters relating to lithology in its reports up to 1872, were either prepared by him or under his direction.

diabasic rock, with sericitic schists, quartzites, iron-ores, and more rarely with limestones. This, which in concert with Dr. Henry Hicks, I have called Arvonian, is the Lower Huronian of C. H. Hitchcock.

IV. The Huronian, which in many regions rests unconformably upon the Laurentian, or upon the Arvonian, constitutes the great greenstone or Pietre-verdi group of the Alps, with its characteristic euphotides, serpentines and chrysolitic and amphibolic rocks. In this series the intervention of sea-water is more evident than in the preceding periods, perhaps for the reason that the sea had become more magnesian from the results of the subaerial decay of erupted plutonic masses.

V. The great series of tender fine-grained gneisses passing into granulites on the one hand and into quartzose mica-schists on the other, makes what I called in 1871 the White Mountain or Montalban series. This in many regions rests directly upon the Laurentian, but it is believed in others to overlie chronologically the Huronian. I say this with all deference to my honoured colleague, C. H. Hitchcock, who, recognizing the fact that the Arvonian and the Huronian are wanting in many regions between the Laurentian and the Montalban, and finding above the latter a series of schists which he refers to the Huronian, maintains that the division is younger than the Montalban. To this I would reply: First, that my observations in the Alps, which are in accord with those of Von Hauer, Gastaldi, and others, are to the effect that the true Pietre-verdi or Huronian comes chronologically between the older and the younger gneisses, which two divisions are there indistinguishable from the Laurentian and Montalban respectively. Secondly, that the Taconian (or Lower Taconic) series, which alike in the Alps and in North America overlies the younger gneiss, has in portions a considerable lithological resemblance to parts of the Huronian, to which its schistose portions are related in character, somewhat as portions of the younger gneisses with mica-schists of the Montalban are to the lower or Laurentian gneisses. Hence it was that Murray, Credner, and for a long time the present writer (who gave the name of Huronian in 1855), confounded the Huronian and the Taconian on Lake Superior.

VI. The great series with quartzites, crystalline marbles, and the iron-bearing schists of that region which, in 1873, I called the Animikie series, is, as I have elsewhere endeavoured to show, identical with the Taconian, for which it was long ago claimed by Emmons, and is distinct from the Huronian alike in geographical distribution and in lithological characters. This Taconian series extends in eastern North America from the Gulf of St. Lawrence to Alabama, including not only quartzites and marbles, but siderite and limonite, and much of the magnetite of Pennsylvania; where it embraces alike the "Primal slates" and the so-called "Altered Auroral and Matinal strata" of H. D. Rogers. It is also the Itacolumitic series of Lieber, in the Carolinas, and constitutes, so far as known, the youngest member of the great succession of crystalline schists. While parts of the Taconian have thus been confounded with

Huronian, there are not wanting portions of its more schistose strata which have a resemblance to certain Montalban rocks. Hence it was that at an early period in the writer's studies he attempted to group Montalban and Taconian under the name (soon after abandoned) of Terranovan. For a detailed account of the whole Taconic controversy, see the author's *Mineral Physiology and Physiography*, and for a more concise statement, but with more new light, "The Taconic Question Restated" in the *American Naturalist* for 1887.

13. The name of Taconian was given to the Lower Taconic of Emmons to distinguish it from his Upper Taconic, which is essentially uncrystalline, and, as shown by its trilobitic fauna, and recognized by Emmons himself, is clearly Cambrian, and is in some regions directly overlaid by Ordovician strata. Beneath the recognized Cambrian, in parts of the North American continent, is a great body of uncrystalline sediments, which I have designated Keweenian. While newer than the Taconian, their relation to the unconformably overlying Cambrian is as yet uncertain.

It is not claimed that the above indicated division of the great pre-Palæozoic or Archæan succession is complete. Further study will probably show that there are other groups, and furnish grounds for subdividing those here proposed. They are, with small help from without, chiefly from the generalizations of a single observer during a period of forty years, and as such are offered as a first attempt at a classification of the stratified crenitic rocks, and as illustrations of the process of mineralogical evolution. It must be remembered that for reasons already assigned (§ 2), none of these groups save the fundamental granite can be supposed to possess the characters of uniformity and universality.

## IV.—ON SOME BRECCIATED ROCK IN THE ARCHÆAN OF MALVERN.

By T. M'Kenny Hughes, M.A., F.G.S.,
Woodwardian Professor, Cambridge.

THE question of the origin of the Archæan rocks is one of such great interest that it will not be thought unimportant on the one hand to record any facts that may bear upon it, and on the other to examine somewhat severely all the evidence that may be from time to time brought forward on the subject. Among the facts which may be adduced in support of the view that the Archæan rocks are altered sedimentary strata, the occurrence of breccias and conglomerates may well claim a foremost place; and a vast amount of superincumbent theory must rest on a very shaky foundation if there be any doubt whether some of those ancient fragmental beds be true conglomerates or not. The manner of occurrence, the mode of formation, and the character of pseudo-breccias and pseudo-conglomerates become therefore questions of first importance.

What one would be at first inclined to accept as evidence of the conglomeratic character of a bed would be that the included fragments were rounded, and that they were of a different character from the mass in which they were imbedded. I have on a former occasion[1] discussed this point, and given examples of rocks made up of fragments differing more or less in character from the surrounding matrix in cases in which I was able to offer abundant evidence that these rocks owed their fragmental character to brecciation in place. I explained the pebble-like form of the fragments by the rounding off of the corners which usually accompanies infiltration from the joint surfaces, and further pointed out how the apparent matrix was derived from the alteration of the more finely comminuted portions of the brecciated mass, and from the decomposition of the outside portion of the larger fragments.

I am now able, as the result of observations made at various times on the Archæan rocks of the Malvern Hills, to supplement and extend these remarks.

It might be argued that the modification induced by chemical change within the mass would be likely to affect equally adjoining fragments of the same size, composition, etc., and therefore, that, if the apparently included fragments were of different nature, not only from the matrix but also from one another, this must be accepted as evidence that the mass was made up of bits transported from different rocks and various localities, especially if the pieces could be matched among the members of the underlying series.

It would be pointed out that a volcanic brecciated conglomerate often seems made up of fragments of rock belonging to the very series in which the agglomerate occurs.

In the Archæan rock which rises abruptly from the level of the New Red west of Malvern Link, near the quarries, there are some bands of rock (Fig. A B) answering these conditions, which might easily be taken for a brecciated conglomerate. The included fragments are of various kinds, different from the matrix, and also unlike one another. Some are coarse light-coloured crystalline syenite, others close-grained pink felsitic rock. The matrix is a claret-coloured earthy, homogeneous, felspathic paste, with here and there a coarser or crystalline structure, or a few imperfect felspar crystals and grains of quartz. The fragments are often quite rounded, like shore pebbles. Following the band along its trend we find variations in the size of the fragments, and in the proportion of the different kinds, but otherwise its general character prevails as far as it is exposed.

If, however, we trace this fragmental mass across its trend into the adjoining part of the rock, we find that the fragments cease to be round, and their sides are bounded by the continuation of the joints which affect the whole rock. The claret-coloured matrix disappears, being represented first by thin bands along the outside of the angular fragments, then by mere lines of colour along the joints. The pink felsitic fragments run together, and are at last seen united in a vein (C D) of compact pink felspar-rock, such as is so common in the Malvern Archæan. Where the vein has got much broken up and displaced, we find sometimes, on the margin and at

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[1] Geol. Mag. Vol. X. 1883, p. 306, "On the Brecciated Bed in the Dimetian of St. Davids."

the sharper folds, even a commingling of fragments of the vein and surrounding rock.

When, moreover, such fragmental beds are observed to coincide with the trend of the ridges, and with the larger divisions of the series which are supposed to represent original differences in the succession, this may be urged as an argument in favour of the conglomeratic character. But in any folded rock the chief crush is apt to run along and be confined to the central portions of the folds, so that the bands of breccia caused by it must necessarily coincide in direction with the trend of the ridge and the strike of the succession of rocks of which the mass is made up, and any rock having a different texture in successive portions, whether original or superinduced, will, during earth-movements, behave just like a sedimentary rock in which there is a succession of beds of different powers of resistance.

In the Malvern Hills, as so often elsewhere, the axes of folding of the older rocks run slightly oblique to the trend of the ridge.

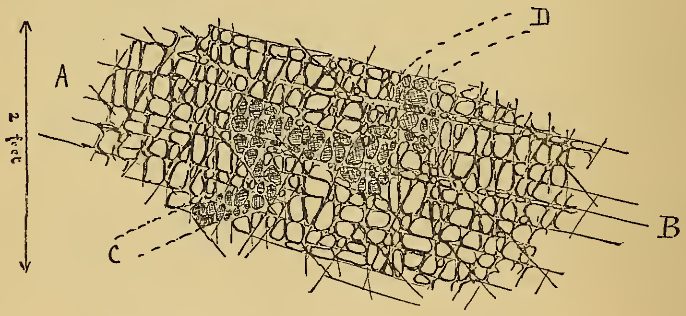

Diagram sketch of part of band of pseudo-agglomerate in the Archæan rocks of Malvern.
*A.B.*—Band of brecciated rock. *C.D.*—Vein of pink felsite.

The margin against which the New Red abuts on the east of the Malvern Hills was probably determined by pre-existing lines of weakness, due to faults and crushes in the Archæan, but the now more important but originally less intense movements which took place after the deposition of the New Red have determined the existing boundary of that series. But the principal divisional planes and sequences indicating the direction of the great folds in the Archæan rock run into the hill obliquely to the margin in the locality to which these observations chiefly refer, namely, the quarries west of Malvern Link. Along these axes, and therefore coinciding with what looks most like strike in the Archæan, run the bands of fragmental rock, and thus, if it had not been that we were able to examine the surrounding rock sufficiently to satisfy ourselves that the conglomeratic character was deceptive, and to see that the breccia passed into jointed rock, we might easily have taken this band as an ancient shingle or agglomerate, to the great confusion of the evidence already sufficiently difficult to unravel.

Thus it is clear that we may in certain cases have a conglomeratic-looking mass composed of rounded pieces of rock differing in lithological character both from the matrix and from one another, occurring along what looks like the strike of the rocks, and yet may be able to make out that it is entirely a superinduced structure due to brecciation in place and subsequent decomposition of the broken rock.

From these observations we may also learn another lesson, viz. that crushing may take place without producing any effects analogous to metamorphism properly defined, and may act in aid of true metaporphism or other chemical change, chiefly by comminuting and preparing the rock for chemical reaction.

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## V.—ARCHÆAN ROCKS.

By G. H. KINAHAN, M.R.I.A., etc.

(Read before the British Association, Manchester, 1887.)

AT the present time the American geologists, both those of the United States and the Dominion of Canada, are at variance as to the groups the Archæan should be divided into; it is however unnecessary to enter into this controversy, as the strata may be conveniently grouped, as in Selwyn's map (1884), into *Norians* or *Labradorians*, excessively coarse gneiss or other granitic rocks; *Laurentians*, gneiss and granite; and *Huronians*, schists with subordinate gneiss.

Some of the authorities both in the States and the Dominion would have us believe that the Archæans originally accumulated as crystalline foliated rocks; that is, the minerals were deposited by chemical action from solution. Others, however, hold that at one time they were ordinary sedimentary rocks, which during one or more successive periods of metamorphic action were changed into their present conditions. The present school of English Archæan geologists seem from their writings to coincide with the Americans, who believe in originally crystalline accumulations.

The facts in favour of the first theory seem to be obscure; we are indeed told that "chemistry forbids" an ordinary sedimentary rock changing into a schist, gneiss or granitic rock; yet in the field we can walk along beds that change from unaltered rocks through schist into gneiss, and thence into metamorphic granite. Such a change may be quite contrary to the chemical laws laid down by such Archæan geologists for their own guidance, but they are patent facts effected by the GREAT CHEMIST, and to be ocularly learnt by any ordinary observer who carefully works out any large tract of metamorphic rocks.

In connection with this subject the value of lithological characteristics may first be mentioned. It is now generally well known that any rocks, no matter to what period they belong, from the newest Tertiaries to the Archæan, if they have been subjected to sufficient metamorphic action, will be changed into schist and gneiss; that is, that foliation will be developed in them, although originally they may have been ordinary sedimentary rocks, volcanic rocks, or even granite. Of course rocks that have once been metamorphosed, may again be so placed that they are subjected to a second, third, or even more periods of action; each, if not too excessive, further developing the foliation. The American rocks called Norians or Labradorians have excessively coarse foliation, some of the measured plates being at least a foot in length; these rocks at one time were considered on account of their structure, to be the oldest Archæan: but further research has demonstrated that they are as young, if not younger, than the associated rocks; as they originally were protrudes or intrudes, generally the latter, possibly of granite, into their associated rocks, and that their present structure is solely due to metamorphic action at successive times. In Ireland intruded courses and tracts of granite in the Castlebar District, Co. Mayo, and near Glenties, Co. Donegal, have been altered into a very coarse gneiss by metamorphic action, while in Slieve Croob, Co. Down, the margin of the granite intrude has also by a similar process been changed into gneiss. It therefore appears evident that if any kind of rock, by sufficient metamorphic action, can be changed into crystalline foliated rock, such structure or composition by themselves cannot be taken as a test of the age of the rocks.

Dana, Le Conte, Selwyn, George Dawson, and other American authorities specially point out that between the American Archæan and the later rocks *there are the distinct records of a vast lapse of time.* In the Dominions this is most conspicuous, the unaltered fossiliferous *Primordial* or *Cambriam* rocks lying unconformably on the Laurentian gneiss, and the Huronian schists; the old rocks having been tilted, crushed up, metamorphosed and afterwards excessively denuded, prior to the Primordial or other later rocks having been deposited on them.

In Europe alone there are in different places representatives of the different Passage Beds between the different geological groups; there are, as Passage Beds between the Cambrian and the Ordovicians, the *Arenig group*; between the Ordovicians and the Silurians, there are the *Llandovery* or *Mayhill Sandstone group*; between the Silurians and Carboniferous, there are the *Devonians* or *Old Red Sandstone*, and so on upwards; it is therefore natural to suppose, that somewhere on the face of the globe there are rocks that represent the equivalents of the Passage Rocks between the Archæan and the Primordial; but if such rocks occur in England or Ireland, which to me appears very questionable, they are not the equivalents of any of the American Archæans, and ought not to be so called, but should be grouped as "Passage Beds" under a new and distinct name.

Except in Scotland, where it has been demonstrated by Murchison, there are no authentic records of a great lapse of time between the so-called Archæans and the later rocks. Circumstances have prevented the writer from being intimately acquainted with the English tracts now declared to be of Archæan age; but he has visited some of them, and in fact believes he was the first to suggest that the rocks in one of them might possibly be Archæan. Now, however, since the real Archæan rocks have been seen and studied, such a suggestion in reference to them, or any other tract of English metamorphic rocks, would be much more cautiously given. With respect to the Irish metamorphic rocks, however, statements can be more confidently made, and to him it would appear that *no rocks in that island are the representatives of the American Archæan, or even of the at present unnamed, or unrecognized, "Passage Beds" between the Archæans and the Primordial.*

Prior to 1878, as has been pointed out in papers published by the Royal Dublin Society and the Royal Geological Society of Ireland, first Jukes and Sterry Hunt, and afterwards Murchison and the writer, pointed out that the equivalents of the Laurentian rocks might exist in places in the provinces of Connaught and Ulster (*Cos. Antrim, Tyrone, Donegal, Leitrim, Sligo and Mayo*). Subsequently Hicks suggested that my supposed Cambrians in Tyrone (*Slieve Gallion District*) were more probably of Archæan age; while still more recently Drs. Callaway and Hull have stated that they have proved the existence of Archæan rocks in different places. But none of the tracts so exalted have the characteristics considered essential by Dana, Le Conte, etc., as *nowhere in Ireland are there records of a great lapse of time between the accumulation of the strata said to be Archæan and those of Cambrian or Ordovician ages.*

As to the rocks at Greenore and Kilmore, Co. Wexford, said to be Archæan, the first are evidently a metamorphic protrude of exotic rocks, and the second are interstratified with their fellows; the rocks in both cases being so intimately intermingled that it is absurd to attempt to separate them; here therefore there is no record of a vast lapse of time between the Archæans and Primordials.

In North-west Ireland, that is, the portions of the Provinces of Connaught and Ulster, between Galway Bay and the eastern boundaries of the Cos. Londonderry and Tyrone, there was one large tract of metamorphic rocks. This has now on it, in places, patches of Silurian and Carboniferous rocks, thus dividing it up into subordinate tracts; yet the connection between all of them is very conspicuous and can be easily traced out.

In Ulster there is an unconformability in these metamorphic rocks; but some of the strata above and below this unconformability have general characters so similar that it is disputed by some; the so-called Archæan are *a portion only of the rocks* below the unconformability. In places both in Ulster and Connaught portions of both the older and later rocks are unaltered, and contain fossils or markings that are considered to be fossils.

In North-west Galway and South-west Mayo, in the unaltered portions of these rock-tracts, there are fossils of Llandeilo types, and after tracing the equivalents of these fossiliferous rocks northward and north-eastward through North-east Mayo, Sligo, and Leitrim, into Donegal, Tyrone, and Londonderry, it induced the opinion, published some years ago (1878), that the later rocks in Ulster, that is, those above the unconformability, represented the upper portion of the Irish Ordovicians (*Volcanic and Slate Series*), and perhaps in part the Llandovery (*Passage Beds between the Ordovicians and Silurians*); while the strata below the unconformability are the equivalents of the Arenig (*Passage Beds between the Ordovician and Cambrian*) and part of the Cambrian; the lower portion of the Ordovician (*Dark shale series*) being absent. And if the markings near Fintown, Co. Donegal, in the black shales belonging to the rocks below the unconformability (*gneiss and schist series*), which were exhibited at the British Association Meeting, Birmingham (1886), turn out to be Graptolites of Arenig types, as some consider them, *such evidence ought to prove the correctness of this suggestion.* This classification originally was made from petrological or stratigraphical evidence.

The Galway area, declared to be of Archæan age, is as follows. To the south-east granitic-gneiss with metamorphic and intrusive granite; these are margined by gneiss and schist; while in the western portion of the area there are rocks, principally argillaceous, very slightly altered, with intrudes of granite. The south-east granitic-gneiss can be traced, first northward, then north-westward, through schist into the "Doolough bed," in the neighbourhood of Killary Harbour; the latter rocks having in them fossils of Llandeilo types; while westward this granitic-gneiss can be traced through schist into the slightly-altered rocks margining the western coast. The latter rocks have all the characteristics of the "Doolough beds," although fossils have not as yet been found in them.

The supposed boundary of the Archæan area is an arbitrary line drawn nearly westward from Clifden to Oughterard; while both north and south of this line the major portion of the rocks are lithologically identical. *Therefore there are no records of a vast lapse of time.* Stratigraphically it seems proved, *that the so-called Archæans of Galway, instead of being the oldest rocks of the country, are the equivalents of the latest Ordovicians.*

In North-west Mayo (Erris) the tract that has been given a brevet rank is a patch of granite and gneiss, in sub-metamorphic rocks. Here there is a marked distinction between the lithological character of the rocks; but there are no records of a lapse of time, as there is no basal conglomerate in connection with the sub-metamorphic rocks, which the description given in the Geological Survey Memoir has led some to believe. The rocks in this tract have undergone much more metamorphism than those in the adjoining county, which led Griffith to believe they were older; possibly they may be of Archæan age—or the still-unnamed Passage Beds; but it seems more probable that they are of the same age as the rocks in North-east Mayo and South Donegal, which are as much, if not more altered, and whose age probably is either Arenig or Cambrian.

In North-east Mayo, Sligo, Leitrim, and Donegal, there are no hard boundaries to the tracts of the so-called Archæans; as the rocks in general graduate one into another, except in a few places where faults or intrudes occur. So gradual is the change, that the supposed boundaries have several times been changed. In fact, they are like the rolling fences of a farm adjoining a common, one time here and another time a quarter of a mile or more away; yet, in reference to the Archæan boundary, each successive line is said to be an "undoubted line of a double hiatus ! ! ! the rocks on one side being Archæan, and on the other the equivalents of the Ordovicians." Yet on both sides of such boundaries there are in places identical rocks; this difficulty has, however, been got over by mapping all rocks inside the lines as gneiss, and those outside as schist—regardless of their lithological characters.

If the Fintown markings are not fossils, *all* the rocks below the unconformability may be of any age, from Arenig to Archæan, *but all must be included*, as they are portions of one regular series. They, however, cannot be the American Archæan, but, possibly, under such circumstances (that is, the Fintown markings not being fossils), they may represent the unnamed passage beds between the Archæans and the Primordial.

In the Co. Tyrone, the rocks of the Slieve Gallion district are more or less similar, lithologically, to the Huronians of Ontario. To the south of them there is a well-marked break in time between them and the fossiliferous "Pomeroy beds" (Llandovery ?). Northward they are bounded by schistose rocks that lie on them unconformably; yet, but for this unconformability, the rocks above and below it are lithologically so similar, that they might be considered as belonging to one group. These Slieve Gallion rocks, although having lithological and other characters that might possibly suggest an Archæan age, are evidently, as has been pointed out in previous writings, the eastern extension of the rocks of the Pettigoe District, South Donegal, in which case they belong either to the Arenig or the Cambrian. The Pettigoe rocks in the new classification have not been given a brevet rank, but are said to be the equivalents of the Ordovicians.

The most northern portion of Ireland, Innistra Hull, off Malin Head, Innisowen, Co. Donegal, consists of gneiss. Possibly this may be a bit of the Laurentian Hills, separated by a convulsion of nature and strayed away, to be stranded and find a home off the coast of Ireland. More probably, however, it is of Arenig age.

It should be mentioned that the natural unconformity in the metamorphic rocks of Ulster is treated very cavalierly; as in some places it is recognized and pointed out as "the undoubted proof of the Archæan age of the rocks below it," while in all places where its position proved that the gneiss and schists below it must be portions of one and the same series, it is ignored and is said not to exist. It may also be interesting to record, that the two advocates for the presence of Archæans in Ireland are at variance; as the one rejects the idea of there being Archæans in South-east Wexford, while the other seems to say that there cannot be Archæans in Donegal, as the so-called "Laurentian gneiss" is an intrusive mass.

## VI.—NOTE ON THE AFFINITIES OF THE SO-CALLED "TORPEDO" (*CYCLOBATIS*, EGERTON) FROM THE CRETACEOUS OF MOUNT LEBANON.[1]

By A. SMITH WOODWARD, F.G.S., F.Z.S.,
of the British Museum (Natural History).

IN a paper read before the Geological Society in 1844,[2] Sir Philip Egerton made known an interesting fossil Selachian from the Cretaceous beds of Mount Lebanon, which he named *Cyclobatis oligodactylus*, and referred to the Torpedinidæ, in consequence of its apparently unarmed skin and the resemblance between its general form and that of the familiar electric Torpedo. Six years afterwards Pictet[3] figured and described a second specimen of the fish, adding some further particulars of the skeleton, and adopting Egerton's determination of its affinities. And quite lately,[4] Mr. James W. Davis has made another contribution to our knowledge of the genus, by describing a larger and more robust species under the name of *C. major.* The fish is again relegated to the Torpedinidæ, and, so far as I have been able to discover, the same original determination has been universally adopted up to the present time.

The fine series of specimens now in the British Museum, however, appear to afford conclusive proof that the imperfections in Sir Philip Egerton's original fossil led to an erroneous interpretation. I have recently determined that the skin was far from unarmed; and a comparative study of the fins has shown that they are totally distinct in character from those of all known genera of Torpedos, while they approximate in a striking manner to those of the "Sting-rays" or Trygonidæ. There seems, indeed, to be no doubt whatever that *Cyclobatis* is truly a member of the last-named family; and there are four principal reasons why this position should be assigned to it rather than that to which it has hitherto been referred. These reasons may be concisely stated as follows.

1. *The pectoral fins are uninterruptedly continued to the end of the snout, and were thus probably confluent in front.* This, as is well known, is one of the main characters of the Trygonidæ, but it is a condition apparently never met with among the Torpedinidæ. I have examined species of all the genera of the latter family, except *Discopyge*, and find that, in no case, do the cartilages of the pectoral fin extend in advance of the antorbital.

2. *The pelvic arch is placed far forwards, and the rays of the pelvic fins scarcely extend posteriorly beyond the extremity of the pectorals.* Though perhaps not of such fundamental importance as No. 1, this peculiarity is much more suggestive of the Trygonidæ than the Torpedinidæ, the living examples of the former often exhibiting it, but the latter rarely or never.

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[1] Read before Section C, British Association, Manchester, 1887.

[2] Sir P. Egerton, "Description of a Fossil Ray from Mount Lebanon (*Cyclobatis oligodactylus*)," Proc. Geol. Soc. vol. iv. pp. 442-446, pl. 5.

[3] F. J. Pictet, "Poissons fossiles du Mont Liban," 1850, p. 55, pl. x. fig. 4.

[4] J. W. Davis, "The Fossil Fishes of the Chalk of Mount Lebanon, Syria," Trans. Royal Dublin Soc. [2], vol. iii. (1887), p. 491, pl. xxi. fig. 1.

3. *There are no traces of median fins.*—In the Torpedinidæ, these fins are always more or less developed, one or two dorsals being invariably present, except in *Temera*, and in this genus the caudal fin is well represented. In the Trygonidæ, on the other hand, the presence of median fins is an exception to the general rule, dorsals never being met with, though sometimes replaced by barbed spines.

4. *The skin is armed with spinous tubercles.* Though not previously observed, the National fossils demonstrate very clearly that the dorsal surface of *Cyclobatis* was provided with at least one median row of prominent spines, and there are numerous minute prickles scattered both over the trunk and fins.

The larger tubercles are best seen in the type-specimen of *C. major* (the rough impressions of a few being shown in Miss Woodward's drawing, *loc. cit.*) ; in another fossil (B. M. No. 49514) which Mr. J. W. Davis has also labelled as pertaining to the same species; and in an incomplete specimen of *C. oligodactylus* (No. P. 99). The first of these shows that the series was continued forward almost as far as the pectoral arch, though the tubercles in advance of the pelvic arch appear to have been much smaller than those behind, and they succeed one another at short intervals. Each of these dermal defences is oval in form, rising into a sharp spine; and those placed more anteriorly have the base radially crimped, while the posterior examples seem to have been smooth, with the spine much more laterally-compressed and thorn-like, and the apex directed backwards. In one small fossil (No. 49557), of doubtful species, the tail has the appearance of being completely encased in rows of the tubercles.

The minute, irregularly-scattered prickles may be most satisfactorily studied in Nos. 49556, 49557, and 49514, their shape and characters being best displayed by the first-named, and their distribution by the two latter. Each of them seems to consist of a small erect, or backwardly-directed, spine, fixed upon a rounded, radially-marked base, being, in fact, a miniature of a larger tubercle, but higher in proportion to its size. There are some indistinct traces of these structures in Egerton's original specimen of *C. oligodactylus*; and the example of *C. major* (No. 49514) already referred to shows them densely arranged upon the margins of the pectoral fins. I have discovered no other dermal calcifications, except the teeth; and the "small hexagonal shining dermal ossicles," mentioned by Mr. Davis (*loc. cit.*), are evidently the superficial calcified tesseræ of the endoskeletal cartilage.

None of the living "electric rays" are known to have the slightest trace of dermal asperities, whereas the presence of these is a marked feature of certain Trygonidæ—especially the genera destitute of barbed caudal spines; and the facts just recorded are therefore corroborative of the inferences drawn from the three previous considerations, namely, that it is to the Trygonidæ rather than to the Torpedinidæ that *Cyclobatis* must be referred.

It would thus appear that there is still no evidence of the existence of Torpedoes in times anterior to the Eocene; and the earliest undoubted members of this family hitherto discovered, are the species made known by Volta[1] and Baron de Zigno[2] from the fish-beds of Monte Bolca, near Verona.

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## VII.—The Extent of the Hempstead Beds in the Isle of Wight.

By Clement Reid, F.G.S.

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

Owing to the impossibility of making an accurate Survey of many of the flatter and Drift-covered portions of England, in the absence of sections, the light boring tools so extensively used by the Geological Survey of Belgium have been experimentally tried during the last few months in the Isle of Wight. The results arrived at are of so much interest that the Director has requested me to draw up this preliminary notice.[3]

The Hempstead Beds, which were thought to be confined to the outlier at Hempstead Cliff and another of unknown extent in Parkhurst Forest, prove to be much more important, indeed they occupy about half the Tertiary area of the Isle of Wight.

To find their limits series of borings were made, radiating in different directions from the highest points in Parkhurst Forest. These proved that the whole of the deposits there represented belong to the lacustrine Middle and Lower Hempstead Beds, for there was no trace anywhere of the *Corbula* or *Cerithium plicatum* zones. The "White Band" was met with in several places in the lower part of the Forest, but the outcrop of the "Black Band" (the base of the Hempstead Series) is a long distance away. It was found—with abundance of its characteristic fossils—less than half a mile from the Chalk, at Gunville, one mile west of Newport, and was traced eastward through Newport to Brading, always parallel with the Chalk, and dipping at high angles away from it. The northern limits pass near Ryde, Wootton, Osborne, and across the Medina to Gurnard, Newtown, and Hempstead.

Though no Hempstead Beds seem previously to have been noticed in the East Medina, they are very well represented there, and must be nearly 200 feet thick. At Wootton there is a small outlier, over 20 feet thick, of the higher estuarine beds full of *Cerithium plicatum*, *C. elegans*, and *Melania inflata*; but I have not yet succeeded in finding any relic of the *Corbula* Beds. Below this are mottled clays with *Unio*, etc., for about 50 feet, resting on thick sands, which in the East Medina seem to represent the base of the Middle Hempstead Beds. Beneath the sands is another series of mottled clays with *Paludina lenta* and *Cyrena semistriata*. These are about 80 feet thick, and have at their base the "Black Band." The Black Band and shales immediately above are very fossiliferous at Newport and

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[1] Volta, "Ittiolitologia Veronese," 1796, p. 251, pl. 61.

[2] A. de Zigno, "Annotazioni Paleontologiche," Mem. R. Istit. Veneto, vol. xx. (1877), p. 452, pl. xvii.

[3] Full details will be given in the new editions of Mr. Bristow's "Geology of the Isle of Wight," and of the Geological Map—which, however, cannot appear for some months.

Wootton, and are full of the characteristic *Hydrobia Chastellii, H. pupa, Neritina tristis, Modiola Prestwichii*, etc.

Borings on each bank of the Medina prove that the Hempstead Beds cross the river unaffected by any fault, as also does the Bembridge Limestone at Cowes. The singular rise of the Osborne Beds at East Cowes, which has always been taken to indicate a fault, is caused by the intersection at right angles of two undulations, which produce a skew dip. Building operations at East Cowes show that the Limestone falls from Osborne to the bank of the Medina, where it can now be examined on the foreshore nearly opposite the exposure on the left bank of the river.

The Bembridge Marls also prove to be of considerably greater thickness than was formerly thought; they probably average about 120 feet.

## VIII.—Bursting Rock Surfaces.

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

THE interesting note by Mr. Strahan in the Geol. Mag. for September, 1887, on explosive slickensides, reminded me of some similar phenomena which were not of unfrequent occurrence near Dent Head and Ribble Head in Yorkshire.

In the limestone quarry from which the black marble of Dent is procured the workmen found that, when they were quarrying the lower beds and struck the rock with a pick or bar, fragments flew up into the air with greater force than could be due to their blow and in an unexpected direction.

Also, when the tunnel was being made above Ribble Head, and the workmen were engaged upon the bed of rock which formed the floor of the tunnel, pieces used to burst off with a loud noise, so that some thought they had discovered a detonating shale.

The explanation in both these cases seemed to be that the bed which was apt to shell off in that unexpected manner rested on shale which yielded to the superincumbent weight on either side, and produced in the tunnel, or in the quarry, where the overlying rock had been removed, what would be called in a coal-mine a "creep" (see Woodcut).

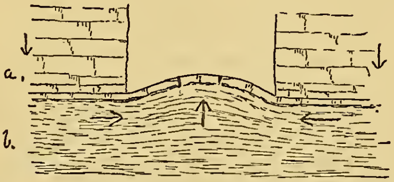

Diagram showing the manner of occurrence of Bursting rock at Dent Head and Ribble Head in Yorkshire. *a* rock. *b* shale; the arrows denote the direction of the pressure.

The shale behaves as a thick fluid or viscous mass, and transmits the pressure and motion. But in the cases to which I refer, a thin bed of the solid rock was left above the shale. This was not compressible, but, where, in the tunnel or in the centre of the quarry, the weight of the overlying rock had been removed, it rose in a slight arch over the upthrust shale, and was thrown into a state of tension, so that when struck, chips and flakes, and sometimes larger pieces, would fly off. These pieces were in themselves quite sound. It was not that the whole mass was like Rupert's drops in a state of molecular unstable equilibrium, as suggested by Mr. Adam, and supported by Mr. Strahan in the case of the explosive slickensides, but it was rather analogous to the effect of drawing a knife across the outside curve of a bent stick; when jagged ends spring off and stand out straight in the original direction of the unbent stick—only in this case the fibrous character of the material prevents the pieces breaking away altogether as if it were rock. That the conditions in the case of the explosive slickensides were similar to those at Dent Head Quarry and the Ribble Head tunnel seems probable from the observation of Watson that "this phenomenon has not been noticed from slickensides where no shale is incumbent," and also from the suggestion of Phillips, "that the removal of one side of a vein would leave the remaining side in a condition of strain resembling that of a strung bow, with a tendency to bulge outwards into the workings. The undercutting would free, so to speak, one end of the bow."

But the observations at Dent Head Quarry and Ribble Head tunnel would show that it was not merely a bringing down of the mass of the vein stuff when undercut that was remarkable, but rather the tendency to shell off in chips and flakes over the whole surface. The beds at Dent Head and Ribble Head were approximately horizontal. Also it would appear from analogy that what the vein stuff did was not to offer a *material* more readily burst up, but a mass of the form and extent which could be bent by settlement of the surrounding rock so as to be thrown into a state of tension all over the exposed surface.

In connection with these inquiries we must always remember that time is an element in the bending of rocks, and that it is the rapidity of the action due to the artificial removal of the overlying mass that causes the rock to break rather than to sag and retain its curved form, as we see so commonly among the contorted strata where nature has applied the pressure more gradually.

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## IX.—Note on *Hylæochampsa.*

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

In my paper on Crocodilia in the July Number of the Geological Magazine, pp. 310–311, I expressed my opinion that the characters given by M. Dollo in his description of the Belgian *Bernissartia* did not appear to me to afford grounds by which that form could be distinguished from *Hylæochampsa*, and I accordingly observed in a note that the *onus* of proving the distinctness of the former rested with its describer. In a note published on pp. 394–396 of the September Number of the Magazine, M. Dollo replies to this criticism, and shows conclusively that the Belgian form is entitled to specific, and very probably to generic distinction from the larger English one.

In respect, however, to the serial position of *Hylæochampsa*, there is no question whatever but that it must be regarded as one of the most specialized members of the Goniophiloid Crocodiles, and from the backward position of the posterior nares and the small size of the supratemporal fossæ that it is probably allied to *Bernissartia*. In my original paper I purposely refrained from quoting Sir R. Owen's description of the orbito-temporal region of *Hylæochampsa*, because, either from being misled by the broken edges of the bones in this region, or from not having at that time directed his attention to the importance of the features of this part, the Professor's description is not altogether satisfactory;[1] but the fact is undoubted that *Hylæochampsa* has the orbit in as complete communication with the lateral or infratemporal fossa[2] as in *Crocodilus* itself.

Assuming that *Hylæochampsa* be distinct from *Bernissartia*, the question will then arise whether the procœlous vertebræ of a small Crocodilian from the Wealden both of Sussex and the Isle of Wight described by Prof. Seeley in the Quart. Journ. Geol. Soc. vol. xliii. p. 212, pl. xii. figs. 7–8, under the name of *Heterosuchus valdensis*, may not belong to the former genus. This view occurred, indeed, to me at the time of writing my above-mentioned paper; but being then unable to distinguish *Hylæochampsa* from *Bernissartia* (in which the vertebræ are amphicœlous), it could not be advanced. In favour of it we may observe that it is highly improbable that the transition from the amphicœlous to the procœlous type of vertebræ precisely synchronized with the union of the pterygoids beneath the narial passage, and therefore that it is highly probable that *Hylæochampsa*, in which the posterior nares are only one step removed from the most specialized type, may have had procœlous vertebræ. I cannot, of course, put forward this suggestion as anything more than a possible, or perhaps probable, contingency; but it clearly shows how undesirable it is (as I hope shortly to show on another occasion) in the case of any particular group to form one genus on portions of the skeleton which are totally unknown in one already described.

Finally, I may observe that in the scheme of classification given on page 312 of my paper I proposed the name Crocodilia Vera for the united Eusuchia and Mesosuchia of Prof. Huxley; on further consideration, however, the term Eusuchia appears such a convenient one in opposition to Parasuchia, that I think it preferable to retain this old and well-known name in a wider sense, than to substitute for it the new one proposed.

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[1] In his reply, M. Dollo enlists Mr. A. S. Woodward on the side of the Teleosauroid nature of *Hylæochampsa*; but I am authorized to state that the latter writer merely followed the lead of Sir R. Owen in this respect, and that having examined the specimen with me when I was writing the original paper, he was fully convinced of the relation of the orbit to the infratemporal fossa being of the type obtaining in the *Crocodilidæ*.

[2] By an inadvertence on p. 310, line 29 from top, of my paper, the words "*chez celui-ci*" are omitted at the conclusion of the quotation from M. Dollo; an omission which alters the sense of the whole passage.

# NOTICES OF MEMOIRS.

## I.—Recent Researches in Bench Cavern, Brixham, Devon.

By William Pengelly, F.R.S., F.G.S., etc.

As long ago as 1839 the workmen in a limestone quarry on the southern shore of Torbay, and adjacent to the town of Brixham, laid bare at the back of the quarry the greater part of a vertical dyke composed of red earth and angular pieces of limestone. The quarrying operations, then discontinued, were resumed in 1861, when the entire dyke was disclosed, and among the materials of an incoherent part of it which fell down, were found some hundreds of osseous remains, including skulls, jaws, teeth, vertebræ, portions of horns, bones, and pieces of bones, identified by Mr. W. A. Sanford, F.G.S., as relics of the Cave-Hyæna, Wolf, Fox (2 species), Bear, Wild Bull, Reindeer, Hare, and Arvicola (2 species). The Hyæna was by very much the most prevalent form; but there was nothing indicating that he found a habitual home there. Not a coprolite was met with, nor was there a single bone scored with his teeth-marks, or broken after any of his well-known modes. The entire absence of anything betokening the existence of man was equally marked. It must be remembered, however, that the finds then met with were all from a mass of heterogeneous material which had filled a fissure nowhere more than two feet wide, and in places not more than a very few inches—not from a cavern in the proper sense of that term.

Adjacent to the left bottom corner of the dyke was the mouth of a low narrow tunnel, having a floor of stalagmite and extending into the hill to an unknown distance, but certainly upward of 30 feet. The proprietor of the quarry declined to allow any scientific investigations to be made, stating that he meant to make such researches himself; but this was never done.

In September, 1885, Mr. W. Else, Curator of the Museum of the Torquay Natural History Society, obtained permission from the gentlemen into whose hands the property had passed, to make such explorations as he might find desirable both in the dyke and in the tunnel; and from that date he has spent on the work all the odds and ends of time he has been able to command. His more recent researches have been mainly carried on in the tunnel, where he found the stalagmite floor, from 6 to 12 inches thick, formed on a reddish cave-earth, having a maximum thickness of 14 inches, and lying on a continuous limestone basis. Beyond a few remains of Hyæna nothing of interest occurred in the stalagmite, but the contents of the cave-earth were more numerous and interesting. In July, 1887, 24 specimens of bone selected from Mr. Else's finds—21 being from the cave-earth in the tunnel and 3 from the dyke—were forwarded for identification to Mr. E. T. Newton, of the Geological Survey of England, who at the end of a very few days returned them with a list containing not only the names of the species to which they belong, but also those of the bones themselves.

Of the 21 from the tunnel one is a relic of a Fox, while all the others are those of the Cave-Hyæna. The three from the dyke represent the Cave-Bear, *Rhinoceros tichorhinus*, and a species of Deer. Among the tunnel finds there were also three coprolites and a solitary part of a left lower jaw of Hyæna divested of its lower border—two facts indicating that the Hyæna occasionally visited the tunnel. Here also was found one, and but one, flint-flake tool. It has the white colour so prevalent in the tools found in the cave-earth of Kent's Hole, and was met with under circumstances admitting of no doubt of its having been made and used by a human contemporary of the Cave-Hyæna in Devonshire.

## II.—On Some Important Extra-Morainic Lakes in Central England, North America, and elsewhere, during the Period of Maximum Glaciation, and on the Origin of Extra-Morainic Boulder-clay. By Professor H. Carvill Lewis, M.A., F.G.S.[1]

The lakes so characteristic of all glaciated districts are due to several causes. Some few are due to an actual glacial scooping out of the rock floor, many to an irregular deposition of the drift, by which former watercourses are obstructed, and still others to the terminal moraine or to the glacier itself. These latter, known as *morainic lakes*, may be divided into *inter-morainic lakes*, *moraine meres*, and *extra-morainic lakes*, according to their position—back of, in, or outside—the moraine. Extra-morainic lakes, if dammed up by the ice front, are temporary in character, disappearing with the retreat of the glacier; but, as they may be of enormous extent if the glacier is large, they may produce deposits of much geological importance. Instances of such lakes occur in Switzerland, and ancient examples occur as well in Northern Germany, Asia, North America, and Central England. They are to be expected wherever a glacier advances against or across the drainage of a country. Mr. Belt supposed that Northern Asia was covered by a lake of this character, caused by the Polar glacier obstructing the rivers flowing north.

In North America, where the terminal moraine has been accurately mapped for thousands of miles, deposits of boulder-clay and erratics occur outside of the moraine, and have been supposed to be due to an older glacier in the first glacial epoch. But the general absence of striæ or of glacial erosion or moraines in this district prove that a glacier was not the agent of deposition. Nor are there any traces of marine life in the deposits. This extra-morainic boulder-clay is narrow in Pennsylvania, where the author has called it "the Fringe," but west of the Missouri is 70 miles wide; and in British America, between the great moraine called the "Missouri Coteau" and the Rocky Mountains, is 450 miles wide and over 1000 miles long. It only occurs where rivers had flowed *toward* the glacier, and is explained as the deposit of great temporary freshwater lakes dammed up by the ice front, the erratics having been dropped by icebergs.

Similar deposits occur in England outside of the terminal moraine,

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[1] Abstract of a paper read at the Manchester Meeting of the British Association, September, 1887.

and have been the subject of much discussion; being held by some to be proof of marine submergence, by others to be the ground-moraine of a glacier. The "great chalky boulder-clay" is the best known of these deposits. There are serious objections to the two theories heretofore advanced to explain this, whilst the hypothesis of extra-morainic freshwater lakes, dammed up by the glaciers, is sustained by all observed facts. The most important of these lakes was one caused by the obstruction of the mouth of the Humber by the North Sea glacier, whose terminal moraine crosses that river at its mouth. This large lake reached up to the 400 feet contour line, and extended southward nearly to London, and westward in finger-like projections into the many valleys of the Pennine Chain. It deposited the "great chalky boulder-clay," and erratics were floated in all directions by icebergs. It was bounded in the Vale of York by the Stainmoor glacier, and Charnwood Forest was an island in it. At its flood period it overflowed south-westward by torrential streams into the Severn Valley and elsewhere, carrying the "Northern Drift" into the south of England. Other glaciers in England were bordered by similar but smaller lakes wherever they advanced against the drainage. Three such lakes were made by the Aire glacier, the largest of them extending to Bradford. The Irish Sea glacier caused many similar lakes high up on the west side of the Pennine Chain, and at its southern end north of Wolverhampton. The overflow streams from the most southern of these lakes joined those issuing from Lake Humber in the Birmingham district, characterized by a "commingling of the drift," otherwise inexplicable. An examination of the supposed evidences for glaciation, and for a great marine submergence in Central and Southern England, shows that neither theory is sustained by the facts. Thus, the supposed striæ on Rowley Rag prove to be rootmarks or ploughmarks; those reported at Charnwood Forest to be due to running water or perhaps icebergs; the supposed drift on the chalk wolds to be a local wash of chalk flints; the high level gravels on the Cotteswold Hills to be pre-glacial; the shells at Macclesfield, Moel Tryfaen, and Three Rock Mountain to be glacier-borne, and not a proof of submergence; the drift on the Pennine plateau of North Derbyshire to be partly made by icebergs floating in Lake Humber, and partly a decomposed Millstone Grit or Bunter Sandstone; and the Welsh erratics on Frankley Hill at a height of 800 feet to be due to a more ancient glaciation.

The conclusion that the glacial phenomena of England are due neither to a universal ice-cap nor to a marine submergence, but to a number of glaciers bordered by temporary fresh-water lakes, is in accordance with all the observations of the author in England and elsewhere.

*Postscript.*—Since the paper was read, of which the above is an abstract, I have found traces of the existence of a very much older series of glaciers than those here described. Since the period of these ancient glaciers, which in many places were more extensive than the modern ones, earth movements have occurred and erosion has removed almost all their deposits and generally obliterated the striæ, so that the region subject only to the older glaciation now resembles a non-glaciated area. The glaciers and their bordering lakes described above should therefore be considered as belonging to the second or last glacial epoch.

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## III.—The History and Cause of the Subsidences at Northwich and its Neighbourhood, in the Salt District of Cheshire.

By Thos. Ward, Esq.

THE frequent occurrence of subsidences in the neighbourhood of Northwich makes it desirable to learn their history and cause.

Northwich overlies extensive beds of salt. These occupy about three square miles. The first or 'top' rock-salt lies at a depth of about fifty yards from the surface, and is covered by Keuper marls, and these by the drift sands and marls. Between the two beds of salt there are 30 feet of indurated Keuper marl. The second, or 'bottom' rock-salt, is over 30 yards in thickness. These beds of salt occupy the lowest portion of an old Triassic salt lake.

The first bed of rock-salt was discovered in 1670, the second in 1781. From about 1730, at which date the river Weaver and the Witton brook were rendered navigable, until after 1781, all the rock-salt mines were in the 'top' bed, and the whole of these with one exception have been destroyed, and in almost every case by water, leaving funnel-shaped nearly circular holes. These are now filled with water and are known as 'rock-pit' holes. The rock-salt mines are now in the lower bed and very rarely fall in. When worked to the boundary, water and brine, either or both, break in or are let in, and the mines are utilized as huge reservoirs.

The falling in of a rock-salt mine is a very rare occurrence, and subsidences of this kind do not give rise to the reports which are met with in the newspapers. The first reported destruction of a mine was in 1750, and from that date to the end of the eighteenth century every two or three years a mine collapsed. In the present century, at considerable intervals of time, collapses of mines have occurred, but these with scarcely an exception were old abandoned 'top' mines.

The subsidences which are so destructive in the town of Northwich and the neighbourhood are entirely caused by the pumping of brine for the manufacture of white salt. It was only about 1770 or shortly afterwards that the first sinking was noticed; since that date subsidence has gone on very rapidly, and much destruction of property has resulted. Large lakes or 'flashes,' one of more than 100 acres in area, and of all depths up to 45 feet, have been and are being formed. Prior to 1770 not more than 30,000 tons of salt were sent down the Weaver navigation; by the end of the century it reached 100,000 tons, and in 1880 had increased to 1,087,000 tons. The whole of this salt was taken off the surface of the first bed of rock-salt by the solvent action of water. In fact, water is the instrument used to mine and carry off the salt to the pumping centre. The brine pumps set up a circulation of the salt water or brine lying on the rock-salt, which flows to the pumping centres. The brine thus removed is replaced by fresh water, which on its passage to the pump saturates itself taking up sufficient salt to make a solution containing about 26 per cent. of salt. This continual removal of salt from the surface of the rock-salt lowers it, and the overlying earths either follow the diminishing surface continuously, or else after remaining suspended for a time suddenly fall into the cavity from which the water has extracted the salt. The brine currents on their way to the pumping centres form deep valleys or troughs, and the surface of the ground overlying forms a facsimile of these hollows. The property on the sloping sides of the valleys is pulled to pieces and destroyed; the windows and doors all get out of form owing to the unequal sinking of the various portions of the house. When, owing to the different nature of the marls and the abundance of sand overlying them, a sudden sinking takes place, the hole extends to the surface and swallows up anything upon the surface—as a horse in a stable, barrels of beer in a cellar, or water butts and other utensils in a yard. The damage done to property is enormous, but thus far no human life has been lost. The most serious part of the matter is that the brine-pumper takes not only his own salt in solution, but that of all his neighbours over whose salt beds the water flows, and neither asks their consent nor pays them for the salt thus obtained. Worse even than this, the owner of the property overlying the brine 'run' suffers most serious damage to buildings, etc., but can obtain no compensation, because amongst the number of brine-pumpers he cannot prove who is doing the particular mischief complained of. This peculiar phenomenon of subsidence in the salt districts is worthy of more consideration than it has hitherto received from scientific men.

## IV.—ON THE OCCURRENCE OF PORPHYRITIC STRUCTURE IN SOME ROCKS OF THE LIZARD DISTRICT.[1] By HOWARD FOX and ALEX. SOMERVAIL.

PROF. BONNEY has described a porphyritic diabase which is seen on the shore at Polpeor; it cuts, in an intricate manner, through micaceous and hornblendic schists. The authors have traced this rock further, and have recognized a porphyritic structure in many dykes and intrusions along the coast which cut through the serpentine, and also in the darker bands of Professor Bonney's 'granulitic group.'

Descriptions of these various localities were given and illustrative specimens exhibited. The crystals of felspar are found to be most numerous in those rocks which lie in the closest proximity to the gabbros and serpentine. They have their long axes at various angles, and are mostly small except at Parn Voose, Cavouga, and Green Saddle. The felspathic and hornblendic lines often circle round the crystals.

Without discussing any theory as to the true nature and origin of the whole of the schists, the authors think that the porphyritic structure so prevalent in the dark bands of the 'granulitic group,' in many of the micaceous and other rocks, as also in the later intrusions cutting the serpentine, indicate an igneous origin for many rocks hitherto regarded as schists.

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[1] See Mr. Teall's paper, *ante*, pp. 484–493.

## CORRESPONDENCE.

### REMAINS OF *BOS PRIMIGENIUS* RECENTLY FOUND AT SOUTHAMPTON.

Sir,—During the progress of the excavation for the purpose of forming a new deep water dock of eighteen acres at Southampton, a fine specimen of the horn cores and part of the skull of *Bos primigenius* has been found.

The river mud with which the excavation begins is of a thickness varying from ten to fifteen feet, below which a bed of peat resting on dark angular flint gravel occurs. Both the peat and the gravel vary in thickness, as the gravel is found more or less in ridges, in the hollows of which the peat attains its greatest depth. It was from one of these thick masses of peat that the remains of *Bos primigenius* were met with at a depth of nearly twenty feet below the surface of the mud, which formed the bed of the tidal estuary at this spot.

The skull was found in one piece, and includes the frontal, occipital, temporal, sphenoid (with both wings), and tympanic bones, with fragments of the pterygoids, and of the ethmoids.

The temporal fossæ are preserved, and the roof of one orbit, and part of the other; the zygomatic arches are incomplete.

The breadth of the forehead, across the centre, is ten inches, and between the orbits about twelve inches. The length of the forehead as preserved is eleven inches, and the length from the frontal crest to the base of the occipital bone is ten inches. The circumference of the cores of the horns at their roots is sixteen and a quarter inches, and the length of the cores round the curvature about twenty-nine inches. The width apart of the horn cores from tip to tip is thirty-four and a half inches.

The specimen has been placed in the Museum of the Hartley Institution, Southampton. T. W. Shore.

### PALÆONTOLOGICAL NOMENCLATURE AND THE TRINOMIAL SYSTEM.

Sir,—An answer given not very long ago in an Examination paper was as follows, "Physical Geography is the work of God, Geology is the work of man." No doubt the candidate who wrote this answer failed to receive full marks; but since the matter was brought to my notice, it has frequently occurred to me that the reply was not altogether inappropriate. Geology and Palæontology are suffering from such an infusion of new and hard names that the ordinary reader and even the hard-working student are often bewildered and baffled in their efforts to comprehend the progress of knowledge. It is not my intention now to discuss any of the new terms applied to our formations and their subdivisions; suffice it to say that most of the suggestions to replace old and well-understood names would, if adopted, be more likely to place obstacles in the path of the inquirer than to assist or encourage his studies. What even more painfully stirs me at the present time is the multiplication of generic or subgeneric names of Ammonites, and the confusion that appears to have arisen concerning what have hitherto been regarded as recognizable species.

It is indeed difficult for the "general geologist" to understand and remember the subgeneric names of Ammonites, especially when the form known as *Harpoceras concavum* has been recently changed again to *Lioceras concavum,* and *H. Murchisonæ* has become *Ludwigia Murchisonæ.* One cannot help wondering what other changes may be in store for us. It is, however, still more perplexing to be told by one who has devoted especial attention to the subject, and who is in every way qualified to speak with authority, that the form which is "called by D'Orbigny, Wright, and others *Am. serpentinus,* and is so labelled in museums and private collections, is the *Ammonites falcifer* of Sowerby." (See S. S. Buckman, GEOL. MAG. Sept. 1887, p. 396.) What is then to become of our "*Serpentinus*-beds"? Again, the same palæontologist tells us that the occurrence of *Ammonites Jurensis* in England is doubtful, in fact he has never yet ascertained its presence in our strata. (Proc. Cotteswold Club, vol. ix. part 2, 1887.) What then is to become of our "*Jurensis*-beds"? Once more, the recognition of the true *Ammonites Sowerbyi* appears to be a source of great difficulty to judge by the remarks made in a recent volume of the Palæontographical Society. (Hudleston, Introduction to Gasteropoda of the Inferior Oolite.) Even the "*Sowerbyi*-beds" are in trouble!

The question that perhaps naturally arises to an outsider is this, cannot these well-known specific names be applied in a sufficiently comprehensive way to include the forms which the older authorities recognized under the names of *A. serpentinus, A. Jurensis,* and *A. Sowerbyi,* respectively?

To go further, would not the adoption of the trinomial system meet all requirements, and be the means not only of doing justice to the more minute and exceedingly important observations made now-a-days, but also of placing the results of this detailed work in a manner more intelligible to the "general geologist"? It would seem likely under present circumstances that some collective grouping of the many species now made must eventually take place, if any individuals except the specialists in each department are to follow the progress of palæontology, or attempt the naming of their fossils: and this grouping might be done under the trinomial system, better, it appears to me, than under the system which introduces subgeneric names. So far as the geologist is concerned, he simply requires a definition of specific characters, and a key to the distribution of each species in time and space. Where particular varieties are confined to special horizons, he can obtain this precise information on the trinomial system. Moreover, the adoption of that system would fulfil all the requirements of the biologist. No doubt many more specimens are available now for study than was formerly the case, and it becomes more and more difficult to draw rigid lines; but there seems to be a tendency to confine specific characters within narrower limits than heretofore, and this perhaps is the real source of the difficulty. I should feel much grieved if these remarks appeared to convey any slight whatever on the careful work of modern palæontologists; but my impression is that the object of their labours will be to a serious extent frustrated if their results are published in too complex a form for the "general geologist." Having said so much about changes of names, perhaps I may be pardoned if I sign myself, Rob. W. Haddow.

Banbury, 8*th Sept.* 1887.

## CHERT IN IRISH CARBONIFEROUS ROCKS.

Sir,—Chert is not, as supposed by Dr. Hinde, a definite characteristic of the Irish Upper Carboniferous Limestone (see chapter v. Manual of the Geology of Ireland, C. Kegan Paul & Co., 1878). Where this limestone is fully represented as in Co. Limerick, etc., the "lower cherty zone" is there best developed; and it occurs *in the lower limestone*, between the "lower shaly limestone" and the "Fenestella Limestone." A second conspicuous zone for chert lies between the Fenestella Limestone and the upper limestone, when of the "Calp type." In the upper limestone of Cork and Kerry there are layers and nodules of chert, but in Limerick, Tipperary, and part of Galway it is rare, while in the rest of Galway and in Clare it is more common. In part of Leinster, between the upper limestone and the Coal-measures lower shales, there is a cherty zone, but in the rest of Leinster and in Munster in all the known sections of the junction of the Limestone and Coal-measure shales, this cherty zone is absent. In Ulster, however, especially Fermanagh, where sections can be seen, this cherty zone is well developed and of a character similar to that described by Dr. Hinde as characteristic of the Yoredale Series, Yorkshire.

According to my experience chert is as frequent, if not more so, in the Lower, as in the Upper Irish Carboniferous Limestone. When it occurs in zones, it is usually accompanied by shaly beds, and is more or less friable; but when in compact limestones like those of the "Burren type," it stands out conspicuously like the nodules, lentils, and layers of flint in the chalk, as can be seen in innumerable places in Cork, Kerry, Clare, Sligo, Fermanagh, etc.; near Athenry, Co. Galway, in a railway-cutting, there is a thick bed.

As Dr. Hinde has been making researches as to the origin of chert, I would specially direct his attention to the chert lentils perpendicular to the stratification in Benmore, Co. Fermanagh, to which attention was first drawn by Thos. Plunkett, M.R.I.A., of Enniskillen, in a paper read before the Royal Dublin Society. Those mentioned in his paper occur in Benmore, but I have since observed them in Belmore and other places in that county. They are lenticular masses in height and depth, and have all the appearance of ordinary chert. I take it that they are the filling in of shrinkage fissures along a line of partial rupture. I would also draw his attention to the lower and middle cherty zones in the Co. Limerick, both of which are remarkable Palæozoic breaks, as in the intervening rock, "Fenestella Limestone," the fossils are quite distinct and much more abundant than in the strata above (Calp) and below (lower limestone with shale partings). I would also draw his attention to the papers published by the Boston Society on the island of Cuba, which I suspect might throw some light on the subject. As suggested in previous writings I suspect that the cherty zones in the Irish Carboniferous Limestone, especially that between the Fenestella Limestone and the Calp, must have some connection with vulcanicity.

Years ago Jukes got chert from Queen's Co., Limerick, Clare, etc., examined by Sorby, and I think I remember that he published about them.

Geological Survey of Ireland. G. H. Kinahan.

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## *RE* "EXPLOSIVE SLICKENSIDES."[1]

Sir,—I should like, if I may, to add a few facts which seem to closely bear upon the subject of Mr. A. Strahan's interesting article in the August Number of your Magazine. They are these:—In driving, exploring, or "opening-out" headings in certain seams of coal, loud reports are very frequently heard, which are often accompanied by the bursting-off from the sides of the excavations of large blocks or masses of coal. The noise made by such "explosions" or reports may be likened to artillery, and often causes men to run out of the place with alarm. Now, these "bumps," as the miners term them, generally occur in situations where the strata are much faulted by dislocations, and increase in importance with depth or thickness of cover. They probably happen most frequently and loudest in single drifts or headings, or those formed in advance of the general workings of the mine; and it is where these excavations are formed in the lower part of the coal-seam that the "bumps" are heaviest and produce greatest effects. Such an instance occurred a few years ago in one of the pits of the Moira Collieries close here, when a sudden and very severe bump completely displaced and shattered a single-brick "brattice"-wall (or partition, dividing the excavation longitudinally for ventilating purposes) for a length of about 24 feet. This wall was, as it were, completely *blown* out, and the men in the place were "jumped-up" off the floor, but not hurt. The wall was about three feet high and built with mortar. Again, in excavatimg the main roadways in the solid coal in the thicker seams of South Staffordshire, very severe bumps take place, and have been known to suddenly displace hundreds of tons of coal, by throwing them off the sides into the road. But in the ordinary course of coal-getting, especially by the method called the "Longwall" (*i.e.*, where all the seam is extracted by one operation), loud reports with bumps are of every-day occurrence, and now and again they have the effect of knocking out the props and sprags (wooden supports to roof and sides) and bring down a quantity of stuff. Also, during the operation of "holing" (under-cutting the coal-seam preparatory to breaking it down), the coal will keep on bursting itself off in little fragments from the face of the excavation with loud explosive reports, often putting the men's candles out. When the coal does this, it is said to have plenty of "life" in it, or "it keeps talking to you."

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[1] See Prof. T. McKenny Hughes' article, *ante*, pp. 511–512.

When in the mine alone and all work is suspended, I have frequently heard strange and unearthly (?) sounds, such as rattlings, scratchings, knockings, etc.—noises called "nackings" by the men. In Yorkshire I have heard of bumps of such magnitude taking place as to throw down large areas of roof in worked-out parts of the pit, and which created a blast in the air of the mine strong enough to knock men over, upset tubs, blow open doors, put out lights, and cause much havoc.

Subterranean rumblings, as is well known, have for several years been heard, and felt too, beneath and in the vicinity of the town of Sunderland; but these are considered to be due, not to coal-mining, but to the dissolution of the magnesian limestone by water which is constantly being pumped through it.

Now, it appears to me, that there is one common cause for all these "explosions," "bumps," "nackings," etc., which is simply this: the upsetting, by the excavation, of the equilibrium of the strains or pressures holding everything fast and firmly together—the removal of the support thereby causing the rocks to get relief and to fly off or apparently to explode. I look upon the phenomena as *miniature earthquakes* in fact.[1] I question very much whether gas has anything to do with these bumps, etc., even in coal-mines, but that they act upon the gas is exceedingly probable. The phenomena are certainly often very striking, and would seem to be worthy of much more attention than they have received. With Mr. Strahan's last paragraph I quite agree.

W. S. Gresley, F.G.S.

Overseal, 8 *Sept.* 1887.

## THE DATE OF THE ICE AGE.

Sir,—Some time ago you inserted a letter of mine in which I contended that a high eccentricity of the earth's orbit and winter aphelion would not produce all the effects which Dr. Croll assigned to them. I venture now to give some reasons for thinking that the Glacial Period did not occur so long ago as Dr. Croll's theory supposes. His principal maximum of eccentricity took place 800,000 years ago, while the last large maximum was about 210,000 years ago. Can the Ice Age have been as remote as this?

I have just returned from a visit to the Lake District, the glacial phenomena of which have been very fully described by Mr. J. Clifton Ward. The traces of ice-action along the sides of the mountains bordering the Valley of Borrowdale are remarkably numerous and well-defined. The sides of these mountains are usually steep and pretty bare, and the rainfall of the district is enormous. At Seathwaite, situated at the head of the valley, Sir John Herschel gives the annual rainfall at 141 inches, and Ramsay at 113 inches. No doubt the rocks are hard volcanic rocks which would stand a good deal of wear; but would the ice-markings be as

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[1] I recollect seeing it stated in a newspaper a few years ago that the wife of the colliery manager was disloged from her seat in the house in Nottinghamshire at the same moment that a very heavy "bump" occurred in the workings of the colliery below, which at the time was, by some, attributed to an earthquake.

distinct as they are if these steep mountain-sides had been exposed to annual rainfall of 100 inches for the last 200,000 years?

Above Grasmere there is a small lake, know as Easdale Tarn, which seems to have been partly formed by a terminal moraine, while earlier ice-markings down the valley seem to indicate that the glacier formerly pursued the same course which the stream from the tarn now follows. Though the drought of the season had been remarkable this stream was not a very small one, yet the work of erosion done by it since the Glacial period was not of a very startling description. It was not what I should expect a rapid mountain-stream (though checked by a small tarn) to effect in 200,000 years.

Such phenomena are by no means peculiar to the Lake District. The great fall of Niagara seems to be an example. There is, I believe, no trace of an earlier post-glacial river-channel. On the contrary, the ice-markings almost down to the water's-edge above the fall seem to show that the glacier followed the same track as the river. The river must, therefore, have commenced cutting out of the gorge as soon as the ice-cap cleared away. But Sir Charles Lyell estimated the time necessary to cut out this gorge at 35,000 years, while others have placed it as low as 12,000. Professor Winchell has estimated the time required to cut out the gorge below the falls of St. Anthony at 8000 to 10,000 years. I am not aware that there is any reason to think that this excavation did not commence until long after the close of the Ice Age.

Man probably existed on the earth in the Glacial, if not the Pre-Glacial, era. But is there any reason to suppose that he existed for at least 200,000 years without making any solid progress in civilization, and then suddenly made the great advances (emanating apparently from more than one centre) which has taken place in the last 10,000 (or perhaps 6000) years? It is not a case of an anthropoid ape slowly developing into a man during a period of 200,000 or 800,000 years; for the earlier skeletons appear to be those of fully-formed men.

For these reasons I think Dr. Croll refers the Ice Age to too remote a period. Further researches on the amount of post-glacial erosion and the erosive power of the streams or rivers engaged in it ought, I think, to enable us to decide the question one way or the other with a tolerable degree of certainty.

Dublin, *Sept. 5th*, 1887. W. H. S. Monck.

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## DR. HINDE ON THE ORIGIN OF CARBONIFEROUS CHERT.

Sir,—Permit me to reply to the article by Dr. Hinde, F.G.S., which appears in the Geological Magazine for the present month (No. 280, p. 435). As I had an opportunity when attending the meeting of the British Association in Manchester of hearing the paper read in Section C, and as I had previously had the pleasure of a visit from its author in this city, I was not unprepared for the onslaught which afterwards took place. I have no wish to maintain a position which subsequent investigation has shown to be untenable, or which requires readjustment; and I am, therefore, quite ready now to admit, what I stated in Manchester, that in examining the slides of chert under the microscope, I had, at least in many instances, mistaken forms of sponge-spicules for those of Crinoid stems. Nor was this, I submit, at all surprising when we recollect that these organisms are often very vague, and that the bands of chert occur intercalated with beds of limestone abounding in stems, ossicles, and plates of Crinoids. It was not unnatural, therefore, that I should have supposed the little discs seen in the chert-sections under the microscope to be minute cross-sections of these stems or ossicles.[1] Dr. Hinde's great experience in the examination of the sponge-structures of the Cretaceous beds has given him an advantage in this line of investigation which certainly has not fallen to my lot; consequently, when on examining my slides in this office, he stated that the forms were those of sponge-structures, I accepted his statement without question.

Dr. Hinde's recent investigations undoubtedly show that siliceous sponge-structures enter far more largely into the composition of Carboniferous chert than has hitherto been suspected, and even, that they exceed in numbers other organic forms; all this I now willingly concede. But I am not prepared to go to the full length of Dr. Hinde's demands, as I understand them, nor to abandon as untenable the proposition that much of the silica of Carboniferous chert has been derived by a transmutation process from the waters of the ancient seas. Not only are there to be found forms, such as those of Corals, Brachiopods and Polyzoa and ossicles of Crinoids, originally calcareous, now occurring silicified in the chert, but the amorphous cementing material of the organic structure which may be supposed to have originally been calcareous has now been transmuted, or may have been directly deposited from the waters under such favourable conditions as those supposed by Mr. Hardman and myself in our original memoir.[2] A similar conclusion has been arrived at by Prof. Renard by a process of investigation analogous to, though quite independent of, that pursued by ourselves. Whatever doubt I might have entertained in regard to my own conclusions, I cannot extend to those of so competent an observer as Prof. Renard. Let me ask Dr. Hinde, does he deny the possibility of siliceous bodies or masses having been formed by the transformation process? If so, he is confronted by the evidence of a large number of the ablest observers, both British and Foreign, amongst whom may be mentioned Bowerbank, Rupert Jones, Sullivan, Sterry Hunt, and Bischof.[3] If so, it is *Hinde contra mundum*; and let me say that these observers appeal to Nature as well as does Dr. Hinde himself.

I feel obliged to Dr. Hinde for having called my attention to the fact that Professor Sollas had previously identified siliceous sponge-spicules in the chert-sections which I had forwarded to him for

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[1] From what Dr. Hinde has stated in his original paper (Phil. Trans. 1885, note, p. 433), it would appear that a more competent observer than myself has fallen into a similar error; from which it will be inferred that it is a matter of much difficulty, and requiring great experience to distinguish the one from the other.

[2] Scientific Transactions, Roy. Dublin Society, vol. i. new ser. (1878).

[3] Bischof: "Chemical and Physical Geology," Cavendish edit. vol. ii. p. 486, *et seq.*

examination. When I wrote my paper for the Royal Society, I had altogether forgotten this circumstance, which I much regret; a copy of the paper itself had been carefully laid aside by me for reference, and suffered the fate of most such papers.[1] Having, however, now referred to this document, I will put it in evidence on the question now discussed, and the reader will hear what Prof. Sollas has had to say. The author examined five of my slides of chert-sections under the microscope, and states as the result of his examination; " in the first place, to completely confirm his (Prof. Hull's) clear descriptions of the appearances presented by them (the chert-sections); and next, to establish the truth of my supposed detection of sponge-spicules," as shown in the plate accompanying my original paper. This is very valuable testimony.

As to the question of the geological position of the so-called "Yoredale Series," I have only to say that I have used the term as it is understood on the Geological Survey throughout the wide district where, in conjunction with some of my colleagues, I mapped these beds some years ago in South Lancashire, Cheshire, Derbyshire, and the adjoining parts of Yorkshire, an area of not less than 2000 square miles. What may be the exact relations of these beds to those of the Valley of the Yore as described by Phillips, I am not prepared to say. It is well known that the Lower and Middle Carboniferous strata undergo considerable alteration both in character and thickness as we proceed northwards from Derbyshire and Cheshire; and I can only now refer Dr. Hinde to my paper on the Classification of the Carboniferous Rocks published in the Quarterly Journal of the Geological Society, vol. xxxiii. for my views on this subject.

In conclusion, I have to add, that if I have misquoted Dr. Hinde, as he affirms, I can only express regret, as I took special care not to do so, as will be seen by referring to my paper in the Proc. Roy. Soc. vol. xlii. p. 305. My late valued colleague, Mr. Hardman, whose name occurs in this controversy, is not now with us to take his share therein, but I feel convinced he would have concurred in what I have written.

EDWARD HULL.

GEOLOGICAL SURVEY OFFICE, DUBLIN, *7th Oct.* 1887.

## OBITUARY.

### JOHN EDWARD LEE, F.S.A., F.G.S., ETC.

BORN DECEMBER 21ST, 1808; DIED AUGUST 18TH, 1887.

DEVONSHIRE has lost another excellent geologist and antiquary in Mr. John Edward Lee, of Villa Syracusa, Torquay. Mr. Lee was born at Newland, Hull, Dec. 21st, 1808. His father having died when he was very young, he was brought up by two uncles, Avison and John Terry, and at sixteen he entered their shipping office in Hull. From the earliest period of his life he took an interest in science, beginning with Entomology, and while living

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[1] Prof. Sollas's paper was published in the *Annals and Magazine of Natural History* for February, 1881.

at Hull he took an active part in the Royal Institution there; frequently at the end of the day's work, he would shut himself in the Museum, and stay far into the night arranging the specimens it contained.

His health failing, he travelled abroad, first in Norway and Sweden, afterwards in Russia and other parts of the continent. During these tours he sketched, and also mastered French and German thoroughly.

In 1841 he entered the Iron Works (J. J. Cordes & Co.) of Newport, Monmouthshire, where he spent the best years of his life.

In 1846 he married Miss Gravely, of Torquay, and they resided at the Priory, Caerleon, till 1868, when anxiety for Mrs. Lee's health decided his removal to Villa Syracusa, Torquay; but he still constantly went back to Monmouthshire for many years.

During all the years of his residence at Caerleon, and later at Torquay, until failing health compelled him to abandon many of his cherished pursuits in life, he worked steadily and uninterruptedly at various branches of science, principally at Geology and Archæology.

He was one of the founders of the Monmouthshire and Caerleon Antiquarian Society, to the Proceedings of which he frequently contributed. He also aided in the formation of the Museum at Caerleon, publishing, under the title of "*Isca Silurum*," an illustrated catalogue of the Roman remains discovered at Caerleon, the ancient capital of the "Silures."

He exchanged fossils with geologists in all parts of the world, and carried on a large correspondence with many foreigners, who had either visited his collection at Caerleon or Torquay, or whom he had met during his numerous continental travels, or others in America and elsewhere with whom he had no personal acquaintance. All his journeys were undertaken with a scientific object, and he was in the habit of carrying small sketch-books with him when travelling, the contents of which he utilized in his publications, many of his sketches appearing in "The Note-Book of an Amateur Geologist," published in 1881.

His principal work was a translation and revision (assisted by the author) of Dr. Keller's Lake Dwellings of Switzerland, printed in 1866, and a second edition (in two volumes) in 1878; all the plates for this work, 206 in number, were drawn by Mr. Lee for the English edition, and illustrate more than two thousand five hundred objects, obtained from between two and three thousand separate lake-dwellings." Mr. Lee's other works are, "Roman Imperial Photographs" and "Roman Imperial Profiles" (the latter being a series of more than 160 lithographic profiles enlarged from coins), both published in 1874.

A translation of Conrad Merck's Excavations at the Kesslerloch, near Thayingen, Switzerland, a cave of the Reindeer period, followed in 1876; and an English version of Prof. Roemer's Bone-cave of Ojcow in Poland in 1884.

One of Mr. Lee's most interesting geological expeditions was made to Italy in 1868, in company with one of his earliest friends, Prof. John Phillips of Oxford, to study the phenomena of Vesuvius, then in active eruption.

Ten years later (1878) the writer of this notice had the pleasure to accompany Mr. Lee to the Eifel district, where, being happily joined by Prof. Ferdinand Roemer, of Breslau, the historian of the Devonian rocks of this region, a delightful fortnight was spent in collecting the fossils of Gerolstein, Prüm, and other localities.

Mr. Lee contributed several important papers to the GEOLOGICAL MAGAZINE on points in Devonian geology which he had worked out; he was the original discoverer of many fossils described by the late Mr. J. W. Salter, F.G.S. (as *Homalonotus Johannis*, etc.)

He gave his most valuable and extensive collection, contained in 31 cabinets and comprising upwards of 21,000 specimens, to the British Museum (Natural History), in 1885. This collection not only embraces a large series of British fossils from all formations, many of which have been figured and described, but a most valuable and instructive collection from almost every important European locality where fossils abound.

Although his bodily powers began of late years to fail, his intellect remained bright, especially on all matters of science, to the last, and after he failed to write, he dictated and signed many letters, giving clear and accurate scientific information to correspondents, and he was full of plans and ideas for the furtherance of science up to the end.

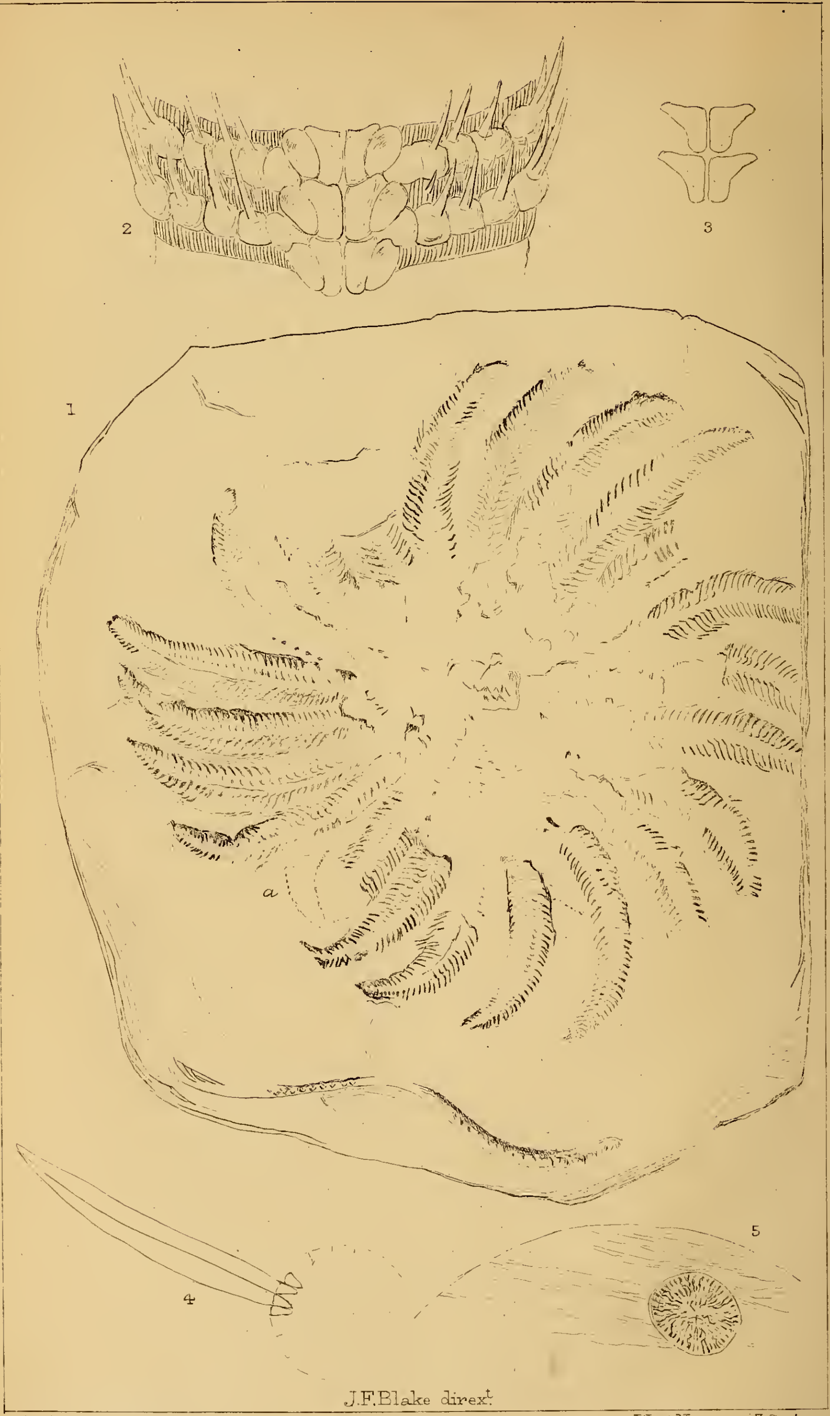
Mr. Lee was a Member of the British Association, a Fellow of the Society of Antiquaries, and a Fellow of the Geological Society of London.

## SIR WILLIAM VERNON GUISE, BART., F.L.S., F.G.S.

BORN 1816, DIED 1887.

SIR WILLIAM GUISE was the eldest son of the late Gen. Sir John Wright Guise, Bart., one of the most distinguished Peninsula officers, by his marriage with Charlotte Diana, daughter of the late John Vernon, Esq., of Clontarf Castle, County Dublin. He was born in the year 1816, and succeeded to his father's title in 1865. He was a Magistrate and Deputy-Lieutenant for Gloucestershire, and served as High Sheriff of that county in 1872. He was also a retired Lieutenant-Colonel of the Royal South Gloucestershire Militia. Sir William married in 1844, Margaret Anna Maria, daughter of the Rev. D. H. Lee-Warner, of Walsingham Abbey. He is succeeded by his eldest surviving son, William Francis George, who was born in 1851.

Sir William Guise was elected a Fellow of the Geological Society in 1841; and although not a founder, was for many years one of the most active members of the Cotteswold Naturalists' Field Club. Only last year he retired from the office of President, which he had held for 28 years. He had a wide general knowledge of Geology, Conchology, Botany, and Archæology, and there were few objects or places of interest in Gloucestershire with which he was not acquainted: thus he was eminently qualified to direct the Excursions of the Club, while his hearty and genial manners contributed much to the enjoyment of the meetings. Sir William Guise died on the 24th September, at his residence, Elmore Court, near Gloucester.



J. F. Blake direx$^{t}$.

A. B. Woodward del. et lith.

West, Newman & Co. imp.

Solaster Murchisoni, *Willn. sp.*

*Yorkshire Lias.*

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. IV.

No. XII.—DECEMBER, 1887.

## ORIGINAL ARTICLES.

### I.—On a New Specimen of *Solaster Murchisoni* from the Yorkshire Lias.

By Prof. J. F. Blake, M.A., F.G.S.

(PLATE XV.)

THE specimen to which the following description applies was found by the Rev. G. Crewdson, F.G.S., of Kendal, at the base of the cliff at Huntcliff. The block in which it lay was separated from the parent rock, and had doubtless fallen from above. The occurrence in the same slab of a portion of an arm of *Ophioderma Milleri* and the general character of the stone leave no doubt that it is derived from the "Star-fish" bed of the Capricornus Zone.

The only other known examples of polyradial star-fish from the Yorkshire or any other Lias are figured on plate v. of Dr. Wright's Monograph of Oolitic Asteroidea in the Palæontographical Society's volume for 1861, issued in 1863. These are named *Plumaster ophiuroides*, and *Luidia Murchisoni* respectively. That our fossil is not the same as the former is very evident from its possessing 22 arms instead of 14, and other differences are soon observed. On comparison with the latter, as represented by its figure and description, it appears very closely allied; but this is described as a *Luidia*. The principal difference between a *Luidia* and a *Solaster*, that can be observed on such examples, is that in *Luidia* the ventral surface of the arms has one medial row of ossicles, with the pores on either side, whereas in *Solaster* there are a pair: a circumstance that results in dried specimens of the latter opening along the ventral side of the rays, while in the former the rays remain intact. Now, on examination of our specimen, it is immediately evident that in this respect it agrees with *Solaster*. Therefore, if the specimen described by Dr. Wright is a *Luidia*, this cannot be the same. This was my opinion when I exhibited the specimen at the British Association at Manchester in September last. But on that occasion Prof. Williamson, who found the specimen figured by Dr. Wright, and also provided the description, considered the new specimen so like the old, that a comparison became necessary. Through the kindness of Mr. J. Woodall, I have been enabled to examine the other specimen in the Scarborough Museum, as it was found to be in too fragile a condition for safe carriage. The result of that examination is that they are undoubtedly of the same species, and that therefore they both belong to the genus *Solaster.*

The new example, however, is so much better preserved, and renders the possible description so much fuller and more accurate, that it is worthy of as much consideration as if it had been a new species. I shall therefore describe it fully.

### SOLASTER MURCHISONI, Williamson (sp.).

Syn. 1836. *Luidia Murchisoni*, Williamson, Mag. Nat. Hist. vol. ix. p. 425.
,, 1855. *Solaster polynemia*, Simpson, Fossils of the Yorkshire Lias, p. 135.
,, 1863. *Luidia Murchisoni*, Wright, Palæontographical Soc. p. 111, pl. v. fig. 2.

*Diagnosis.*—Diameter 4–6 in. Central aperture $\frac{1}{6}$ diameter. Rays 20–22. Angle-plates long, triangular. Ambulacral area with a pair of ossicles, anvil-shaped. Pores large. Interambulacral area half clothed, ossicles 5 on ventral surface, each with a spine, terminal one with two. Dorsal surface with branching ossicles loosely netted.

*Description.*—The new specimen is about 4 in. in diameter. It has been buried in the stone with its ventral surface downwards, by which means an external cast has been produced of the ventral surface of its arms. Upon this has been pressed down the dorsal surface which covers over and hides the central opening, and shows sharply marked triangular, or bent impressions irregularly scattered, which are interpreted as the casts of a loose network of dorsal ossicles. The arms are 22 in number (see Fig. 1). Some are broken, but most are complete, and come to a rather blunt termination. Along the centre of each (see Fig. 2) is seen a raised band, corresponding to a depression in the animal. This band is threefold, the centre line is the interval between the ambulacral ossicles, which are like anvils placed back to back, as seen in the depressions of the cast. The pores are large and form the two outer bands, occupying the concavity of the ambulacral ossicles. Each of these ossicles is continued outwards and also somewhat radially by a subtriangular ossicle—and then by four others—all of the interambulacral series. Each of these four had a spine in its centre, and the outermost an additional larger one at the end. These latter clothe the sides of the rays with a layer of spines. It is possible there were smaller spines also on the softer part which intervened between each of these rows of interambulacral ossicles and the next. These rows form cross lines in the cast, with a gentle concavity in the radial direction, and each ray has nearly 50. In one spot a fragment of a ray has been reversed and its dorsal surface is seen. This shows the insertions of the spines at the sides; but the remainder is so smooth that the paxillæ must have been very small. This is all that can be learnt from this specimen, which is beautifully preserved in a fine micaceous, earthy sandstone, well suited to retain impressions.

The original specimen, now in the Scarborough Museum, under the charge of Mr. Phillips, who gave every facility for its examination, is in a shaly matrix, which, in spite of preserving materials, has cracked, and is very liable to shale off entirely. It shows 20 arms and the central aperture is well-preserved, being about $\frac{1}{6}$ of the whole diameter. The inner ends of the rays open out in the ambulacral line, and on either side is found a projecting triangular ossicle, whose cast is well preserved. These are thus arranged in closely opposed pairs in the interambulacral line (see Fig. 4). The features of the ventral side of the rays are not well preserved; but in four places at least the casts of the pair of ambulacral ossicles are seen, and they are of the same shape as in the new specimen (see Fig. 3). The somewhat separated rows of interambulacral ossicles are preserved as grooves, in the base of which are seen the pits which indicate the spines. The larger ones at the ends are also marked by the marginal pits, and the casts of the spines themselves are seen diverging from them. Towards the margin of the central aperture is seen the madreporiform tubercle which, with the exception of the casts of a few ossicles, is the only relic of the dorsal surface that is preserved. This is beautifully shown, it is of the ordinary type with radiating pores, and it is about $\frac{1}{10}$ inch in diameter (see Fig. 5).

It is thus seen that in all comparable points the two specimens agree, while each contributes something special to the description, which between them is rendered about as complete as we can well expect in the case of such an ancient relic of the group. The new specimen is now one of the ornaments of the Kendal Museum, whose development the discoverer has done so much to promote.

### DESCRIPTION OF PLATE XV.

Fig. 1. New specimen of *Solaster Murchisoni*, in the Kendal Museum. Found by Rev. G. Crewdson in the Capricornus beds of Huntcliff. Natural size.
,, 2. Portion of a ray of the same restored. Enlarged.
,, 3. Ambulacral ossicles of the type specimen. Enlarged.
,, 4. Angle plates at the inner ends of the rays of the type specimen.
,, 5. Madreporiform tubercle of the type specimen. Enlarged.

## II.—Gastaldi on Italian Geology and the Crystalline Rocks.[1]

By T. Sterry Hunt, M.A., D.Sc., LL.D., F.R.S.

The present writer in 1883 reviewed the history of the rocks of the Alps and the Apennines with especial reference to the geological relations of serpentine and its associates, in a paper which appeared in the first volume of the Transactions of the Royal Society of Canada, and is reprinted, revised and with some additions, as the tenth chapter of his volume entitled "Mineral Physiology and Physiography" (Boston, 1886). Therein he gave a somewhat detailed account of the labours in Italian geology of the late Professor Bartolomeo Gastaldi, of Turin, a list of whose publications on that subject from 1871 to 1878, so far as known to the writer, will there be found, including his letter to Quintino Sella, in 1878, on the general results of explorations made in 1877 (*loc. cit.*, 458). In doing this the present writer said, "I feel that I am both rendering a veritable service to science and paying a tribute to the memory of my honoured friend and correspondent of many years," stating at the

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[1] Read before the British Association for the Advancement of Science, Section C, Manchester, Sept. 4, 1887.

same time that "the work of Gastaldi, interrupted by his death in 1878, was unfortunately left incomplete." This statement was not quite exact in one particular, since he survived till January 5, 1879, when there passed away, universally honoured and beloved, one who brought to the study of geology, with a spirit of complete devotion, a rare genius and a breadth of view which will assure him a first place among the geologists of our time.

In the chapter above mentioned the writer proceeded to consider the history of the so-called Tertiary serpentines of Monte Ferrato in Prato (Tuscany), and those of parts of the Ligurian Apennines which he had personally examined, and, in opposition to the opinion of most Italian geologists, and some others who have studied them, maintained that they were really but portions of the ancient *pietre verdi* zone, identical with that of the Alps, underlying, in the regions in question, the beds of Eocene age; which latter, by subsequent terrestrial movements, have been disturbed, broken and even inverted, so as to seem to pass beneath the serpentinic rocks. The indigenous and neptunian character of serpentine, maintained on stratigraphical evidence in North America by E. Emmons, by Logan, and by the present writer, was not only held by Gastaldi and Delesse, but is maintained by Stapff, by Lotti, and by Dieulefait. The hypothesis of a plutonic origin has moreover been so much modified by recent Italian geologists, as Taramelli, Capacci, Issel, and Mazzuoli, that instead of supposing them to have been erupted like basalts, they now conceive that serpentines, and the associated rocks of the ophiolitic group, were formed by submarine eruptions, in Tertiary time, of magnesian and feldspathic muds, of unexplained origin but of no very elevated temperature; which subsequently consolidated and crystallized into euphotide, diorite, and serpentine, with their associated feldspars, enstatite, chrysolite, and other minerals.

In the change of chrysolite into serpentine, as I have elsewhere shown, "one hundred parts by volume of the former species, with a specific gravity of 3·33, if converted into serpentine of specific gravity 2·50, without change in its content of silica, must lose one-eighth of its weight of magnesia, and acquire the same amount of water instead, while at the same time its volume will be augmented one-third, or to one hundred and thirty-three parts." That such a change takes place in some instances, probably through the action of carbonated waters removing a portion of magnesia from chrysolite, and leaving behind the more stable hydrated and colloid silicate, serpentine, is evident. Until, however, the precise conditions under which this may take place are better understood, we cannot explain why in some cases chrysolite is exempt from such change. I have long since described in the vicinity of Montreal, in Canada, cutting the limestones and pyroschists of the Ordovician series, great masses of a granitoid chrysolitic dolerite, itself of Palæozoic age, in which the chrysolite, in large crystals, often predominates, and is still unchanged, hard, and anhydrous. The assumption, lightly made by some plutonists, that chrysolite is always of plutonic origin, and serpentine always a product of epigenesis, rests upon a slender foundation, and is in contradiction with a great number of facts. While the production of chrysolite from mixtures in a state of igneous fusion is well known, and while the chrysolitic rocks just mentioned are, as I have endeavoured to show, the result of crystallization and partial eliquation in a truly plutonic mass, it is not less certain that to other chrysolitic rocks a neptunian origin must be assigned; as was maintained by the writer in 1879, for the so-called lherzolite or chrysolite-rock which, accompanied by enstatite, serpentine, and chromite, is interstratified with the younger gneissic and mica-schist series in North Carolina. The same may be said of the similar chrysolite rocks in Norway, which, like these, are gneissic in structure and interstratified in crystalline schists. In this connection I have also elsewhere noted the variety of chrysolite known as glinkite, found in nodules in talcose or micaceous schists in the Urals, and that purely magnesian chrysolite or forsterite which occurs abundantly in crystalline limestone in eastern Massachusetts. It appears evident that chrysolite, like pyroxene, feldspars, spinel, and many other species, is generated alike by plutonic and by neptunian agencies.

As regards serpentine, while it may occur as a product of the decay of chrysolites either of igneous or of aqueous origin, no one who has intelligently studied the mode of its occurrence in grains, nodules, interstratified layers and beds, sometimes hundreds of feet in thickness, in the crystalline limestones and dolomites of Archæan rocks alike of Laurentian and of Taconian age, and even in Palæozoic strata, can doubt the direct formation of serpentine and its accompanying silicates, in such cases, by aqueous deposition. Its separation from solutions is also made apparent by the frequent occurrence of veins carrying the species marmolite and chrysotile (which are but crystalline forms of the same silicate as serpentine) either with or without calcite, traversing ophiolitic rocks, and even, as noticed by Gastaldi, in serpentinic breccias of comparatively recent date.[1]

Gastaldi had already, in 1871, expressed in general terms his opinion that "all the serpentinic masses of the Tuscan and Ligurian Apennines," as well as the similar rocks in Calabria, are but prolongations of the great pietre verdi zone of the Alps, in which he included what are known as the Apuan and the Maritime Alps. To the same horizon also he referred the so-called ophitic rocks of the Pyrenees. From my own observations in Italy in 1881, I could not doubt the correctness of these earlier generalizations of Gastaldi, who however apparently did not verify his conclusions by personal observations of the so-called Eocene serpentines of Liguria and Tuscany until 1878, a few months before his death, when he examined both of these regions with especial reference to the question. His final conclusions thereon, a fortunate circumstance now permits me to give to the world.

There lies before me a letter of eleven pages, to my address, from

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[1] For a detailed discussion of the questions here raised as to serpentine and related silicates, see The Genesis of Serpentine, in the author's Mineral Physiology and Physiography, pp. 497–509; also further for analyses and description of the chrysolitic dolerite, *ibid.* pp. 211–213.

Gastaldi, written in French, and dated Turin, July 20, 1878, which reached me in London in due time. After reading the first and last pages of this epistle, concerning matters which demanded and received an immediate answer, it was put aside for careful perusal, and by a curious chance was mislaid, and believed to be lost until recovered during the present year (1887). As it is the last recorded word of Gastaldi with regard to various geological problems which had occupied many years of his life, and moreover sustains fully my own opinion formed three years later regarding the rocks in question, as set forth above, I have thought it well to translate into English this precious letter, omitting only those portions which have no reference to the subject before us,—premising that with the exception of the references to the regions then lately examined by him, the conclusions, for the greater part, are already embodied in his previously published papers and in the present writer's summary of them:—

"Turin, July 20, 1878.

"Dear Friend and Colleague,—On returning from a long campaign in the Apennines of Prato (Tuscany) and the Apennines of Liguria, I was agreeably surprised to receive your letter from Montreal of June 25, announcing your speedy departure for England. . . . . I am very glad that you are about to give us a historical and critical work on the Azoic rocks of North America, respecting which it has not been easy to get clear ideas, on account of the extent of the literature and the difficulty of procuring it. I agree with you that we are now enabled to place on a solid foundation the classification of the Azoic rocks, and you may rely on my support of your views which you will lay before the International Geological Congress, where your skill in exposition will be more effectual, because the facts are evident. I cannot myself attend the Congress, for at that time it is necessary that I should be in the high valleys of the Maritime Alps; besides which please consider that I am sixty-one years of age, and cannot put off labours which involve great fatigue, and of which I may not be capable another year. . . .

"You propose to give in your volume my conclusions as to the crystalline terranes of the North of Italy. For this I thank you with all my heart, and demand permission to set forth a summary of my observations.[1] As to crystalline rocks, I am even more radical than you; for me all crystalline rocks are stratified; for me there is no plutonism; for me volcanic activity commenced only with the lavas of the Lower Tertiary; at least I know no intrusive rocks in the Alps; the porphyries there are, to my eyes, sedimentary.[2] I

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[1] The volume here referred to was that on Azoic Rocks, being Report E. of the Second Geological Survey of Pennsylvania, 1878 (8vo. pp. xxi. and 253), and was already printed at that date, a point which I had apparently not made clear to Gastaldi, who sent the notes for the volume in question, as well as for use at the Geological Congress of 1878, where, however, the time had not yet come for their presentation. The volume on Azoic Rocks contains a brief summary of the views of Gastaldi, drawn from his published papers.

[2] I have elsewhere remarked that Gastaldi, misled by his too exclusive Wernerianism, appears to have included under the name of porphyry both stratified neptunian rocks and intrusive plutonic or pseudoplutonic rocks of more than one kind.

divide the crystalline rocks into two great zones; the lowest consisting of the oldest rocks of the Alps, and probably of the globe, is that of the central, ancient, or primitive gneiss. It is emphatically the zone of the orthoclase feldspar, and is very poor in minerals. The other zone is that of the *pietre verdi*, or green rocks, and is especially the zone of the triclinic feldspars, like those of the diorite, euphotide and apenninite. The granites themselves of this zone—and I cite those of Elba, of Baveno, of Mont Orfano, and of Alzo, etc.—although characterized by the beauty of their crystals of orthoclase, are rich in albite. I have cited apenninite, which will be new to you, so that I give the following explanation. Our geologists have long recognized in the Apennines of Savoy the presence of a great body of protogine or protogine-like gneiss. This rock is composed of quartz and feldspar, in nodules rather than in crystals, and of chlorite. A rock of the same character has been recognized by Giordano in the Grand Cervisa. Now the feldspar of this rock, which in the Ligurian Apennines, as well as in the Pennine Alps, occupies a large surface, is in part soda-bearing, and I have thought best to distinguish it from the true protogine, the feldspar of which is orthoclase, by the name of apenninite.

"In a great many localities in the Alps we see the pietre verdi resting against the central gneiss, but in others the same series is found lying nearly horizontally thereon. In the latter case meteoric agencies destroy this superimposed series, and thus extend more and more the area of the ancient gneiss, already widely exposed. Were the rocks of the pietre verdi zone thus made to disappear from the Alps, the height of these in many places would be much reduced (thus, for example, the Grand Cervisa and the Grivola are formed of this zone); and when at last these rocks were destroyed, we should find the region entirely occupied by the ancient gneiss. In a word, the mass of the Alps is formed of the ancient or primitive gneiss, here and there overlain by the rocks of the pietre verdi zone."

[For illustration of these different relations two figures are given in the letter, one of which is along the valley of Lanzo, showing the stratified pietre verdi series resting at a considerable angle upon the ancient gneiss (the stratification of which is not indicated), and overlaid by more recent sediments. The other section, in the valley of Chisone, represents the ancient gneiss overlaid by a stratum of lherzolite, one of serpentine, and one of diallagic euphotide, the attitude of all three being nearly horizontal.]

"The ancient gneiss is very poor in minerals, but includes a limited number of other rocks, such as quartzite, amphibolite, and crystalline limestone. The zone of the green rocks or pietre verdi, on the contrary, is very rich in minerals, as well as in varieties of rocks. Whence have come the minerals of this zone, since they have not [apparently] traversed the gneiss? Whence the porphyries and the granites of this same zone, which we nowhere find intersecting the gneiss? We must conclude—and direct observation of the facts demonstrates it—that the masses, the veins, and the so-called bedded veins in which the zone of the pietre verdi is so rich, are characteristic elements of these rocks, and do not come from great depths. The porphyries and the granites, which are found so frequently in this zone, are not intruded rocks, since they do not traverse the underlying gneiss, but of sedimentary origin, like the limestones, the calcareous and argillaceous schists which accompany them. These are points upon which it seems to me important to insist.

"At Chaberton, a mountain of the Cottian Alps, I found resting directly upon the serpentinic series a semi-crystalline limestone holding organic remains. Not then suspecting a hiatus in the succession, I was led to suppose that these fossils, which were badly preserved, might be very ancient, and my friend Michellotti, who was so good as to study them, thought like myself that they were Lower Palæozoic forms. Upon these fossils I have published two papers.[1] It appears, however, that our notion of the existence of Silurian [Cambrian] forms in the Alps was an illusion.[2] I subsequently discovered more complete sections in the valley of the Macra, and in that of the Stura de Caneo (Maritime Alps), and in these, in limestones which appear to be a continuation of those of Chaberton, we have found a good number of fossils which have been described by Messrs. Zittel and Gümbel, and show the existence in the Alps, above the zone of the pietre verdi, of various Mesozoic and Cænozoic terranes. Resting upon the crystalline rocks we have, first a quartzite alternating with a semi-crystalline limestone, then a compact limestone with layers of anthracite, followed by another compact limestone of Triassic age, with *Encrinurus liliiformis*, and finally by a series of limestones, Liassic, Jurassic, and Cretaceous; the whole overlain by Nummulitic and more recent Tertiary strata. The complete succession is then (1) The ancient central or primitive gneiss, with quartzite, crystalline limestone, graphite, etc. (2) The pietre verdi series, principally formed of serpentine, lherzolite, euphotide, diorite, variolite, porphyry, calc-schists, apenninite, etc.; (3) The anthracitic series; (4) Triassic; (5) Liassic; (6) Jurassic; (7) Cretaceous; (8) Nummulitic, Miocene, Pliocene." [This is illustrated in the letter by an ideal section.]

"The excursions which I have lately made in the Apennines of Prato in Tuscany, and in the Ligurian Apennines, had for their object to study the serpentines of these regions. Some geologists of my acquaintance have lately given themselves much labour and pains to confute my views of the age and the nature of the serpentines. They wish to establish that these are eruptive rocks, in many cases interstratified with the beds of the Upper Eocene—a proposition which is wholly untenable. The serpentines as well as the other rocks of the pietre verdi series are ancient rocks, pre-Silurian in age, and are of types which have not been formed in later times. In regarding these from this point of view, the geology of all those

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[1] Sul fossili del calcare dolomitico del Chaberton; Roma, 1876. Su alcuni fossili paleozoici delle Alpi marittimi et dell' Apennini ligure; Roma, 1877.

[2] In Sardinia, however, Lower Palæozoic forms, both Cambrian and Ordovician, are met with; Mineral Physiology and Physiography, p. 476.

regions in which the pietre verdi series plays an important part becomes easy to understand; but it is, on the contrary, extremely complicated if we consider the rocks of this series as intrusive. In a great many parts of the Alps we see these rocks rising into considerable elevations, as in Monte Viso; elsewhere again they are overlain by the anthracitic series, by the Trias, or by still more recent terranes. Thus in the valleys of the Bormida, and the Erro, and in other valleys of the Ligurian Apennines, they are directly covered by the Miocene; and again, as in the Apennines of Bologna, of Florence, etc., are overlain by the Eocene or the Upper Cretaceous. The separation of the two chains, Apennine and Alpine, is but a geographical fiction; it would be absurd to attempt to separate them geologically. I have visited the valleys and the depressions along which geographers have drawn the lines of separation, and have there found nothing but Alpine rocks, serpentine, apenninite, calc-schists, etc. . . .

"To-morrow I leave for the Maritime Alps, where I shall remain for about a month in order to visit the valleys of the Macra and the Stura, that of Geno and that of the Vermagna, making for the third time this journey, which is a weary and a painful one, especially for the valley of the Macra, where one is forced to undergo many privations. I am delighted to think that our literary correspondence is renewed, and regret very much that circumstances deprive me of the pleasure of being with you at the Congress in Paris. . . .

"Affectionately yours,

"To Mr. T. Sterry Hunt. B. Gastaldi."

As regards the pietre verdi series, of which he has here so well set forth the importance, I have in the volume already quoted (Mineral Physiology and Physiography) shown that Gastaldi not unfrequently employed it, as in the foregoing letter, to designate the whole succession of crystalline schists above the ancient or central gneiss—speaking of these collectively as the "newer crystalline series." This however, includes a great body of younger gneiss and mica-schists above the group characterized by serpentine, euphotide, diorite, etc., which he has here so clearly defined as resting upon the ancient gneiss. Neri, in his sections in north-western Italy, distinguishes above the ophiolitic or pietre verdi horizon, a group of mica-schists with granites, while Gerlach described the same as recent gneiss and granite, followed by gneissic mica-schists. Gastaldi himself, in more detailed accounts, used the term pietre verdi in the same restricted sense as Neri. Thus in 1874 (*Studii geologici sulli Alpi occidentale*, part 2) he speaks of "the pietre verdi properly so-called," and declares it to be comprised between "the ancient porphyroid and fundamental gneiss," and "the recent gneiss, which latter is finer-grained and more quartzose than the other." He elsewhere in this same memoir speaks of this higher portion of the "newer crystalline series" (oftentimes, as in the above letter, comprehended in his "pietre verdi zone") as a mica-schist,—a gneissic mica-schist,—as recent gneiss and mica-schist,—and also as a very micaceous gneiss, often passing into mica-schist and sometimes hornblendic. He says farther, "I will not assert that when specimens of this newer gneiss are confusedly mixed with those of the more ancient, it would always be practicable to distinguish them petrographically; but I do not hesitate to affirm that their distinction in the field is not difficult; on account of the frequent alternation of the younger gneiss with the other characteristic rocks of the upper series [micaceous and hornblendic schists, etc.], while the older gneiss, however wide its extent, is generally unmixed with other rocks."

Above this recent gneissic and mica-schist division, but below the anthracitic group, and included in the "newer crystalline series" of Gastaldi, there is a considerable thickness of crystalline schists, often soft and unctuous, and variously described as argillaceous, talcose, and micaceous, or as grey lustrous schists, which are sometimes sericitic. These, moreover, include quartzite, karstenite, dolomite, and banded and statuary marbles, with occasional serpentines and amphibolic rocks. Serpentines are also met with in intimate association with the younger gneisses, and hence Gastaldi often spoke of the whole triple group of the newer crystalline series above the ancient gneiss as the "pietre verdi zone." To each of these three divisions he, in common with other Alpine geologists, assigns a thickness of several thousand metres.

While these great divisions of the crystalline rocks were thus being defined in the Western Alps, Von Hauer had already, in 1868, shown the same succession further to the eastward, in the Lombardo-Venetian Alps, where he distinguished, first, the ancient gneissic and granitic rocks, called by him the central gneiss; second, a great thickness of green rocks or pietre verdi, including serpentine, euphotide, and diorite, with various amphibolic and chloritic rocks, together with saccharoidal limestones; and, third, a recent gneiss and mica-schist series. Gastaldi, at an early date in his studies, recognized in the older or central gneiss the Laurentian series of North America, and in the succeeding green rocks, or pietre verdi proper, the group which I had in 1855 called Huronian. It was not until 1870 that I attempted to define as a distinct and newer series the group of younger gneisses and mica-schists in North America, called by me subsequently, in 1871, the White Mountain or Montalban series, and corresponding both lithologically and stratigraphically to the recent gneiss and mica-schist series already recognized in 1868 by Von Hauer in the Eastern Alps, indicated by Gerlach in the Western Alps in 1869, and described more at length by Gastaldi in 1871. The work of none of these was known to me when, in 1870, I first set forth the distinctness of this great group of younger gneisses and mica-schists in North America, and also indicated their existence in the Scottish Highlands.

I had, in 1881, an opportunity of examining this upper gneissic series in the Western Alps, near Biella in the province of Novara, and in company with Quintino Sella (who with Berutti had carefully mapped the region), of going over a section which had been studied and described alike by Gerlach and by Gastaldi. Here, besides the ancient gneiss, with included graphitic and pyroxenic limestone, the whole indistinguishable from the Laurentian of North America, and also the characteristic serpentinic or proper pietre verdi group overlying it, I found the recent gneiss and mica-schist series apparently overlying transversely both of these, and seemingly identical with the Montalban or younger gneissic series of the White Mountains and of Philadelphia in North America. An absence of the ophiolitic or true pietre verdi group between the older and the younger gneissic series, which is apparent elsewhere in the Alps, and in many places in North America, may be due either to non-deposition or to erosion. The existence of conglomerates holding rolled pebbles in the younger gneissic series, both in Europe and America, shows erosion to have played an important part in Archæan as in later times, and is in harmony with the observed stratigraphical discordances in the crystalline rocks, each one of the upper divisions in turn being found to rest upon the ancient gneiss.

The younger gneissic or Montalban series I have found well displayed in Mont St. Gothard and in the Ticino basin in Switzerland. To it also apparently belong the granulite rocks and the mica-schists of the Mittelgebirge in Saxony, with their dichroite-gneiss, lherzolite, and garnetiferous serpentine, and also the micaceous gneisses of the Erzgebirge, with their included limestones and amphibolic rocks, and their overlying mica-schists. In these latter are found the remarkable conglomerate beds described by Hauer in 1879, the pebbles of which are apparently derived from the ancient or central gneiss, of which they have the characters.[1]

While thus referring the younger gneisses and mica-schists alike of Saxony and of the Alps to the Montalban, I have maintained that the uppermost division of the newer crystalline series of Gastaldi is to be regarded as the equivalent of the Taconian or Lower Taconic of North America, designated by Lieber the Itacolumitic series; a great group of strata which is traced from the Gulf of St. Lawrence, with some interruptions, nearly to the Gulf of Mexico, and westward to the basin of Lake Superior and beyond. This series should be carefully distinguished from the Upper Taconic, a younger uncrystalline series, different in geographical distribution, and containing a well-defined Cambrian fauna. The Taconian or Lower Taconic, whose real stratigraphical relations were already clearly defined more than fifty years ago by Amos Eaton, has since, by various theorists of the metamorphic school, been alternately regarded as altered Cambrian, altered Ordovician, altered Silurian, altered Carboniferous, and in part even as altered Triassic;[2] a history which recalls that of the similar strata of the Apuan Alps, including the marbles of Carrara and Massa, which have by different writers been

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[1] See for a detailed discussion of the questions here involved, the author's "Mineral Physiology and Physiography," on The Geology of the Alps and the Apennines, pp. 457–482; The Serpentines of Italy, pp. 482–496; and further, The Metamorphic Hypothesis, pp. 654–673.

[2] For a detailed acconnt of the Taconic controversy see the author's "Mineral Physiology and Physiography," 517–686; also, more concisely and with new facts, "The Taconic Question Restated," Amer. Naturalist, Feb. Mar. and Apl. 1887.

referred to various horizons from Cretaceous down to pre-Palæozoic, at which latter they are placed by Gastaldi, in the upper part of his "newer crystalline series," as also by Jervis in the second volume of his valuable treatise, *I Tesoro Sotteranei dell' Italia.*

This Taconian or newest crystalline group embraces in North America besides quartzites (sometimes in flexible elastic layers) and crystalline limestones affording both banded and statuary marbles, large deposits of iron-ores, alike magnetite, hæmatite, and limonite, the latter being formed by epigenesis, in some cases from pyrites and in others from siderite. It also includes a great mass of argillites, and of soft unctuous schists, often described as talcose, and though more generally sericitic, sometimes containing chlorite and talc, together with occasional amphibolic and feldspathic rocks, massive serpentines and ophicalcites, and bearing throughout a marked resemblance to the upper division of the newer crystalline series of the Alps.

As the writer has elsewhere pointed out, the chemical and mineralogical conditions of the underlying pietre verdi horizon were repeated, though with diminished intensity, at this later time in the history of the newer crystalline series, producing in the younger rocks thereof such resemblances to the older that the Taconian strata were not unnaturally confounded with the Huronian. Thus, to the south of Lake Superior, Emmons having in 1846 recognized the Taconian, he was led, when the Huronian was announced in 1855, to maintain (in an unpublished paper) that it was in no way distinct from his Lower Taconic. On the other hand, the present writer, in common with Murray, Credner, and others, included these same Taconic rocks in that region with the Huronian, and it was not until after a prolonged study of the Taconian in the more eastern regions of North America, that he was enabled to show that the two series had really been included in the Huronian as defined in the vicinity of Lakes Superior and Huron; where also the recent gneisses and mica-schists are met with, as well as the ancient or primitive granitoid gneiss. In like manner, as we have seen, Gastaldi was led, from such lithological likenesses, to include the upper and lower division of his newer crystalline series, with their intervening recent gneisses and mica-schists, under the comprehensive name of the pietre verdi zone. These partial resemblances between the crystalline rocks of succeeding divisions serve to illustrate the different stages in the process of evolution of the crystalline rocks in successive ages by chemical agencies from an originally undifferentiated mineral matter, as I have endeavoured to set forth in a recent paper on "The Elements of Primary Geology."[1]

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[1] Geological Magazine, November, 1887.

## III.—ON THE GENUS *PILOCERAS*, SALTER, AS ELUCIDATED BY EXAMPLES LATELY DISCOVERED IN NORTH AMERICA AND IN SCOTLAND.[1]

By ARTHUR H. FOORD, F.G.S.

THE genus *Piloceras* was founded by J. W. Salter in 1859[2] upon the siphuncle of a shell closely allied to *Endoceras*. It was supposed by Salter that the invaginated sheaths observed in the siphuncle of *Piloceras* "represented the siphuncle and septa combined," the septate part of the shell not being preserved in the specimens described by him.

A year after the appearance of Salter's memoir, E. Billings (at that time Palæontologist to the Canadian Geological Survey) described a fossil from the Calciferous Sandstone (= Tremadoc) under the name of *Piloceras Canadense*.[3] This exhibited the septate part of the shell in conjunction with the siphuncle.

The general form of this species was well characterized by Billings as that of a "short, thick, curved Orthoceratite."

This appears to have been the first discovery of the septa of *Piloceras*, associated with its siphuncle, for the generic identity of Salter's and Billings's species is now put beyond all doubt.

Again, in 1881 Sir William Dawson[4] described a new species of *Piloceras* (*P. amplum*) from the Calciferous Sandstone of Lachute, near Montreal, which threw much new light upon the internal structure of the shell.

But the most complete examples of *Piloceras* hitherto met with were collected in 1885 by Messrs. Seeley and Brainerd, at Fort Cassin, in the State of Vermont, from rocks considered to be of the age of the Birdseye Limestone (= the Lower Llandeilo, nearly). These fossils were described and beautifully illustrated by Professor R. P. Whitfield, of New York,[5] who was enabled to show by means of almost perfect specimens, the body-chamber, septa, siphuncle (in place), and even the test of the species, which he very appropriately named *Piloceras explanator*.

M. Barrande,[6] whose information about *Piloceras* was very scanty, constituted it a subgenus of *Cyrtoceras*, on account of its curvature, and Professor Blake[7] disposes of it in the same way, though only provisionally, for he remarks, "The organism, whatever it is, must wait further elucidation by materials not yet extracted from the rocks."

Finally, about four years ago, Mr. B. N. Peach, of the Geological Survey of Scotland, found specimens of *Piloceras* at the typical locality, Durness, Sutherlandshire, in which both septa and siphuncle

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[1] The substance of this paper was read before the British Association at Manchester, in September last.

[2] Quart. Journ. Geol. Soc. vol. xv. p. 376.

[3] Canadian Naturalist and Geologist, vol. v. p. 171.

[4] Canadian Naturalist, new ser. vol. x. No. 1.

[5] Bull. Amer. Mus. Nat. Hist. vol. i. No. 8, p. 323, pl. xxviii. New York, 1886.

[6] Syst. Sil. de la Bohême, vol. ii. Texte, v. 1877, p. 905.

[7] British Foss. Cephalopoda, pt. i. p. 186.

were preserved, though in a very imperfect condition. These specimens have been very kindly entrusted to me for description by Mr. H. H. Howell, Director of the Geological Survey of Scotland.

They consist of a large number of the detached siphuncles of *Piloceras*, belonging most probably to more than one species. Many of them exhibit more or less distinct traces of the attachment of the septa in the form of encircling ridges, which give them a ringed appearance.

Fig. 1.

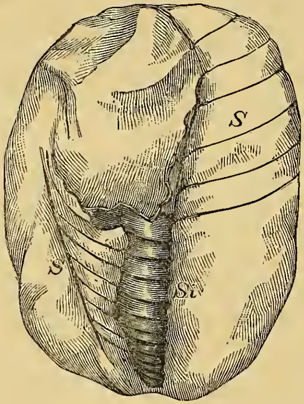

Fig. 1.—*Piloceras invaginatum* ?, Salter; *S*, *S*, remains of septa; *Si*, siphuncle, a little restored in the lower part, with ridges marking the attachment of the septa. (One-half natural size).

One of them shows the siphuncle in its natural position (Fig. 1). This is probably the *Piloceras invaginatum* of Salter. The septa must have been extremely thin and fragile, as in most cases they have been broken away from the siphuncle, which is usually found completely detached from them.

In the specimen I have figured the septa appear as delicate lines upon the weathered surface of the rock. They are from 1½ to 3½ lines distant from each other, measuring them from the narrower to the broader end of the siphuncle. The latter is apparently marginal, as in *P. explanator*, Whitf. The exact rate of tapering of the shell cannot be ascertained, owing to the absence of the shell-wall on one side of the specimen, but it may be assumed to have been high.

Another example, showing obscure traces of the septa in contact with the siphuncle, is most probably the small species referred to by Salter in his paper above mentioned, but it is too imperfect to characterize.

Many of the detached siphuncles in Mr. Peach's collection differ from each other in their rate of tapering, and distance of septa (estimated by the distance of their encircling ridges); but I do not feel justified in creating another species out of such imperfect material. The smallest siphuncle in the collection measures 8 lines in length and 4 lines in its greatest diameter: the largest $4\frac{1}{2}$ inches in length, and $1\frac{3}{4}$ in its greatest diameter. Neither of the specimens measured are perfect. The walls of the siphuncles are usually composed of chalcedony of a minutely concretionary structure.[1]

In comparing the structure of *Piloceras* with that of other Cephalopods, we are at once reminded of *Endoceras*, and the resemblance between these two forms did not escape Salter's experienced eye. In both genera the siphuncle is very large in proportion to the shell, and in both it is furnished with a series of conical or funnel-shaped sheaths, which apparently communicate with one another by means of a small central tube, the "endosiphon" of Hyatt (Figs. 2, 3). This tube is regarded by Hyatt as analogous to that which has long been known in *Actinoceras*, and science is indebted to that able observer for its discovery in *Endoceras*.[2]

Fig. 2.

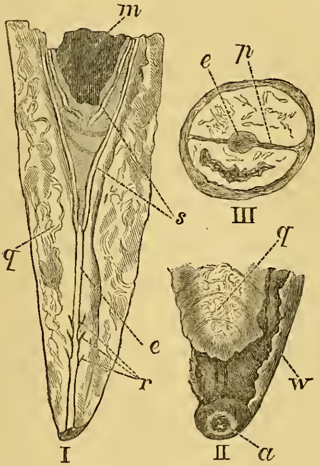

Fig. 3.

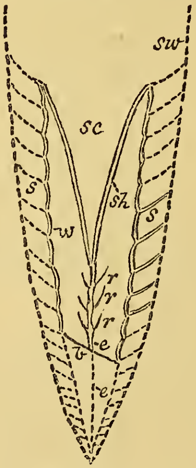

Fig. 2.—I. Section of siphuncle of *Piloceras*, sp., showing two of the funnel-shaped sheaths, *s*; *e*, the endosiphon, with *r*, remains of former sheaths?; *m*, matrix filling what remains of the cavity of the siphuncle; *q*, quartz infilling. II. Posterior extremity of another siphuncle much eroded, but showing an aperture, *a*, at the apex by which the endosiphon may have communicated with the initial chamber; *w*, wall of the siphuncle, and *q*, quartz forming the infilling between this and one of the sheaths. III. Transverse section of another siphuncle showing in the centre the endosiphon *e*, and what appears to be a partition *p*, representing perhaps the septum or "central shelly plate" of Dawson. (All the figures are of natural size.)

Fig. 3.—Vertical section of an imperfect siphuncle, with a few of the septa attached, of *Piloceras amplum*, Dawson, cut in the direction of the shorter diameter of the shell, which was of an elliptical form, judging by that of the siphuncle. *s w*, shell-wall; *s c*, siphuncular cavity; *s h*, sheath; *w*, internal wall of siphuncle; *s*, *s*, septa; *b*, broken extremity of siphuncle; *r* and *e*, same as in Fig. 2. The dotted lines are restorations. (Slightly reduced from Dawson's figure, which is itself a little smaller than the original specimen.)

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[1] This form of chalcedony used to be called beekite, but it differs so slightly in composition from ordinary chalcedony that that name is no longer employed for it by mineralogists.

[2] Proc. Boston Soc. Nat. Hist. vol. xxii. April 4, 1883, p. 261.

Professor Hyatt, whose conclusions regarding the present genus are based upon Principal Dawson's paper, explains the origin of the sheaths in *Piloceras* to be due to the widening of what he terms the "fleshy siphuncle" near the body-chamber. The sheaths lie somewhat loosely in the siphuncle, and they are supposed by Dawson, upon the evidence of the specimen described by him (Fig. 3), to have existed only temporarily, and to have been successively absorbed, the last one only becoming completely calcified. In the Durness specimens, however, it is not an uncommon thing to find two or three of the sheaths preserved, their walls standing out in relief from the surrounding matrix, which has been removed by weathering.

A series of short, upwardly projecting lines are observed to spring from the sides of the endosiphon (Figs. 2 and 3), where it is slightly swollen. These lines are conjectured by Dawson to be the remains of the membranous or fleshy sheaths which have become absorbed, as suggested by Hyatt. The close correspondence of these structures in the Scotch and Canadian species is very apparent in Figs. 2 and 3. It is also noticeable that above the sheath whose apex is perforated by the endosiphon there is another one, in a somewhat shrunken condition; this appears also to be perforated, presumably for the passage of the endosiphon, if indeed that organ extended beyond the apex of the larger sheath below, but of this I have no proof, as no vestige of it can be seen above where it is figured. There is every reason to suppose, though I am not able to demonstrate the fact, that the endosiphon opened into the initial chamber, or at least into one of the earlier of the septal chambers, since in all specimens in which the apical extremity of the siphuncle is preserved, it is found to be perforated.

It should be mentioned that Principal Dawson in his description of *P. amplum* refers to the endosiphon as a "vertical partition" crossing the lower part of the siphuncle; but Hyatt, recognizing its tubular character in the figure, interpreted it in the manner already described. Nevertheless there seems to have been an internal septum extending upwards from the lower part of the siphuncle, between the wall of the latter and that of the sheath into which the endosiphon opens. This septum shows itself in some transverse sections of the siphuncle in the manner indicated at *p*, Fig. 2, III., and it can be traced for some distance upwards in the vertical section of this and of other specimens. I am unable, however, to give any satisfactory account of it, owing to its imperfect condition. I venture to think that Sir William Dawson, seeing this septum at the broken end of his specimen (Fig. 3, *b*), concluded that the endosiphon (*e, e*) above it was its upward continuation.

As regards the infilling of the siphuncle in *Piloceras*, it seems obvious that the space between the inner wall of the siphuncle and the first permanent sheath was not originally solid, because it is not filled with the matrix, but either with calcareous, or dolomitic, or siliceous matter, introduced by infiltration. Something was therefore required to give support to the sheaths, and this was supplied, in part at least, by the endosiphon, and perhaps also by the "septum" above mentioned.

Whatever the functions of the endosiphon may have been, I do not imagine that it played such an important part in the vital economy of the animal as did the same organ in *Actinoceras*. The large endosiphon in the latter gave off tubuli which passed through the membranous walls of the siphuncle by means of foramina.[1] Sir Richard Owen conjectured that these tubuli served "for the passage of blood-vessels to the lining membrane of the air-chambers."[2] At any rate, a vital connection was maintained between the endosiphon and each of the septal-chambers in *Actinoceras*, which was wanting in *Piloceras*.

The genus *Piloceras* may now be thus redefined:—

Shell more or less broadly conical; slightly curved; somewhat compressed laterally; elliptical in section. Septa rather numerous. Siphuncle formed by the prolongation and conjunction of the necks[3] of the septa; marginal; very large; partaking of the curvature of the shell; provided internally with one or more conical, or funnel-shaped sheaths, which are united at the top with its margin. These sheaths apparently communicated with one another by means of the endosiphon, which perforates the apex of the siphuncle. The endosiphon originated in one of the earlier of the septal-chambers, if not in the initial chamber itself.[4]

Five species of *Piloceras* have now been described, viz:—

*P. invaginatum*, Salter.
*P. Canadense*, Billings.
*P. Wortheni*, Billings.
*P. amplum*, Dawson.
*P. explanator*, Whitfield.

Thus, nearly all the structures in the siphuncle and some of those of the chambered portion of the shell of *Piloceras* described by Dawson and Hyatt are demonstrable in the splendid series of specimens brought together by Mr. Peach.

The great desideratum now is to obtain a specimen which will disclose the connection between the apex of the siphuncle and the chambered part of the shell. For this purpose a tolerably perfect specimen would be required. Perhaps some of the material so ably dealt with by Professor Whitfield may supply the want? One can scarcely expect to find sufficiently perfect specimens in the Durness rocks.

From a geological point of view *Piloceras* is interesting on account of its association in Scotland and in eastern North America with a little group of fossils in which several species appear to be common to both countries.

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[1] These are beautifully preserved in many examples of *Actinoceras* in the British Museum (Nat. Hist.).

[2] Palæontology, 2nd ed. 1861, p. 102. See also L. Saemann, Ueber die Nautiliden, Palæontographica, Band iii. 1845, p. 121, Tab. xviii.

[3] Called "funnels" by Prof. Hyatt. "Siphonalduten" of the Germans; "goulots" of the French.

[4] Hyatt in his definition of *Piloceras* (loc. cit. p. 266) states that it is "often annulated," but this is evidently an inadvertence, because the outer shell was unknown when he wrote, and remained so until the specimens described by Prof. Whitfield saw the light, and these showed only "a few transverse wrinkles of growth." He probably had in his mind the detached siphuncles, which have an annulated appearance caused by the adherent remains of the septa.

Salter enumerates amongst others the following American species in the Durness Limestone; some of which, however, are too imperfect for accurate identification:—

*Orthis striatula*, Emmons [non Schlotheim].
*Ophileta compacta*, Salter.
*Maclurea matutina* ? Hall.
*Orthoceras arcuoliratum*, Hall.
——— *undulostriatum*, Hall.
——— *vertebrale* ? Hall [very doubtful].

In addition to these, there are among the fossils I received from the Geological Survey of Scotland, specimens of *Endoceras* in a very fragmentary condition, but resembling certain small (?) species with very closely approximate septa, described and figured by Billings from the Calciferous group of Canada.[1]

A *Cyrtoceras*, very probably the *Oncoceras* ? referred to by Salter, is also in a condition unfit for determination.

Though the Durness fossils are by no means well preserved, yet it can hardly be disputed that their general facies, as Salter affirmed, is American rather than European. The testimony of the fossils, so far as it goes, is supported by that of the rocks, for we learn from Mr. Peach[2] that in the order of succession of the beds in the North-west Highlands of Scotland an almost exact counterpart is presented of the strata "exposed along the axis of older Palæozoic rocks, stretching from Canada through the Eastern States of North America."

"In the latter region," continues Mr. Peach, "the Silurian strata of Sutherlandshire are represented by (1) the Potsdam Sandstone, always described as being vertically piped by *Scolithus*, like the "pipe-rock"; (2) the Calciferous group; and (3) part of the Trenton Limestone.

He further argues, that the beds in these widely-separated areas, though probably not contemporaneous, were homotaxial, and he supposes that the species migrated from one province to the other "along some old shore-line or shallow sea," some barrier separating them from Wales and Central Europe.

## IV.—Woodwardian Museum Notes: on some Anglesey Dykes. II.

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

In the northern half of Anglesey occur several intrusions of dark hornblendic rocks, some specimens of which were placed by Henslow in the collection made by him for the Woodwardian Museum. These rocks present a type unusual in Britain, and show some peculiarities which are of considerable interest.

A few years ago Professor Bonney found on the south-west coast of the island some boulders of a rock which he described[3] under the

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[1] Canadian Naturalist, 1859, vol. iv. p. 361.

[2] Presidential Address before the Royal Physical Society of Edinburgh, Nov. 1885.

[3] Q. J. G. S. vol. xxxvii. p. 137, 1881: vol. xxxix. p. 254, 1883: vol. xli. p. 515, 1885. See also Teall, "British Petrography," pp. 81, 82; plates iv. and vi. 1886.

name of Hornblende-picrite. It was subsequently pointed out by Professor Hughes that the probable source of these rocks was to be found in certain intrusive masses near Llanerchymedd, and indeed such boulders are scattered about rather abundantly in that neighbourhood and to the south-west. The rock in question seems, however, to be the common type of the larger eruptive masses in the north of Anglesey, and brief notes on slides cut from selected specimens taken in place may be found not unprofitable. The rocks were noticed and megascopically described in Henslow's Memoir.[1]

There are three localities in each of which similar varieties occur. The first lies to the north and north-east of the town of Llanerchymedd, where the map of the Geological Survey shows nine intrusions. These masses, not properly dykes, have an oval or elongated form, with lengths of from 200 yards to three-quarters of a mile, their long axes running generally with the strike of the adjacent strata. These beds, Arenig according to Professor Hughes,[2] are baked at the junction, but not extensively altered. On Henslow's map no attempt is made to separate the several patches, which are marked as one area of "greenstone." I have collected specimens from the six masses lying between Rhodogeidio and Llandyfrydog, but am not able to state whether the three patches to the north of the latter place are of similar characters.

A large irregularly-shaped mass appears on the western slope of Llaneilian Mountain, in the north-eastern corner of Anglesey. This has been mentioned by Professor Hughes and examined microscopically by Professor Bonney. It too pierces rocks probably of Arenig age, as well as the debatable Amlwch series. Our specimens are from Pengorphwysfa.

The third area is situated to the east of Llanbabo, among the alluvial deposits of the River Alaw. The exposures here are, according to Henslow, "not well exhibited," and they have escaped the notice of the Survey; but the locality is verified by Professor Hughes, who obtained a similar rock from south-west of Glas-grug.

Rocks having many points in common with these occur as parts of some large dykes in Holyhead Island; but they will be more conveniently considered apart, and our present description will apply only to the three groups of intrusive masses mentioned above. The specimens are selected as follows:—

I. Hafod-in-in dyke (A 130, 131);
Rhodogeidio dyke (A 132);
Llys Einion dyke (A 86, 91, 94, 134, and Hughes Coll. 33);
Maen Chwynt dyke, probably (Sedg. Coll. 37);
Llandyfrydog dyke (Henslow [695]);
II. Llaneilian Mountain intrusive mass (A 35, 37, and Hughes Coll. two slides), all from Pengorphwysfa near Amlwch; also Henslow [715];
III. Dykes or masses east of Llanbabo (Henslow [711, 712]).

Besides these, a large number of hand-specimens from all the localities have been examined.

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[1] Trans. Phil. Soc. Camb. vol. i. 1822.

[2] Q. J. G. S. vol. xxxviii. p. 26, 1882.

The constituent minerals of these rocks are apatite, ilmenite, pyrites, magnetite, olivine, felspar, augite, hornblende, and biotite; besides leucoxene, serpentine, calcite, quartz, chlorite, epidote, and other secondary products.

Apatite is often abundant in slender prisms, and seems to be always the earliest formed constituent.

Iron-ores are almost always among the original minerals, and sometimes magnetite and ilmenite are recognizable in the same slide. Ilmenite when best developed shows in skeletons of intersecting rods choked with grey leucoxene; in other places the presence of a titaniferous mineral can only be inferred from these cloudy grey masses. Magnetite sometimes forms rods, but more usually imperfect cubes. There is also secondary granular magnetite resulting from the alteration of the iron-bearing silicates. In some of the original grains a scarcely perceptible brown translucency may indicate picotite.

Olivine is rarely abundant, and for the most part not detected. Occasionally rounded and oblong patches of serpentine show the characteristic mesh-structure; but the bulk of this substance met with in the slides can be clearly traced to the decomposition of pyroxene and amphibole minerals, and is usually mixed with chlorite. The rocks east of Llanbabo, however, show plenty of olivine.

Felspar of the lime-soda series seems to have been a universal constituent, and locally abundant. In most of the slides this mineral is replaced by calcite, chlorite, and quartz. Where the felspar is fresh enough to exhibit its original characters, it seems from its low extinction-angles to be never a very basic variety: it may be referred, if this test is trustworthy, to andesine and oligoclase. Twin-lamellation on the albite-law is almost always seen, but the pericline twinning rarely. The felspar is usually later than the ilmenite, and earlier than the augite and hornblende, which it penetrates; but in some slides from Llys Einion the felspar partly penetrates and partly moulds the hornblende.

Augite is not always present, but it is probable that this mineral has been essential in all these rocks, and has been in great part replaced by hornblende. In some slides from the Llys Einion and Llanbabo dykes the process of conversion can be traced. The two minerals have the orthopinacoids and the clinopinacoids parallel: they are most intimately associated, with an extremely irregular line of division, and the augite often remains as a core surrounded by brown hornblende.

Hornblende is the most abundant mineral in these rocks, and occurs in several distinct varieties. It is the prevalence of one or other of these varieties, as much as any essential diversity of constitution in the rocks, that gives rise to the difference of aspect observable in hand-specimens.

Original hornblende is found in well-formed crystals, usually from one-eighth to half an inch in length. The terminal planes are probably in most cases the usual (011) and $(\bar{1}01)$, but the basal plane also occurs (001), and a very oblique one which may be $(\bar{2}01)$.

The cross-section always shows the prism form (110) well developed, often truncated by the clinopinacoid (010), and sometimes the orthopinacoid (100). Twinning on the usual law is common. The prismatic cleavages are well-developed, and rarely the clinopinacoidal cleavage is nearly as well marked. The colour is usually brown, with strong pleochroism, vibrations parallel to the axes of elasticity giving: $\gamma$, deep chestnut brown; $\beta$, a less deep brown; $a$, a pale brown. The absorption is then $\gamma > \beta >> a$; more rarely it is $\gamma = \beta >> a$. Sometimes, however, this original hornblende is brownish-green, the vibrations parallel to the $\gamma$-axis giving a pale grass-green, and perpendicular to it a very pale brown. The larger crystals occasionally present a mode of alteration different from the ordinary chloritic and serpentinous changes, and consisting sometimes of a brown coloration, sometimes a decoloration and decomposition into a granular substance. These alterations affect the hornblende along certain planes, which are not parallel to the prismatic cleavage, but to the clinopinacoid, and are perhaps to be regarded as "solution-planes" (*Lösungsflächen*).

Another kind of hornblende, probably also original in the usual sense, is often present in the dykes to the north of Llanerchymedd. A cross-section of a brown hornblende crystal is seen, showing the prism and clinopinacoid faces, but upon the latter a later accretion of green hornblende-substance, in crystalline continuity with the brown, has reduced or entirely built over the clinopinacoids, extending the prism-planes at their expense. From its relation to surrounding minerals and from its always presenting definite crystal boundaries, this later growth of green hornblende seems to have originated before the final consolidation of the rock.

Next comes the hornblende resulting from the alteration of original augite. The "paramorphic" origin of hornblende from pyroxenic minerals has received so much notice in recent years, that there is no need to enlarge upon it here, further than to remark that the term "paramorphism" is strictly applicable only when the two minerals yield identical analyses, which is probably an unusual case. In the present instance it is most likely that some chemical as well as physical change is involved. The hornblende thus produced is brown, compact, and well-cleaved: in fact a study of the Anglesey dykes, as well as rocks from several localities in Carnarvonshire, bears out the conclusion of Lossen and others, that neither colour nor structure affords any reliable criterion for discriminating between original hornblende and that resulting from the amphibolisation of augite. It is possible that some of the hornblende may be derived from a rhombic pyroxene, and indeed the slides from the rocks east of Llanbabo have a mineral resembling altered enstatite. Professor Bonney has noticed the same in the Llys Einion dyke and boulders.

Some slides (*e.g.* from the Hafod-in-in dyke) contain a considerable quantity of a rather pale, dull, brownish-green or greenish-brown hornblende without crystal boundaries. Compared with the foregoing varieties, it is seen to be less clear and less strongly coloured, to give lower polarisation-tints, and to have its cleavage-traces often less pronounced. It is later than the original brown hornblende, which it includes. It also includes augite, without any definite crystallographic relation to it, and so is probably not 'paramorphic.' On the whole, it seems likely that this dull-coloured hornblende is a secondary growth posterior in date to the consolidation of the rock, though this cannot be regarded with certainty, as in the following case.

Lastly, we have hornblende, sometimes green, but more commonly colourless, forming a sharply-defined border to original hornblende crystals, and filling the interstices between them. A study of the slides leaves no doubt that this new growth of hornblende-substance has taken place subsequently to the consolidation of the rock. In some cases it can be verified that the new hornblende extends into the space formerly occupied by felspar crystals. Again, the interspace between two or three original or paramorphic hornblendes is found to be filled by colourless substance, which between crossed Nicols breaks up into distinct portions in crystalline continuity with the several adjacent crystals. This is exactly analogous to the cement of secondary quartz observed by Dr. Sorby and others between the grains of certain quartzites. Sometimes a well-bounded original crystal has a sharply-defined border of greener hornblende, and outside this a margin of colourless hornblende-substance with ragged outline abutting upon patches of calcite dust, etc., which probably represent destroyed felspar. In such a case the double border is all in crystalline continuity with the original crystal. The secondary hornblende here described gives rather higher polarisation-tints and a slightly wider extinction angle than the other varieties of the mineral.

Mr. Van Hise, who was the first to notice the "secondary enlargement of hornblende fragments" in conglomerates, has recently described[1] a like phenomenon in altered diabases from Michigan and Wisconsin, and he cites similar results arrived at by Becke[2] in 1883. I am not aware that this secondary growth of hornblende on the margins of pre-existing crystals has been recognized in British rocks, although Prof. Bonney, referring to the rocks now under discussion, has remarked on the sudden transition from dark brown to almost colourless hornblende, and has figured a very characteristic case in a similar rock from Little Knott in Cumberland.[3] The Rhodogeidio and Llys Einion dykes furnish the best examples.

The only remaining mineral that calls for special notice is the brown mica, which has been mentioned above as biotite, although its characters are not easy to make out very definitely. It is not abundant except in some specimens from Llandyfrydog, which have to the eye almost a lamprophyric aspect. In his specimen [695] especially Henslow remarks the presence of "small shining plates, apparently diallage." These are the flakes of mica, and their peculiar lustre is explained on examination under the microscope.

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[1] Amer. Journ. Sci. May, 1887, 3rd ser. vol. xxxiii. p. 385.
[2] Tscherm. Min. u. Petr. Mitth. vol. v. part ii. 1883.
[3] Q. G. G. S. vol. xli. plate xvi. fig. 2, 1885.

The slide appears at the first glance totally unlike all the others, showing only numerous flakes of mica in a confused mass of decomposition products, without any trace of augite, olivine or hornblende. The mica is less strongly coloured and less pronouncedly dichroic than is usual in biotite, except in the bleached mineral often met with in the lamprophyres and some peridotites. It gives, however, a moderately deep or rather light brown for vibrations parallel to the cleavage-traces, and a paler brown in the direction at right angles to this. The extinctions are sensibly parallel and perpendicular to the traces, and a cleavage-flake is dark between crossed Nicols. The plates are split into thin lamellæ separated by lenticular grains and layers of a colourless, doubly refracting mineral. The interposition of calcite lenses between the foliæ of biotite has been noticed by Zirkel, Hussak, and Williams, but here the mineral is not calcite. Each lenticular grain consists of portions differently oriented, and there is sometimes a radial fibrous appearance suggestive of a zeolitic mineral. The mica includes also a large quantity of granular magnetite. A slide [711] from the Llanbabo mass contains precisely similar flakes of mica, though in much less quantity, and the mineral appears to be closely connected with the brown hornblende, as if resulting from its alteration. This slide probably shows the beginning of a process of which the Llandyfrydog specimen represents the final stage. The secondary production of biotite in place of hornblende is seen also in the Pen-y-rhiwiau and Penarfynydd rocks mentioned below, and in some other Welsh rocks, such as the syenite of Llanfaglen near Carnarvon.

The structural variations of each dyke have not been studied in detail. As Henslow and Professor Hughes have pointed out, the megascopic characters often change largely in a very short distance, though the microscope shows that these variations do not always import any considerable difference in constitution. The more felspathic type of rock sometimes occurs as segregation-veins in the darker and more hornblendic. The dykes grow rather finer-grained at the immediate margin, and these portions are more susceptible to destructive weathering action than the coarser rock. A slide (A 134) from Llys Einion, close to the junction with the shales, shows advanced decomposition; but besides the calcite, ‘viridite,’ etc., there remains an abundance of felspar in good crystals, and partly bleached brown hornblende in crystals and ophitic plates, the latter bordered by colourless fringes of the usual secondary growth.

The coarse black type of rock, with its cement of secondary hornblende, is very durable, and, as has been remarked, the erratics are mainly of this variety. The dykes themselves form prominent features in the country, which doubtless led Henslow to map the whole district north of Llanerchymedd as consisting of these rocks. The smaller dolerite dykes of southern Anglesey, on the other hand, make but little show at the surface, and are difficult to find; a fact indicated on the Survey Map, where the greater part of the dykes marked are on the sea-shore.

The affinities of the rocks described above have been discussed by Prof. Bonney, who points out their close resemblance to that of Pen-y-rhiwiau near Clynnog-fawr, Carnarvonshire, and the so-called Diorite of Little Knott in Cumberland. With the latter I am not acquainted, but a number of slides cut from selected specimens of the Pen-y-rhiwiau mass show the closest resemblance to these Anglesey dykes, especially those of Rhodogeidio, Llys Einion and Hafod-in-in. There are the same minerals associated in the same manner,[1] the amphibolisation of the augite, the secondary marginal growth of colourless amphibole, and the apparent conversion of the brown hornblende into biotite being all well exhibited. There is more olivine than in the Anglesey 'dykes,' although this constituent is variable in amount, and a few other differences are to be noted; but the rocks may well be classed together. Bearing in mind the comparatively small quantity of olivine found, the constant presence of felspar, and that not of a basic variety, the common occurrence of original iron-ores, and the general structure of the rocks, they seem to find their most natural place among the olivine-bearing hornblende-diabases, rather than with rocks of ultrabasic type.

The mode of occurrence of these masses is different from that of the beautiful hornblende-picrite of Penarfynydd, which forms a massive bank 200 or 300 feet in thickness, and of very uniform character. It is worthy of note that the intrusions of Llys Einion and Llaneilian Mountain, as well as Penarfynydd, occur in Arenig strata, and the slates at Pen-y-rhiwiau are referred to the same age: I do not know with what degree of probability the Skiddaw slates of Little Knott can be assigned to the Arenig also.

## V.—TWO NEW FRENCH METEORITES.

Preliminary Notice by JAMES R. GREGORY.

TWO Meteorites from France have recently come into my possession from a private source, one of which, though not of a recent fall (1836), has neither been described nor chemically examined, and which I now briefly bring to notice, it being of a most rare type. The other is of a much more recent fall (1875), and is of a much more ordinary character, being similar to many other meteorites of the same class; this stone also appears not to have been described, nor has any notice of it been published. It is somewhat a remarkable coincidence that these two stones should have fallen in the same Department, although at such widely different dates, and from the data and notes I have received from careful inquiries, I now bring forward the following details of these two aerolites.

### I. AUBRES, COMMUNE OF THE CANTON OF NYONS (DRÔME), FRANCE.

This meteoric stone fell on September 14, 1836, at 3 p.m., in calm weather and blue sky, at Aubres, Commune of the Canton of Nyons, in the department of Drôme, France. It fell on a hard and pebbly

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[1] The resemblance even extends to the 'solution-planes' in the brown hornblende, parallel to the clinopinacoid (010). The slides from Pen-y-rhiwiau, however, contain an abundance of pale grass-green actinolite in blades and fan-shaped bundles.

road, near to a tree under which a shepherd named Favier had taken refuge. This man hearing—to use his own words—"something snore which came from the heavens," observed the fall and found the stone, which had forced itself in spite of the hardness of the road into the soil, it is not stated to what depth—probably no great distance, owing to the fragile character of the meteorite; he afterwards drew it out with his stick, the end of which was stated to have been burnt by the heat. This is probably a fancy, as the nature of the stone would preclude the idea of any great heat being present, it being essentially a stony meteorite, containing apparently no free nickel-iron, and consequently less likely to be hot, or so hot as meteorites containing much metallic particles, they being better conductors of heat. The man states that having allowed it to cool he took it to his master's house, where it was broken to find out what was inside, and then seeing it was "a stone like other stones," it was thrown upon a shelf and forgotten. In 1845 the Pasteur Muston of Bordeaux, who was interested in mineralogy, happening to hear of the circumstances of the fall, went and examined it, afterwards purchasing it, and who had retained it, till it came into my possession. No other stone was found, or believed to have fallen, nor has any public notice appeared of the circumstances attending its fall. It was found by simple peasants who saw nothing very wonderful in it.

This very interesting stone at present weighs 567 grammes, though probably at the time of its fall it must have weighed about 800 grammes, a portion being broken off by the shepherd who secured it, and which is probably lost. It is of an extremely fragile nature and more like that very rare type the Bustee meteorite. It has a highly crystalline structure, exhibiting broad cleavages of an almost white mineral, it has also a very brecciated appearance, but does not seem to contain any of the peculiar mineral named osbornite by Prof. Maskelyne, who first described this mineral in the before-named stone of Bustee; it contains certain small brown patches which may prove to be osbornite on careful examination. The crust is extremely thin, of a pale brown colour, and somewhat vitreous and sufficiently translucent to show the brecciated structure of the stone within, in this respect it also resembles the Bustee meteorite; some parts of this crust exhibit a slight iridescence. In form it is somewhat oval, rather flattish, and pitted with the frequent pittings characteristic of many meteorites as well as meteoric irons.

## II. COMMUNE OF MORNANS (DRÔME), FRANCE.

This meteorite fell in September, 1875, in the Commune of Mornans, Canton of Bordeaux, Department of Drôme, France, the exact date apparently is not known; it is said to have fallen in calm clear weather, and followed an explosion which was preceded by a gust of wind, and gave during its fall a harmonious sound compared to that of an organ; many minute details seem to have either been forgotten or were not observed at the time of the fall.

The stone probably weighed about 1300 grammes, and when it came into my possession weighed 1170 grammes. In form it is rather rectangular, with rounded angles and prominences, being thicker in the middle of the stone. The interior is of a fine-grained granular structure of a bluish-grey colour, and contains several of the veins or faults like the meteorite of Chateau Renard and others, and belongs to the chondritic class of meteorites; it contains a comparatively small amount of iron, which is evenly disseminated throughout the mass, the crust is of a moderate thickness and of a dull black colour; about one-half of which is covered with a brownish stain, probably where it rested on the soil, a character frequently observed in other meteorites. A single stone apparently only fell, at least no others were found. The fragment broken off was said to be for the purpose of analysis, but the result is not known, as no public notice has been made of this fall.

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## VI.—NOTES ON PLIOCENE BEDS.

By ROBERT GEORGE BELL, F.G.S.

FOR some years past the Upper Tertiaries of England have not received such a liberal share of attention as was bestowed on them at one time by the older geologists, probably in part because of the impression unwittingly encouraged by some of the authorities in science, that little original work in the way of discovery can now be done in connection with the organic contents of the Upper Tertiary deposits, the number of species already recorded being very large.

Other considerations, such as the comparative shortness and insignificance (geologically considered) of the period of time during which these deposits were forming, have also doubtless tended to divert the attention of the younger students of geology to the more difficult and less known faunas in older formations.

And yet the termination of the discovery of new species would seem to be as far off as ever. Very little is actually known of the fossil forms of many of the lower classes of organisms; indeed, excepting in the Mollusca, the information that has at present been published is extremely meagre, our knowledge of the Annelids, Echinoderms, Polyzoa, and many other groups of the Invertebrata, in which the Pliocenes of Britain are very rich, is in fact astonishingly behind that which has been attained as regards Mollusks and Vertebrates.

Independent of fresh discoveries, there is a line of research which may with advantage be followed by the palæontologist dealing with material already identified, and about which much is known. He may seek to trace out the life history in time and space of a species or group of species, which, having appeared in some antecedent period, has lived on to our own time. For such purpose the present generation possesses many advantages, the numerous recent deep-sea explorations having revealed facts respecting geographical and bathymetrical distribution which help to elucidate the condition of the Tertiary seas, and thus to enlarge our acquaintance with the zoological history of many fossil forms.

Research on similar lines was advocated some years ago by the late Edward Forbes to the zoologists of his day. He remarks that "to get at the causes of such phenomena (the distribution of species), we must trace the history of the species backward in time and inquire into its connection with the history of geological change." It is evident that such a course of investigation as that suggested by Forbes must prove to be equally beneficial to palæontological students, and its wisdom has been often manifested of late years, during which experience has shown how dependent each line of study is upon the other.

The earliest indication of the Pliocene period in Britain seems to be the strongly ferruginous deposit at Lenham near Maidstone, occupying the so-called pot-holes of the Upper Chalk surface, and spreading over a considerable extent of the North Downs; at this place the impressions of shells in this hard rock are plentiful, and so far as present observation goes are of Pliocene forms. The locality has never been thoroughly examined, and would well repay patient exploration. The latest list of the species, which, however, is not exhaustive, is in a communication by Mr. Clement Reid, F.G.S., to "Nature" (No. 876, August 12th, 1886), and contains some which have not yet been found in our Crags. The age of this Lenham bed is now generally regarded as that of the similar Diestien deposit in Belgium.

Mr. Reid holds that this deposit is contemporaneous with our Coralline Crag. However that may be, the writer must strongly demur to the association of either of these deposits with those found in the well-sinkings near Utrecht, the fossils of which are so well identified and delineated by Dr. J. Lorié, in the paper referred to by Mr. Reid.

The high northern character of many of the Mollusca found in these beds is unmistakeable, and is closely correspondent with that of the fauna of the upper deposits of the Red (Butley) Crag. It is significant that no such Arctic forms as several of those mentioned by Dr. Lorié have ever occurred either in the Lenham or Coralline beds.

The fauna of these earlier deposits indicate a warmer temperature and a nearer relation to Miocene times than that possessed by the Red Crag. The *Cassidarias*, *Pyrulas*, *Volutes*, and other shells, *Fusus alveolatus* and *F. consociale*, for instance, all of semi-tropical character, occur in certain zones of the earlier Crag in some profusion, and generally in perfect condition; indeed, where the matrix is dry, they may compare favourably with the French Tertiary shells. In the later Crags the southern species thin out and fast disappear as we rise higher in the series, and in the case of species which are not uncommon to both, *e.g. Voluta Lamberti*, the condition is rarely perfect, and the fine sculpture observable in the Coralline Crag shells is always absent; even those shells which undoubtedly lived in both formations, such as *Buccinopsis Dalei*, have materially altered in shape and size after the advent of the Red Crag, and appear in greatly increased numbers.

The changes both in diversity of climate and of life have doubtless been very great in the East Anglian area during the Pliocene period; the species quoted above are a few examples among many which exhibit these alterations. Do not such facts imply that a much longer time than is generally allowed, is necessary to account for the variation and extinction of species, which occurred during the formation of the Crags?

At Walton-on-the-Naze, the Red Crag is shown (as the late Mr. Searles Wood always insisted) in its earliest and purest condition; it is the most instructive section at present visible, and contains by far the largest number of species, especially of Mollusca, of which about 235 have been recorded up to the present time; yet many of the genera of the older Crag, particularly those of southern habit, are absent, and others exist only in a dilapidated or fragmentary state.

An examination of the deposit shows that it was formed in a shallow depression of the London Clay, in the central and deepest part the Crag beds being almost horizontal and undisturbed. Here a number of *Pectunculi* may be found, with their valves united, and in the position in which they lived and died. Just above this bed the large Almond Whelk, *Fusus antiquus*, makes its first appearance in geological history, and so far as evidence is concerned this seems to have been its birth-place; it comes in as it were with a rush (as at a much later date did *Tellina Balthica*), the deposit at this spot being full of them in the finest and most perfect condition.

The appearance of this shell in our Pliocenes may be taken as one of the best indications of the great change of climatic conditions which had occurred since the close of the Coralline Crag; it may be seen in plenty in the Red Crag beds overlying the Coralline at Sutton (the best and almost only instance where the superposition can be seen); but it has never been observed in an earlier deposit, either here or on the Continent.

Another striking evidence of change of condition in the East Anglian area is that this shell is the first and best representative of a family or section (Neptunea) of the old Linnæan genus *Murex*, which is almost exclusively confined to the Boreal and Arctic regions of the world. Not only this species, but the whole of this particular section (if the doubtful subgenus *Sipho* is excepted) had, so far as has been ascertained, no previous existence to Red Crag times, since which period it has continued with undiminished vitality, and in recent seas it is as plentiful in suitable places as formerly, and exhibits still more variety than in the limited Crag area.

The sculpture of the earliest form agrees in its fine striation with that almost universal with these shells round the coasts of Great Britain, and more particularly with those on the sandy flats round the mouth of the Thames. Only in St. George's Channel off the Irish coast does the carinated variety occur in any number. Several other northern forms of Mollusca have been found here at various times, some quite recently, as *Fusus Islandicus* (Chemnitz), and it would seem to point to the existence there of one of those old boreal outliers mentioned by Edward Forbes as among the indications of a former glacial climate.

The shells of *Fusus antiquus* found in the lower beds of the deposit at Walton are invariably sinistral; but in the middle zones of the Red Crag about Sutton the dextral shell occurs plentifully, and both forms are often carinated; but in the upper horizon in the neighbourhood of Butley, and in the Norwich Crags, these carinations are more pronounced, and the reversed shells generally fewer. It is here that the Boreal and Arctic Mollusca are most numerous, and that the number and size of shells having southern affinities dwindle into smaller proportions.

The contention of Mr. Searles Wood that this species first appeared in the reversed state, afterwards becoming dextral in the course of time, certainly appears to agree with known facts. In the grey sand at Walton, as in the Belgian equivalents of this zone, no dextral forms have been found, although in the upper *Red* Crag at this section two broken and worn specimens have rewarded a long continued search.

How to account for this important variation of form is more problematical: is it dependent on alteration of climate? Perhaps the gradually cooling condition of the Crag seas was prejudicial to the original state of the shell, the dextral variety may be a hardier form gradually superseding the other, until it has become the rare exception only occasionally found. The cold seas of the Arctic climate certainly possess two Molluscs, *Buccinum deforme*, Midd., and *B. Harpa*, Morch. (*Heliotropis*, Dall.), which are always sinistral, and Middendorf mentions the reversed *F. antiquus* as found in the Polar Sea and Russian Lapland, and Woodward as from the Sea of Ochotsk; but these examples must be extremely rare, and altogether it seems that the sinistral condition of any of the shells of Mollusca, whether that condition be normal or not, is much less frequent in cold than in warm or even temperate seas. In Great Britain it is doubtful whether the reversed *Fusus* has been found living anywhere except in the neighbourhood of the German Ocean, where among many thousands of others an example closely approaching the Walton type is occasionally seen; but in Vigo Bay, in the north of Spain, a small colony still lingers, the late Mr. McAndrew having collected it with a number of other shells of Celtic character. The specimens do not seem to differ materially from other coarsely striated forms, and are certainly identical with those from the Pleistocene deposits of Sicily; but there is no certain authority for its existence in the Mediterranean.

The small reversed form from the Wexford gravels may be mentioned here; it is different from any other known to the writer, being very thick and quite smooth; it is said to be associated with many southern shells. So little, however, is accurately known with regard to the position or contents of the various beds of marine gravels in Ireland, that at present any conclusions must be premature.

The variety of form and sculpture exhibited by this species in the Red Crag is more than equalled by its divergence in modern times, The *Fusi* found in the Northern Hemisphere no doubt present great differences, but in their general characters most of them have a strong resemblance to one another, and, considering the long lapse of time *Fusus antiquus* has lived, the many geographical positions it has occupied, the different conditions, climatal and otherwise, in which it now exists, is there not reason to conclude that it is the original parent stock from which most of the species now inhabiting the Northern Hemisphere have branched forth?

The New England shell called *Fusus tornatus* by Gould (Inv. Mass. 2nd edit. p. 37) closely resembles some examples collected at Bramerton, near Norwich; it is recognized by him as resembling the Crag fossil; its relation to *Fusus despectus*, L. (which again it is almost impossible to divide from the carinated form of *F. antiquus*) is acknowledged by later authorities, such as Verrill, Sars, and Friele. In the Red Crag, however, the carinations are seldom, if ever, shown so sharply as in the last-named shell, possibly from abrasion as in the case of most Crag Gasteropods; in their present aspect with their strong coarse carinæ, they nearly resemble the older shells of *F. liratus*, Martyn, a native of Behring Sea. *F. fornicatus* of Linné, which has the carinæ coarse and undulating, has not been met with in the Crag, although sought for diligently by the late Mr. Wood.

On the Pacific Coast of North America *Fusi* are scarce in number, *F. tabulatus* of Vancouver not having much resemblance to our shell; but on the opposite coasts of North-Eastern Asia varieties of the common form occur in the seas of North Japan. The Aleutian promontory and group of islands probably deflecting many of the Arctic Molluscs inhabiting deep water to the Asiatic side, where they are carried south by the main current of water which sets that way.

The fragmentary character of the geological record is very apparent in the Pliocenes of Northern Europe, but their total absence in North America, and our limited knowledge relating to any of these deposits (small in extent as they are) outside the British Islands, imposes great difficulty and consequent imperfection in such life studies as have been attempted above.

## VII.—The Dimetian of St. Davids.

By T. Mellard Reade, F.G.S.

HAVING been lately at St. Davids, I made some observations in relation to the Porth-lisky granite or Dimetian of Dr. Hicks, which may be worth recording in the pages of the Geological Magazine.

Perhaps it may be well for me to state that previous to my examination I had no bias whatever in favour of any of the explanations of the geology of St. Davids which have been offered by Hicks, Geikie, or Blake.

With Dr. Hicks's map in hand[1] I examined many of the contacts of the granite with the surrounding rocks, but could see no evidences of any faulting sufficient to justify its title to be recognized as a distinct Archæan formation.

The evidences I did collect, as will be seen in the sequel, tend to

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[1] Pre-Cambrian Rocks of Pembrokeshire, Q.J.G.S. vol. xl. p. 560.

show that the rock is not in any sense Archæan, but is post-Cambrian and intrusive.

First, a few words with regard to the nature of the faults required on Dr. Hicks's hypothesis to entitle the granite or granitoidite to be considered the oldest of the Archæan series he has sought to establish at St. Davids.

The bedded rocks surrounding the granite boss have a high dip often approaching the vertical. On the one side to the south and in contact with it lie the admittedly Cambrian rocks, and on the other to the north-west also in contact, the underlying volcanic series or "Pebidian" of Hicks. Now as the "Dimetian" (granite) is in Dr. Hicks's view older than either series, yet occurs between them, it cannot have been placed in its present position by the folding which tilted the Cambrians and volcanics. It must therefore have been pushed through these highly-inclined rocks as a sort of plug, consequently Dr. Hicks in his map has shown the granite cut off from the surrounding rocks by a set of boundary-faults. To establish the existence of such a remarkable phenomenon would require the most complete and reliable evidence—such evidence as I venture to think has not yet been given.

If we consider the throw required in this way to bring the "Dimetian" into its present position, we shall find that it will have to be estimated by thousands of feet. Does any geologist venture to assert that the so-called junction faults represent any such a movement? On the contrary, had such tremendous displacements occurred, I hold that geologists would have universally recognized them, whereas some dispute the very existence of the junction-faults. Unless some one holding Dr. Hicks's view can frame a consistent theory by which the "Dimetian" can be got into its present position without the aid of these great throws, I shall continue to hold this reasoning unassailable.

It may be said that these are mere general considerations that are not conclusive, or at least do not carry conviction to some minds. Let us see if there are evidences of another class which support this contention.

In the much-examined junction of the granite and Cambrian conglomerate on the right bank of the Alan at Porth-clais, of which there is a wood-cut in Dr. Hicks's paper[1] the granite shades off into the conglomerate, here not much more than a coarse grit, in a way to make their separate recognition difficult. The conglomerate in consequence of a reversed dip lies upon the green Cambrian shales or sandstones,[2] which dip under it and the granite to the north at an angle of about 62°.

The conglomerate is seen also above the granite, but probably this is only the junction face disclosed through the granite having been removed from the front of the conglomerate. To explain myself

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[1] Q.J.G.S. vol. xl. p. 532.

[2] The rock is very like the grauwackes of Wigtonshire. Hicks calls it greenish sandstone, Geikie green shale; it is of an intermediate constitution, but I adopt the term shale.

fully would require a plan and sectional elevation; but so much has already been laid before the geological public with regard to this particular junction that I refrain from the infliction.

The Cambrian rocks to the south of this junction strike across the harbour of Porth-clais nearly due east and west, and on the left or east bank the granite is directly in contact with the green Cambrian shales. The conglomerate is not to be seen. At a distance of about 30 feet north of this contact, and embedded in the granite, is a vein[1] of green shale about 18 inches across, and another about 10 feet nearer to the contact about 6 inches across. Both these veins of shale, but especially the thinner one, have a rudely columnar structure at right angles to their direction. Excepting that this shale is a little more indurated and more like slate in its constitution, it is similar to the Cambrian green shales that overlie the basal conglomerate. These veins are in my view undoubtedly part of the Cambrian shale entangled in the granite, so that the granite must be post-Cambrian.

I cannot see any way of escaping from this conclusion. I may add that the conglomerate in contact with the granite, as before described on the opposite side of the valley, is converted into an extraordinarily tough rock. Though I saw no veins of granite penetrating the adjoining rock, I have little difficulty in recognizing these alterations as ordinary contact phenomena.

In the face of this strong evidence to the contrary, it appears to me that the presence of "dirty quartz" in the conglomerate like that in the granite, a resemblance that may be accidental or fanciful, but is much insisted upon by Dr. Hicks, has no great weight in proving that the conglomerate is largely made up of materials from the granite, and that therefore the granite is pre-Cambrian.

## NOTICES OF MEMOIRS.

### I.—Note on a few of the many remarkable Boulder-stones to be found along the Eastern Margin of the Wicklow Mountains. By Professor Edward Hull, LL.D., F.R.S., Director of the Geological Survey of Ireland.[2]

AMONGST the evidences of the former existence of an extensive sheet of ice descending from the Wicklow Mountains towards the shores of the Irish Sea is the occurrence of boulder-stones, chiefly formed of granite or granitoid gneiss, derived from the mountainous range to the westward, of a size seldom equalled —probably not surpassed—amongst the British Isles. As the Association includes in its labours the task of collecting details regarding erratic blocks, it may prove of interest, if I record a few cases which have come under my own notice.

1. *The Mottha Stone.*—This remarkable boulder is perched on the summit of Cronhane Hill, above Castle Howard, and is a conspicuous object from all directions. It consists of grey granite,

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[1] I use the term "vein" because it best describes the form in which these remnants of the shale occur.

[2] Read before Section C. (Geology), British Association, Manchester, Sept. 1887.

and rests upon Lower Silurian slate. Its dimensions are nearly as follows:—length, 14 feet; height, 9 feet; breadth, 9 feet. It contains about 35 cubic yards of matter, and its weight would be about 70 tons. From the site of the Mottha Stone, at a level of 816 feet above the sea, the eye ranges westward along the magnificent valley of Glenmalure, to the flanks of Lugnaquilla, at a distance of about ten or twelve miles, whence, as we may suppose, the granite block started on its journey. In its course it must have crossed the deep hollow of the Avonmore valley, which extends just below the feet of the observer transversely to the path of this remarkable erratic block.

2. *Castle Kevin.*—In the valley between Castle Kevin and Moneystown, where large boulders are numerous, there lies a block of granite, partially imbedded, of which the dimensions are:—length, 15 feet; breadth, 10 feet; height, 9 feet (imbedded portion —probably 3 feet—is not included in above). This block contains about 50 cubic yards of matter, and is about 100 tons in weight. The birthplace of this boulder was probably the mountainous tract about Mullaghcleevann, 2783 feet in height, lying at the head of the valley in which is situated the deep waters of Lough Dan. and it probably travelled a distance of eight or nine miles in an E.S.E. direction.

3. The last boulder-stone that I shall mention is the largest I have met with in co. Wicklow—perhaps in the British Islands. It stands behind a cottage by the roadside, near Roundwood Church, and is quite as large as the cottage itself, to which it forms a good protection from the storms descending from the mountains behind. This boulder consists of granitoid gneiss, resting on Lower Silurian slate and grit. Its dimensions are (q. p.):—length, 21 feet; breadth, 14 feet; height, 12 feet. Its form is somewhat oval, and it contains about 120 cubic yards of matter, and is about 240 tons in weight. The source of this block, which lies at an elevation of about 800 feet above the sea, was probably in the same locality with that of the Castle Kevin boulder, and the distance travelled was about six or seven miles.

The blocks above noticed, with many others of smaller size, do not belong to any of the local glaciers which once filled the valleys towards the close of the glacial epoch, and which have left numerous well-formed moraines in nearly all the principal valleys descending from the Wicklow range. They are to be referred, in all probability, to the earlier stage of intense glaciation, in which the whole district was covered with perennial snows and ice, moving eastward into the hollow now occupied by the waters of the Irish Sea.

## II.—ON THE REPUTED CLAVICLES AND INTERCLAVICLES OF *IGUANODON*.

### By Professor H. G. SEELEY, F.R.S.[1]

THE author showed, by superimposing a figure of the reputed clavicle upon the bone figured by Mr. Hulke as clavicle and interclavicle of *Iguanodon* (Quart. Journ. Geol. Soc. vol. xli. pl. xiv.),

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[1] Abstract of a paper read before the British Association, Manchester, Sept. 1887.

that the supposed sutures are fractures, and that the supposed interclavicle has no existence, except as an ossification posterior to the reputed clavicles. Then it was urged that these bones are unparalleled by any vertebrate clavicles, while the reputed pubes of Crocodiles and pre-pubes of other animals offer a more probable analogy.

The ossification in front of the pubis in *Ornithosaurus* is of similar form in several genera. And in Crocodiles the ossification of the fibrous extension which connects the reputed pubes with the sternal ribs would produce a bone like the supposed interclavicle of *Iguanodon*. Hence it was urged that these bones in *Iguanodon* are pre-pelvic, and the author identified them with the pre-pubic bones.

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## III.—The Classification of the Dinosauria. By Professor H. G. Seeley, F.R.S.[1]

THE author discussed the structure of the animals named *Dinosauria*, and concluded that the group had no existence, the constituent animals belonging to two orders which have no affinity; they are named *Omosauria* and *Cetiosauria*, the former with a sub-avian pubis and ischium; the latter with those bones sub-lacertilian.

The *Omosauria* is defined as having the ventral border of the pubic bone notched out so that one limb is directed backward parallel to the ischium, while the other limb is directed forward. The ilium has a slender prolongation in front of the acetabulum.

The *Cetiosauria* is defined by having the pubes directed forward with a median symphysis, but with no posterior limb to the bone. The anterior prolongation of the ilium has a vertical expansion.

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## IV.—On the Mode of Development of the Young in *Plesiosaurus*.

By Professor H. G. Seeley, F.R.S.[1]

THIS paper was descriptive of a specimen submitted to the author by J. F. Walker, Esq., F.G.S. It is a phosphatized nodule from the Lias of Whitby, measuring about 10 cm. by 7, by 5. On its surface are four more or less complete specimens regarded as fœtal *Plesiosauri*, together with fragments of at least three others. They are remarkable for having the flesh mineralized with phosphate of lime, and still show many characters of the external form of the body, but slightly distorted by decomposition. Only one individual has the head preserved, its extreme length is about 14 mm. The nares are terminal, like those of an emydian chelonian. The superior aspect of the head behind the frontal bone is occupied by muscular substance. The skull rests on one side against the matrix, so that its transverse width is not clearly shown, but it was wider than the neck, and narrows in front of the orbit towards the nares, which curve a little downward. The eyes look obliquely upward and outward, and have a diameter of two millimetres. The neck has a length of 4·5 centim. Behind the head it is about 4 millim. deep, and as wide; it widens to a centim. where the expansion takes place at the shoulders, and there the depth is about 8 mm. A sharp median ridge down

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[1] Abstracts of papers read before the British Association, Manchester, Sept. 1887.

the middle of the neck divides its superior aspect into two oblique moderately convex surfaces. Other individuals show that this ridge was prolonged down the back and tail, but less elevated. The body is about as long as the neck. On the right side it has suffered some abrasion and injury in cleaning, and is not quite symmetrical, being a little larger on the left side. It is about 2·4 centim. wide, convex from side to side, and less convex in length. The expansion from the neck is rapid, and attenuation posteriorly is marked so that the body has a long egg shape. The tail appears to be short and conical, and curves rapidly downward in every specimen. The height of the body was not more than half its width. The limbs are imperfectly preserved. The distance between them on the left side is 2·4 centim. The anterior limb appears to be the larger. The entire length of the specimen is 12·5 centim.

This individual lies over the neck of another specimen which was larger, and appears to have measured 15 centim. without the head. It shows the fore limbs to have been very wide relatively to their length, and to have measured in the antero-posterior direction 1·1 centim. at the junction with the shoulder on the right side; it is flattened, extended horizontally, imperfect distally, and curved somewhat backward, but evidently short as compared with the adult. The hind limbs of this specimen are not seen.

Other individuals are smaller, and have the body only about half as wide. They are very narrow in the anterior part of the body, and there appears to be only a slight budding of the fore limbs.

Hence, I regard this specimen as showing that the *Plesiosaurus* was viviparous, and that in one species from the Lias many were produced at one birth. The species was probably a long-necked one, and may have been *P. homalospondylus*, since the head in young animals is relatively large, and here it is $\frac{1}{9}$ of the total length of the animal.

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## V.—UPON A SIMPLE METHOD OF PROJECTING UPON THE SCREEN MICROSCOPIC ROCK SECTIONS BOTH BY ORDINARY AND BY POLARIZED LIGHT. By E. P. QUAIN.[1]

KNOWING the difficulty experienced in pointing out to students any particular crystal in a rock-section when viewed with the microscope direct, I attempted to project the images on the screen, and by the aid of comparatively simple apparatus met with very gratifying success, both with ordinary and with polarized light.

The tube of the microscope was screwed out and replaced with a cork, through which a hole had been cut to carry the ordinary one-inch micro-objective and behind it the analyser of the microscope. The polariscope and rock-section occupied their usual position, as when used with the microscope in the ordinary way. The microscope stand being inclined into the horizontal position was placed in front of the object-lens of the lime-light lantern. The object-lens of a lantern usually consists of a combination of two lenses. If so, the back lens is taken out, and the front lens only

[1] Abstract of a paper read before the British Association, Manchester, Sept. 1887.

used, acting as an extra condenser, concentrating the light upon the rock-section, and causing it to pass through the polariser and the analyser. A little adjustment of the light was required to get it well through both polariser and analyser, but this with a little care was soon done, and a bright picture several feet in diameter was projected upon the screen, showing the crystals well defined, and exhibiting very strikingly the changes of colour, etc., characteristic of the crystals when viewed by polarised light, and in such a manner as to be well seen by a number of people at once, and also allowing the lecturer to readily point out any particular crystal or crystals to which he desires to draw the attention of his audience.

As the optical axes of the lantern and microscope did not coincide, the lantern was placed on a board provided with four levelling screws with which the necessary adjustments were readily made.

Much better effect may be got if the "Joblowsky" form of prisms made by Zeiss are used instead of the usual Nicols prisms, on account of their greater aperture and shorter length.

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## VI.—THE PERMIAN FAUNA OF BOHEMIA. By Prof. Dr. ANTON FRITSCH, Director of the Royal Bohemian Museum in Prague.[1]

PROF. Dr. Anton Fritsch, of Prague, Bohemia, read a paper on the Permian Fauna of Bohemia. After having mentioned the 73 species of *Labyrinthodonts*, of which he has given figures in his work "Fauna der Gaskohle," and of which he exhibited the electrotypes and restored models in the galleries of the Owens College, he communicated the discovery of a very peculiar genus *Naosaurus* (Cope). He then explained some unpublished plates of *Ctenodus*, *Orthacanthus*, *Hexacanthus*, and a new Ganoid Fish, *Trissolepis* with three kinds of scales. He proved *Acanthodes* to be very near to Selachians, and lastly he drew attention to the gigantic fish (*Amblypterus*) 113 cm. long exhibited in the galleries.

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## VII.—REPORT ON THE FOSSIL PLANTS OF THE TERTIARY AND SECONDARY BEDS OF THE UNITED KINGDOM. By J. S. GARDNER, F.L.S., F.G.S.[1]

THE small balance carried forward from last meeting has been expended in visiting the localities in which fossil plants have previously been met with. The beds near the Pier at Bournemouth seem more than usually inaccessible, but a fall from the cliff has brought down some of the dark clays, and in these were parts of a large feather Palm and other leaves. I was fortunate enough, however, to secure at the west end of the cliffs a new species of *Acer* and a fine leaf of *Dryandra acutiloba*, really a *Myrica*, a rare leaf at Bournemouth, and one of the few that extend upward from the Lower Bagshot into the Bournemouth horizon.

I have again visited Alum Bay, but the pipe-clay on the shore has become still more diminished, and there is no hope that any more fossil plant-remains will be obtained there in our time. No distinct plant-remains are obtainable from the same horizon at

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[1] Abstracts of papers read before the British Association, Manchester, Sept. 1887.

Whitecliff Bay, though I had some hope that this might be the case. The drought was unfavourable to collecting at Barton and Hordwell, where most interesting fruits are washed out during heavy rains, and I procured no plants during my visits there this year; but it favoured, on the contrary, collecting at Lough Neagh, by lowering the level of the lake; and I am able to add a new *Pteris*, an exquisitely preserved fruit, and many Dicotyledons to the Flora, and a *Paludina* to the Fauna.

No plant-remains are obtainable this year at Reading, nor do any of the other brick-pits in which plant-remains have occurred seem in exactly a favourable state, at the moment, for collecting, so that it appears undesirable to ask for further grants for this purpose at present. The Lower Eocene Floras are, however, still insufficiently known, and excavations at Bromley or elsewhere in the Woolwich horizon would, I anticipate, yield especially important results. In the mean time, an enormous mass of material has now been accumulated, which will require years of patient research to digest. Advantage has been taken of the presence of that distinguished Palæobotanist, the Marquis de Saporta, at our meeting, to go through the drawings, numbering more than a thousand, that I have already made of the plants so far collected. He is completely astonished at the richness of our Eocenes, and considers them to be unrivalled. The Reading and Bournemouth horizons contain plants which do not appear in Europe until much later Tertiary times, seeming to have passed very slowly across Europe towards Eastern Asia, which may be considered their present home, their chief affinities being with floras indigenous to that part of the globe, rather than with those of America and Australia, as hitherto supposed.

In conclusion, it may be mentioned, that although, owing to the drought and other causes, already referred to, the results of this year's labours have been but small, when contrasted with the magnificent collections obtained in former years; yet, notwithstanding these adverse circumstances, several important additions have been made by me to the palæophytological collections in the British Museum which will doubtless prove of good service in elucidating the Eocene flora of Britain.

## REVIEWS.

### Les Eaux souterraines aux époques anciennes. Par A. Daubrée, etc. One Vol. pp. 443, with numerous Illustrations. (Vve. Ch. Dunod, Éditeur, Paris, 1887.)

THIS work treats of the part which underground waters have played in the origin and modification of the substance of the Earth's crust. In the preface Mons. Daubrée alludes to the ideas of Bernard Palissy and others as to the analogy which exists between what we should call organic and inorganic bodies, and to the belief that the latter possess a sort of quasi-vitality. Questions bearing on this subject have lately attracted the attention both of the President of the Geological Society and the Editor of this MAGAZINE. It is quite sufficient for our present purpose that water should be deemed an important agent in causing "stones to grow." But a few years have elapsed since a celebrated geological chemist declared that the alkahest, or universal menstruum, was neither more nor less than water, aided by heat, pressure, and the presence of other substances. The author of the work now under consideration has already demonstrated in his celebrated "Études synthétiques" the important part played by underground waters charged with various substances in the formation of minerals; and he now proceeds to point out how their history furnishes us with a remarkable example of the continuity of operations past and present. Even in places where they no longer flow, these underground waters have left us indications of their movements and their chemical energy, so that we are enabled to follow them in all the details of their "régime."

Of all mineral substances which have been formed in the wet way, zeolites are amongst the most obvious, and Mons. Daubrée has elsewhere observed that these may be regarded as a kind of extract of the rocks, which have themselves been subjected to continued lixiviation. Entering more fully into this question in the present work, he gives examples of their development and mode of formation, together with that of the associated minerals, quartz, agate, and chalcedony. There is no lack of appropriate illustrations: the section of an agate is particularly fine. He still seems to regard the canal shown by some of them as an inlet of infiltration. The zeolitic minerals of Plombières are discussed at some length: sections of the zeolite-bearing bricks are given, effective alike for showing the minerals themselves as well as the structure of the brick. The bricks thus transformed present considerable resemblance to certain altered volcanic rocks. The siliceous products of the bricks resemble, he says, the acid rocks, whilst the zeolites and globules of palagonite in these same bricks recall the basic rocks. All these changes have been effected since the days of the Romans by waters of a moderate temperature.

The study of the formation of metalliferous deposits affords still more remarkable testimony alike to the solvent and depositing powers of underground waters. Substances, which under ordinary conditions are regarded as insoluble, have been deposited in various ways, as in veins, segregations, beds, etc. *A propos* of this subject Mons. Daubrée does not fail to point out the celebrated instance at Bourbonne-les-bains, so well described in the "Études synthétiques," where old Roman coins by their decomposition have yielded metallic sulphides under the action of warm mineral waters.

This branch of the question is a very large one, and has received ample treatment both from Mons. Daubrée, and also from the late John Arthur Phillips, in his excellent treatise on "Ore Deposits." One cannot fail to perceive that these authors are disposed to ascribe the bulk of the phenomena, as regards veins, segregation-veins, beds, etc., mainly to the action of waters, warm or cold. It is true that such actions are often the most powerful in the neighbourhood of eruptive rocks, which are frequently accompanied by veins having a concretionary structure, either metalliferous or sterile. "This is not so much an immediate product of the rocks themselves as a gentle and prolonged deposit proceeding, some from gaseous emanations, others and these the most numerous from powerful mineral and thermal springs, whose first origin must be attributed to the appearance of the eruptive masses, and whose circulation is effected by the aid of the cracks or fractures of the ground" (Daubrée, *op. cit.* p. 143). There can be no better proof of the intimate connection between mineralizing waters and metallic veins than is afforded by the wonderful phenomena of the Steamboat Springs in Nevada, of which a notice was given in the Quarterly Journal of the Geological Society by William P. Blake as long ago as 1864. Since then the whole of this Comstock region has been the subject of numerous memoirs. According to Mr. Phillips (Ore Deposits, p. 532), these rocks have been carefully assayed, with the results that the neighbouring diabase contains a notable amount of the precious metals, of which the larger proportion is contained in the augite; that the decomposed diabase contains about one-half as much of these metals as the comparatively fresh rock; and that the relative quantities of gold and silver, both in the fresh and decomposed diabase, correspond fairly well with the known composition of the Comstock bullion. There does not seem any reason why these facts should exclusively favour the theory of lateral secretion, but they serve to confirm the notion as to the eruptive rocks being, in this case, the primary source of the metallic wealth of the country, which has been extracted and concentrated, as it were, for the benefit of miners by the aid of heated and mineralized waters, in such fissures as the Great Comstock Lode, where the process may still, to a certain extent, be in operation.

The replacement of limestone by ironstone, and the phenomena connected with iron deposits generally, are also fully treated by the author, who reproduces some of Mr. Kendall's sections showing the mode of occurrence of hæmatite in Cumberland and North Lancashire.

Next comes the question of the change in rock-masses on a large scale—and firstly, as to the mineralization of fossils, and the formation of nodules (rognons), etc. There can be no difficulty in believing that water, in conjunction with dissolved salts and gases, has replaced shell substance by a more or less pure mineral calcite, and that sometimes the replacing substance has been silica, carbonate of iron, or other mineral, even specular iron, as some bivalves he mentions in the Lias. The numerous silicified woods also find a place here. The flints of the Chalk he treats as concretionary bodies, and he gives a telling figure of orbicular silex as developed in the shell of a *Gryphæa.* The chemical alteration of silicated rocks is next dealt with; and here Mons. Daubrée observes with regard to the kaolinization of felspar, that this has not in all cases been effected by surface agents; he suggests aqueous and other emanations in connection with the deposits of tin-ore.

A considerable number of pages are devoted to the great question of metamorphism. With respect to contact metamorphism, it is not quite clear how far the results, in all cases, have been brought about through the agency of water. Of course, where quartz and numerous anhydrous silicates have been developed in a limestone, which itself has become crystalline in the vicinity of an eruptive rock; supposing such a limestone to have been a nearly pure calcareous rock originally, the ingredients of so many silicates have in all probability been introduced by the agency of waters which owed their impregnation in part to the eruptive rock itself. In dealing with the far more important subject of regional metamorphism, we gather in the first instance that the author excludes the great fundamental gneisses. Although the subject is very fully treated, it is not easy to assert what part water is considered to have played in producing the results; undoubtedly heat, pressure, and and chemical solvents are required in addition to mere water. After the admirable experiments detailed in the "Études synthétiques," and repeated here with excellent illustrations, it has been abundantly shown that anhydrous silicates can be produced in the wet way. Perhaps this is even more than is required in some cases, since the phyllades of the Ardennes are largely composed of such hydrous minerals as sericite and chloritoid, or chlorite, in addition to quartz. We have also the general statement (p. 375) that the water enclosed in clays, combined and fixed, has had a "preponderating action in the development of metamorphic phenomena."

Lastly, Mons. Daubrée considers the light which past and present phenomena are able to throw upon each other. He alludes to the great vertical and horizontal extent over which the course of ancient waters is often discernible. Measured by the standard of historical time, existing hot springs enjoy a great stability, though in general the old thermal springs, which have brought the metallic minerals and their gangues into the veins of so many regions, are now dried up. The relative geological age of ore-deposits is discussed, ranging from the great iron-masses of Scandinavia contemporary with the gneiss, to the Tertiary deposits of Comstock, associated with trachytic greenstone.

He concludes as follows:—"It is thus that water has played a unique part throughout all time in the earth's crust; aided, it is true, by secondary substances, it has been the chief *mineralizer*, even for minerals such as quartz and the anhydrous silicates in whose presence it is altogether inactive at temperatures which prevail on the surface of the globe, and whose origin for this reason was for long time considered beyond its influence.

"However, this does not concern the past merely. There is nothing to prove that operations of this nature are arrested. On the contrary, it is more than probable that, as each day goes by, similar actions are contributing to the formation of new minerals; but these take place in interior regions which are not accessible to our observations. In descending but a few mètres from the surface we find silicates of the family of the zeolites and combinations of sulphides similar to those of metallic veins. Unfortunately we cannot observe the products of reactions which take place of necessity lower down in the ascending conduits of these springs or in proximity to the laboratories of volcanoes. Superheated water, which betrays itself outside by thermal springs and volcanic exhalations, must produce slowly and silently in the interior of the globe effects both considerable and permanent and, as formerly, give birth to various minerals.

"In its ceaseless circulation subterranean and deep, and by its work principally chemical, water simulates a kind of vital action which is perpetuated in the earth's crust throughout the ages of our planet." W. H. H.

## REPORTS AND PROCEEDINGS.

### Geological Society of London.

November 9, 1887.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "Note on the so-called 'Soapstone' of Fiji." By Henry B. Brady, F.R.S.

The Suva deposit, which has a composition very similar to that of the volcanic muds at present forming around oceanic islands in the Pacific, is friable and easily disintegrated. The colour ranges from nearly white to dark grey, the mass being usually speckled with minerals of a darker hue. Under the microscope the rock presents the character of a fine siliceous mud with crystals of augite, etc., together with the sparsely scattered tests of Foraminifera. The approximate chemical composition of typical specimens is:—Silica, 50 per cent.; alumina, 18 per cent.; lime and magnesia, from 5 to 6 per cent.; ferric oxide, from 3 to 8 per cent.; water, 16 per cent. with a small proportion of alkalies, chiefly potash, and but small trace of carbonates.

The author's attention was chiefly directed to the common grey friable rock, which may be softened in water and washed on a sieve, the residue consisting mainly of Foraminifera with a few Ostracoda. Of three specimens examined, 1 is a light-grey rock from close to the sea-level; 2, of a lighter colour, from about 100 feet elevation; 3 is nearly white and somewhat harder, and was derived from an intermediate point. So far as the Microzoa are concerned, the first two present no differences which might not be observed in dredgings from the recent sea-bottom, taken at similar depths a little distance apart. The third appears to have been deposited in somewhat deeper water. There is a marked scarcity of arenaceous Foraminifera.

Then followed notes on the rarer and more interesting species, together with a list of the 92 species of Foraminifera found. Of these, 87 are forms still living in the neighbourhood of the Pacific islands. Two of the remaining 5 are new to science, and the rest extremely rare. The author concluded that these deposits are of Post-Tertiary age, formed at depths of from 150 to 200 fathoms in the neighbourhood of a volcanic region. The following new or little-known species were selected for illustration:—*Ellipsoidina ellipsoides*, var. *oblonga*, Seguenza; *Haplophragmium rugosum*, D'Orb.; *Ehrenbergina bicornis*, nov.; *Sphæroidina ornata*, nov.

2. "On some Results of Pressure and of Intrusive Granite in Stratified Palæozoic Rocks near Morlaix, in Brittany." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

The author briefly described the banded Palæozoic slates in the neighbourhood of Morlaix, and gave a general account of their microscopic structure. They are greatly contorted and folded, and have evidently undergone very severe pressure. The result of this, as it appears to him, has been the development of minute scales of a light-coloured mica, especially in the darker (originally argillaceous bands) and certain corresponding changes in the more quartzose layers. The cleavage-planes often cut the surfaces of bedding and of this micro-foliation, which are parallel, at high angles, and so are of the nature of "*Ausweichungsclivage.*"

In certain places these banded slates, after they have attained the aforesaid condition, have been affected by intrusive granites. The result has been the intensification of the changes which were already incipient. The quartz granules have been doubled in size, the flakes of mica have become four or five times as large, the black material of the argillaceous bands has been gathered into larger granules, and seemingly reduced in quantity (probably by partial oxidation of the carbon), and in some cases andalusite crystals or grains of considerable size have been developed. The rock has become comparatively hard, instead of friable, and the cleavage-planes are "soldered up" by the development of mica along them. In its general aspect one of these banded rocks (where free from andalusite) bears considerable resemblance, macroscopic and even microscopic, to one of the less coarsely crystalline, distinctly banded mica-schists, supposed by many to occupy a rather high position in the Archæan series.

3. "On the Position of the Obermittweida Conglomerate." By Prof. T. McK. Hughes, M.A., F.G.S.

The author gave an account of a visit to the section at Obermittweida, 50 miles S.W. of Dresden, where there is an apparent intercalation of conglomerate and sandstone in a gneissic series. West of the stream at Obermittweida there is seen a crushed but not much altered conglomerate of felsite and other pebbles, above which gneiss and mica-schist rest, apparently in true sequence numerically. Below the conglomerate no rocks were seen, but at a little distance to the eastward coarse flaked muscovite-schists and gneissic rocks were exposed, apparently underlying it. By a diagram the author showed how the conglomerate might belong to much newer beds caught in a synclinal fold of the schists, and he advanced various arguments in support of this explanation.

4 "On the Obermittweida Conglomerate: its Composition and Alteration." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

The author is indebted to Professor Hughes for the opportunity of examining a fine series of specimens of this rock, collected by the latter. The pebbles vary from well-rounded to subangular, some of the smaller fragments occasionally being practically unworn. The matrix is sometimes granular to the unaided eye, sometimes very fine. The whole mass has evidently been subjected to considerable pressure.

The associated gneiss is a moderately coarse gneiss, containing two micas and garnet. It has a general resemblance to rocks which, in the Alps, appear to occur about or rather below the middle of the crystalline series.

The fragments consist of various kinds of rocks. Those examined microscopically are referred to granitoid rock (3 varieties), mica-schist, quartz-schist, quartzite, hälleflinta (?).

The matrix is almost wholly composed of quartz and mica (two species, but mostly brown), with some felspar. The materials appear to have undergone a certain amount of metamorphism, by augmentation of the original fragments, and to some extent by development of new minerals. The author is of opinion that the materials are rather more altered than is usual in Palæozoic greywackes and conglomerates, but that the comparatively small amount of alteration, and the character of the included fragments, render it highly improbable that the conglomerate is in stratigraphical sequence with the above-described gneiss, or with any similar series of rocks; and so, if Archæan, it must belong to one of the latest epochs in that period.

5. "Notes on a part of the Huronian Series in the Neighbourhood of Sudbury (Canada)." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

The specimens noticed by the author were in part collected by him in the summer of 1884, when the Canada Pacific Railway was in process of construction, and in part subsequently supplied to him by the kindness of Dr. Selwyn, Director-General of the Geological Survey of Canada.

The eastern edge of the district assigned to the Huronian consists of rocks, which may possibly be part of the Laurentian series modified by pressure. But after crossing a belt of these, barely a mile wide, there is no further room for doubt. All the rocks for many miles are distinctly fragmental, except intrusive diabases or diorites. These fragmental rocks are grits, conglomerates, and breccias, which are described as far as about two miles west of Sudbury. The included fragments in these rocks appear to have undergone some alterations subsequent to consolidation: these are described. In some cases the changes appear to be anterior to the formation of the fragments. The matrix also has undergone some change, chiefly the enlargement of quartz grains, and the development or completion of mica-flakes, as in the Obermittweida rock.

The author gave some notes on other specimens collected by him along the railway, further west, and on those supplied to him from near Lake Huron by Dr. Selwyn. As a rule these are but little altered. Some contain fragments of igneous rocks, apparently lavas.

The author discusses the significance of the changes in these rocks, as bearing on general questions of metamorphism, and states that, in his opinion, the name Huronian, at present, includes either a series of such great thickness that the lower beds are more highly altered than the higher, or else two distinct series; and he inclines to the latter view. Both, however, must be separated from the Laurentian by a great interval of time, and neither exhibits metamorphism comparable with that of a series of schists and gneisses, like the so-called Montalban. The newer reminds him often of the English Pebidians.

## CORRESPONDENCE.

### LYDEKKER, BOULENGER, AND DOLLO ON FOSSIL TORTOISES.

Sir,—I have read with interest the notes on the above subject which appeared in the Geological Magazine for June and September, I find that the two first-named gentlemen have overlooked a paper of mine, which will relieve me of the charge of erroneous treatment of the genus *Pleurosternum* which they make. The paper was published in 1870,[1] and prior to those of Professor Rütimeyer which they cite as authority for determination already made by me. The learned authors quote me as stating that in the genus *Pleurosternum* there is "no intergular shield, and the genus is accordingly referred by me to the Cryptodira; whereas its true position, as was pointed out by Prof. Rütimeyer, is with the Pleurodira; and with that group—the Pelomedusidæ and Peltocephalidæ of Gray—characterized by the presence of eleven, instead of nine, plastral bones." On a subsequent page (274–5) they consider the *Platemys Bowerbankii*, of Owen and Bell, "in regard to which Prof. Rütimeyer has already pointed out that the specimen figured by the same writers under the name of *Emys lævis* is merely the young of the former, and that owing to the presence of a small mesoplastral bone, the reference to *Platemys* is incorrect, and it is suggested that the species may probably belong either to *Podocnemis* or *Peltocephalus*."[2]

In my paper of 1870 I remark, "The genus *Platemys* as adopted [in Maack's work] may be cited. It embraces nine species according to the present work, the genus *Pleurosternum* of Owen being referred to it. This is done because the additional pair of thoracic bones which characterizes it is found in a rudimental condition in *Platemys Bowerbankii*; and *Platemys Bullockii* of Owen presents the intermarginal scuta of *Pleurosternum*, and because of the general resemblance in specific characters between the latter and the *Pl. concinnum*. To us, however, the genus *Pleurosternum* appears to be Cryptodire, not Pleurodire, as it lacks the intergular scutum of the later suborder, and to represent a peculiar family of that group characterized by the possession of ten instead of eight sternal bones. *Platemys Bullockii*, *P. Bowerbankii*, and *Emys lævis*, Owen and Bell, appear on the other hand to be Pleurodira, and to be referable to two families of that suborder. The *Pl. Bullockii*, on account of its five pairs of sternal bones, to the Sternothæridæ, and on account of

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[1] Die bis jetzt bekannten Schildkörten, u. d. bei Theilheim in Hannover neu afgefunden altesten Arten derselben; von Dr. G. A. Maack; a review by E. D. Cope, Amer. Journal Sci. Arts, 1870, L. pp. 136.

[2] "The figure shows that its affinity appears to be rather with the former than the latter, and it may accordingly be provisionally referred to that genus."

its intermarginal scuta to a new genus, which I call *Digerrhum.* The last two in their rudimental fifth pair of sternals, resemble many *Pleurodira*, and cannot be distinguished from the genus *Podocnemis* now living in the Amazon."

In this paragraph I have made the references adopted by Rütimeyer, Lydekker and Boulenger, but I did not use the name *Pleurosternum* for the *Pl. Bullockii.* Believing that the *Pl. concinnum* represented that genus, I removed the *Pl. Bullockii* from it. It now remains to ascertain the characters of the *Pleurosternum concinnum*, since no reference is made to it by the authors of the paper on which I am now commenting, but who regard the *Pl. Bullockii* as typical of the genus.

M. Dollo well remarks (September Number) that the absence of dermal sutures cannot alone place a genus of Tortoises in a separate family from forms which possess such sutures. He regards *Erquilenesia* as most resembling *Euclastes*, but not to belong to the Propleuridæ. But I think *Euclastes* is one of that group, and I suspect that Dollo's characters of the skull define the group better than the number of costal bones, which will however distinguish the genera.

E. D. Cope.

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## ORIGIN OF CERTAIN BANDED GNEISSES.

Sir,—Mr. Teall's paper on the origin of certain banded gneisses (p. 484) is a contribution of the utmost value to the discussion of a very difficult subject. But, as I am responsible for another theory concerning these gneisses, may I be allowed to say, that though I admit the importance of the hypothesis, I still see great difficulties in the way of accepting it. These gneisses of the Lizard must not be regarded alone; a hypothesis which might alleviate our difficulties here (and they are undoubtedly great) might increase them elsewhere—and thus, did I assign an igneous origin to all the crystalline rocks south of St. Keverne, I should find it difficult to know where to stop in applying the explanation to other regions. Moreover, if we are to explain these banded gneisses as the rolling or crushing out of a complex of igneous rocks, not only must the flexibility of the rocks have been very great, but also this complex originally must have been a very intricate one. Now I have had a fairly large experience in the habits of igneous rocks, and, so far as this goes, such complications as would be required here are both rare in occurrence and limited in extent. Yet at the Lizard the banded series is of considerable thickness, and can be traced along the coast for full two miles. I admit, however, that when I wrote my two papers, I sometimes failed to distinguish between structures significant of original constitution and those due to subsequent mechanical action, for our knowledge of the latter is of very recent date; but to what extent I will not venture to say until I can again examine the whole district. This I hope to do, but for various reasons must defer the pleasure for a time. Probably it will be some years before we can fairly determine the claims of conflicting hypotheses; meanwhile it is well for science that Mr. Teall has advanced one with so much moderation in statement, and clearness in reasoning. Perhaps one day he may claim me as a thorough-going convert; but at present I anticipate that it will be my ultimate fate here, as in other things, to maintain that truth lies between opposite extremes.

As I am writing, I may as well briefly notice another criticism on some work of mine in the south-west. In the Transactions of the Devonshire Association a paper has recently appeared (p. 349), advocating the old view of a gradual transition between the slaty and the crystalline series in the Start and Bolt Head districts. As the writer has "to confess to much ignorance as to the methods and results of microscopic research," and the question is one in which such methods are essential in order to distinguish real differences, and avoid being misled by superficial resemblances, I cannot admit that he is qualified to investigate the subject, or waste time by discussing it with him, and will only say, that, though since I wrote the paper I have frequently examined my specimens and slides, I have seen no reason to alter my opinion as to the separateness of the two groups of rocks. Moreover, a paper will shortly appear in the Quarterly Journal of the Geological Society, by a careful observer in the field and worker with the microscope, in which much additional evidence is brought forward in favour of my view. It would be thought strange if any one were to enter into a dispute as to the interpretation of a corrupt passage in a chorus of a tragedy of Æschylus, without a preliminary study of the niceties of the Greek language; yet this is the course which some persons follow in petrology, and seem to think that thereby they are doing a service to science.

T. G. Bonney.

## OBITUARY.

### REV. W. S. SYMONDS, M.A., F.G.S.

Born 1818; Died 1887.

Forty years ago, the promotion of Natural Science throughout the country was mainly entrusted to the agency of the various local Field Clubs and Natural History Societies, amongst the most active and useful of which may be mentioned the Malvern Natural History Field Club, the Woolhope Naturalists' Field Club, and the Cotteswold Club. It was in the districts over which these clubs held sway that the subject of our present notice passed the best years of his life and carried on those geological labours with which his name will always stand associated.

Mr. Symonds was born at Hereford in 1818, being the son of William Symonds, Esq., of Elsdon, Herefordshire. After passing through his school-days with Mr. Allen at Cheltenham, and reading with the Rev. J. P. Sill, he was sent to Christ's College, Cambridge, where Sedgwick was then in the height of his popularity as a geological lecturer. He took his degree in 1842, and in 1843 he was appointed Curate of Offenham, near Evesham, where he became acquainted with Mr. Hugh Strickland, from whom he received many of his first lessons in Natural History. In 1845 he was presented to the Rectory of Pendock, near Tewkesbury.

Mr. Symonds married, in 1840, Hyacinth, daughter of Samuel Kent, Esq., of Upton-on-Severn, and had issue three sons and one daughter; the latter only now survives him, and is married to Sir J. D. Hooker, K.C.S.I., F.R.S.

From an early date Mr. Symonds became the friend and associate of Sir William Vernon Guise, Bart., of Elmore Court, near Gloucester, and it is significant that the two attached friends died within a few days of one another, viz. 15th and 24th Sept. (see Geol. Mag. Nov. 1887, p. 528).

Mr. Symonds assisted in the foundation of the Woolhope Naturalists' Field Club, and was elected its President in 1854. He was also President of the Malvern Naturalists' Field Club from 1853 and for many years subsequently.

In 1857 he visited Dublin, in order to attend the Meeting of the British Association, and availed himself of the opportunity to make a geological tour through Ireland (see Geologist, 1858, pp. 292-296 and 330–335). In this year he also published a work entitled "Stones of the Valley."

In 1858 we find him busy in the field exploring the bone-bed of the Upper Ludlow rocks and their characteristic fossils (Geologist, 1858, p. 15). Mr. Symonds examined in 1859 the reptiliferous sandstone near Elgin (see Edinburgh New Phil. Journ. 1860, vol. xii. p. 95), and in the year following he was watching the results of the geological sections exposed in the Malvern and Ledbury Tunnels with Mr. A. Lambert (Geologist, 1861, p. 148). In 1863 he made a geological ramble through Wales, an account of which he communicated to the Worcester Nat. Hist. Soc. Trans. 1864. A new edition of his book entitled "Old Bones, or Notes for young Naturalists," was issued in 1864, the first edition having appeared in 1859.

In the summer of 1866, accompanied by his friend Sir W. V. Guise, Bart., Mr. Symonds visited Belgium, and under the guidance of Prof. Dupont, explored the Bone-Caverns of the Valley of the Lesse, and gave an interesting description of the same to the Woolhope Naturalists' Field Club (Geol. Mag. 1866, pp. 564–570).

In 1871 Mr. Symonds published, in Dr. H. Woodward's Monograph on the Merostomata, some interesting Notes on Silurian localities in the West of England where these fossil Crustacea occur (see Pal. Soc. Mon. Brit. Foss. Crustacea, 1871, part iii. pp. 92–104). In the same year Mr. Symonds explored the Hyæna-Den (known as King Arthur's Cave) on the Great Doward, Whitchurch, Ross (see Geol. Mag. Vol. VIII. p. 433).

In the year following (1872) he brought out his "Record of the Rocks," an excellent and readable handbook for students of the Geology of the West of England.

The autumns of 1874, 5, and 6, were spent in company with Sir Wm. Guise, Mr. Lucy, and others, in exploring the volcanoes and tracing the ancient glaciers of Auvergne and those of the Haute Loire and the Ardèche (see the Pop. Sci. Rev. vol. xv. 1876, and N. Ser. vol. i. pp. 1, 250, 329, 1877).

In 1880 Mr. Symonds published a second edition of his book entitled "Old Stones," and also his romance of "Malvern Chase," which reached a third edition in 1883. In this year he issued two more works, namely, "Hanley Castle," a romance; and the "Severn Straits," a geological work. Althogether he was the author of more than forty papers which have appeared in various scientific journals.

The main object of Mr. Symonds' active and useful career, and to the furtherance of which all his best energies were directed, was the promotion of a love for Geological, Botanical, and Archæological pursuits and studies, amongst the very large circle of educated people in the West of England by whom he was surrounded, whose tastes he strove to elevate and direct, and whose leisure hours he endeavoured to occupy with healthful and intellectual pursuits.

Although a clergyman and a Justice of the Peace for the county of Worcestershire, he was above all things an ardent Naturalist and Geologist, and he was never so happy as when conducting the members of his own Naturalists' Field-clubs over some classical region in "Siluria," with every spot of which he was familiar.

For several years before his death he had been compelled by ill-health to withdraw from his parish duties, but he remained as full of interest in all scientific matters as ever to the last.

Mr. Symonds died on the 15th September, at Cheltenham.

His loss, like that of his friend Sir W. V. Guise, will long be felt in the West of England, where the services and presence of both had exercised so beneficial an influence over a very wide and intelligent community for nearly half a century.—H.W.[1]

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August Friedrich Count Marschall, of Burgholzhausen and Tromsdorf, who has frequently contributed to the Geological Magazine, as well as to the Quart. Journ. Geological Society, notes on Geology and Palæontology, especially from the researches of his Colleagues in Vienna, died suddenly on the 11th of October, in his 83rd year. He was a Foreign Correspondent of the Geological Society of London, and Correspondent and Member of many other learned Societies,—also Hereditary Marschal in Thüringia, Imp. Roy. Chamberlain, and formerly Archivist of the Imp. Roy. Geological Institute of Vienna. His frequent communications on papers read at the Academy, Institute, and other Societies, forwarded by him to various European friends and periodicals, were continued with his usual industry (his motto being "Nunquam otiosus") to within a short time of his death. His "Nomenclator zoologicus," combining both recent and fossil genera, published by the Zoologico-Botanical Society of Vienna in 1873, is a very valuable book of reference; and the "Ornis Vindobonensis," 1882, is written in conjunction with Dr. A. von Pelzeln, also bears evidence to our deceased friend Count Marschall's scientific zeal and usefulness.—T. R. J.

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[1] We regret to record the death, on October 4th, at Tonga, of Mr. H. F. Symonds, only remaining son of the late Rev. W. S. Symonds. He was Consul at Samoa and Deputy Commissioner of the Western Pacific. He was only 32 years of age and a man of great promise.

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STEPHEN AUSTIN AND SONS, PRINTERS, HERTFORD.

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