THE

GEOLOGICAL MAGAZINE.

NEW SERIES.

DECADE IV. VOL. VII.

JANUARY—DECEMBER, 1900.

THE
GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology:

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

NOS. CCCCXXVII TO CCCCXXXVIII.

EDITED BY

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

OF THE BRITISH MUSEUM OF NATURAL HISTORY;
PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY,
VICE-PRESIDENT OF THE ZOOLOGICAL AND MALACOLOGICAL SOCIETIES;
MEMBER OF THE LYCEUM OF NATURAL HISTORY, NEW YORK; AND OF THE AMERICAN PHILOSOPHICAL SOCIETY, PHILADELPHIA; HONORARY MEMBER OF THE YORKSHIRE PHILOSOPHICAL SOCIETY; OF THE GEOLOGISTS' ASSOCIATION, LONDON; OF THE INSTITUTION OF MINING AND METALLURGY, LONDON; OF THE GEOLOGICAL SOCIETIES OF EDINBURGH, GLASGOW, HALIFAX, LIVERPOOL, AND SOUTH AFRICA; CORRESPONDING MEMBER OF THE GEOLOGICAL SOCIETY OF BELGIUM; OF THE IMPERIAL SOCIETY OF NATURAL HISTORY OF MOSCOW; OF THE NATURAL HISTORY SOCIETY OF MONTREAL; AND OF THE MALACOLOGICAL SOCIETY OF BELGIUM.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., F.C.S., &c.

WILFRID H. HUDLESTON, M.A., F.R.S., F.G.S., F.L.S., F.C.S.

GEORGE J. HINDE, Ph.D., F.R.S., F.G.S., &c.

AND

HORACE BOLINGBROKE WOODWARD, F.R.S., F.G.S., &c.

NEW SERIES. DECADE IV. VOL. VII.

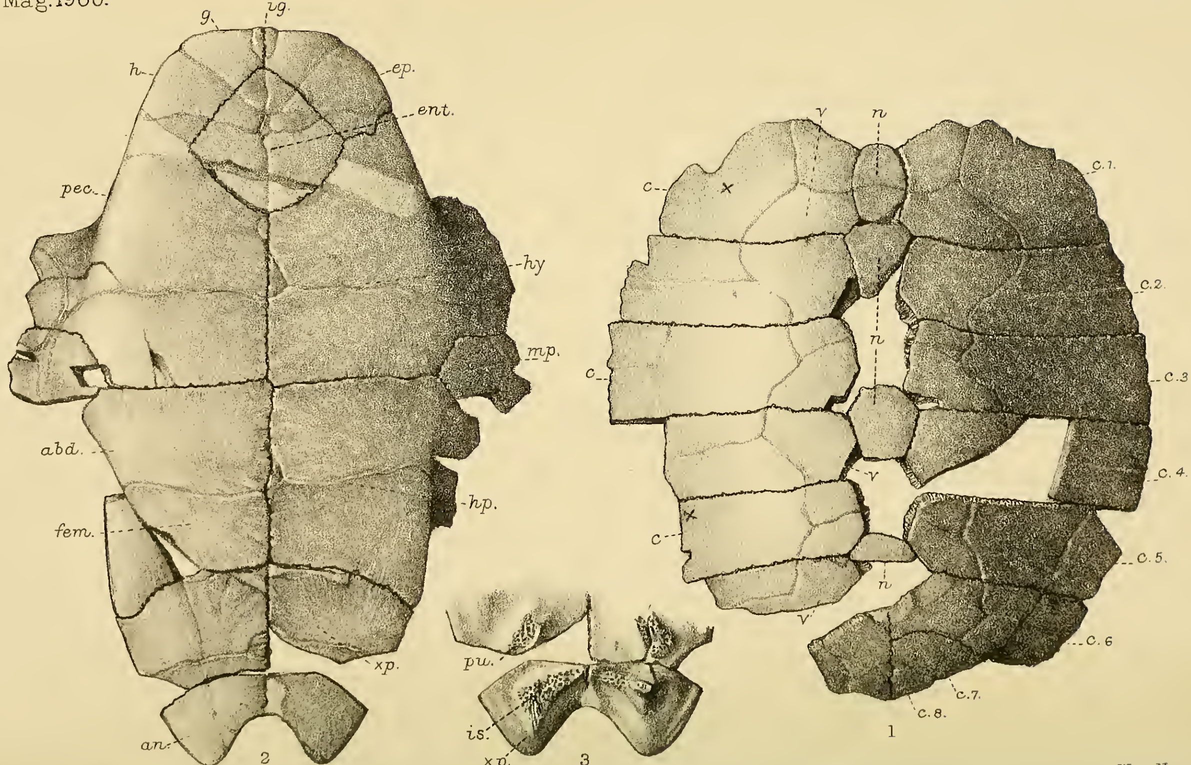
JANUARY—DECEMBER, 1900.

LONDON:
MESSRS. DULAU & CO., 37, SOHO SQUARE.
1900.

HERTFORD:
PRINTED BY STEPHEN AUSTIN AND SONS.

LIST OF PLATES.

LIST OF ILLUSTRATIONS IN THE TEXT.



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

Podocnemis ægyptiaca. *sp. nov.* Lower Miocene, Egypt.

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

No. I.—JANUARY, 1900.

ORIGINAL ARTICLES.

I.—On a New Species of Chelonian (*Podocnemis ægyptiaca*) from the Lower Miocene of Egypt.

By C. W. Andrews, B.Sc., F.G.S., of the British Museum (Natural History).

(PLATE I.)

THE occurrence of fossil reptiles in the Lower Miocene of Moghara in Egypt has already been referred to in a paper published in the last volume of this journal (1899, p. 481), where a short account of the deposits in which the remains are found has been given. The specimens which have been received from Captain H. G. Lyons, R.E., Director-General of the Egyptian Geological Survey, include bones and scutes of Crocodile, Trionyx, and of the Chelonian which forms the subject of the present notice. Of the two former the remains are too imperfect for determination, and further material is desirable; but in the case of the last it has been found possible to reconstruct the plastron and most of the carapace, and from these it can be shown that this Chelonian belonged to the Pleuradiran group, and is referable to the genus *Podocnemis*, forming a new species, to which the name *Podocnemis ægyptiaca* may be applied. At the present day the genus is found only in South America and Madagascar, but, as in many other cases in which the modern representatives of a group are confined to the Southern Hemisphere, where they may occur in widely separated areas, in the Tertiary period species existed in the Northern Hemisphere. In the present instance two species of *Podocnemis* have been recorded from the Lower Eocene of England and India—that from the former being *Podocnemis Bowerbanki* (=*Platemys Bowerbanki*; *Emys lævis*, Owen), from the London Clay of Sheppey; that from the latter, *Podocnemis indica*, from Nila in the Salt Range. The present species is interesting as showing that in early Miocene times the genus existed in Africa, whence probably it spread into Madagascar, now one of its headquarters.

Description of the Specimens.

The carapace of the type-specimen, as figured (Pl. I, Fig. 1), is very incomplete in its peripheral region, for, although some portions of the marginal bones are preserved, it has not been possible to fit them into their places. Of the remainder of the carapace the neurals 3 and 5 are wanting, 2 and 6 incomplete, all the costals are imperfect at their outer ends, and much of the posterior ones is broken away. The general form is somewhat depressed, and there is no trace of any keel. The neurals (*n*) were six in number, the first being the largest and the last relatively very small. There are eight pairs of costals (*c*, 1–8), of which the last two meet in median suture; possibly also the sixth pair were only partly separated by the last neural. The positions of the facets for union with the inguinal and axillary buttresses of the plastron are marked + in Fig. 1 of the Plate. The furrows marking the boundaries of the horny plates are very distinct; the vertebral shields are somewhat balloon-shaped, and in their anterior half are nearly twice as wide as they are posteriorly. The outlines of three complete vertebrals are preserved and portions of two others.

The general form of the plastron is shown in Fig. 2, Pl. I. The entoplastral (*ent.*) is lozenge-shaped, with slightly convex posterior borders. There is a pair of small mesoplastrals wedged in between the outer ends of the hyo- and hypoplastra. The xiphiplastra (*xp.*) bear on their upper surfaces rugose prominences (Fig. 3), indicating the firm sutural union of the ischia (*is.*) and pubes (*pu.*) with the plastron. The posterior border of the plastron is notched.

There is a very small intergular (*i.g.*), the posterior end of which does not extend so far back as the anterior angle of the entoplastron, and only separating the gulars (*g.*) for about a third of their length. The sutures between the humerals and pectorals cross the entoplastron in front of its middle point. In the proportions and arrangement of these anterior plastral shields this species approaches *P. madagascariensis* very closely. The abdominal, femoral, and anal shields do not present any peculiarity.

The total length of the plastron is 33·5 cm.; the length of the bridge, 13·3 cm.; width of plastron immediately in front of bridge, 15·5 cm.

The existence of a firm sutural union between the pelvis and plastron shows that this Chelonian belonged to the Pleuradiran group, and the presence of mesoplastra further indicates that it is referable to the family Pelomedusidæ. In this family the mesoplastra are small and laterally situated in two genera, *Pelomedusa* and *Podocnemis*, to the latter of which the fossil approaches most nearly, and, as already mentioned, is in some respects extremely similar to *Podocnemis madagascariensis*.

The remains of *P. ægyptiaca* seem to be very common at Moghara, and some of the specimens indicate that it attained a considerably greater size than the specimen now figured.

EXPLANATION OF PLATE I.

Carapace and Plastron of Podocnemis ægyptiaca (type-specimen).

Fig. 1.—Carapace (dorsal view). Fig. 2.—Plastron (ventral view).
Fig. 3.—Xiphiplastral region of plastron (upper surface).
(About one-third natural size.)

abd. Abdominal shields.
an. Anal shields.
c_{1-8}. Costal plates.
ent. Entoplastral plate.
ep. Epiplastral plate.
fem. Femoral shield.
g. Gular shield.
h. Humeral shield.
hp. Hypoplastral plate.
hy. Hyoplastral plate.
i.g. Intergular shield.
is. Surface for union with ischium.
mp. Mesoplastral plate.
n. Neural plate.
pec. Pectoral shield.
pu. Surface for union with pubis.
xp. Xiphiplastral plate.

II.—On a *Patellina*-limestone and another Foraminiferal Limestone from Egypt.

By F. Chapman, A.L.S., F.R.M.S.

(PLATE II.)

THE specimens dealt with in this paper were collected by the Officers of the Geological Survey of Egypt, and I have been requested by Dr. H. Woodward, on behalf of Captain H. G. Lyons, R.E., F.G.S., the Director-General, to give an account of the various species of Foraminifera met with during the progress of the Survey.

The *Patellina*-limestone.

These specimens bear the Survey label No. 11*c* (827). The rock occurs on a plateau between Cairo and Suez, the geological position of which Mr. Barron is inclined to consider as the base of the Miocene grits and marly clays (letter dated 29th July, 1899). The exact locality whence these samples came is situated six kilometres west of Camp 35, in lat. N. 30° 17′ 55″, long. E. 32° 18′ 14″.

The rock is of the greatest interest on account of the presence of a new species of *Patellina*, which constitutes a large proportion of the limestone. The relative abundance of the *Patellinæ* in the rock can be well seen in the photograph (Pl. II, Fig. 1) of a thin section taken haphazard from the rock-specimen. This genus appears to be hitherto quite unknown in the limestones of Egypt.

Besides *Patellinæ* there are other foraminifera associated with it in this rock, belonging to the genera *Biloculina*, *Miliolina*, *Orbiculina*, *Alveolina*, *Bigenerina*, *Discorbina*, *Truncatulina*, *Gypsina*, *Polytrema*, and *Nonionina*.

The limestone is ochreous-yellow to pale brown in colour. The matrix of the rock is somewhat spongy, cavities caused by chemical solution and recrystallization being seen here and there, whilst in section the foraminifera other than the *Patellinæ* frequently have a space between the wall of the test and the matrix by which it is partially filled. When the rock is crushed for the extraction of the smaller organisms the casts fall out, leaving the walls of the tests adhering to the matrix.

The microscopic structure of the enclosing rock-mass is distinctly crystalline, which condition is probably due to subsequent molecular disturbance of the calcareous mud in which the foraminifera were embedded, and which has resulted in the formation of a granular calcitic material, in which scalenohedra are an abundant crystalline form, especially on the borders of the cavities.

Besides foraminifera there are some obscure examples of polyzoa. An ostracod (*Bairdia*, described below) also occurs in some numbers, represented both in section and by a specimen isolated from the rock.

Scattered through the rock are some rounded grains of quartz averaging 1 mm. in diameter, and often containing strings of minute inclusions or gas cavities.

OSTRACODA.

Family BAIRDIIDÆ.

BAIRDIA, McCoy [1844].

BAIRDIA SUBDELTOIDEA (Münster).

Cythere subdeltoidea, Münster, 1830, Jahrb. Min., p. 64; 1835, p. 446.

Bairdia subdeltoidea (Münster), Jones & Sherborn, 1887, p. 387; idem, 1889, Mon. Tert. Entom., p. 16, pl. i, figs. 15*a*, *b*. Egger, 1895: Naturhist. Vereins Passau, Jahresb. 16, p. 42, pl. ii, figs. 20*a*, *b*.

The specimens found in the Egyptian limestone are of medium size, with the valves united. In the sections of the rock they occur with some frequency. The species has a rather wide range in time, since it is characteristic and common in all the Cretaceous deposits beginning at the Aptian, or Lower Greensand of England; and it also occurs in beds of Middle Eocene age at Bracklesham and in the older Pliocene of Northern Italy.

? Lower Miocene: from a plateau between Cairo and Suez. Frequent.

FORAMINIFERA.

Family MILIOLIDÆ.

Subfamily MILIOLINÆ.

BILOCULINA, d'Orbigny [1826].

BILOCULINA BULLOIDES, d'Orbigny.

"Conchula minima, etc.," Plancus, 1739: De Conch. min. nat., p. 23, pl. ii, fig. 6.

Biloculina bulloides, d'Orb., 1826: Ann. Sci. Nat., vol. vii, p. 297, No. 1, pl. xvi, figs. 1–4; Modèle, No. 90.

B. Peruviana, id., 1839: Foram. Amér. Mérid., p. 68, pl. ix, figs. 1–3.

B. ringens (Lam.), Parker, Jones, & Brady, 1865: Ann. Mag. Nat. Hist., ser. III, vol. xvi, p. 35.

B. lucernula (*pars*), Schwager, 1866: Novara-Exped., Geol. Theil., vol. ii, p. 202, pl. iv, figs. 17*a*, *b*.

B. bulloides, d'Orb., Terquem, 1882: Mém. Soc. géol. France, sér. III, vol. ii, p. 153, pl. xxiii, fig. 38.

Miliolina ringens (Lam.), Goës, 1882: K. Svenska Akad. Handl., vol. xix, p. 131, pl. x, figs. 363–365, 386?

Biloculina bulloides, d'Orb., Brady (=*B. lucernula*, Schwager, Schlumberger), 1884: Rep. "Challenger," vol. ix, p. 142, pl. ii, figs. 5, 6. Schlumberger, 1887: Bull. Soc. géol. France, sér. III, vol. xv, pp. 574–579, pl. xv, figs. 10–13 and woodcuts 1–5. Egger, 1895: Abhandl. k. bayer. Akad. Wiss., vol. xviii, Abth. 2, p. 217, pl. i, figs. 16–18. Rupert Jones, 1895: Mon. Foram. Crag, pt. ii, pp. 101 and 102.

B. bulloides is quite a common species in the *Patellina*-limestone. On crushing the rock the little subspherical tests are seen amongst the débris, and projecting from the surfaces of the larger fragments. They often have the shell-wall perfect, and are occasionally noticed as casts. The contour of the test in these Egyptian specimens is very typical, having a globose penultimate chamber and a slightly elongated aboral neck. Passage forms occur which link this species with its more pyriform variety next described.

Although *B. bulloides* ranges throughout the Tertiary fossiliferous strata to recent times, yet the fossil forms seem to be distinct in some of their characters, as shown by Schlumberger.

? Lower Miocene: from a plateau between Cairo and Suez. Common.

Biloculina bulloides, var. inornata, d'Orb.

Biloculina inornata, d'Orb., 1846: Foram. Foss. Vienne, p. 266, pl. xvi, figs. 7–9.

B. bulloides, d'Orb., var. *truncata-gracilis*, Reuss, 1867: Sitzungsb. Akad. Wiss. Wien, vol. lv, p. 69, pl. ii, fig. 2.

B. bulloides, var. *inornata*, d'Orb., Rupert Jones, 1895: Mon. Foram. Crag (Pal. Soc.), pt. ii, pp. 101–2, pl. vii, figs. 1*a*–*c*.

The slightly elongate variety of *B. bulloides* may be referred to *B. inornata* of the Vienna Tertiaries. It is not so common as the typical *B. bulloides* in this Egyptian limestone, but is represented, nevertheless, by several good examples.

Besides its original occurrence in the Miocene of the Vienna Basin, this variety has been found in many fossiliferous deposits of Pliocene age.

? Lower Miocene: between Cairo and Suez. Frequent.

MILIOLINA, Williamson [1858].

Miliolina oblonga (Montagu).

Vermiculum oblongum, Montagu, 1803: Test. Brit., p. 522, pl. xiv, fig. 9.

Miliolina seminulum (L.), var. *oblonga* (Montagu), Williamson, 1858: Recent Foram. Gt. Brit., p. 86, pl. vii, figs. 186, 187.

M. oblonga (Mont.), Brady, 1884: Rep. Chall., vol. ix, p. 160, pl. v, figs. 4*a*, *b*. De Amicis, 1893: Boll. Soc. Geol. Ital., vol. xii, fasc. 3, pp. 27, 178, 179, 317. Goës, 1894: K. Svensk. Akad. Handl., vol. xxv, No. 9, p. 110, pl. xx, figs. 850, 850*f*. Rupert Jones, 1895: Mon. Foram. Crag, pt. ii, p. 120, pl. iii, figs. 31, 32; pl. v, fig. 5. Millett, 1898: Journ. Roy. Micr. Soc., p. 267, pl. v, figs. 14*a*, *b*.

Examples of this somewhat variable species were found with both the triloculine and the quinqueloculine forms. The triloculine variation is more typical. The quinqueloculine form seems to be somewhat closely allied with *Miliolina alveoliniformis*, Brady, and also with Schlumberger's subgeneric type of *Pentellina*.

Miliolina oblonga dates back as far as the Eocene period, and it is found living at the present day, usually in shallow water.

? Lower Miocene: from a plateau between Cairo and Suez. Rare.

MILIOLINA SUBROTUNDA (Montagu).

Vermiculum subrotundum, Montagu, 1803: Test. Brit., pt. ii, p. 521.
Quinqueloculina subrotunda (Mont.), d'Orb., 1826: Ann. Sci. Nat., vol. vii, p. 302, No. 36.
Miliola (*Quinqueloculina*) *subrotunda* (Mont.), Parker & Jones, 1865: Phil. Trans., vol. clv, p. 411, pl. xv, fig. 38.
Miliolina subrotunda (Mont.), Brady, 1884: Rep. Chall., vol. ix, p. 168, pl. v, figs. 10, 11.
M. subrotunda (Walker & Boys), Goës, 1894: Kongl. Svenska Vet.-Akad. Handl., vol. xxv, p. 109, pl. xix, figs. 846, 847.
M. subrotunda (Mont.), Rupert Jones, 1895: Mon. Foram. Crag, pt. ii, p. 120, woodcut, fig. 9. Millett, 1898: Journ. Roy. Micr. Soc., p. 502.

The specimens from the Egyptian limestones are very typical.

As a fossil this species dates from Miocene times. It is an essentially shallow-water form at the present day, and this is the case with the other Miliolines recorded from the Egyptian Miocene limestone.

? Lower Miocene: from a plateau between Cairo and Suez. Frequent.

MILIOLINA TRIGONULA (Lamarck).

Miliolites trigonula, Lamarck, 1804: Ann. du Muséum, vol. v, p. 351, No. 3. 1822: Anim. sans Vert., vol. vii, p. 612, No. 3.
Triloculina Austriaca, d'Orb., 1846: Foram. Foss. Vienne, p. 275, pl. xvi, figs. 25–27.
Miliolina trigonula (Lamarck), Williamson, 1858: Recent Foram. Gt. Brit., p. 83, pl. vii, figs. 180–182. Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 86, pl. xxiv (i), figs. 6*a*–*d*. Brady, 1884: Rep. Chall., vol. ix, p. 164, pl. iii, figs. 14–16. Sherborn & Chapman, 1889: Journ. Roy. Micr. Soc., p. 484, pl. xi, fig. 1. Terrigi, 1891: Mem. Roy. Com. Geol. Ital., vol. iv, pt. i, p. 66, pl. i, fig. 4. Goës, 1894: Kongl. Svenska Vet.-Akad. Handl., vol. xxv, p. 115, pl. xxii, fig. 870. Millett, 1898: Journ. Roy. Micr. Soc., p. 503.

There is some variability in the dimensions of the Egyptian specimens, but they are otherwise characteristic. Schwager has recorded this species from the cherty *Alveolina*-limestone, between Siut and Farâfrah; in the *Miliolina*-limestone of the Arabian Desert at Wady Natfe; also similar forms near Minieh and Mokattam.

M. trigonula dates from the Eocene period, and is also found fossil in Miocene strata and onwards to the present day.

? Lower Miocene: from a plateau between Cairo and Suez. Frequent.

Miliolina inflata (d'Orbigny).

Triloculina inflata, d'Orb., 1826: Ann. Sci. Nat., vol. vii, p. 300, No. 10. Römer, 1838: Neues Jahrbuch, p. 393, pl. iii, fig. 72. Michelotti, 1841: Mem. Soc. Ital. Sci., vol. xxii, p. 299, pl. iii, fig. 11. D'Orb., 1846: Foram. Foss. Vienne, p. 278, pl. xvii, figs. 13–15.

Quinqueloculina inflata (d'Orb.), Parker, Jones, & Brady, 1871: Ann. Mag. Nat. Hist., ser. iv, vol. viii, p. 249, pl. viii, fig. 16.

Triloculina inflata, d'Orb., Terquem, 1878: Mém. Soc. géol. France, sér. iii, vol. i, p. 56, pl. v (x), figs. 16*a*–18*b*. Idem, 1882: ibid., vol. ii, p. 165, pl. xvii [xxv], figs. 4–6.

Miliolina lucens, Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 87, pl. xxiv, figs. 7*a*–*d*.

The inflated varieties of the type *M. seminulum* may be referred to the above specific name. *M. inflata* is a common Tertiary form, and is most typical in the Eocene and Miocene formations. Schwager records his *M. lucens* from the cherty *Alveolina*-limestone and marl between Siut and Farâfrah; on the Nekeb-el-Farudj; in the upper beds of El Guss-Abu-Said, and in the *Alveolina*-limestone of Wady Natfe in the Arabian Desert.

? Lower Miocene: from a plateau between Cairo and Suez. Frequent.

Miliolina seminulum (Linné).

Serpula seminulum, Linné, 1767: Syst. Nat., 12th ed., p. 1,264, No. 791; 1788, 13th (Gmelin's) ed., p. 3,739, No. 2.

Vermiculum intortum, Montagu, 1803: Tert. Brit., p. 502.

Quinqueloculina seminulum (L.), d'Orb., 1826: Ann. Sci. Nat., vol. vii, p. 303, No. 44.

Miliolina seminulum, Williamson, 1858: Recent Foram. Gt. Brit., p. 85, pl. vii, figs. 183–185.

Quinqueloculina seminulum, Jones, Parker, & Brady, 1866: Foram. Crag, p. 9, pl. iii, figs. 35, 36.

Miliolina seminulum, Greene, 1871: Manual Protozoa, p. 15, fig. 3*g*.

Quinqueloculina semilunum [*seminulum*] (L.), Terquem, 1875: Anim. plage Dunkerque, fasc. 1, p. 40, pl. vi, fig. 8.

Miliolina seminulum (L.), Brady, 1884: Rep. Chall., vol. ix, pp. 157–160 (woodcuts, figs. 3*a*–*c*); pl. v, fig. 6. Sherborn & Chapman, 1886: Journ. Roy. Micr. Soc., ser. ii, vol. vi, p. 742, pl. xiv, fig. 1. Rupert Jones, 1895: Mon. Foram. Crag, pt. ii, p. 116. Millett, 1898: Journ. Roy. Micr. Soc., p. 505.

M. seminulum is a common species in the *Patellina*-limestone from Egypt, and the specimens are well developed.

As a fossil this foraminifer dates from the Lower Eocene period, and it is also a well-known shallow-water species at the present day.

? Lower Miocene: from a plateau between Cairo and Suez. Common.

Miliolina polygona (d'Orbigny).

Quinqueloculina polygona, d'Orb., 1839: De la Sagra, Hist. Phisiq., etc., Cuba, "Foraminifères," p. 198, pl. xii, figs. 21–23.
Miliolina seminulum (L.), Goës, 1882, "Ret. Rhiz. Caribb. Sea": Svenska Vet.-Akad. Handl., vol. xix, No. ix, figs. 353, 354.
Miliolina Gussensis, Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil., p. 85, pl. xxiv (i), figs. 5*a–d*.
M. polygona (d'Orb.), Goës, 1894: Svenska Vet.-Akad. Handl., vol. xxv, No. 9, p. 111, pl. xxx, figs. 854–854*g*; idem, 1896, Bull. Mus. Comp. Zool. Harvard, vol. xxix, No. 1, pt. xx, p. 83, pl. viii, figs. 11–18.

This species in the Egyptian limestone varies much as to size, but the specimens are constant in the characters of the test.

The specimens named *M. Gussensis* by Schwager were found in the argillaceous beds with *Operculina libyca* of El Guss-Abu-Said (Libyan Stage).

In recent soundings this form affects warm areas, usually in the neighbourhood of coral reefs. Goës found this species in the West Indies at a depth from 300 to 400 fathoms.

? Lower Miocene: from a plateau between Cairo and Suez. Frequent.

Subfamily Peneroplidinæ.

ORBICULINA, Lamarck [1816].

Orbiculina adunca (Fichtel & Moll).

Nautilus orbiculus, Fichtel & Moll, 1803: Test. Micr., p. 112, pl. xxi.
N. angulatus, idem: ibid., p. 113, pl. xxii.
N. aduncus, idem: ibid., p. 115, pl. xxiii.
Orbiculina adunca (Fichtel & Moll), Lamarck, 1816: Tabl. Encycl. et Méth., pl. cccclxviii, figs. 2*a–c*. D'Orbigny, 1839: Foram. Cuba (in Sagra's "Hist. phisiq. Cuba"), p. 81, pl. viii, figs. 8–14. Brady, 1884: Rep. Chall., vol. ix, p. 209, pl. xiv, figs. 1–13. Agassiz, 1888: Three Cruises "Blake," ii, p. 160, figs. 486, 487.

Both casts and perfect specimens of *Orbiculina* occur in the *Patellina*-limestone.

O. adunca is known from Eocene and Miocene rocks, and at the present time it is confined to fairly shallow water of warm areas.

? Lower Miocene: from a plateau between Cairo and Suez. Common.

Subfamily Alveolininæ.

ALVEOLINA, d'Orbigny [1826].

Alveolina ellipsoidalis, Schwager.

Alveolina ellipsoidalis, Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 96, pl. xxv (ii), figs. 1*a–i* and 2*a–c*.

Examples of the above species are quite common in the *Patellina*-limestone, and one perfect enough for identification was isolated by crushing the rock. It is probable, but not quite certain in the absence of sections, that the *Alveolina Hauerii* of d'Orbigny[1] from the Miocene of Nussdorf is of the same type. Schwager's specimens came from the *Alveolina*-limestone of the Wady Natfe in the Arabian Desert (Libyan Stage).

? Lower Miocene: from a plateau between Cairo and Suez. Common.

Alveolina lepidula, Schwager. (Pl. II, Fig. 1.)

Alveolina lepidula, Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 98, pl. xxv (ii), figs. *3a–g*.

This species, viewed towards the septal face, gives an ovate, pointed outline. It was suggested by Schwager that it may represent an immature stage of the foregoing species. It was found by that author associated with *A. ellipsoidalis* from the Wady Natfe, Arabian Desert.

? Lower Miocene: from a plateau between Cairo and Suez. Very common.

Family TEXTULARIIDÆ.

Subfamily Textulariinæ.

BIGENERINA, d'Orbigny [1826].

Bigenerina capreolus (d'Orbigny).

Vulvulina capreolus, d'Orb., 1826: Ann. Sci. Nat., vol. vii, p. 264, No. 1, pl. xi, figs. 5, 6; Modèle, No. 59.

Schizophora Neugeboreni (?), Reuss, 1861: Sitzungsb. böhm. Gesellsch. Wiss., vol. ii, p. 13.

Grammostomum capreolus (d'Orb.), Parker & Jones, 1863: Ann. Mag. Nat. Hist., ser. III, vol. xi, p. 93.

Textilaria flabelliformis (young stage), Gümbel, 1868: Abhandl. bayer. Akad. Wiss., Cl. ii, vol. x, p. 647, pl. ii, figs. 83*a, b*.

Venilina Hæringensis, Gümbel, 1868: ibid., p. 649, pl. ii, fig. 84 (*bis*), *a*, *b*.

Schizophora Hæringensis, Hantken, 1872: Mittheil. Jahrb. ungar. geol. Anstalt., vol. i, p. 136, pl. ii, figs. 17*a*, *b*.

Bigenerina capreolus (d'Orb.), Brady, 1884: Report Chall., vol. ix, p. 372, pl. xlv, figs. 1–4.

A good vertical section of the above species occurs in one of the slides. It is recognized by the pointed aboral end and the fine arenaceous structure of its test.

As a fossil *B. capreolus* makes its first appearance in the Eocene of the Bavarian Alps; it was also found in the *Clavulina-Szaboi* beds of Hungary; and it is known from the newer Tertiaries of Italy (Mio-Pliocene). The depths at which this species occurs in recent deposits ranges from fairly shallow water to about 700 fathoms. At the present day it is generally found in the North Atlantic Ocean.

? Lower Miocene: from a plateau between Cairo and Suez. One specimen.

[1] Foram. Foss. Vienne, 1846, p. 148, pl. vii, figs. 17, 18.

Family ROTALIIDÆ.

Subfamily Rotaliinæ.

PATELLINA, Williamson [1858].

Generic Synonymy.[1]

Orbitolites, pars, Lamarck [1801], Defrance.
Madreporites, Blumenbach [1805].
Orbulites, Lamarck [1816].
Cyclolina, pars, d'Orbigny [1846], Carter.
Orbitolina, d'Orbigny [1847], Bronn, d'Archiac, Gras, Parker & Jones, Carter, Martin.
Orbitulites, Bronn [1848].
Patellina, Williamson [1858], Carpenter, Parker & Jones, Brady, Alcock, Parfitt, G. M. Dawson, Miller & Van den Broeck, Robertson, Schulze, Terquem, Siddall, Berthelin, Shone, Wright, Fritsch, Hantken, Zittel, Howchin, Chapman.
Conulites, Carter [1861].

The above synonymy is given in order that the claim of *Patellina* as the name of the genus may be readily seen. The subject of the nomenclature has already been discussed by Carpenter, Parker, & Jones,[2] and, later, by Professor Rupert Jones.[3]

It will perhaps be useful to point out briefly the shortcomings of the various names earlier than *Patellina*.

Orbitolites is now retained for one of the two types originally confused under the same name.

Madreporites does not stand according to the Strickland Rule No. 11, since it implies a false relationship; moreover, the name was previously used by Deluc (1802) in connection with *Orbitolites*.

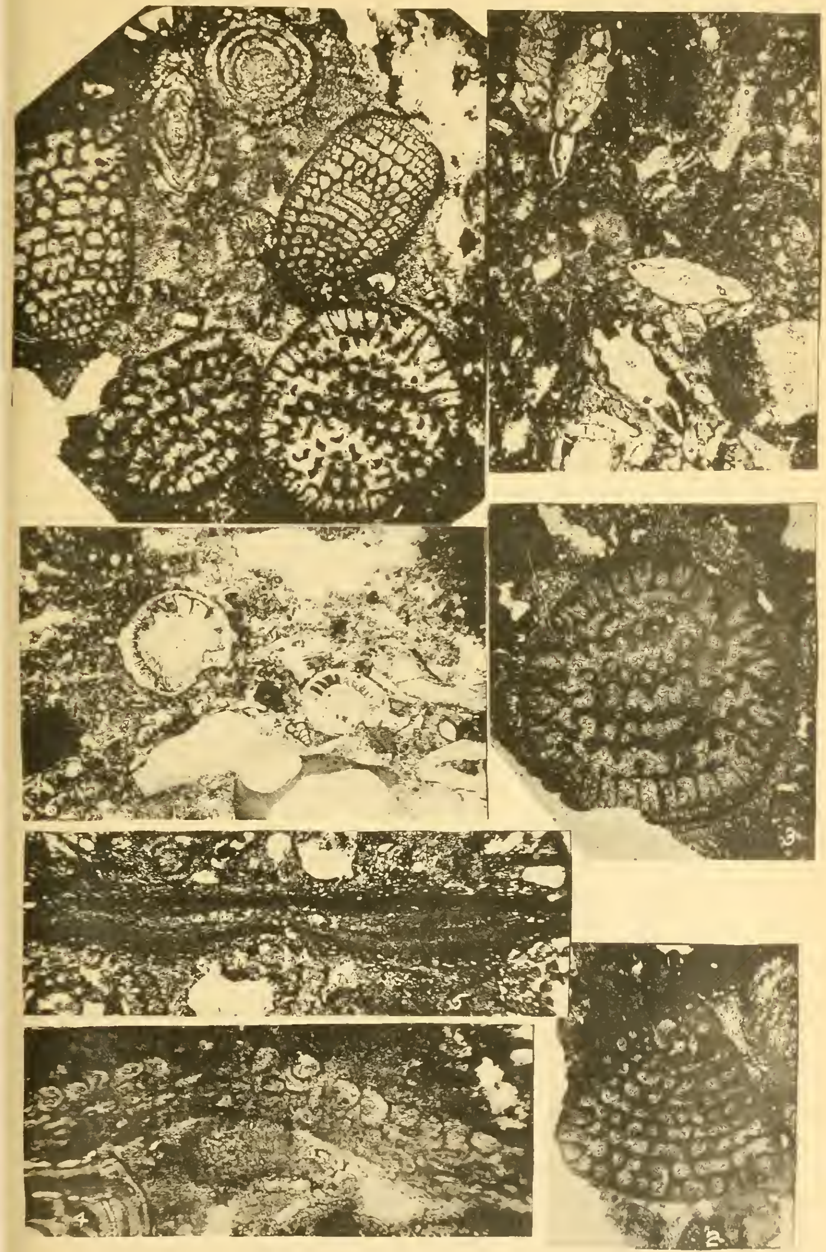
Orbulites, an improved form of *Orbitolites*, was used by Lamarck when describing specimens belonging to that and the present genus.

Cyclolina used to denote a depressed, complanate form, probably of the present genus, but by no means typical.

Orbitolina appears to have been originally used in the sense of a recent form of *Orbitolites*, which was at the time thought to be a fossil genus, the terminations *ina* and *ites* being used by Lamarck and others for recent and fossil specimens respectively. This generic term has been largely used on the Continent to designate the *Patellinæ* with large tests and thick shell-walls, and which are so common in various Cretaceous beds in France, Spain, and Switzerland. Should these particular forms be proved to possess hyaline or tubulated shell-structure, there is no ground for retaining the name even as an isomorphic arenaceous group with *Patellina*.

Orbitulites is evidently a misspelling.

[1] For references see Sherborn's Index to Genera and Species of the Foraminifera, 1896.
[2] Introd. Foram., 1862, p. 229. Also Ann. Mag. Nat. Hist., ser. III, vol. xii (1863), p. 212.
[3] Cat. Foss. Foram. Brit. Mus., 1882, p. 84.



:., PHOTO. MORGAN & KIDD, COLLOTYPE.

TERTIARY FORAMINIFERA FROM EGYPT.

Patellina was well described by Williamson, who took the typical little *P. corrugata* for the purpose. This form is quite hyaline throughout. In most cases the large fossil forms above referred to show very little evidence of hyaline structure, but it is extremely probable that this absence of tubulation is due to recrystallization of the calcitic substance of the shell-wall. In the Egyptian *Patellina*, however, by careful examination under high powers, a distinct but extremely fine tubulation can be made out in portions of the shell-wall better preserved, the tubules sometimes radiating in a characteristic manner.

Conulites was founded on specimens of *Patellina* from India, but described at later date than Williamson's type-form. This form approximates very closely to the Egyptian species in general structure.

The whole group of the *Patellinæ* require a systematic and exhaustive study, and this I believe is being undertaken by Mr. A. Vaughan Jennings, who possesses a valuable collection of material for the purpose. I will here express my sincere thanks to Mr. Jennings for much assistance in making comparison with specimens of *Patellina* from his collection.

Patellina Egyptiensis, sp. nov. (Pl. II, Figs. 1–3.)

Test conoidal, in vertical section nearly equilateral, the two sides slightly convex, straight, or incurved in the middle of the test; base circular in outline, and with a slightly convex surface; peripheral edge rounded. The chambers are arranged on two plans, consisting (1) of an internal cone of chamberlets arranged at the apex in a spiral, and afterwards annular, or discoidal, each disc being subdivided into chamberlets by labyrinthic or irregular septa, the chamberlets alternate with those above and below; (2) of a cortical or external layer of rectangular chambers, partially subdivided by imperfect septa attached to the outer wall of the chamber and projecting inwards. The spire at the apex or aboral end of the test is large and simple, consisting of about one and a half turns, and in some cases the primordial sphere is well shown. The primordial chamber is most frequently megalospheric, measuring about $\frac{1}{60}$ inch (·416 mm.) in diameter; one sphere of the microspheric type measures $\frac{1}{96}$ inch (·26 mm.) in diameter.

In vertical section the cone is seen to be divided laterally by curved floors parallel with the convex surface of the base. These are subdivided somewhat irregularly by vertical septa in the central area. Average height of test, $\frac{1}{5}$ inch (5 mm.); average diameter at the base, $\frac{1}{6}$ inch (4·16 mm.).

Affinities.—The present species differs considerably in point of structure from the large Cretaceous *Patellinæ*, the chief distinction of the latter forms being the more or less hemispherical or spherical shape of the chambers constituting the cortical layer. In the Tertiary specimens the cortical chambers are decidedly rectangular.

I have lately taken the opportunity of examining the specimens of '*Conulites*' *Cooki*,[1] both in the collection at the British Museum (Natural History)[2] and in the Carter Collection at the Geological Society, in order to make a comparison of the Indian with the Egyptian species. In the collection at the Geological Society's Museum the best specimens of *Patellina Cooki* are mounted on slide No. 40 of the Carter Collection, and are numbered 2 (from Kelat), 3 (from Sind), and 4 (from Arabia). The sections of *P. Cooki* show the cortical layer to consist of rectangular chambers, but these, unlike the Egyptian specimens, are without the secondary imperfect septa or dissepiments seen in the latter.

Some West Indian specimens of Miocene age kindly lent me by Mr. Jennings show this secondary septation of the cortical layer, but the chambers in these are more crowded and narrower than in *P. Egyptiensis*, and the species is probably new.

It is interesting to note that *Patellina Cooki* is associated with the following foraminifera in the Indian limestone as given by Carter in the paper above mentioned, namely: *Alveolina elliptica*, *Nummulites obesa*, *N. perforata*, *N. Carteri*, *Assilina exponens*, *A. spira*, and *Orbitoides dispansa*. The limestone in which these foraminifera occur appear to belong to the Kirthar Group (Eocene).[3] In these Eocene beds the shell-structure exhibits the simplest plan. In the Egyptian beds, probably Lower Miocene, we have the intermediate stage in the development of the cortical layer. Finally, in the West Indian Miocene, presumably newer in age, the transition of the outer chambers is carried out still further.

Thus there appears to be a progression of this form in a westerly direction.

? Lower Miocene: from a plateau between Cairo and Suez. Very abundant, forming about 50 per cent. of the bulk of the rock.

DISCORBINA, Parker & Jones [1862].

Discorbina, sp., near D. globularis (d'Orbigny).

Rosalina globularis, d'Orb., 1826: Ann. Sci. Nat., vol. vii, p. 271, pl. xiii, figs. 1–4; Modèle, No. 69.

Discorbina globularis (d'Orb.), Parker, Jones, & Brady, 1865: Ann. Mag. Nat. Hist., ser. III, vol. xvi, p. 30, pl. ii, fig. 69.

Our specimen occurs in a section of the rock, but there is little doubt, from the thick peripheral wall and globular segments, that it is referable to the above species. It is a well-known fossil in Middle Eocene, Miocene, and Pliocene beds.

? Lower Miocene: from a plateau between Cairo and Suez. One specimen.

[1] See Carter, 1861, Journ. Bombay Br. Roy. As. Soc., vol. vi, p. 83. Also Ann. Mag. Nat. Hist., ser. III, vol. viii, p. 457, pl. xv, fig. 7.

[2] To Mr. R. B. Newton and Mr. W. R. Jones I am indebted for their kind attention when examining these specimens at the British Museum and the Geological Society.

[3] See Manual of Geology of India, 1893, Medlicott & Blanford, 2nd ed., revised by R. D. Oldham, pp. 305–7.

TRUNCATULINA, d'Orbigny [1826].

Truncatulina Ungeriana (d'Orbigny).

Rotalina Ungeriana, d'Orb., 1846: Foram. Foss. Vienne, p. 157, pl. viii, figs. 16–18.

Truncatulina Ungeriana (d'Orb.), Reuss, 1866: Denk. Akad. Wiss. Wien, vol. xxv, p. 161, No. 10. Brady, 1884: Rep. Chall., p. 664, pl. xciv, figs. 9*a–c*.

The example found is very typical, and has the form of the test well preserved; it was obtained by powdering the rock. The above species makes its appearance in beds of Cretaceous age, and it occurs commonly throughout the Tertiary formations.

? Lower Miocene: from a plateau between Cairo and Suez. One specimen.

Subfamily Tinoporinæ.

GYPSINA, Carter [1877].

Gypsina crassitesta, sp. nov. (Pl. II, Fig. 4.)

Test hyaline and adherent; coarsely perforate; consisting of series of dome-shaped segments overlying one another alternately and in about five or more successive layers. The first series of chambers more spherical than the later ones. The test is adherent to thin shell fragments or consolidated pieces of sand. Average diameter of the chambers, $\frac{1}{96}$ inch (·26 mm.). The largest specimen found measures $\frac{9}{25}$ inch (9 mm.) in length; height, $\frac{1}{33}$ inch (·75 mm.).

The recent *Gypsina inhærens* (Schultze)[1] has a similar habit of growth to this species, but it is usually much thinner in its shell-wall. The present species has coarse tubuli, such as is often present in *Gypsina*. The nature of the thick walls also reminds one of a similar character seen in *Carpenteria*. *Gypsina vesicularis*, var. *discus*, Goës,[2] may also be compared with the above species with regard to the depressed form of the test, especially in one of our specimens, where the peripheral edge is neatly rounded off.

? Lower Miocene: from a plateau between Cairo and Suez. Frequent.

POLYTREMA, Risso [1826].

Polytrema papyracea, sp. nov. (Pl. II, Fig. 5.)

Test adherent, consisting of layers of somewhat acervuline but much elongated chambers, extending along the plane of attachment. The test often attains the length of $\frac{1}{4}$ inch (6·25 mm.); greatest thickness, $\frac{1}{36}$ inch (·694 mm.).

A passage form between this species and the well-known recent *Polytrema miniaceum* (L.) has been found in certain Tertiary and recent limestones, and will shortly be described. The present species is distinguished by its limited extent and compressed lenticular shape.

[1] *Acervulina inhærens*, Schultze, 1854: "Organismus Polythal.," p. 68, pl. vi, fig. 12.

[2] Bull. Mus. Comp. Zool. Harvard, 1896, vol. xxix, No. 1 (xx), p. 74, pl. vii, figs. 4–6.

? Lower Miocene: from a plateau between Cairo and Suez. Frequent.

Family NUMMULINIDÆ.

Subfamily Polystomellinæ.

NONIONINA, d'Orbigny [1826].

Nonionina Boueana, d'Orbigny.

Nonionina Boueana, d'Orbigny, 1846: Foram. Foss. Vienne, p. 108, pl. v, figs. 11, 12.

This species is represented both by casts and sections in the Egyptian limestone. In the casts the retral processes of the segments are faithfully reproduced, and the umbilical protuberance is well shown. The general form of the test is subcircular, compressed, with a rather sharp keel, and numerous narrow chambers.

Fossil specimens of this shallow-water form have been recorded from the Oligocene of Germany and the Miocene of the Vienna Basin and Southern Italy; and I have lately identified a variety of this species in the Miocene of California.

? Lower Miocene: from a plateau between Cairo and Suez. Common.

With regard to the age of the foregoing species of foraminifera in the *Patellina*-limestone, should the exact stratigraphical horizon of the rock as Lower Miocene be confirmed, it is of much interest to note the general aspect of the fauna, which strongly tends to confirm this idea, although there are one or two exceptions, such as the presence of *Alveolinæ* found by Schwager much lower in the series (Libyan Stage) in Egypt. Since no Nummulites have been observed in our rock-specimens we cannot but regard the occurrence of the *Alveolinæ* as indicating an upward range of considerable extent.

Limestone with *Operculina*, etc.

These specimens are labelled Box D, 5, 6, and 7 (1,257), near Erment, right bank of Nile Valley. Captain Lyons considers these beds to be of Pliocene age. The colour of the limestone is of a pale cream to a whitish tint. The foraminifera are not numerous in this rock, but *Operculina* may be detected on the fractured surfaces. In section the rock is a fine granular or crystalline limestone, with some included fragments of a denser and somewhat amorphous-looking limestone scattered through it, especially in specimen D 6. There are also traces of lamellibranch shells and echinoderm spines. The organisms in this rock are deposited very uniformly, their length coinciding with the plane of bedding, so that the sections taken at right angles to one another show the shells cut in two directions, longitudinal and transverse, in the separate slides. The foraminifera are fairly numerous, but rather small, and comprise the genera *Textularia, Globigerina, Gypsina, Amphistegina*, and *Operculina*.

FORAMINIFERA.

Family TEXTULARIIDÆ.

Subfamily Textulariinæ.

TEXTULARIA, Defrance [1824].

Textularia sagittula, Defrance.

Textularia sagittula, Defrance, 1824: Dict. Sci. Nat., vol. xxxii, p. 177; vol. liii, p. 344; Atlas Conch., pl. xiii, fig. 5. Brady, 1844: Rep. Chall., vol. ix, p. 361, pl. xlii, figs. 17, 18.

Several sections of this species occur in the limestone. It is easily recognized by its elongated contour and numerous chambers. *T. sagittula* has a wide range in time, being known as far back as the Aptian.

Pliocene: near Erment, right bank of Nile Valley. Frequent.

Textularia agglutinans, d'Orbigny. (Pl. II, Fig. 6.)

Textularia agglutinans, d'Orb., 1839: Foram. Cuba, p. 136, pl. i, figs. 17, 18, 32–34. Brady, 1884: Rep. Chall., vol. ix, p. 363, pl. xliii, figs. 1–3.

The specimen found in the limestone from Egypt is typical in form, but rather small. In the fossil condition this species occurs as far back as the Carboniferous Limestone formation.

Pliocene: near Erment, right bank of Nile Valley. One specimen.

Family GLOBIGERINIDÆ.

GLOBIGERINA, d'Orbigny [1826].

Globigerina conglobata, Brady.

Globigerina conglobata, Brady, 1879: Quart. Journ. Micr. Sci., vol. xix, n.s., p. 72; idem, 1884, Rep. Chall., vol. ix, p. 603, pl. lxxx, figs. 1–5; pl. lxxxii, fig. 5.

The examples of the above species found in the *Operculina*-limestone are fairly typical, but are somewhat rounder in outline than recent specimens. *G. conglobata* appears to make its first appearance in beds of Miocene age.

Pliocene: near Erment, right bank of Nile Valley. Frequent.

Family ROTALIIDÆ.

Subfamily Tinoporinæ.

GYPSINA, Carter [1877].

Gypsina vesicularis? (Parker & Jones).

Orbitolina vesicularis, Parker & Jones, 1860: Ann. Mag. Nat. Hist., ser. iii, vol. vi, p. 31, No. 5.

Gypsina vesicularis (Parker & Jones), Carter, 1877: Ann. Mag. Nat. Hist., ser. iv, vol. xx, p. 173.

There is a fragment of a *Gypsina* occurring in one of our slides, which seems to come nearest to the structure seen in *G. vesicularis*; on the other hand, there is just the possibility that it is an irregular example of the more regularly-built *G. globulus* (Reuss). Both species date from the Miocene.

Pliocene: near Erment, right bank of Nile Valley. A fragment.

Family NUMMULINIDÆ.

Subfamily Nummulitinæ.

AMPHISTEGINA, d'Orbigny [1826].

Amphistegina Lessonii, d'Orbigny.

Amphistegina Lessonii, d'Orb., 1826: Ann. Sci. Nat., vol. vii, p. 304, No. 3, pl. xvii, figs. 1–4; Modèle, No. 98.

A. mamillata, d'Orb., 1846: Foram. Foss. Vienne, p. 208, pl. xii, figs. 6–8.

A. rugosa, id.: ibid., p. 209, pl. xii, figs. 9–11.

A. gibbosa, Williamson, 1851: Trans. Micr. Soc. Lond., ser. I, vol. iii, p. 110, pl. xvii, figs. 1, 2.

A. Lessoni, d'Orbigny: Parker, Jones, & Brady, 1865, Ann. Mag. Nat. Hist., ser. III, vol. xvi, p. 34, pl. iii, fig. 92.

A. semicostata, Kaufmann, 1867: Geol. Beschreib. des Pilatus, p. 149, pl. viii, fig. 18.

Hemistegina rotula, id.: ibid., p. 150, pl. viii, fig. 19.

A. Lessonii, d'Orb., Moebius, 1880: Foram. Mauritius, p. 99, pl. x, figs. 10–14; pl. xi, figs. 1–3.

A. Parisiensis, Terquem, 1882: Mém. Soc. géol. France, sér. III, vol. ii, Mém. iii, p. 124, pl. xiii, figs. 3*a*, *b*.

A. Lessonii, d'Orbigny, Brady, 1884: Rep. Chall., vol. ix, p. 740, pl. cxi, figs. 1–7.

The above synonymy refers especially to the thick varieties of *A. Lessonii*, since the examples met with in the *Operculina*-limestone belong to that group. The specimens are well-grown, and exhibit in all cases a well-developed cone of non-tubulous shell material.

Typical specimens of *A. Lessonii* date from the Eocene period, and they abound in some rocks of Miocene and Pliocene ages.

Pliocene: near Erment, right bank of Nile Valley. Frequent.

OPERCULINA, d'Orbigny [1826].

Operculina ammonoides (Gronovius). (Pl. II, Figs. 6, 7.)

Nautilus ammonoides, Gronovius, 1781: Zooph. Gron., p. 282, No. 1,220, and p. v (expl. Tab.).

N. Balthicus, Schroeter, 1782, Naturforscher, vol. xvii, p. 120; 1783, Einleitung, vol. i, p. 20, pl. i, fig. 2.

Operculina complanata (Defrance), Parker & Jones, 1857: Ann. Mag. Nat. Hist., ser. II, vol. xix, p. 285, pl. xi, figs. 3, 4.

O. ammonoides (Gronovius), Parker & Jones, 1861: Ann. Mag. Nat. Hist., ser. III, vol. viii, pp. 229, 230.

Brady, 1884: Rep. Chall., vol. ix, p. 745, pl. cxii, figs. 1, 2.

A. Silvestri, 1893: Mem. Pontif. Accad. N. Lincei, vol. ix, p. 217, pl. vi, fig. 5.

Rupert Jones, 1897: Mon. Foram. Crag, pt. iv, p. 364, pl. vii, figs. 34*a*, *b*. Also, var. *curvicamerata*, Jones, ibid., p. 365, pl. v, fig. 33.

The Egyptian specimens are neat and typically shaped. The septation, however, is rather more crowded and narrower than usual. In vertical section the test appears to be somewhat strongly limbate. In the limestones from near Erment this species is very common, but does not constitute a large proportion of the rock.

It is interesting to note that the previous geological occurrences of *O. ammonoides* agree with the age of these present rocks, since it has been met with in beds not older than the Pliocene of Calabria; it was also found in the English Coralline Crag, and it has been noted from the Pleistocene of Norway. As a recent organism it occurs in fairly shallow water, and has a wide geographical range, including the Mediterranean and the Gulf of Suez.

Pliocene: near Erment, right bank of Nile Valley. Very common.

EXPLANATION OF PLATE II.

Fig. 1.—Limestone with *Patellina Egyptiensis*, sp. nov., and *Alveolina lepidula*, Schwager. ? Lower Miocene: between Cairo and Suez. × 12.

Fig. 2.—Vertical sections of *Patellina Egyptiensis*, showing the primordial spire. ? Lower Miocene: between Cairo and Suez. × 16.

Fig. 3.—Basal section of *Patellina Egyptiensis*, showing the central and cortical arrangement of the septa. ? Lower Miocene: between Cairo and Suez. × 16.

Fig. 4.—*Gypsina crassitesta*, sp. nov., vertical section. ? Lower Miocene: between Cairo and Suez. × 16.

Fig. 5.—*Polytrema papyracea*, sp. nov., median section. ? Lower Miocene: between Cairo and Suez. × 16.

Fig. 6.—Limestone with *Operculina ammonoides* (Gronovius) in median section, and *Textularia agglutinans*, d'Orb. From specimen D 5. Pliocene: near Erment, right bank of Nile Valley. × 13.

Fig. 7.—Limestone with *Operculina ammonoides* (Gronovius) in vertical section. From specimen D 5. Pliocene: near Erment, right bank of Nile Valley. × 15.

Species of Foraminifera described in this paper.

1.	*Biloculina bulloides*, d'Orb. . . .	? L. Miocene: between Cairo and Suez.
2.	,, ,, var. *inornata*, d'Orb.	,, ,, ,,
3.	*Miliolina oblonga* (Montagu) . . .	,, ,, ,,
4.	,, *subrotunda* (Montagu) . .	,, ,, ,,
5.	,, *trigonula* (Lam.)	,, ,, ,,
6.	,, *inflata* (d'Orb.)	,, ,, ,,
7.	,, *seminulum* (Linné) . . .	,, ,, ,,
8.	,, *polygona* (d'Orb.) . . .	,, ,, ,,
9.	*Orbiculina adunca* (Fichtel & Moll) .	,, ,, ,,
10.	*Alveolina ellipsoidalis*, Schwager . .	,, ,, ,,
11.	,, *lepidula*, Schwager . . .	,, ,, ,,
12.	*Textularia agglutinans*, d'Orb. . .	Pliocene: near Erment.
13.	,, *sagittula*, Defrance . . .	,, ,,
14.	*Bigenerina capreolus* (d'Orb.) . . .	? L. Miocene: between Cairo and Suez.
15.	*Globigerina conglobata*, Brady . . .	Pliocene: near Erment.
16.	*Patellina Egyptiensis*, sp. nov. . .	? L. Miocene: between Cairo and Suez.
17.	*Discorbina globularis* ? (d'Orb.) . .	,, ,, ,,
18.	*Truncatulina Ungeriana* (d'Orb.) . .	,, ,, ,,
19.	*Gypsina vesicularis* ? (Parker & Jones)	Pliocene: near Erment.
20.	,, *crassitesta*, sp. nov. . . .	? L. Miocene: between Cairo and Suez.
21.	*Polytrema papyracea*, sp. nov. . . .	,, ,, ,,
22.	*Nonionina Boueana*, d'Orb. . . .	,, ,, ,,
23.	*Amphistegina Lessonii*, d'Orb. . .	Pliocene, near Erment.
24.	*Operculina ammonoides* (Gronovius) .	,, ,,

Ostracoda.

Bairdia subdeltoidea (Münster) . . . . ? L. Miocene: between Cairo and Suez.

III.—Modern Denudation in North Wales.

By J. R. Dakyns.

The subject of denudation is so important that I propose giving a few instances of denudation and of the transport of material that have actually come under my own observation or that of my friends. Where one sees the same familiar crags and pinnacles year after year, apparently quite unchanged, one may perchance fancy that denudation is at a standstill; but anyone who, in scrambling across the screes that clothe many a steep hillside, finds them moving beneath his feet, or perhaps has clattering about his ears a shower of stones dislodged by some wandering sheep, will at once perceive that it is not so: for it is obvious that if the mere tread of such a small beast as a sheep, shepherd or other pedestrian, can set scree rolling downhill, it must be in a very unstable state, and may be expected to move in a conspicuous manner under more potent forces than the tread of animals. Observation shows that this is the case. Not a year passes without some conspicuous fall of scree or of solid rock, owing chiefly to great downpours of rain. Leaving general statements, I will now give actual instances of the fall of rock or movement of scree that have recently taken place in the Snowdon district.

In the Summer of 1897 a large mass of earth and rock débris was washed by heavy rain down the hillside overlooking the east end of Llyn Llydaw, leaving a conspicuous scar which is still quite distinct. A similar scar close by, which is actually marked on the Ordnance six-inch map, was doubtless formed in a similar manner. Later on, in August, under another downpour of rain, a similar scar was formed on the Glyder near the head of Llanberis Pass.

In June, 1898, after a great deal of wet weather, while the summits were still enveloped in mist, I was scrambling along the slope of Lliwedd, above Cwm Llan, when I was startled at hearing from the side of Snowdon a noise like that of an explosion, followed by the sound of falling rocks. Turning quickly round, I saw issuing from the mist a quantity of earth and stones rushing down the mountain-side, and leaving long trails ploughed out of the loose material clothing the steep slope. Going up next day I found that a large mass of rock, weighing several hundred tons, had slipped down the hillside. The landslip was evidently due to a tiny rill having been swollen by the recent rains and having washed away some material supporting the highly weathered rocks, whose points of support then gave way with snaps like explosions of gunpowder. I once saw a somewhat similar fall of rocks in Norway caused by a thunder-shower. In August, 1899, during heavy rain, a long conspicuous scar was formed in scree on the side of Yr Aran. On November 3rd, the day of the great gale, when from fifteen to twenty streams were tearing down the mountain-sides, where usually there are only two or three, the high-level footpath to Snowdon was in three places either completely washed away or obliterated by being overwhelmed with stuff washed down the side of Crib y Ddysgl. A few days after this, on going to seek shelter from rain in an old adit level, where I had often sheltered two years ago, I found it completely covered with screes, which had either come down in a similar manner previously or had gradually accumulated during the last two years. Another old level, which was open when I was a boy, has long since been quite covered by scree.

A long red scar is to be seen on the hillside between Lliwedd and Galt y Wenallt: this was formed in March some years ago by an avalanche caused by the sudden melting of the winter's snow under heavy rain. A friend of mine saw and heard it come down with a roar like thunder.

Another cause of the fall of rocks is lightning. I often see freshly broken rocks that look as if they must have been broken by lightning: such a one I noticed the other day below Crib Goch, which had probably been struck by lightning during the thunderstorm that occurred on the 20th of July, 1899; but it is not often that we actually know as a fact that such and such a rock has been struck by lightning. During the great thunderstorm that occurred in North Wales in the middle of August, 1898, a mass of rock was broken and thrown down near Llyn Teyrn. This is known to have been done by lightning, as it was not there till after the storm. It is still quite distinct.

It will thus be seen that scree is perpetually moving down to a quite conspicuous extent under the influence of water, and that large landslips and falls of rock are also caused by heavy rain and by lightning. I have not had an opportunity of observing in Wales the transport of stones by ordinary mountain torrents; but doubtless such torrents behave in Wales as similar streams do in Yorkshire, about which I happen to know something. I once lived at Kettlewell in Craven, in a room overlooking a mountain torrent. I had not been there very long before there was a deal of heavy rain; and one night, after all the village folk had gone to bed, I heard a bumping noise as if a heavy cart were jolting over a rough road; so, being surprised that anyone should be driving a cart at dead of night, I opened the window and looked out, and I then discovered that the noise was caused by boulders bumping against one another as they were swept down by the beck that flowed under my window. Whenever there was heavy rain on the hills, that bumping noise was heard. The beck, when in spate, which it often was, invariably rolled great stones down to the river Wharfe. No doubt mountain streams in Wales and in other hilly countries do likewise. I may here remark that this transport of stones may go on in clear water. In such a country as the volcanic parts of Cumberland and Westmorland, where there is no shale, very little peat, and all the rocks are hard, a stream, even when in spate, will run quite clear. but it is hurrying stones on along its bottom all the same. The effect of this may be seen in many places in the great spreads of gravel that occur where a mountain stream enters a river valley, as for instance where such a stream enters the valley of the

Aire from the hills above Kildwick and Cononley. I have given the above-mentioned observations to prove that there is now going on a steady transport of material, but the same conclusion is manifest to the reason, for there are places on the mountains where the rock is conspicuously bare, naked, and fresh-looking, being free from asperities and from vegetable growth; such spots, reason tells us, are the places where there is a perpetual or oft repeated fall of stones from above. There is such a naked rock on Clogwyn y Garnedd, under the summit of Snowdon; and though I have not actually seen stones falling there, I am as sure that the naked appearance of the rock is due to falling stones as if I had seen them fall. Such bare places on the mountain-sides are very conspicuous in some parts of Norway; and the natives tell you that they are due to 'stane scree.'

Another sign that a rock is now wasting away is this: if the ground beneath a cliff is thickly strewn with blocks of the same rock as that of which the cliff is composed, you may be quite sure that the cliff is now wasting away. A geologist must be careful how he hammers such a cliff at its foot, for even a slight blow of his hammer may bring down a mass of rock on to his head. Again, the spiky character of a serrated ridge is proof that the ridge is wasting away. Such wasting away is mainly due to frost; and I have noticed that in the Spring the mountain-sides are in a more crumbly and unstable state than at any other time of the year. This is doubtless due to the winter frosts. I have now said enough to show that denudation is steadily going on, though its amount may be small in comparison with the size of the hills.

IV.—On Sandstone Pipes in the Carboniferous Limestone at Dwlban Point, East Anglesey.

By Edward Greenly, F.G.S.

THE low, but rocky headland of Dwlban Point forms the western corner of Red Wharf Bay, on the east coast of Anglesey;[2] and is on the coastline of the principal tract of Carboniferous rocks in the island, not very far from the boundary fault which runs out to sea beneath the sands of the bay. The Carboniferous Limestone near the Point is for the most part a light-grey, crystalline rock, with abundant crinoids, corals, and other marine fossils. There are, however, four beds of sandstone, varying from 2 to 9 feet thick, and some of the Limestone itself also contains scattered grains of quartz. The sandstones are clean white rocks, generally fine, but with occasional thin seams of small pebbles.

Now the foreshore at Dwlban Point is composed of a massive bed of light-grey, crystalline Limestone. The surface of this bed, at a little creek close to the headland, is pierced by a large number of

[1] Abstracts of this and of the succeeding paper were read before the British Association, Dover, 1899.

[2] During the first examination and the mapping of this ground I was accompanied by my friend Mr. J. R. Dakyns. I should like to add also that most of the phenomena here described were noticed more than twenty years ago by Mr. G. H. Morton, F.G.S.

circular pits, varying from 1 foot to 7 feet in diameter. The margins of these having been glaciated, they open out in trumpet-shaped forms, but each can be seen to be, or to have been, filled with a plug of fine white sandstone, descending into the Limestone at right angles to the bedding. (See Figures illustrating the succeeding paper.)

These plugs can be seen in various stages of denudation. Some have been worn down flush with the surrounding Limestone, and some of the smaller ones have been excavated so as to leave an almost empty pit or pothole with a little sandy matter in the bottom. In one part of the shore, however, the plugs have been left standing each in its circular pit, some 4 or 5 feet above the level of the surrounding rock (Fig. 1); and the foreshore here presents

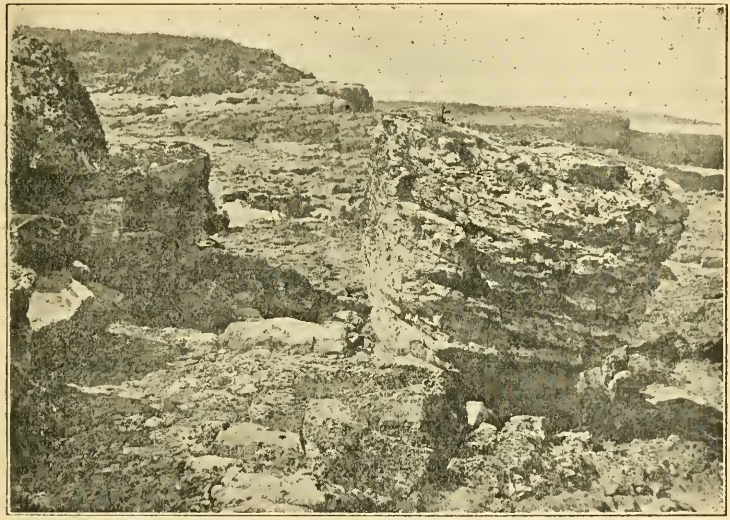


Fig. 1.—Sandstone Pipe in Carboniferous Limestone, Dwlban Point, Anglesey. Looking N.N.W.

a most extraordinary appearance, great masses suggestive of gigantic fossil corals, or of the Paramoudras of the Chalk, standing up from the rocky ledges, while others, torn out by the sea, lie prostrate in all directions.

The Limestone is here the highest bed seen, but as we proceed a few yards to the S.S.E. in the direction of the dip (which is at about 4°–5°) a bed of sandstone, about 2 feet thick, comes on above, forming the foreshore in its turn as the beds come down; and a little further still, in a low cliff, this is surmounted by about 7 feet of dark shale, and this by another Limestone of ordinary type, some 8–10 feet in thickness. (Fig. 2.)

Now at the exposed junction between the piped or lower Limestone and the overlying sandstone, there are numerous pipes, and the material of their plugs can be seen in cross section to be continuous with that of the sandstone above. There is no sign of collapse in this bed of sandstone; indeed, the upper surface of the bed is in most cases gently domed upwards over the openings of the pipes, so as to present a hummocky surface on the foreshore. In some cases also there is a domed joint or crack in the sandstone over the head of the plug.

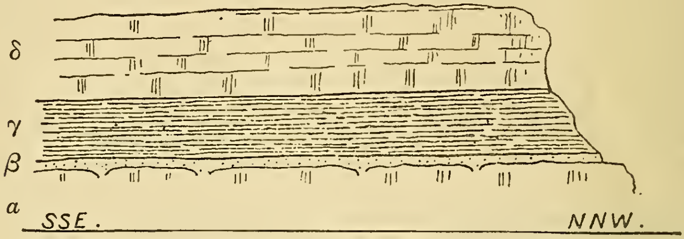


Fig. 2.—Diagram Section at Dwlban Point.
a, Piped Limestone; *β*, Sandstone; *γ*, Shale; *δ*, Upper Limestone.

The larger pits seen at Dwlban Point are about 6 feet in diameter at the top, and can be traced to a depth of about 5–6 feet. But about 230 yards to the south, at an inland crag across the débris of some ancient quarries, is a section showing a pipe no less than 12 feet in depth. (Fig. 3.) The rock pierced by the pipe is a very

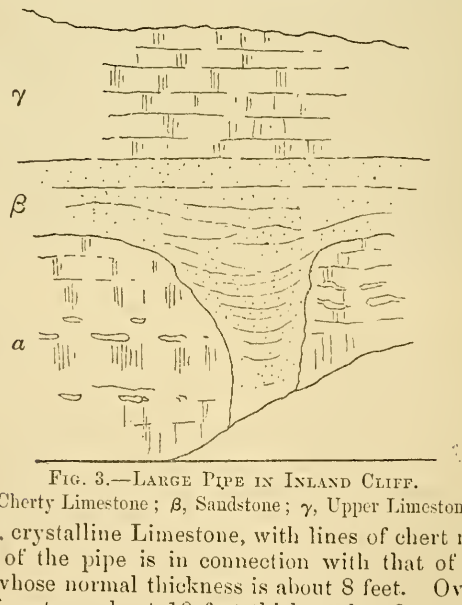


Fig. 3.—Large Pipe in Inland Cliff.
a, Cherty Limestone; *β*, Sandstone; *γ*, Upper Limestone.

massive grey, crystalline Limestone, with lines of chert nodules, and the material of the pipe is in connection with that of the base of a sandstone whose normal thickness is about 8 feet. Overlying this is another Limestone about 10 feet thick, rather fine and dark, and poor in fossils. Except at the pipe the sandstone lies in perfect conformity with both Limestones. It is a white, hard rock, mostly fine, but with some lines of pebbles. The funnel-shaped pipe, whose bottom is not seen, gives rise to a shallow cave, and in this it appears to widen out somewhat behind the face of the crag, as though it were there more basin-shaped than where cut by the plane of section. The bedding of the sandstone in the pipe is somewhat irregular, and bends gently downwards near the mouth.

The material of the plugs is a fine white, hard sandstone, weathering light brown. It weathers also very cavernously, as though calcareous, though a specimen examined at home did not effervesce with acid. There are a few small lenticular nests of little pebbles, but no pebbles were observed more than 1 inch in diameter. The weathered plugs show marked bedding, which is parallel to that of the series as a whole. There seem also a concentric structure and concentric colour banding. The jointing tends to be radial.

In both cases the Limestones penetrated by the pipes are thoroughly marine, as shown by the fossils, though at Dwlban Point the upper parts become somewhat sandy. No unconformity can be observed between the beds, but just below the base of the sandstone at the coast the Limestone becomes full of cracks, which widen upwards into small fissures filled in with sand and pebbles.

Whatever their origin, the pipes appear to be contemporaneous with the series as a whole. There is no sign of collapse in the beds above them, for the gentle downward bend in the great pipe affects only the material within the pipe itself, and not the overlying beds; indeed, the tendency is to a heaping into domes above them. They are suggestive of potholes, but there is no really coarse material in them, pebbles, though present, being both rare and small. The smaller plugs seem to be the more pebbly.

The suggestion has been made that the beds overlying the piped Limestone represent fresh-water episodes and upheaval, with accompanying denudation.[1] Shales and sandstones in similar positions in the Penmon area do, indeed, contain abundant plant-remains, though no pipes were observed by me there. But at Dwlban Point the shale above the sandstone (γ, Fig. 2) has yielded a shell which, though very poorly preserved, Mr. E. T. Newton, F.R.S., who was so good as to look at it for me, believes to be *Spirifera ovalis*, while the sandstone itself contains what seem to be annelid castings. Mr. J. Bennie, formerly of the Geological Survey of Scotland, has also very kindly examined the shale for minute organisms, but has hitherto failed to find any. The whole series therefore appears to be marine. The fissuring of the upper surface of the Limestone, however, points to an interval of exposure after hardening; and it is interesting also to note that the Penmon Sandstones above alluded to contain pebbles of Carboniferous Limestone (Q.J.G.S., 1896, pp. 628, 629). We may conclude, then, that the piping took place during an interval of shallowing, and, perhaps, exposure of the sea-bottom. This was probably quite local, for the sandstones in this region are for the most part of very limited extent.

[1] By Mr. P. F. Kendall, F.G.S., during the discussion at the meeting of the British Association.

It is curious that these pipes should occur in the same area at three different horizons, the great pipe being somewhat above those of the Dwlban Point, while some seen to the north of Benllech must be much lower in the series.

V.—On Deflected Glacial Striæ at Dwlban Point, East Anglesey.

By Edward Greenly, F.G.S.

THE Limestone of the foreshore at Dwlban Point is magnificently glaciated, the ice-worn surfaces being preserved for a distance of some yards from the Boulder-clay. The striæ where undeflected run N.N.E.–S.S.W., which is in agreement with the general direction of the glaciation on that part of the coast.

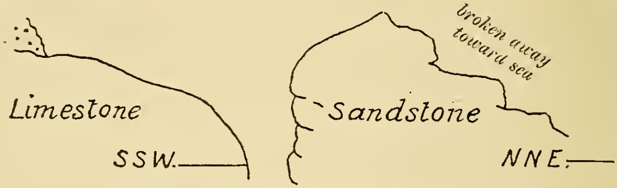


Fig. 1.—Profile of Glaciated Pit.

The rock is not merely striated, but furrowed, and in one furrow a ledge of rock facing N.N.W. is undercut so as to overhang some 3 or 4 inches, the slope of the overhanging surface being as much

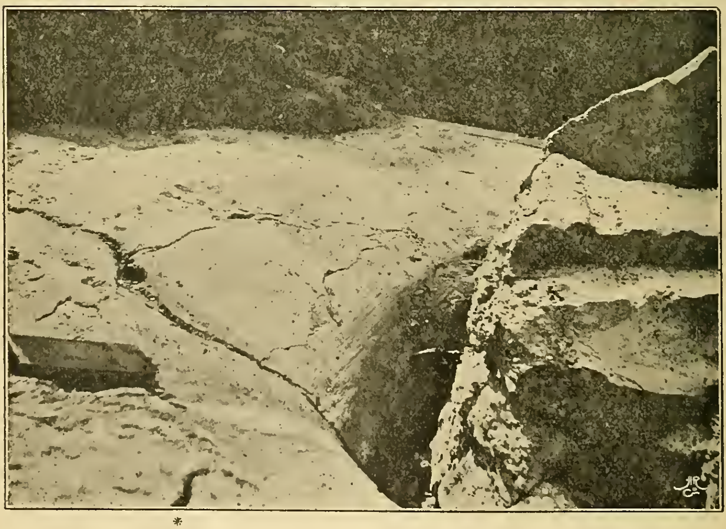


Fig. 2.—Deflected Glacial Striæ, Dwlban Point, Anglesey.

The normal direction of striation is that of a line joining the small round hole on the left with the small fissure at *. Boulder-clay is seen in the background; and, on the right, part of a Sandstone plug in its pit.

as 15°–30° from the vertical. This undercut furrow is distinctly smoothed and striated.

The trumpet-shaped mouths of the pits described in the foregoing paper are beautifully ice-worn, though the heads of their sandstone plugs are for the most part rough and angular.

The striæ are deflected on passing across the mouths of the pits. In the case of one pit, about 6 feet in diameter, whose profile with its plug is shown in Fig. 1, the striæ sweep completely round in the moat-like hollow surrounding the plug, until on its S.S.W. side they are pointing more than 20° N. of W. These deflected striæ are shown, for part of their course, in the photograph[1] (Fig. 2). On the broad and gently convex surface of Limestone just outside the hollow they have the normal direction S. 25°–30° W., so that the deflection in the space of some 2 yards is nearly 90°.

The agent which produced this phenomenon and that of the undercut furrows must have adapted itself, it would seem, as a practically plastic body, to every irregularity in the surface of the rock.

A Red Clay, somewhat poor in stones, rests upon the ice-worn surface, forming a cliff about 12 feet high.

VI.—Note on a Boring through the Chalk and Gault near Dieppe.[2]

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

THE following particulars of a boring for water made at Puys, near Dieppe, in 1898 have been communicated to me by Messrs. Legrand and Sutcliff, and as they appear to indicate a succession of beds very similar to that occurring beneath Dover, the present seems a fitting occasion for placing on record a brief account of the boring.

Puys is a small village less than a mile and a half north-east of the entrance of Dieppe Harbour, and the site of the boring is at an hotel by the sea-shore, the well-mouth being not more than 50 yards from high-water mark and about 45 feet above mean sea-level.

The beds passed through by the boring are described as follows, the thicknesses being given in metres and in feet:—

	Metres.	Feet.
Chalk without flints	156	511½
Greensand and sandy clay	2	6½
Gault clay	42	137¾
Black sand and pyrites, passing down into clean quartzose sand	11½	37¾
	211½	693½

[1] For this photograph and that illustrating the preceding paper, as well as for the lantern slides and other photographs of these phenomena, used at the British Association, I am indebted to Mr. J. Trevor Owen, M.A., Headmaster of the County School, Carnarvon.

[2] An abstract of only the first part of this paper was read before the British Association at Dover, September, 1899.

According to the diagrammatic section of the coast-line given by Hébert in 1872, Puys stands on the chalk of the *Holaster planus* zone,[1] which corresponds to the lowest part of the flinty chalk east of Dover. Thus the chalk traversed by the boring is the equivalent of the whole of our Lower and Middle Chalk. In 1875 Hébert estimated the thickness of the *planus* zone near Dieppe at 11 metres (36 feet) and that of his zone of *Inoceramus labiatus* (our zones of *Rhynchonella Cuvieri* and *Terebratulina gracilis*) at 70 metres (230 feet). The three zones taken together, therefore, are estimated at 266 feet, and if we deduct this from the 511½ feet of chalk traversed by the boring, there remains 245½ feet as the thickness of the Lower Chalk. This is rather a greater thickness than might have been expected for the Lower stage, and it is probable that the Middle Chalk or Turonian is rather thicker than Hébert supposed. As a matter of fact he measured 65 metres of it in the cliff itself, and its base is nowhere exposed; hence it is not at all unlikely that its full thickness is nearly 75 metres (or 247½ feet), and in this case the thickness assignable to the Lower Chalk will be 228 feet, which is a more probable amount.

The two metres of greensand and sandy clay at the base of the Chalk probably corresponds with what we know as the Chloritic Marl or zone of *Stauronema Carteri*. This has a thickness of about 15 feet at Folkestone, but not more than 4 feet near Eastbourne.

As nothing of the nature of sandstone or 'gaize' is recorded in the boring, we may assume that nothing of an 'Upper Greensand' character is present below Dieppe, and that the zone of *Ammonites rostratus* is represented by clay and marl as it is at Wissant and Folkestone. This is interesting as showing that what may be called the Folkestone facies of Gault extends as far as Dieppe, which is about 78 miles south of Folkestone and rather less from Wissant.

November 10.—Since the above was written I have received, through the kindness of Monsieur G. Dollfus, a more complete account of this boring. The following is a translation:—

		Thickness. Metres.	Depth. Metres.
	Ground excavated ...	2·75	2·75
Cenomanian & Turonian.	White marl	59·25	62·00
	Soft white marl	4·25	66·25
	Grey marl ...	·45	66·70
	White marl	3·30	70·00
	Grey marl with flints	4·00	74·00
	Hard white marl ...	14·30	88·30
	Hard marl (with *Inoceramus labiatus*)	22·70	111·00
	Grey chalk	20·25	131·25
	Grey chalk with flints	6·25	137·50
	Grey chalk	8·50	146·00
	Greenish sandy clay	10·20	156·20
	Green sandy clay ...	2·10	158·30
Gault.	Black clay	41·20	199·50
	Clayey green sand	6·80	206·30
	Grey sand ...	3·15	209·45
	Black sandy clay ...	2·05	211·50

[1] Bull. Soc. Géol. France, ser. II, vol. xxix, p. 586.

The only specimen seen by Mons. Dollfus was one of a hard chalk with fragments of *Inoceramus labiatus*; this he is inclined to refer to the Turonian, but as the species also occurs in the highest part of our Lower Chalk, I am disposed to think the base of the Middle Chalk was traversed at 88·30 metres, i.e. 289½ feet. He agrees with me in regarding the "green sandy clay" as the base of the Cenomanian, which thus has a thickness of 229½ feet.

The only important difference between the account furnished to me and that communicated to Mons. Dollfus is in regard to the lowest beds, for it seems that the boring passed through the grey sand at 209·45 metres and entered a black sandy clay. It is impossible to suppose the Vectian sands to be only 10 feet thick below Dieppe, nor is it likely that a thick bed of black sandy clay should occur in them; consequently M. Dollfus believes that both the sand and the clay belong to the Gault.

In support of this view he sends the particulars of another boring recently made at the Château d'Eu in the valley of the Bresle, about 16 miles north-east of Dieppe. Samples and fossils from this boring were seen and determined by M. Munier-Chalmas, and there is consequently a much greater certainty about the horizons. The following is a translation :—

		Thickness. Metres.	Depth. Metres.
	Alluvia of the valley of the Bresle	10·89	10·89
Turonian.	White chalk with *Rhync. Cuvieri*	8·61	19·50
	Firm white chalk with some flints	11·90	31·40
	Chalk without flints, some hard lumps	16·70	48·10
	Chalk without flints, very sticky	2·40	50·50
	Grey chalk	·83	51·33
	Soft yellow chalk	1·67	53·00
	Grey and white chalk, in hard and softer beds alternating, *Inoc. labiatus*	17·46	70·46
Cenomanian.	Grey and blue argillaceous chalk, with *Belemnites*	3·12	73·58
	Soft white chalk, with *Holaster*	8·62	82·20
	Grey compact chalk	3·42	85·62
	Marly grey chalk	22·38	108·00
	Greenish-grey sandy chalk	16·18	124·18
	Green clayey glauconitic chalk	14·82	139·00
Upper Gault.	Black clay with *Inoceramus*	11·75	150·75
	Greenish quartzose sand	6·75	157·00
	Black and green sandy clay	1·50	159·00
	Pure green sand	1·60	160·60
	Green and black clay, with *Ammonites auritus* and *Am. splendens*	2·60	163·20
	Greenish-grey sand and sandstone	2·90	166·10
	Bed of greenish sandstone	·16	166·26
	Green sand with large grains of quartz	1·54	167·80
	Black sandy clay	1·10	168·90
	Green quartzose sand (not pierced)	—	171·80

This boring is very interesting in several ways. In the first place the base of the Turonian is clearly fixed at 70·46 m., and the base of the Cenomanian at 139 m. This gives a thickness of 68·54 m. (= 224·8 feet) for the Cenomanian or Lower Chalk, thus corroborating my interpretation of the Dieppe boring. In the next place the curious alternations of black clay and green sand, which evidently belong to the Upper Gault (zone of *Ammonites rostratus*), are very noteworthy.

Lastly, it is remarkable that these sands in the Gault should yield an abundant supply of water. In the case of the Dieppe boring the water rose to about 12 feet above the surface, and at Eu it rose to 50 feet above the surface with a yield of 750,000 litres in the 24 hours.

The beds traversed by the two borings may be summarized thus :—

	Dieppe. Feet.		Château d'Eu. Feet.
Surface deposits	9 ?	...	35·7
Middle Chalk	280·3	...	195·4
Lower Chalk, with Chloritic Marl at the base	229·6	...	224·8
Gault (not pierced)	174·5	...	107·5
	693·4		563·4

NOTICES OF MEMOIRS.

Diprotodon australis. Fossil Remains of Lake Callabonna. Part I: Description of the Manus and Pes of *Diprotodon australis.* By E. C. Stirling, C.M.G., F.R.S., etc., and A. H. C. Zietz, F.L.S.

THIS lavishly illustrated memoir contains the first instalment of the description of the remarkable series of skeletons of *Diprotodon* discovered some years ago in the dried-up bed of Lake Callabonna in South Australia. A brief account of the discovery was published in *Nature* (vol. l, 1894, pp. 184 and 206) by Professor Stirling, and a description of the remarkable bird-remains from the same locality has also appeared.

The present memoir deals with the structure of the fore and hind feet, which are almost the only important parts of the skeleton not described by Owen. The collections included a considerable number of more or less complete feet, so that the authors have been able not only to describe in great detail the separate bones, but also to give restorations of the manus and pes, both of which exhibit some remarkable characters.

The fore-foot possesses five complete digits, of which the fifth is the largest; the fifth metacarpal has a broad flange-like expansion on its outer side. The pisiform bears more than half the articular surface for the ulna.

The hind-foot also possesses five digits, but the first consists of the metatarsal only. The second and third digits are extremely slender, the fourth only a little stouter, but the fifth is very much thicker, the metatarsal bearing a great flange-like expansion. The whole foot is a most remarkable structure, but, although considerably modified on account of the great weight it had to bear, it still retains distinct marsupial characters.

The general conclusions arrived at by the authors are as follows:—

"Marsupial characters are evident in both the manus and pes of *Diprotodon.*

"So far as the individual constituent bones are concerned they present resemblances to their homologous parts in both the Phalangeridæ and the Phascolomyidæ, but the approximation to the former is, on the whole, greater than to the latter.

"On the other hand, regarding the feet as a whole, they, in their shape and proportions as well as in the character and degree of the attenuation of the second and third digits of the pes, are more readily comparable to these members in the Phascolomyidæ.

"With the more specialized pes of the Macropodidæ, comparison of that of *Diprotodon* yields scarcely any points of resemblance, except in so far as the character of the degradation of the hind-feet, similar in kind but varying in degree, affords evidence of the marsupial nature of both."

The memoir is excellently illustrated by a series of eighteen very good photographic plates, including two of the restored manus and pes.

REVIEWS.

I.—Fossil Radiolaria. By Dr. G. J. Hinde, F.R.S., F.G.S.

1. "Note on some Radiolarian Chert from the South Uplands of Scotland": Quart. Journ. Geol. Soc., vol. xlvi (1890), Proc., p. 111, and Ann. Mag. Nat. Hist., ser. vi, vol. vi (1890), p. 40.
2. "Note on the Radiolaria in the Mullion Island Chert." By G. J. Hinde, Ph.D., V.P.G.S. Quart. Journ. Geol. Soc., vol. xlix (1893), pp. 215–218, pl. iv.
3. "Note on a Radiolarian Rock from Fanny Bay, Port Darwin, Australia." By George Jennings Hinde, Ph.D., V.P.G.S. 8vo; pp. 221–226, pl. iv. Quart. Journ. Geol. Soc., vol. xlix (1893).
4. "On a well-marked Horizon of Radiolarian Rocks in the Lower Culm-measures of Devon, Cornwall, and West Somerset." By G. J. Hinde, Ph.D., F.R.S., F.G.S., and Howard Fox, Esq., F.G.S. 8vo; pp. 609–667, pls. xxiii–xxviii. Quart. Journ. Geol. Soc., vol. li (1895). Supplementary Note, etc., Trans. Devon Assoc., vol. xxviii (1896), pp. 774–789.
5. "On the Radiolaria in the Devonian Rocks of New South Wales." By G. J. Hinde, Ph.D., F.R.S., F.G.S. 8vo; pp. 38–63, pls. viii and ix. Quart. Journ. Geol. Soc., vol. lv (1899).
6. "On Radiolaria in Chert from Chypon's Farm, Mullion Parish, Cornwall." By George Jennings Hinde, Ph.D., F.R.S., F.G.S. 8vo; pp. 214–219, pl. xvi. Quart. Journ. Geol. Soc., vol. lv (1899).
7. "Description of Fossil Radiolaria from the Rocks of Central Borneo." By Dr. George J. Hinde. 4to; 36 pp., with 4 plates. (E. J. Brill, Leyden; and H. Gerlings, Amsterdam: 1899.)

AMONG the various minute aquatic organisms that have persistent structure within or without their bodies, several kinds have been recognized by naturalists, with more or less exact discrimination, since natural history became a definite study, after the dark ages of mediæval ignorance had cleared away. Thus the relatively large 'water-fleas' of streams and ditches, and the sand-like 'ammonites' of the Adriatic, were objects of curiosity for some, and the Diatomaceæ, mistaken for Infusoria, were before long carefully studied, from both fresh and salt waters. So also the spicules of Sponges were noticed, classified, and figured. Together with some of the foregoing, in either a recent or fossil state, other minute organisms, of great beauty in their delicacy and symmetry, had been met with, but their real place in nature was not determined until within fifty years ago. These, when alive in the sea, have a jelly-like body, invested or supported by a complex but delicate and often elegant framework of meshes and spicules, mostly siliceous. Johannes Müller, of Berlin, indicated their true alliance by grouping them as "Rhizopoda Radiaria seu Radiolaria," in 1858.

These attractive little organisms were known to exist in the Mediterranean and other seas, and to be fossil in thick strata at Barbadoes and elsewhere. During the Voyage of the "Challenger" in 1873–6, they were found to constitute a large percentage of the ooze over extensive oceanic areas. After long study of these organisms, Dr. E. Haeckel, determining their essential characters and modifications, classified them, with descriptions and illustrations, in his "Die Radiolarien," 1862, and the "Report of the Scientific Results of the Voyage of the 'Challenger' during the years 1873–76": Zoology, vol. xviii, 3 parts (1887).

The nuclear or medullary body, with its enclosing membrane or open-worked shell, either central or at one end of the axis, is enveloped with a protecting (cortical) sarcode, which extrudes pseudopodia, and in many cases is strengthened and invested by spicules, meshes, and radial spines, usually of silex, and of manifold form and arrangement. The persistent forms are usually regarded as belonging to the '*Polycistina*' of Ehrenberg and Müller. (*Polycistina* = many baskets; *Polycystina* = many bladders; used sometimes indifferently.)

In the case of those that have no shell, and those in which the radial spines are not composed of hard silica, there is little or nothing left in the fossil state. Otherwise numerous individuals remain more or less perfect in various rocks of the Palæozoic, Mesozoic, and Cænozoic formations. They mostly present "either simple or concentric latticed shells, some with relatively long radial spines; and they are similar in character to recent Radiolaria, and probably referable to the same genera as the latter."

However much modified in the individuals of different groups, yet the inner or nuclear capsule and the outer capsular investment (calymma) may be, their essential character is always recognizable. The spicules in the naked forms of the Spumellaria, and the hard parts of the other groups, constitute subsidiary evidences of the generic and specific differentiation.

In these, as in other low forms of life, Nature is so lavish of her productive power in the multiplicity and almost endless variations of growth, that at first sight it seems to be impossible to find the clue to the apparent entanglement of structural peculiarities in the investments and their bizarre outgrowths. The clue, however, as noted above, is afforded by the innermost organ.

This is itself lost to the geologist, but its latticed capsule, and the radial spines which partly form the transverse bars and beams of the whole organism, may have remained, more or less imbedded in limestones, shales, and sandstones, probably altered into marbles, schists, and quartzites. Indeed, many fine-grained siliceous rocks now appear to have resulted from Radiolarian ooze itself.

In comparing the fossil and the recent specimens, the student has to recollect that the general form is either globular, ellipsoidal, or like vases, caps, umbrellas, discs, irregular stars, chambered cones, etc., all perforate, fenestrate, or reticulate, with the meshes lengthening out into spines on the surface or at the edges. The radial rod-like spines, whether or not beginning in the middle of the nuclear lobe, are often united by branching spicules at or near the surface of the calymma, and similarly become involved in the outer lattice-shell.

In the Spumellaria the skeleton, if present, consists of either pure silica or of a peculiar silicate (silicate of carbon?); the rods are solid, as in the Nassellaria, and do not begin in the centre. In the Acantharia the rods begin in the centre, and consist of acanthin. In the Nassellaria the skeleton is siliceous; the rods are solid, usually monaxial, and belong to the outer capsule (calymma). In the Phæodaria the skeleton consists of a silicate, and belongs to the outer capsule.

Radiolaria from strata of Tertiary age have been examined by many observers. Some are figured by Ehrenberg, who gave neatly executed drawings, but did not otherwise advance our scientific knowledge of these microzoa. In his "Mikrogeologie," 1854, some Radiolaria appear (as 'Polycystina') from Tertiary beds at Ægina, Zante, and Caltanisetta, Sicily. These are noted, as to their geological age, in the Ann. Mag. Nat. Hist., ser. IV, vol. ix (1872), pp. 223, 225, and 228.

Messrs. Jukes-Browne & Harrison, treating of the siliceous rocks of Barbados (Quart. Journ. Geol. Soc., vol. li, 1892, pp. 193–4), refer to Haeckel's statement that many of the Barbadian Radiolaria are not known in the modern oceanic ooze, and that about 25 per cent. of those fossil forms are present in the ooze. These results are taken as determining a Pliocene age for the West-Indian siliceous strata referred to.

Cretaceous Radiolaria have been freely studied: for instance, by Rüst, 1888; Zittel, 1888; Pernet, 1891; Fritsch, 1893; Hill & Jukes-Browne, 1895; and Cayeux, 1897. They have not, however, been fully classified and strictly compared with other faunæ.

Jurassic Radiolaria are known chiefly from Dr. Rüst's Memoir in the "Palæontographica," vol. xxxi (1885).

M. Lucien Cayeux[1] has compiled a table of the geological occurrence of Radiolaria of Mesozoic and earlier date, in which he refers

[1] "Contribution à l'étude micrographique des Terrains sédimentaires, etc." (4to, Lille, 1887), p. 206. The Cretaceous Radiolaria of France and Belgium are dealt with at pp. 185–206 and 450–452, pls. vii and viii.

SPUMELLARIA	Sphæroidea to the Pre-Cambrian, Silurian, Devonian, and Senonian. Prunoidea to the Silurian, Devonian, Carboniferous, Permian?, and Senonian. Discoidea to the Silurian, Devonian, Permian, and Jurassic.
NASSELLARIA	Cyrtoidea to the Pre-Cambrian, Devonian, Carboniferous, and Senonian.

These results differ somewhat from those given in this notice of Dr. Hinde's Radiolarian researches.

Dr. G. J. Hinde, whose important memoirs descriptive of Radiolarian rocks from different parts of the world are enumerated at the head of this article, noticed in 1890 some chert beds, composed mainly of Radiolaria, from the South Uplands of Scotland (in Lanarkshire and Peebleshire), belonging to an Ordovician formation equivalent to the Llandeilo-Caradoc series of Wales, and in which the late Dr. H. A. Nicholson had already observed these microzoa.

In 1893 Dr. Hinde determined two genera of the Order Sphæroidea, and three of Prunoidea, in the chert of Mullion Island off the Lizard Peninsula, Cornwall, and suggested that they may be of the same age as the Ordovician cherts of Scotland.

In the same year, examining a siliceous rock from Fanny Bay, Port Darwin, Northern Australia, he found one genus of Prunoidea, five genera of Discoidea, and three of Cyrtoidea.

In 1895 Dr. Hinde found in the cherts of the Lower Culm-measures of Cornwall, Devon, and West Somerset, one genus of Beloidea, eight genera of Sphæroidea, three of Prunoidea, seven of Discoidea, and four of Cyrtoidea. Of these twenty-three genera, "twenty-one have been previously determined from the Palæozoic formations of this country and the continent"; and of these, seventeen have been determined by Dr. Rüst from the Culm of Germany, Sicily, and Russia.

In the same year Dr. Hinde examined some Radiolarian rocks of Devonian age from New South Wales, namely, siliceous claystones and shales, volcanic tuff, and chert from Tamworth, also jaspery cherts with few and badly preserved Radiolaria from Bingera, Barraba, and Jenola Caves. Although some associated Corals indicate a Devonian age, the Tamworth Radiolaria correspond on the whole with those from the Ordovician (Lower Silurian) phosphorites and siliceous shale of Cabrières and Languedoc, described by Rüst ("Palæontographica," vol. xxxviii, 1892), and those of the South Uplands of Scotland, of corresponding age (Hinde, p. 60). The apparent absence of Cyrtoidea distinguishes this from Mesozoic and Tertiary faunæ; the predominating forms being Sphæroidea, with medullary tests and radial spines. The Cyrtoidea were either not represented or by a small minority in the earlier deposits.

The Tamworth Radiolaria are:—

	Genera.	Species.
Beloidea	1	1
Sphæroidea	14	28
Prunoidea	4	7
Discoidea	8	12
Plectoidea	2	6
	29	54

The Ordovician chert of Chypon's Farm, in Mullion parish, continuous with the Radiolarian chert of Mullion Island, was examined in 1899, and yielded: Sphæroidea, 3 genera (with 3 species); Prunoidea, 3 genera (6 species); and Discoidea, 1 genus (1 species).

Dr. Hinde's latest memoir on Radiolaria has been prepared as an Appendix for the "Geology of Central Borneo," to be published by Professor Dr. G. A. F. Molengraaf, of the Dutch Exploring Expedition, in 1893–4. In his Introduction Dr. Hinde describes the outcrops and general character of the Radiolarian rocks under notice, namely, jaspers, cherts, hornstone, and diabase tuff. Their local occurrence in the siliceous rocks and in the tuffs, and the distribution of these fossil Radiolaria in other countries, are indicated in the table at pp. 44–46, and treated in detail in the text:—

	Genera.	Species.
Beloidea	1	1
Sphæroidea	5	17
Prunoidea	5	12
Discoidea	6	16
Cyrtoidea	13	54
	30	100

These rocks are stated to underlie strata of Cenomanian age, and they seem to belong either to the latest Jurassic or the earliest Cretaceous age, as is the case also with the Radiolarian cherts and jaspers of the Coast Range in California.

Great services have been rendered to geology by Dr. Hinde's elucidation of the relics of some very obscure Invertebrata, in his successful studies of the Silurian Conodonts, of Sponges of every group and age, and now of Palæozoic and other Radiolaria. He has thus indicated how the relative age of many rocks may be determined by the evidence of several kinds of microscopic fossils.

II.—*Helicoprion*—Spine or Tooth?

"Ueber die Reste von Edestiden und die neue Gattung *Helicoprion*." By A. Karpinsky. Verhandl. k. russ. min. Ges. St. Petersburg, ser. II, vol. xxxvi, No. 2, with 4 pls. and 72 text-figs. (1899).

PALÆONTOLOGISTS are indebted to the eminent Director of the Imperial Russian Geological Survey for one of the most exhaustive memoirs on a fossil ever published. Dr. Karpinsky's description of the strange 'ichthyodorulite,' *Helicoprion*, is a model of what such a work should be—thorough from every point of view, geological, chemical, and biological. It is, moreover, illustrated by exquisite plates, besides numerous text-figures, representing not only the outward form of the problematical fossils dealt with, but also every feature of their microscopical structure.

Helicoprion, to a superficial observer, looks much like an ammonite; but on closer inspection it is easily recognizable as a spiral consisting of teeth firmly fixed together by their bases. Fragments of a more or less similar spiral have already been described under the name of *Edestus* from Carboniferous strata in North America, Russia, and Western Australia; but no specimens at all approaching the two best of the fossils now made known by Dr. Karpinsky have hitherto been discovered. The rival theories by which *Edestus* has been sometimes ascribed to the jaws, sometimes to the external dermal armour of a shark or skate, can thus be discussed again in the light of important new facts. If the Edestidæ must still remain as Elasmobranchs of uncertain zoological position, the memoir before us at least makes great accessions to our knowledge of the essential points in the structure of their so-called segmented spine.

The new fossils forming the subject of the memoir were discovered by Mr. A. Bessonow in the Permo-Carboniferous (Artinsk Series), near Krasnoufimsk, in the Government of Perm. They comprise two nearly complete spirals from 0·238 m. to 0·260 m. in diameter, besides three fragments, and were sent by their discoverer to the Museum of the Imperial Geological Survey, St. Petersburg. The ends of both spirals are incomplete, but both exhibit approximately 3½ whorls, all in one plane and apparently bilaterally symmetrical. The segments or teeth of the central whorls are relatively very small, but they rapidly increase in size towards the periphery, and are largest at the free outer end. In one specimen 136, in the other specimen 146 segments are preserved or indicated. The segments resemble those of the typical species of *Edestus* in all respects, except that the enamel extends far down the middle of the side of the base, and there is a notch at the inner extremity of the base. These two features, together with the remarkable extent of the spiral, are rightly judged by Dr. Karpinsky to be the marks of a distinct genus, which he names *Helicoprion*. All the new specimens are placed in a single species, named *H. Bessonowi* after their discoverer. *Edestus Davisi*, H. Woodw., from the Carboniferous of Western Australia, is provisionally referred to the same new genus.

After a detailed description of the general characters of these remarkable fossils, Dr. Karpinsky illustrates their microscopical structure by a series of beautifully prepared sections. They are shown to consist of vaso-dentine, without any trace of bone-cells; and the superficial enamel seems to be the ordinary gano-dentine or vitro-dentine.

Chemical analyses by Mr. B. Karpow are also discussed, and the conclusion is arrived at that the fossil itself consists chiefly of a substance closely resembling apatite.

Two or three of the specimens exhibit numerous small granules over and around the bases of the segments. These are next treated in great detail, and the description is again illustrated by beautiful microscopical preparations, of which figures are given. Dr. Karpinsky regards these granules as shagreen or placoid scales, though he finally admits that he does not know shagreen granules of precisely the same structure in any other Elasmobranchs. In our opinion they are not dermal structures, but the well-known granular calcifications of Elasmobranch cartilage,[1] which are often mistaken for shagreen by palæontologists.

Having described the new fossils and determined their generic and specific characters, Dr. Karpinsky concludes with a most exhaustive discussion of their true nature, which is facilitated by the concise sketch of our previous knowledge of *Edestus*, given as an introduction to the memoir. He regards four results as established: (i) that *Helicoprion* belongs to an Elasmobranch; (ii) that the bases of all the segments of the spiral were embedded in the soft parts of the fish; (iii) that the spiral must have been situated in the vertical median plane of the fish; and (iv) that the whole of the spiral, except the large end, must have been exposed. In a diagrammatic sketch he represents the problematical fossil as originating in the upper jaw, and curling forwards and upwards so that the spiral forms a terrible weapon above the snout. On this supposition, each individual would possess only a single weapon of the kind.

In connection with the last-mentioned circumstance, it would be interesting to know whether the five examples of *Helicoprion* discovered in the quarry near Krasnoufimsk were found close together at one time, or whether there is any other evidence of their natural association. For a recent discovery by Dr. Traquair in the Lower Old Red Sandstone of Turin Hill, Forfarshire,[2] proves undoubtedly that there were Palæozoic sharks with sharp, piercing teeth, which were never shed, but became fused into whorls as the animal grew. If he be correct, the teeth in these Lower Devonian sharks even formed spirals; for he considers that the so-called *Onychodus anglicus* from Ledbury, figured in the Brit. Mus. Catal. Foss. Fishes (pt. ii, pl. xv, fig. 1), truly belongs to the same Elasmobranch genus as the head from Forfarshire. It is well-known that the crushing dental plates in the Elasmobranch Cochliodontidæ sometimes became considerably in-rolled at the outer margin where they could not break away.[3] The discovery of Elasmobranchs with cutting or piercing teeth similarly disposed is therefore not surprising. The fact that the known specimens of *Edestus* and *Helicoprion* are bilaterally symmetrical does not necessarily relegate them to the median line, if they happen to be whorls of teeth; for several of the anterior rows of teeth in the living *Chlamydoselache* exhibit essential bilateral symmetry.[4] Moreover, it may be remarked that the possibility of *Edestus* and *Helicoprion* being whorls of teeth from the mouth is not negatived by the absence of lateral facettes or marks of contact with adjoining whorls: they may have been well separated, as in the existing shark just mentioned. The conception

[1] Compare figures by Williamson, Phil. Trans., 1851, pl. xxx, fig. 29; and A. Fritsch, "Fauna der Gaskohle," vol. ii (1889), p. 101, figs. 178, 180.

[2] R. H. Traquair, "Notes on Palæozoic Fishes": Ann. Mag. Nat. Hist. [7], vol. ii (1898), p. 69 (*Protodus scoticus*, E. T. Newton, sp.).

[3] E.g. *Cochliodus contortus*, Ag.: J. W. Davis, Trans. Roy. Dublin Soc. [2], vol. i (1883), pl. lii, figs. 4*a*, 5.

[4] S. Garman: Bull. Mus. Comp. Zool. Harvard Univ., vol. xii, No. 1, p. 6, pl. ii.

of a gigantic shark armed in both jaws with several series of teeth like those now described under the name of *Helicoprion* is, indeed, sufficiently startling; but it seems to us more likely to be realized than the hypothesis which Dr. Karpinsky's most interesting researches have led him to propose. A. S. W.

III.—Fauna der Gaskohle und der Kalksteine der Permformation Böhems, von Dr. Ant. Fritsch, F.R.G.S. Bd. iv, Heft 1, Myriopoda, Pars 1; and Bd. iv, Heft 2, Myriopoda, Pars 2, Arachnoidea. 4to; pp. 1–32 and 33–64, pls. cxxxiii–cxliv and cxlv–cliii. (Prague, 1899.)

THE progress of this important work, dealing with the fauna of the Gas-coal of Bohemia, has been noticed from time to time in the Geological Magazine. In the fourth volume the author commences the description of the Articulata of the Permian formation. There is little to say concerning the Hexapoda, or Insects proper; three species of *Phryganea* are recorded as evidenced by the cases of the larvæ of the Caddis-fly, and some fragments of the wings of the adult insect. Of Orthoptera (Cockroaches) he describes *Etoblattina Bohemica*, *Arthroblattina Lubnensis*, and two others, chiefly from wings, and three insects of uncertain determination.

Pages 13 to 55 of the two parts are occupied with descriptions and figures of the wonderful series of Myriopoda, of which no fewer than thirty-four species are enumerated, some being smooth unspined forms like the modern *Julus*, others armed with rows of powerful curved and branched spines (each compound or double division of the body bearing two pairs of legs), well-developed tracheæ, a head furnished with compound and simple eyes (ocelli), and one pair of antennæ.

Such forms of centipedes have long been known from the Carboniferous Series, both in England and America. The earliest record of the discovery of terrestrial Arthropods from the Coal-measures of England was made by the late Rev. P. B. Brodie in 1845, in his "History of Fossil Insects." In this work Professor Westwood states that he regarded the organism (which we now know to be part of a gigantic spined Myriopod) as the remains "of some large Caterpillar furnished with rows of tubercles." The late J. W. Salter in 1863 described a similar fossil from the Clay-ironstone of the Staffordshire Coalfield under the name of *Eurypterus* (*Arthropleura*) *ferox*, and referred to it, as a most curious crustacean fragment, part of the spined abdomen of a *Eurypterus*. Messrs. Meek & Worthen, in their Geological Survey of Illinois (1868), were the first who correctly recognized these fossils from America as the remains of gigantic spined Myriopods. Similar forms have since been described by Scudder in America and Dr. Woodward in England (see Geological Magazine, 1887).

Numerous illustrations are given in the text to show the character and arrangement of the rows of branched spines upon the sides of the dorsal surface of the segments, the trachæal openings, the jointed legs, the form of the head, the compound eyes, the ocelli, the antennæ, and the jaws. Nineteen plates are likewise devoted to the illustration of the various forms of these curious Myriopods, giving full detail of their structure and ornamentation. One form of King-crab is also described under the name of *Prolimulus Woodwardi* (Fritsch). The shales in which these remains abound are pyritous, and the fossils in them very rapidly perish. In order, therefore, to rescue the evidence of these organisms from destruction, the author has hit upon the idea of making electrotypes of all the important specimens, which thus become permanent records in the Prague Museum. This is no novel process, however, as Jules Marcou introduced the same method of electrotyping the Trilobites of Canada forty years ago.

One cannot fail to be impressed by the great antiquity of these curious forms of many-jointed terrestrial air-breathers, which even at this early geological period enjoyed so wide a geographical distribution over the globe. Their primitive character and simple elongated forms, with sometimes cylindrical, sometimes flattened body, present the greatest resemblance to the Annelids in the serial similarity of the rings of the body and in their mode of locomotion.

The genera described by Dr. Fritsch embrace *Acantherpestes*, 3 species; *Euphoberia*, 2 species; *Isojulus*, 3 species; *Pleurojulus*, 6 species; *Anthracojulus*, 1 species; *Pylojulus* (*Xylobius*), 4 species; *Acroglomeris*, 2 species; *Archiscudderia*, 5 species; *Glomeropsis*, 4 species; *Hemiphoberia*, 1 species; *Purkynia*, 1 species; *Heterovorhoefia*, 1 species; and *Sandtneria*, 1 species.

The Arachnoidea also appear to claim a very early place among the air-breathers in geological time. No scorpions are here figured by Dr. Fritsch, although some of the earliest examples of this remarkable type were obtained by Count Sternberg from Bohemia. The spiders are represented by the genera *Hemiphrynus*, 2 species; *Promygale*, 3 species; *Arthrolycosa*, 3 species; and *Pyritaranea*, 1 species. On plate cliii is figured a remarkable example of *Arthrolycosa prolifera*, a female having a cocoon of well-developed young attached to its body. Enlarged figures of some of the embryo spiders are given. One is at a loss to understand how the small shells known as *Spiroglyphus vorax* happen to be found attached to the body of a spider (*Promygale rotundata*, pl. cliii, fig. 4); these small discoidal spiral shells were formerly considered as the cases of marine, or at least aquatic, Annelids. They were probably forms of some kind of parasitic tube-dweller, perhaps terrestrial.

We cannot help expressing regret that the draughtsman who prepared the plates had not possessed a more delicate and artistic perception of the objects he has delineated. They might have been made so much more beautiful by being less coarse and heavy in execution, and the expenditure in colouring seems to us to be after all of doubtful value compared with extreme accuracy of minute detail and correct drawing of the outlines.

All praise is due to Dr. Fritsch for the earnest labour he has bestowed for so many years in bringing out his great work on the fauna of the Gas-coal of Bohemia. It has cost the author much money, which we fear he will never be recouped; but students of palæontology all over the world cannot fail to be grateful to him for making them acquainted, by means of this work, with the rich and varied fauna of the Permo-Carboniferous Series of Bohemia.

IV.—The International Geography. By Seventy Authors. Edited by Hugh Robert Mill, D.Sc., F.R.S.E., etc. 8vo; pp. xx and 1,090, with 488 Illustrations. (London: George Newnes, Limited, 1899. Price 15*s*.)

If any evidence were wanting in order to prove the vast and ever-increasing importance which a knowledge of geography has of late years assumed, we have but to turn to the enormous development which the closing years of the century has witnessed in the issue of maps, both geological and topographical, and the cheapening of their production so as to bring them within the reach of all who seek for such knowledge as they convey.

Along with maps of all kinds, come naturally in importance handy books of reference bearing upon all questions of geography which maps portray graphically, but do not explain so fully as can be done in a textbook. Dr. Hugh Robert Mill, from the vantage-ground of his position as an officer of the Royal Geographical Society of London, has been enabled, with the aid of a whole army corps of authors, to bring together in a little over 1,100 well and clearly printed pages, a complete summary of the globe, arranged under countries, giving in each case an account of its general configuration and geology, its river-systems, climate, natural resources, and a brief notice of its fauna and flora. The several peoples are described as to race, language, history, and mode of government; with their manufactures and external trade; and especially the main industries peculiar to each country; with their system of internal communications. The political divisions are considered individually, together with notices of towns. All towns with populations of 100,000 and upward are separately noticed, and all other towns which are of special importance. In every case where it is possible, the characteristics of the site which determines the position of a town, or the geographical conditions which minister to its prosperity, have been noticed. A statistical table, giving the area and population at the last two censuses of the whole country, and in federal countries of the constituted states; the average values of exports and imports for three five-yearly periods, ten years apart, e.g., for 1871–75, 1881–85, 1891–95, have been taken, and the chief towns with their population at the two last censuses.

The introductory general discussions of mathematical, physical, commercial, and political geography are written from a strictly *geographical* point of view, and in a purely *general* manner, referring only to such phenomena or conditions as are not restricted to particular regions. The object has been, not to give a treatise on the subject named, but to supply the few general facts and principles necessary to the comprehension of the special geography of each individual country. The general description of each continent refers only to the largest and most determinative features, and these are taken in the following order: coasts, surface, geology, climate, flora, fauna, anthropology, history, including territorial changes of the largest order.

To afford some further insight into the arrangement of the work we may mention that the principles and progress of geography are treated by Dr. H. R. Mill; mathematical geography, dealing with the form and dimensions of the earth, and the methods employed for determining and representing the positions of places upon its surface, a chapter full of most valuable and concise information, is by Dr. A. M. W. Downing, F.R.S.; maps and map-reading, by the veteran cartographer, E. G. Ravenstein; the plan of the earth, dealing with its form, is by Dr. J. W. Gregory, F.G.S., of the British Museum,[1] and treats of "the tetrahedral theory of the earth," which we need not now discuss here, but refer our readers to this work and to Gregory's original paper (Geographical Journal, 1889, vol. xiii, p. 225).

The next chapter on "Land-Forms," by Dr. Hugh Robert Mill, treats of the relative divisions of the earth's crust into oceanic plateau, continental slope, continental plateau, and culminating area; of land-forms, of the materials of the earth's crust, giving the nature of the geological formations, their order of succession, and the subsequent forms and features produced by crustal movements, subaerial and marine denudation, and the result of rivers. Sir John Murray and Dr. Mill follow with a chapter on the oceans, which is concise and up to date. In this, as in other parts of the work, in consequence of the earnest effort made to condense the greatest amount of information into the smallest possible space, the 488 text-illustrations suffer in consequence, both in size and quality, and some of them hardly do justice to the work. This will, we hope, be recognized, and remedied in a second edition, which is certain to be called for. Mr. H. N. Dickson follows with a chapter on "The Atmosphere and Climate"; and Professor J. Arthur Thomson, on "The Distribution of Living Creatures," in which the author discusses that most interesting question, the relation of the dry-land and fresh-water faunas to the littoral fauna, the pelagic, the deep-water, and the abyssal faunas, and suggests that a *littoral* fauna was probably the original one whence have been derived on the one hand the pelagic and abyssal faunas, and on the other those of the fresh waters and dry land. Professor Brooks, on the contrary, maintains that the pelagic fauna was primitive, for there the conditions of life are easiest; while Sir John Murray takes the fauna of the 'mud-line,' i.e. the boundary between the abyssal and the littoral (or neritic) regions at an average depth of about 100 fathoms, as the primitive life-zone. Here the minute organic and inorganic particles derived from the land and surface-

[1] Just appointed (as we write) to the Chair of Professor of Geology in the University of Melbourne, Victoria, Australia.

waters find a resting-place upon the bottom, the great feeding-ground of the ocean, and which seems to be very densely peopled. He holds to the view "that in early geological times there was a nearly uniform high temperature over the whole surface of the globe, and a nearly uniformly distributed fauna and flora; and that with the gradual cooling at the Poles, species with pelagic larvæ were killed out or forced to migrate towards the Tropics, while the great majority of the species which were able to survive in the Polar areas were those inhabiting the mud-line" (p. 95).

"The Peoples of the Earth and the Distribution of Mankind," which forms the subject of a chapter by A. H. Keane, deals with the human race from a geological as well as a zoological standpoint. Of course, the Pliocene man from Java, *Pithecanthropus erectus* (spelt in error 'erect*is*'). takes a prominent place, but we have always felt that Dr. E. Dubois's discovery rested upon extremely slender evidence, and that too large a superstructure of theory should not be built upon so small a foundation of fact. After treating of the various races of mankind, the writer remarks that from Neolithic times the Ethiopic and American groups have been losing, whilst the Caucasians and Mongols have been everywhere gaining ground, with results expressed in terms of population as under:—

Caucasians	770,000,000
Mongols	540,000,000
Ethiopians	175,000,000
Americans	22,000,000
Total	1,507,000,000

We can only hope that in the struggle of races the Caucasian may maintain his superiority over the Mongol, but time alone will show whether he will be able to do so or not.

Part I ends with a chapter on Political and Applied Geology, by Dr. J. S. Keltie, Secretary of the Royal Geographical Society, carrying us to p. 121, which may be considered to conclude the introductory matter of the volume.

Part II contains the sum and substance of the work itself. Commencing with the geography of Europe, pp. 123–421, Asia follows next, pp. 422–574, taking in Japan and the East Indian Islands. The next section deals with Australia and Polynesia, pp. 575–663. North America commences book 4, pp. 664–781. Central and South America occupy book 5, pp. 782–888. Africa forms book 6, pp. 889–1024. The last section of the book treats of the Arctic and Antarctic regions (pp. 1025–1053), a chapter full of interest both for geologists and geographers.

As a proof of the value of this book as a handy work of reference, it may be mentioned that the index contains about 15,400 names of places described and localized in the body of the work, besides references to temperatures, winds, climate, population, animals, plants, geology, minerals, rivers, mountains, fisheries, timber, and endless other matters that may well be included in such a comprehensive work.

We are much indebted to the editor and his vast array of authors for this valuable volume, which is certain to find a place in every scientific library, and in every series of books of ready reference in both private and public libraries in England, America, and our Colonies.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—November 22, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair.

The President, having requested all present to rise from their seats, expressed in feeling terms the sorrow felt by the Society at the unexpectedly sudden loss of an esteemed Fellow and genial friend, Dr. Henry Hicks, F.R.S., V.P.G.S., to whose energy and perseverance the Quarterly Journal owed so many papers, and from whom many more valuable contributions might have been expected in the years to come. The following resolution had been passed by the Council that afternoon, and a copy thereof had been communicated to Mrs. Hicks with an expression of sincere sympathy:—

"That the Council desire to place on record their great grief at the loss which Geological Science and the Geological Society have sustained by the death of their Vice-President, Dr. Henry Hicks, who so recently occupied the Presidential chair, and so energetically attended to the welfare of the Society."

The President then said that the Society had to deplore another severe loss in the person of their revered friend, Sir J. William Dawson, C.M.G., F.R.S., who died at Montreal on Sunday, the 19th inst. The Council had passed the following resolution:—

"That the Council have heard with deep regret of the decease of the old and valued Fellow of the Geological Society, Sir J. W. Dawson, who for nearly fifty years has taken an active part in advancing geological knowledge in general, and more especially with regard to the great Dominion of Canada; and they desire to assure Lady Dawson, and the distinguished Fellow of the Society, Dr. George Dawson, of the Council's sincere sympathy in their loss."

The following communications were read:—

1. "On some Remarkable Calcisponges from the Eocene Tertiary Strata of Victoria (Australia)." By George Jennings Hinde, Ph.D., F.R.S., F.G.S.

The greater number of the sponges described were discovered by Mr. T. S. Hall, M.A., of Melbourne University, in incoherent detrital beds of Eocene age, in the southern part of Victoria; a few were picked out of some washings of fragmental polyzoa from the same district and horizon, by Mr. B. W. Priest. Some of the specimens are in an extremely perfect condition, and their structural details are as distinctly shown as in recent sponges. They are also of more than local interest in that they are the first fossil forms described of a group of calcisponges, the Lithonina, characterized by the peculiar aberrant forms of some of the spicules, and the mode in which they are closely fitted and organically fused together to form the skeletal mesh. This structure has, so far, only been recognized in one recent species, *Petrostroma Schulzei*, Döderlein, from the Japanese Sea.

The sponges are small, unattached, with a glassy, firm, resistant skeleton, calling to mind that of siliceous Lithistida. They are built up of a great variety of spicular forms; some are simple rods, with three- and four-rayed spicules, similar to those in recent calcisponges; but the majority are aberrant four-rayed forms, with three of the rays curved and with obtuse or expanded ends which are clasped, and fused as well, to the surfaces of adjacent spicules. The connected spicules form continuous anastomosing or radial fibres resembling those in the fossil Pharetrones, to which they are in some other respects similar, and it is probable that the spicules in the fibres of some members of this family were likewise organically cemented together. The common *Porosphæræ* from the Upper Chalk, generally regarded as Hydrocorallines allied to the recent *Millepora*, are also closely related to the above sponges, and the author hopes shortly to publish the evidence for their affinity to this group.

The Victorian sponges are placed in four new species, belonging to three genera: two of these are new; the other, *Bactronella*, Hinde, was founded on some peculiar calcisponges of Jurassic age, now known to be Lithonine in character.

2. "The Silurian Sequence of Rhayader." By Herbert Lapworth, Esq., F.G.S.

This paper opens with a general reference to the Ordovician and Silurian complex of Central Wales, and a notice of the geological work hitherto done in the region. The stratigraphical relations of the Silurian formations which occur in the country surrounding the town of Rhayader (Radnorshire) are then described in detail. Typical and confirmatory sections are given, demonstrating the complete local sequence of the rocks of the Rhayader district. These are illustrated by lists of characteristic graptolites. These fossils are compared with those of Southern Scotland, Sweden, and North Wales, showing that the graptolite succession is everywhere similar, and fixing the age of the Rhayader Series as representing the Lower Llandovery, Upper Llandovery, and Tarannon of other areas. Finally, several new species of *Climacograptus* and *Diplograptus* are described.

The author establishes the following sequence :—

Rhayader Group (Pale Shales).			= Gala and Tarannon Group.
Caban Group.	Gafallt Beds.	Gafallt Shales.	= Upper Llandovery, May Hill, and Upper Birkhill.
		M. Sedgwicki-grits.	
	Caban Conglomerates.	Upper Conglomerate.	
		Intermediate Shales.	
		Lower Conglomerate.	
Gwastaden Group.	Gigrin Mudstones.	Pale Grey Mudstones.	= Lower Llandovery and Lower Birkhill.
		Zone of *M. convolutus*.	
		Calcareous Nodule-beds.	
	Ddôl Shales.	Zone of *M. fimbriatus*.	
		,, *M. cyphus*.	
		,, *M. tenuis*.	
	Dyffryn Flags.	*D. modestus*-flags.	
		Rottenstone Beds.	
		Micaceous Flags & Grits.	
	Cerig Gwynion Grits.		
	Blue-black Shales.		= Bala and Hartfell.

No single section, taken in any direction across the Rhayader country, shows the complete succession. In any area some one group is always better developed than others; and some portion of at least one group is certain to be missing. The lowest, or Gwastaden Group, has a maximum thickness of over 1,800 feet. It is underlain, apparently conformably, by highly cleaved dark-blue shales, and overlain unconformably by both the Caban and Rhayader Groups. The base of the Gwastaden Group is formed of a thick mass of grauwackes, which thin to the east and thicken to the west. They contain *Climacograptus*, and pass up into mixed flags and grits with *Climacograptus* and *Diplograptus*. These are succeeded by shales and mudstones in which the first Monograptidæ appear. These become dominant in the upper part.

The succeeding Caban Group has a maximum thickness of 1,500 feet. Its lower division consists of two massive conglomerates, separated by shales; its higher division is made up of fine-grained grits, shales, and flags. Each member of the group is overlapped to the east by the next subgroup above it, until eventually the whole group disappears beneath the Rhayader Pale Shales, which in the eastern areas rest directly on the Gwastaden rocks.

The Rhayader Group consists of pale-green, blue, and grey shales and mudstones, which overstep on to the Gwastaden beds; and may possibly pass completely over them, and rest on the dark shales farther east.

After the Gwastaden rocks were laid down, the sea-floor appears to have been elevated and denuded, a hollow being scoured out to the eastward. Rapid sinking followed, and the sea filled the hollow with the Caban sediments, practically levelling it up by the time that the deposition of the Pale Slates began.

Tables of fossils enable the author to establish a complete comparison of the whole of the local zones of the Rhayader district with those of Southern Scotland, Wales, and Sweden. In the Rhayader area we find, for the first time in Britain, the entire Valentian succession developed in one general sequence of rocks, with a more or less common lithological character, and with a fauna composed throughout of similar palæontological types.

II.—December 6, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair.

Dr. Blanford said that he had been asked by Professor Judd, who was unable to attend, to say a few words about certain photographs sent by Mr. E. H. L. Schwarz, and representing the Dwyka boulder-bed and the rounded and grooved underlying surface, in the neighbourhood of the Orange River near Hopetown and Prieska. The importance of these photographs lay in the evidence which they afforded on a disputed point. Dr. Sutherland and Mr. Griesbach had called attention to the evidence of ice-action presented by the Dwyka Conglomerate in Natal, and additional evidence had been brought forward by several observers, especially by Mr. Dunn from the Orange Free State and Cape Colony, and recently by Dr. Molengraaff from the Transvaal. Other observers, however, and especially the late Professor Green, had disputed the glacial origin of the Dwyka beds. The photographs now exhibited would, the speaker thought, convince most geologists that the phenomena presented were due to ice-action. The resemblance to similar photographs shown to the Society in 1896 by Professor T. W. Edgeworth David, and representing the beds corresponding to the Dwyka Conglomerate in South Australia, was noteworthy. Evidence of glacial action in Upper Palæozoic times had gradually accumulated from India, Australia, and South Africa, and there was a probability that similar indications existed in South America.

The following communications were read:—

1. "On the Geology and Fossil Corals and Echinids of Somaliland." By Dr. J. W. Gregory, F.G.S.

British Somaliland consists of a high plateau, of which the northern scarp is separated from the Gulf of Aden by a belt of low hills and plains known as the Guban. The southern plateau consists of Archæan gneisses, quartzites, amphibolite-schists, chloritic schists, and pegmatites. It is capped by purple grits, red sandstones, and conglomerates, which are covered by limestones of Neocomian, Turonian (? Cenomanian), and Eocene ages. The Neocomian limestone, which may be correlated with that of Singeli described by Rochebrune, occurs at Dobar in the Guban; while a Jurassic limestone, probably of Bathonian date, occurs at Bihendula in the Guban. Fossils collected from these limestones and from raised reefs of Pleistocene age, by Mr. and Mrs. Lort Phillips, Miss Gillet, Mr. G. P. V. Aylmer, Captain E. T. Marshall, and Mr. F. B. Parkinson, have been examined by the author, who tabulates a list of corals and echinids. One new genus and fourteen new species of corals are described, belonging to the genera *Stylophora, Stylina, Columnastræa, Prionastræa, Favia, Metethmos, Cyclolites*, and *Litharæa*, and one new species of *Pseudodiadema*. The evidence of the collections is sufficient to show that a Neocomian limestone occurs both on the summit of the Somali plateau and on the floor of the Guban, and that some marine limestones of Lower Tertiary age (probably Eocene) also occur on the plateau. It is therefore evident that the foundering of the Aden Gulf is post-Eocene in age.

2. "Note on Drift-gravels at West Wickham (Kent)." By George Clinch, Esq., F.G.S.

The author describes two beds of Drift-gravel at West Wickham. The first, occupying the bottom of a dry valley, yields, in a section exposed at Gates Green, material derived from the Chalk and the Lower Greensand; and distinct, although perhaps not direct, relation with the denudation of the Weald is claimed for it. The other bed of gravel is of later age, and has yielded many Palæolithic implements and flakes. The specimens of these exhibited were found by the author between 1880 and 1885, and they establish the existence of Drift-gravels about a mile south of Hayes Common. Some of the implements have lost their pointed ends and bear other indications of use, many are smoothed and rounded by Drift-wear, but a few are entirely unworn, while some, particularly the larger examples, are bruised and crushed by such influences as the ploughshare and waggon-wheels. Most of the implements have a superficial colouring, varying from a pale straw-tint to a rich ochreous-brown. "The association of much-worn implements, unworn implements, and flakes, cores, and waste-chips, in the same bed of Drift-gravel points to the fact that we have here a collection of material which was brought from a great variety of places, and has undergone a great variety of conditions and changes."

3. "On the Occurrence in British Carboniferous Rocks of the Devonian Genus *Palæoneilo*, with a Description of a New Species." By Dr. Wheelton Hind, B.S., F.R.C.S., F.G.S.

The family Nuculidæ is represented in Carboniferous rocks by the genera *Nucula, Nuculana*, and *Ctenodonta*, and to these must now be added *Palæoneilo*, which the author describes from two fine specimens in the Museum of Practical Geology, from Carboniferous Shale (Yoredale Shale) south of Hammerton Hall, Slaidburn, Yorkshire. It is remarkable that a genus so well developed in Devonian times should be found at the top of the Carboniferous Limestone Series, but not in intermediate beds. Hall's diagnosis of the genus is given, with additional remarks, and a new species is described and contrasted with *Ctenodonta* (*Palæoneilo*) *lirata*, Phil., from the Devonian of Baggy.

CORRESPONDENCE.

THE GENERA *APATOKEPHALUS* (BRÖGGER) AND *TRAMORIA* (REED).

Sir,—With reference to the fauna of the Waterford Ordovician beds, it will be of interest to the readers of the Geological Magazine to learn that Professor Brögger informs me that the trilobite which I have recently described (Q.J.G.S., vol. lv, 1899, p. 758, pl. xlix, figs. 14–16) as *Tramoria punctata*, gen. et sp. nov., belongs without any doubt to the genus *Apatokephalus*, which was established by him in 1896 ("Ueber die Verbreitung der Euloma-Niobe Fauna [der Ceratopygenkalkfauna] in Europa," *Nyt Magazin fur Naturvidenskaberne*, Bd. xxxv, 1896, pp. 179–185, 200) for a group of species related to *Dikellokephalus* occurring in the widely distributed Euloma-Niobe fauna. In this country this fauna is contained by the Shineton Shales and the Tremadoc of North Wales. The form named by Salter *Conocoryphe invita* belongs to this new genus *Apatokephalus*, and the following species from Europe and America are also mentioned by Brögger as occurring in beds with this Euloma-Niobe fauna :— *Apatokephalus serratus*, Boeck; *A. angusticauda*, Ang.; *A. finalis*, Walcott; *A. Schlotheimi*, Billings; *A. magnificus*, Billings. We have now to add *Apatokephalus punctatus* to the above list, and the generic name *Tramoria* must be dropped.

Professor Brögger adds that this identification lends important support to my view that the fauna of the Waterford beds has a facies resembling that of the homotaxial Scandinavian beds, especially of the Asaphus Stage (Ét. 3, Brögger). The occurrence of genera characteristic of the Euloma-Niobe fauna in beds of a higher stratigraphical horizon in Wales, and their association with a later fauna of a different character in shallow-water deposits, are facts also noticed by Brögger in the paper referred to. With regard to the wide geographical distribution of this fauna and the presence of its most characteristic genera of trilobites in distant areas, Brögger shows that it extended from 65° N. lat. to 43° N. lat., and is represented not only in Sweden but at Hof in Bavaria, St. Chinian in Languedoc, Shropshire, North Wales, and America, wherever the bionomical conditions were favourable. No barrier, therefore, between the Baltic and British provinces can have existed at this time, and it is shown that the supposed distinct characters of the trilobitic faunas are based upon an erroneous separation of genera and species owing to a want of acquaintance with foreign specimens.

F. R. Cowper Reed.

Woodwardian Museum, Cambridge.
November 29, 1899.

THE GEOLOGICAL SURVEY OF EGYPT.

Sir,—Since the commencement of this Survey in October, 1896, the officers attached have carried out a geological and topographical reconnaissance over a large portion of the country, besides a certain amount of more detailed work in some areas. During this time many new facts have been brought to light, in numerous cases necessitating entirely different conclusions to those arrived at by earlier observers in the same field.

Unfortunately, up to the present, the Egyptian Government has not been able to publish any maps or descriptions of the regions surveyed, and even if, as proposed, publication is undertaken in the coming year, a considerable time must necessarily elapse before the accumulated results of three years can be brought out.

In an abstract report in the *Zeitschrift für praktische Geologie* for November, 1899, of a paper entitled "Neues zur Geologie und Paläontologie Aegyptens," by Dr. Max Blanckenhorn, the following statement occurs:—"Den von v. Zittel beschriebenen Cenomanvorkommen reihen sich zwei neue im eigentlichen Aegypten gelegene und von Blanckenhorn gefundene an. Das erste liegt im O. des Nils am Gebel Chebrewet; das zweite, westlich des Nils gelegene, ist das der Oase Baharia mitten im Eocänplateau der Libyschen Wüste. Das letztere weist auch in Limonit umgewandeltes Holz (*Palmoxylon*) und gut erhaltene Abdrücke von Dicotyledonenblättern in demselben Versteinerungsmittel auf, ein vielversprechender Aufschluss über die Kreideflora Aegyptens."[1]

As the copy of this abstract report was sent to this Survey by Dr. Blanckenhorn himself, I am forced to conclude that he claims to have himself discovered the existence of rocks of Cenomanian age in Baharia Oasis, which as far as I know he has never visited, and can only have derived his geological information from an examination of my own specimens.

In view of this, it is advisable to put on record some of the more important conclusions at which I have arrived. They are briefly as follows:—In 1897 the discovery of the existence of extensive faults along the west margin of the Nile Valley, and the absence of high fluviatile deposits, pointed to the conclusion that the Nile gorge is not a "valley of erosion," but probably a line of rift and faulting. In 1899 similar faults were again found along the east side between Assiut and Kena.

A thick and extensive series of limestones, tufas, clays, sandstones, and pebble-beds has been shown to occur throughout the Nile Valley, from Esna to the Fayoum on the west side and from Kena to Minia on the east, during work carried on between 1896 and 1899. Although they are generally of fresh-water origin, Mr. Barron and I, by the discovery of marine foraminifera in these beds near Luxor in January, 1897, showed that marine conditions existed far up the Nile Valley in comparatively recent times, these beds being probably of Pliocene age. In 1897 an extensive series of fossiliferous Cretaceous beds of Cenomanian to Danian age was discovered and mapped in Baharia Oasis, and the junction of the Cretaceous and

[1] To the occurrences of Cenomanian rocks described by Zittel are added two new ones, situated in Egypt proper. The first lies on the east of the Nile at Gebel Chebrewet; the second, situated on the west of the Nile, is that of the Oasis of Baharia in the midst of the Eocene plateau of the Libyan Desert. The latter also shows wood (*Palmoxylon*) converted into limonite, and well-preserved impressions of Dicotyledonous leaves in the same matrix. This exposure promises to afford valuable information as to the Chalk-flora of Egypt.

Eocene in this area was found to be marked by a strong unconformity and overlap. This had never been previously recognized in Egypt. In 1898 the existence of thick bone-beds, probably of considerable commercial value, was discovered in the Oasis of Dakhla. Again, in 1897, in the Abu Roasch district, near the Pyramids of Giza, the junction of the Cretaceous and Eocene was again found to be unconformable, instead of being marked by lines of fault, as formerly supposed. In the Western desert, and in one case in the Eastern desert also, igneous intrusions have been discovered at isolated spots in the sedimentary areas.

This brief statement of a few of my own results is rendered still more necessary in view of the fact that there are at the present time several observers about to visit the same regions. The details connected with these questions will probably be dealt with in the Survey Memoirs.

HUGH J. L. BEADNELL.

CAIRO, *7th December*, 1899.

ORGANIC REMAINS FROM CAMBRIAN ROCKS OF BRAY.

SIR,—The question of the age of the ancient beds of Bray and Howth has recently attracted some attention in connection with the additions to our knowledge of Cambrian and Pre-Cambrian rocks in other places. The true nature of the real or supposed fossils in these Irish beds is therefore an urgent one. *Oldhamia* has been obliged to submit to a verdict of Not proven, at the best. It is naturally asked whether *Histioderma* is to meet with a similar fate. Unfortunately, inquiries from various workers elicited the fact that the type-specimen was missing from the Irish Survey Collection.

Recently, however, in rearranging the mineral collection of the Royal College of Science for Ireland, we were fortunate enough to find four specimens of *Histioderma*, with their original tablet; these have now been restored to the Survey Collection, and will be exhibited in the Museum of Science and Art, Dublin. Two of the specimens are the internal and external casts of the same object, the former being the actual specimen figured as *Histioderma Hibernicum* by Dr. J. R. Kinahan in his paper "On the Organic Relations of the Cambrian Rocks of Bray and Howth; with Notices of the most remarkable Fossils": Journ. Geol. Soc. Dublin, vol. viii (1858), pp. 68–72, pl. vi, fig. 2.

A moment's examination of the actual specimens is enough to remove all doubt of the organic nature of *Histioderma*. It consists of a cup-shaped expansion, with two sets of approximately parallel ridges which intersect each other obliquely, and a conical root-like continuation below. Without denying the possibility of the correctness of Kinahan's explanation that the ridges represent the tentacles of an annelid, we cannot help thinking that the general appearance rather suggests that they are lines of thickening in a continuous muscular envelope.

GRENVILLE A. J. COLE.
JOHN W. EVANS.

ROYAL COLLEGE OF SCIENCE FOR IRELAND.
December 16, 1899.

Very truly yours
Osmond Fisher

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

No. II.—FEBRUARY, 1900.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists: Rev. Osmond Fisher, M.A., F.G.S.

(WITH A PORTRAIT, PLATE III.)

THE subject of this notice belongs to a family of which several members have occupied high positions as clergymen and scholars. His father, the Ven. John Fisher, the early friend and patron of Constable, was Archdeacon of Berks, Canon of Salisbury, and Vicar of Osmington and Gillingham in Dorset; his grandfather, the Rev. Philip Fisher, D.D., was Master of the Charterhouse; and his great-uncle, the Rev. John Fisher, was preceptor to the Princess Charlotte, and subsequently Bishop, first of Exeter and afterwards of Salisbury.

Osmond Fisher was born at Osmington on November 17, 1817, and was named after the patron saint of his father's church. The district is an interesting one for geologists, and, while a mere child, Osmond used to accompany his uncle, the Rev. George Cookson, when collecting fossils in the neighbouring cliffs. At the age of 11 he was sent to Eton, where two years were spent under the fiery Dr. Keate without his receiving a single lesson in arithmetic. A year at home, spent in pursuing his natural bent for science, was followed by his removal to the house of his uncle, the Rev. W. Fisher, at Poulshot, in Wiltshire. Here he took up geology again, made out the structure of the neighbourhood (on the same horizon as Osmington), and collected fossils from the Coral Rag and other strata, some of which are now in the Woodwardian Museum. During the next two years he lived with his grandfather, the Master of the Charterhouse, and studied at King's College, London, where he began to read mathematics. He also heard one or two lectures from Lyell and Daniell, who were then Professors at the College, and roamed about the geological galleries of the British Museum.

In 1836 Fisher proceeded to Jesus College, Cambridge; and, though equally capable of taking a classical degree, fortunately decided on a mathematical career. After degrading a year on account of ill-health, he graduated as 18th wrangler in 1841. He was ordained deacon in 1844, and at once took the sole charge of his uncle Mr. Cookson's living at Writhlington, near Radstock, in the Somerset Coalfield, and was also elected a Fellow of his College.

In 1845 he was ordained priest, resided for a short time at Cambridge, and in the following year was appointed curate-in-charge of All Saints, Dorchester, where he lived for seven years. Here his leisure time was spent in geologizing along the Ridgway fault and in the neighbourhood generally. He frequently visited his uncle, Mr. Cookson, at Poorstock, near Bridport, and collected many fossils from the Inferior Oolite there, which are now in the Woodwardian and Dorset County Museums, the latter of which he assisted in founding. While he was at Dorchester the Geological Survey began mapping the district, and Mr. Fisher was able to give many hints to Mr. Bristow, who was in charge of the work. He also met A. C. Ramsay and E. Forbes when they came down to inspect its progress.

In 1853 Mr. Fisher became tutor of Jesus College, Cambridge. He had on previous occasions attended some of Sedgwick's lectures, and so made an acquaintance, which now ripened into friendship. Sedgwick had been his proposer when he was elected a Fellow of the Geological Society in 1852.

The busy life of a College tutor left little leisure for geology in term-time, but the vacations were still spent in Dorchester, where he worked hard at the Purbeck rocks. The results of his studies are contained in a paper read before the Cambridge Philosophical Society in 1854. The greater part of the collections he made at this time are now in the Woodwardian Museum, and include a series of fossil insects which have never yet been described. He afterwards took up the geology of the Bracklesham Beds, and gave the results of his investigations in a paper read before the Geological Society in 1862. The fossils then obtained are likewise to be found in the Woodwardian Museum.

In 1857 Mr. Fisher was presented by his College to the living of Elmstead, near Colchester, and was married to Maria Louisa, daughter of Mr. Hastings N. Middleton, then residing at Ilsington House, near Dorchester. While at Elmstead he spent a week with Henslow in Suffolk, and afterwards collected a little from the Crag and Pleistocene beds at Walton-on-the-Naze. In the absence of other more interesting subjects, he now turned his attention to denudation. His work on the 'trail,' which was done at this time, is perhaps one of the most important of his purely geological investigations. In 1867 he removed to Harlton Rectory, another College living, but shortly afterwards was left a widower, with five sons, all of whom are now living.[1]

Harlton is a quiet country village about six miles from Cambridge, far enough from railway-lines and main roads to acquire a certain sense of retirement, but close enough to a great centre of learning to stimulate thought and encourage original investigation. There are few villages in England so well known by name to geologists, many of whom have experienced the kindly hospitality of its present Rector.

[1] Some of the facts above given are, by the kind permission of the anonymous author, taken from an article in the *Cambridge Review*, March 16, 1893.

Mr. Fisher's removal to Harlton was almost concurrent with a change in the nature of his work. Pure geology was not, indeed, neglected, but it gradually gave place to the study of the great problems presented for solution by the earth's crust. The British Association met at Norwich in 1868, and Mr. Fisher was invited to open the proceedings of the Geological Section with a paper on the "Denudations of Norfolk." The coprolite deposits of the Cambridge Greensand and the mammaliferous deposits at Barrington also occupied a good deal of his attention, and form the subjects of papers read before the Geological Society in 1872 and 1879.

It is interesting to notice that Mr. Fisher, who is now the foremost opponent of the contraction theory, was many years ago one of its strongest advocates. He was, indeed, an independent discoverer of the theory. It occurred to him as early as 1841, the year in which he took his degree, and was suggested by the ridging up of cracked and re-frozen ice in one of the locks of the river Cam. In his delight at the discovery, he tells us, he forthwith vaulted over a five-barred gate. The idea, however, lay apparently dormant for many years; and it was not until April, 1868, that the first of his three well-known memoirs was read before the Cambridge Philosophical Society. At this time Mr. Fisher was orthodox in his views. He accepted the solidity of the earth's interior on the authority of Lord Kelvin as "almost certain," and considered that the outer crust would lose the support of the inner portions "probably from the effects of contraction in cooling."

When he is presented with a new theory, Mr. Fisher's first impulse is to test it numerically. The cause invoked may be a true one, but is it also sufficient? Is it capable of producing effects of the amount as well as of the kind observed? Here the mathematician steps in with advantage and offers useful aid to the geologist. In Mr. Fisher's first memoir the process is applied to the contraction theory. He shows that, if an outer spherical shell could be isolated from the mass within, it would at once be crushed by lateral pressure till it rested on that mass. The contraction theory thus invokes a true cause of rock-folding. To prove the sufficiency of the theory, he calculates roughly the order of magnitude which mountain-ranges, if so formed, might be expected to assume; and concludes that "the theory seems to be at any rate not deficient in its capability for producing the results attributed to it."

Five years later, in June, 1873, we find Mr. Fisher defending the contraction theory against Captain F. W. Hutton in the pages of this Magazine; but, within a very few months, his allegiance to the theory must have begun to waver. The paper referred to contains the groundwork of his estimate of the mean height of the surface-elevations of the globe. He was then led to calculate more closely the mean height of the elevations that would be produced by the contraction of the earth in cooling; and his work is described in a second memoir read before the Cambridge Philosophical Society in December, 1873. The discrepancy is so great (more than 9000 feet in the one case, and less than 800 feet in the other) that Mr. Fisher felt compelled to give up the contraction theory in its original form. Crust-folding he still attributed to lateral pressure brought into action by a shrinking interior, and he refers, though not with entire approval, to the view which he repeated in the first edition of his future work that the earth consists of a solid crust and nucleus with an intervening liquid layer.[1]

The third of the Cambridge memoirs, read in February, 1875, shows that his belief in such a constitution had gradually strengthened; for he investigates the form into which a uniformly thin flexible crust would be thrown if the support of the liquid substratum were from any cause withdrawn.

About this time, the direction of Mr. Fisher's inquiries was slightly changed. Mr. Mallet had shortly before published his well-known memoir dealing with the origin of volcanic energy. There is a fascination about the theory he advanced, but Mr. Fisher's quantitative analysis at once laid bare its weak point, though several months elapsed before the controversy was closed.

The evening of an active life can hardly be better employed than in revising the work of earlier years, and this is especially the case when that work has been devoted mainly to the solution of a connected series of problems. It can then be regarded almost as calmly as if it were another man's; there is ample time for considering criticisms without bias, for filling up gaps, and for exhibiting all the different portions in their true relations to one another. In 1880, at the age of 63, Mr. Fisher began the work with which his name will always be connected. The "Physics of the Earth's Crust" is, however, not merely a reprint or revision. It included, indeed, all those parts of his memoirs which seemed to him worthy of preservation, but the additional material forms a notable fraction of the whole. The book was published at the end of 1881, and in spite of its highly technical character, has from the very first met with a considerable sale.

Many a man, after so great a success, might have been content to rest upon his laurels. But Mr. Fisher seems to have regarded this first edition as a mere instalment, as a kind of guarantee that his work should not be wasted by sudden illness or death. During the years which followed he has not ceased to strengthen his theory, by building up fresh defences and by raids into the enemy's country. By 1889 a second edition had in his opinion become necessary (the remainder of the first being withdrawn from sale), and in 1891 this was supplemented by an appendix of three additional chapters.

Besides the papers incorporated in the "Physics of the Earth's Crust," Mr. Fisher has written many others, which have appeared in different scientific journals. The last of the series was published only seven months ago in the Philosophical Magazine, and deals with the residual effect of a former Glacial epoch upon underground temperature.

The Geological Society, always so ready to welcome the contributions of mathematical geologists, awarded Mr. Fisher the balance of

[1] At present he regards the solidity or otherwise of the nucleus an open question.

the proceeds of the Lyell Fund in 1887, and the Murchison Medal in 1893. In 1878 he was appointed Honorary Fellow of King's College, London, and in 1893 Honorary Fellow of Jesus College, Cambridge. In 1895 his portrait was painted by Mr. Coney. A copy of the picture was subsequently made by Mrs. H. A. Morgan, and accepted by the Society of Jesus College, in the hall of which College it now hangs. The admirable photograph here reproduced was taken by Mr. R. H. Lord of Cambridge in 1898.

The "Physics of the Earth's Crust" with its appendix may be said to consist of two distinct parts, a destructive part and a constructive part. In the first Mr. Fisher is chiefly occupied by a criticism of the contraction theory from the point of view of its insufficiency to account for existing elevations. If his assumptions are all correct, there can be little doubt that he has proved his case, whether the interior be wholly solid or partly liquid, and whether the shrinking of the nucleus be due to loss of heat or loss of included steam by means of volcanic eruptions. Of the other and more valuable part, there is no need to insert any description here. Mr. Fisher has himself given an exhaustive summary in his concluding chapters for the benefit of non-mathematicians, and every good textbook of geology contains some account of it. On re-reading the book after the lapse of several years, the points which chiefly strike one are perhaps the wonderfully close agreement between the theory and the phenomena to be explained by it, and the ingenious manner in which the physical objections to the existence of a liquid substratum are encountered.

It is impossible at the present time to make any estimate of the permanent value of Mr. Fisher's work. There can be no doubt that it is more highly appreciated in foreign countries than it is in England; for Mr. Fisher's views are generally regarded as unorthodox here, while abroad the balance is probably in their favour.

It is unfortunate that English opinion as to the condition of the earth's interior should be mainly led by a few mathematicians whose chief interests lie elsewhere. No controversialist is bound, or can be bound, to examine every criticism of his work, but so long as careful and conscientious criticisms are left unanswered, the judgment of others with regard to that work must be held in suspense. Mr. Fisher's investigations cannot be brushed aside as of little or no consequence. We may or may not believe in the practical solidity of the earth's interior; but, if we do consider this view as the more probable, we cannot but feel that the objections which he has offered require serious examination, and that our lines of communication for further advances are menaced until his attack is definitely repelled.

In reflecting on Mr. Fisher's work as a whole, one cannot help being struck by his self-sacrificing boldness. It is no light thing for a thoughtful man to spend the better part of thirty years' leisure in working out a theory the foundation of which *may* be swept away by some future discovery. In such a position many of us would guard our work with jealous watchfulness from all unfriendly glances. But at fourscore years and more, Mr. Fisher welcomes criticism; his only complaint is that he cannot get enough of it. What he most of all desires, and what his patient labour deserves, is that his work should be subjected to a searching examination. But until his conclusions are proved to be wrong, we may fairly claim a wide toleration for whatever views on the physics of the earth's crust seem to us most nearly in accordance with the nature of geological phenomena.

Some time or other, no doubt, Mr. Fisher's chief life-work will be weighed in the balance. Whether it be found wanting or not, no one will dispute that he has solved one problem with complete success. However bitterly he may have been attacked, his courtesy has never failed. He is one of the few men whose part in controversy has enriched, and never degraded, science. He can look back upon a long life of fruitful labour and of kindly service to his fellow-men. At the same time he can reflect that he has never written a harsh word that he could now wish to be withdrawn.

C. Davison.

II.—New Fossil Bird and Fish Remains from the Middle Eocene of Wyoming.

By Charles R. Eastman, Cambridge, Mass.

(PLATE IV.)

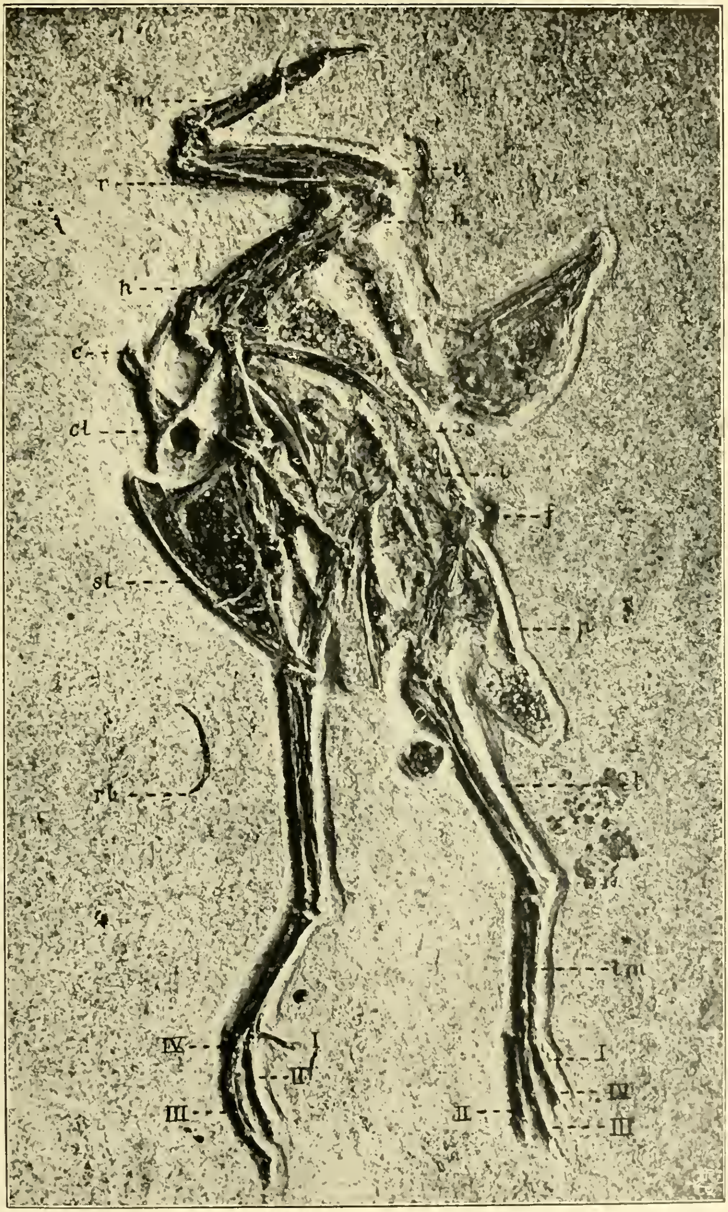
The Green River Shales of Wyoming have long been noted for their numerous and beautifully preserved fossil fishes. Fragmentary traces of bird-remains have been met with in the same horizon from time to time since the year 1869, when the first fossil feather reported from North America was obtained by Dr. F. V. Hayden.[1]

During the past summer the Museum of Comparative Zoology at Cambridge, Massachusetts, has come into possession of two remarkable specimens from the fish-bearing shales near Fossil, Wyoming. One of these is a gigantic Lepidosteid, of which only detached scales and vertebræ have hitherto been known; the other is a nearly perfect skeleton of a gallinaceous bird. It is the writer's intention to present a detailed description of both fossils at some future time, but meanwhile it is possible the following notes may be of interest.

Gallinuloides Wyomingensis, gen. et sp. nov. (Plate IV.)

Short-billed, stout-legged birds attaining the size of a gallinule, rail, or small coot, and resembling these forms in general characters. Coracoid straight and stout, without subclavicular process; furculum V-shaped, with well-developed hypocleidium. Wings short, bones of hind-limb of medium length. Femur one-fifth and tibia rather more than two-thirds longer than the tarso-metatarsus. The latter is flattened from back to front, has moderately expanded extremities, and a deep anterior channel occupying nearly the total length, which in the type measures 34 mm.; second trochlea slightly shorter than the fourth, and not produced towards the inner side. Lateral toes

[1] Amer. Journ. Sci. [3], vol. xi (1870), p. 272.



Gallinuloides Wyomingensis, gen. et sp. nov.

Middle Eocene : near Fossil, Wyoming.

subequal, about two-thirds as long as the middle one, and hallux one-third as long; middle digit and tarso-metatarsus of equal length. Plumage unknown.

The general appearance of this specimen is shown in the accompanying Plate, which is reproduced from a photograph without retouching. It will be seen that the body lies with its right side embedded in the matrix, the right hind-limb in advance of the left, the humeri elevated and overlying a bend in the neck. The right fore-wing is wanting, and the left is doubled over so as to expose the humerus from the palmar and the remaining wing-bones from the opposite or ventral aspect. The pelvis also is seen from the ventral side, the right hind-limb from in front, and the left partly from in front, partly from one side. Thus, one of the femora presents a lateral and the other an anterior view, but the coracoids and scapulæ are so turned as to exhibit mutually corresponding sides.

To speak of the imperfections first, the ribs are broken and confused, the caudal vertebræ are wanting, the dorsal displaced and in part scraped away by careless use of tools in the hands of a collector, and the cervicals in part concealed by the humeri. Between the scapulæ, and between the humeri and occiput, the vertebral column appears largely in section, owing to unfortunate mutilation. Most serious of all, however, is the damage done to the head, the bone-substance being so cut into or scraped away as to make it impossible to distinguish the separate elements. Depredations of this nature are wholly inexcusable, and cannot be too severely censured.

The *sternum* is well shown in lateral aspect, its body, however, being much compressed. The latter gives off a very long and slender intermediate xiphoid process, and a stouter and shorter external xiphoid, the distal extremities of both being expanded. The costal condyles for articulation with the sternal ribs are very small, and the costal process of only moderate proportions. There is a well-developed rostrum or manubrium, and the coracoid grooves are broad and deep. The coracoids themselves are relatively short and stout, without subclavicular processes and foramina; their sternal facets are considerably arched, and there is a faint hyosternal process. The clavicles form a narrow V-shaped arch, implying reduced powers of flight. The scapulæ are long and slender, with well-developed glenoidal and acromial processes, and are not distally expanded.

The bones of the *fore-limb* do not require special comment. The right humerus is seen in radial aspect, and shows a broad deltopectoral crest and prominent distal condyles. The latter are especially well displayed in the palmar view presented by the left humerus. Effects of pressure are apparent in the extreme width of the remaining wing-bones. It is possible, in addition, that the ulnæ of both wings are superimposed or are crushed contiguous to one another. Since the photograph was taken, all the limb-joints have been more fully exposed with the point of a needle.

The *pelvis* leaves much to be desired in the way of preservation. It presents the visceral aspect to view, the sacro-iliac roof being embedded in the rock; part of the sacrum is concealed by the overlying left femur. The anterior border of the ilium is convex; the post-acetabular portion is broader than the fore part, but of about equal length. The right acetabulum is distinctly shown, and measures 3·5 mm. in diameter. Just behind it lies the elongate-elliptical ischiadic foramen, and at the junction with the pubis is seen a very small obturator foramen. The pubes are long and delicate, slightly convex outward, and do not appear to have been attached to the ischia posteriorly. Only the first two caudal vertebræ are preserved. Concretionary structures are the cause of the discolorations in line with the distal extremities of the pubes, and adjacent to the left scapula.

The bones of the *hind-limb* are all more or less flattened by pressure. The femora are stout, nearly straight, and exhibit moderate-sized rotular channels and distal condyles. The left tibia is seen from the fibular side, with the fibula itself—together with the procnemial and ectocnemial processes—very much flattened. Of the distal condyles the inner is slightly the larger in fore-and-aft extent, the outer in transverse. An oblique bridge over the groove for the extensor tendons is faintly indicated close to the condyles. The tarso-metatarsus is flattened from front to back, traversed by a deep longitudinal groove along nearly the entire anterior face, has the external tibial facet on a lower level than the internal, and the second and fourth trochleæ of about equal size. The phalangeals of the first three toes are of about the same proportions as in the common pigeon, those of the fourth toe are longer. The proportions of principal parts are given in the subjoined table:—

Table of Measurements.

	Length in mm.		Length in mm.
Head	48	Manus	46
Scapula	48	Femur	42
Coracoid	27	Tibia	58
Furculum ...	33	Tarso-metatarsus	34
Crista sterni ...	58	I. Digit (7 + 4)	11
Humerus	47	II. ,, (11 + 8 + 6)	25
Ulna	49	III. ,, (12 + 10 + 8 + 6) ...	36
Radius	45	IV. ,, (7·5 + 5·5 + 4 + 4 + ?4)	25

Height of knee-joint (estimated) ... 90 mm.
Total height (estimated) ... ... 220 mm.

Six cervical vertebræ are discernible in section between the occiput and distal portion of the left humerus, the length of the series being 4·5 mm. Possibly six or seven more lie concealed beneath the humeri and glenoidal end of the right scapula. Measuring along the loop indicated by the position of the vertebral column gives a length of 85 mm. for the entire series of cervicals; the length of the dorsal series cannot be precisely estimated.

Relationships.—The characters outlined in the above cannot be brought into strict agreement with any one modern ornithic family, but appear to be transitional between true gallinaceous birds and the group typified by coots, rails, and gallinules. With the last-named the present skeleton exhibits a number of features in common, and there is also some resemblance to curassows. An annectant type or a generalized organization is exactly what we should expect to find, considering the antiquity of the remains. For palæontological purposes, the limits of modern bird-divisions must be considerably extended, and this becomes the more imperative the further we recede in geologic history. Hence, in the present instance, we shall not be very far wrong in assigning to the new form a position intermediate between the orders Paludicolæ and Gallinæ, as these are commonly understood.

From the late Tertiary of America a number of representatives of the two last-named orders have been described by Cope,[1] Marsh,[2] and Shufeldt,[3] but so far as the writer is aware but one genus, and that a crane (*Aletornis*, Marsh), is known from the Eocene. The fragments described by Marsh as *Telmatornis priscus* and *T. affinis* from the Cretaceous marls of New Jersey are referred by him to the Rallidæ. *Rallus* itself and typical Gallinæ are first met with in the Upper Eocene of Europe.

Lepidosteus atrox, Leidy.

Only one of the eight 'species' of Lepidosteids described by Leidy, Cope, and Marsh, from the American Tertiary, is founded upon anything like a complete fish. This is *Lepidosteus cuneatus* (Cope), a small form about 30 cm. in length, from the Miocene of Central Utah. The remainder are established upon detached scales, jaw-fragments, and vertebræ, many of them too imperfect for generic determination. Our knowledge of European Lepidosteids is likewise confined to the same class of fragments. The fact is, fossil gars are very rare, and are known only from Eocene and Lower Miocene horizons.

Cope[4] observed that in French examples the maxillary is much less segmented than in recent gars; also that two of the American species (*L. atrox*, Leidy, and *L. glaber*, Marsh) have the "mandibular ramus without or with reduced fissure of the dental foramen, and without the groove continuous with it in *Lepidosteus*." Upon such slight differences he erected the new genus *Clastes*, to which all the American species are commonly referred. The complete specimen obtained this summer from Fossil, Wyoming, proves that a generic separation from *Lepidosteus* is impossible; the name *Clastes* therefore becomes a synonym, and it is further probable that the so-called *Clastes anax* of Cope is identical with Leidy's *L. atrox*.

The new specimen is beautifully preserved as a whole, the only serious defect being that the cranial bones are more or less crushed.

[1] Bull. U.S. Geol. Surv. Terr., vol. iv (1878), No. 2.

[2] Amer. Journ. Sci. [3], vol. ii (1871), p. 126; ibid., vol. iv (1872), pp. 256–8; Proc. Acad. Nat. Sci. Philad., 1870, p. 11.

[3] Journ. Acad. Nat. Sci. Philad., vol. ix (1892), pp. 411–416.

[4] "Tertiary Vertebrata," bk. i, p. 53 (Rept. U.S. Geol. Surv. Terr., vol. iii, 1884).

The tail and hinder part of the trunk present the right lateral aspect to view, but the remainder of the body lies squarely on the ventral surface and is flattened out symmetrically on both sides by pressure. The fins are superbly preserved, and with their bundles of finely articulated rays and fringe of biserial fulcra make a striking appearance. The total length of the fish is 1·7 m., of which the head forms about 0·5 m. In point of size, relative length of head, fin-structure, and squamation, there is a very close resemblance to the recent Alligator gar, or *L. viridis*, Günther; the dentition is much the same, and the number of longitudinal and transverse scale-series is the same in both. A detailed description of the new specimen will form the subject of a separate paper; it will be sufficient for the present to point out that the modern gar, and more particularly the Alligator gar, has existed from at least Eocene times essentially unchanged.

EXPLANATION OF PLATE IV.

Gallinuloides Wyomingensis, gen. et sp. nov. Middle Eocene: Fossil, Wyoming. *c*, coracoid; *cl*, furculum; *f*, right femur; *h*, *h'*, humeri of left and right wings respectively; *i*, ilium; *m*, manus; *p*, pubis; *r*, radius; *rb*, detached rib; *s*, scapula; *st*, sternum; *t*, tibia; *tm*, tarso-metatarsus; *u*, ulna; I–IV, toes.

III.—Some Snowdon Tarns.

By J. R. Dakyns, Esq.

I HAVE from my boyhood been intimately acquainted with Snowdon and its neighbourhood, and for some years past I have been investigating the geology of the district in a systematic manner. In doing this I have paid particular attention to the lake basins, and shall in the following pages give an account of some of my investigations as far as they have gone. I say as far as they have gone, because I hope in the future to make by means of a level more accurate measurements than can be made with a pocket aneroid; and I also hope that next Summer the lakes and tarns will be sounded either by myself or by someone else; for at present we know nothing about the depth of Llyn dur Arddu, next to nothing above that of Glaslyn, and very little about Llydaw, though that little is of great importance.

I will now proceed with my account. Glaslyn at its outlet is bounded by rock on the north side and by drift on the south, but the shape of the ground shows that the drift is merely a mound of no great thickness, banked against the Gribbin, as the rocky spur is called which separates Glaslyn from Llydaw. At a distance of about twenty yards from the lake solid rock is seen in the bed of the outflowing stream at less than six feet below the level of the lake. This to my mind proves without any reasonable doubt that the lake lies in a rock basin; for, as I said above, the drift is apparently of but little thickness, and the lake is certainly more than six feet deep: I have myself dived into it to a greater depth than that. I will not, however, insist upon this; for at the old mill, seventy yards from the lake, *solid rock extends right across the* *stream* from the Gribbin on one side to the cliffy ground, on the other, along which the road from the mines runs. From this point in the stream one can ascend to the summit of Snowdon, either by the Gribbin on the south or by way of Crib y Ddysgl on the north, without treading on anything but solid rock. This point is, as measured by an aneroid, 40 feet below the level of the lake. Consequently, unless Glaslyn is less than 40 feet deep, it must lie in a rock basin, even if we neglect the fact that rock is seen in the stream at only a few feet below the level of the lake. We do not know the depth of Glaslyn, but it is probably more than 40 feet deep; for on the north side, near the mine, rock comes down to the water at a slope of 30°, and on the opposite side the average slope of the rocks coming down to the lake is even more than 30°.

I conclude, then, that Glaslyn occupies a rock basin. In their paper on the Lakes of Snowdon, Messrs. Marr and Adie write in reference to the outflow of Glaslyn, with all the emphasis of italics, "*the bottom of the drift-filled depression is at a lower level than the present stream,* which runs at the side of the valley, being separated from the lowest part by a low shelf of rock." What they call the present stream is an artificial watercourse made by the old miners to carry the surplus water of the lake clear of their works. Comment is needless.

Llyn Llydaw is dammed up by glacial deposits; but at 250 yards from the outlet solid rock is seen in the issuing stream and on both sides of it. This point in the stream is by my aneroid from 25 to 30 feet below the level of the lake. Mr. Watts, however, considers the first live rock seen by him in the stream to be 40 or 50 feet below the level of the lake. At 250 yards from the present outlet, in a N.N.W. direction, there is a depression by which the lake may possibly have once discharged itself; and at about 225 yards from the lake solid rock is seen in the bottom of this depression and on both sides thereof. According to the aneroid this point is 40 feet below the level of the lake. The space between the present outflowing stream and the above-mentioned channel is occupied by drift which thins away eastward, so that immediately south of the little pool, shown on the Ordnance six-inch map, rock forms the surface of the ground. The place where the rock is seen in the said depression, as stated above, is just where it is joined by another depression, which runs down from the little pool, and it is along this line that Mr. Marr imagines the lake to have formerly drained.

Consequently, in all possible outlets, real or imaginary, to Llydaw, solid rock is first met with in descending from the lake, at a level no lower than 40 or 50 feet below its surface. Llydaw must then lie in a rock basin unless it is less than 50 feet deep; but we have reason for believing that it is much deeper than 50 feet. Many years ago a man's clothes and boots were found lying beside the lake. It was supposed that the owner had been drowned. A professional diver was fetched up from Caernarvon, and search was made for the missing body. The late Henry Owen, the well-known landlord of Pen y Gwryd, was present at the search; and he told a friend of mine that in one place no bottom was reached at the depth of 200 feet. Unless, then, this estimate was grossly erroneous Llydaw must lie in a rock basin.

There is not much to be said about Llyn dur Arddu. It lies at the head of Cwm Brwinog under the precipice called Clogwyn dur Arddu, which forms the south side of the Cwm, and rock is seen at the outlet on the south side of the stream; but no rock is to be seen on the north side of the lake, nor, as far as I know, for a long distance down-stream; in fact, on that side nothing is to be seen but a steep bank strewn with large blocks of stone, so that we cannot tell whether the tarn lies in a rock basin or not. Although nothing but the rock-strewn bank is to be seen on the north side of the Cwm, yet the unsophisticated intellect conceives that the Cwm is bounded on that side, too, by solid rock, hidden, however, by superficial detritus. There is absolutely no evidence to support the assertion of Messrs. Marr and Adie that the lake once drained more northward down a valley now buried under moraine. Not only is there no evidence in favour of such a view, but the chances are all the other way, for it presupposes a far greater thickness of drift than is known to occur in any part of the district. There are many places in the Snowdon region where the thickness of the glacial deposits can be measured. As far as I know, these deposits are thickest under Yr Aran, on the left bank of the Colwyn, about a mile above Pont Caer-gors, and here the thickness is less than a hundred feet. In most cases it is much less than this. Thus it is most improbable that there should be in Cwm Brwinog so great a thickness of drift, and that for the distance of a mile or more, as must be the case if there is such a buried valley as Messrs. Marr and Adie assume.

The tarns in Cwm Glas are so shallow that they are of little importance, but the lower one, Llyn Glas, most certainly lies in a rock basin, for, without going below the level of the tarn, one can walk all round it without ever treading on anything but solid rock.

I shall not at present say more about Cwm Glas, nor about Cwm Brwinog, as I hope on a future occasion to deal fully with the geology of these corries. Nor shall I now treat of the Snowdonian lakes as distinct from the tarns; but as Messrs. Marr and Adie, in the part of their paper on the Snowdon lakes dealing with Llyn Cwellyn, have indulged in some speculations and statements about a part of the country with which I am intimately acquainted, I must point out some mistakes into which they have fallen.

On p. 55 of their paper they say "a drift-filled depression is traceable up a tributary joining it" (the main stream) "a few yards south-east of Cwellyn State Quarry." This is a mere assertion: no proof is offered of the existence of drift in this depression; it is simply assumed, and in fact no proof can be offered, for along the course of the little valley there are no sections in superficial material save one near Ffridd quarry, where a pit has been dug for walling-stones in some loose stuff which may be morainic. Throughout the rest of its course there is no evidence of the existence of glacial drift; but on the contrary some evidence that there is no drift in the depression, for solid rock is seen close to the stream at 100 yards north of the narrow-gauge railway; and still further north the valley is cumbered with large angular blocks consisting entirely of diabase, which have fallen from the cliffs above. There is no drift, for were there any we should find stones of many different sorts, and many of them would be rounded. So Mr. Marr's drift-filled gorge 350 feet deep is a mere figment of the imagination. I must also remark that judging from the shape of the ground Llyn Cwellyn is probably a great deal more than 50 feet deep.

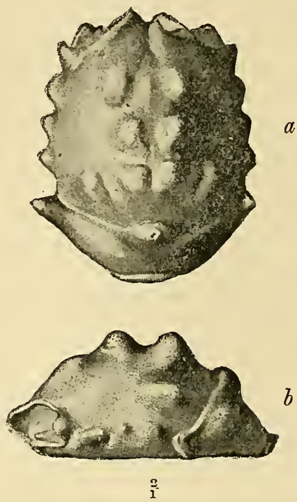
As to the peaty watershed near Pitts Head, it matters nothing whether it is "composed of an alluvial deposit" or not, for the solid rock comes to the day in so many places that the superficial covering is evidently merely a thin skin.

On the next page the authors say "the bed of the Colwyn runs over drift until within a short distance of Beddgelert." I am sorry to be obliged to contradict the writers, but the above statement is incorrect. Neither the Colwyn nor its bed runs over drift immediately south of Pitts Head watershed, for solid rock is seen in the bed of the river at Pont Caer-gors and at several other places for more than 550 yards down-stream. at which distance the river actually runs in a rocky gorge. The eastern side of the Colwyn valley is formed of solid rock, not only throughout the whole of this distance, but for much further south. A low bank of drift forms the western margin of the river immediately south of Pont Caer-gors. This drift obviously lies as a tablecloth on a gently sloping surface of rock which comes to the day 300 yards west of the bridge. No drift-buried gorge is possible here. The upshot is that Messrs. Marr and Adie, in their hurry to escape from a rock basin, have invented an impossible gorge to carry the water of Llyn Cwellyn across a mountain range whose lowest point is 650 feet above the sea, that is, 186 feet above the present level of the lake. This is a brilliant effort of the imagination, though hardly of the scientific sort, but it does not come near that of the old Welsh, who imagined an underground connection between Llyn Cwellyn and the Llanberis lakes to account for the existence of char in both.

IV.—Note on a Crustacean *Mesodromilites Birleyi*, gen. et sp. nov., from the Gault of Folkestone, Kent.

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

One of the results incidental to the meeting of the British Association for the Advancement of Science at Dover in September last was a visit paid to Folkestone by the members of Section C (Geology). Among the ladies present was Miss Caroline Birley, well known both as a traveller and for the deep interest which she has always taken in palæontological research; she is also the owner of an excellent private museum of minerals and fossils, mostly collected by herself. Miss Birley was fortunate in obtaining from Mr. J. Griffiths, the resident geological collector, a small but well-preserved carapace of a Gault Crustacean, believed at the moment to be the usual *Necrocarcinus Bechei* (Deslongsch., sp.), a form about as abundant in that locality as the *Palæocorystes Stokesii* (Mantell, sp.). The specimen, enlarged twice natural size, is clearly depicted in the accompanying illustration in the text.



Mesodromilites Birleyi, gen. et sp. nov.

Gault: Folkestone. *a*, dorsal aspect; *b*, profile of same specimen. Drawn twice the natural size. The original specimen is in the possession of Miss Caroline Birley.

A more careful examination of the original convinced me that I was in error in referring this Crustacean to *N. Bechei*, or indeed to any species of *Necrocarcinus*; and after a lengthened search for an analogue I was compelled to believe it to be a new form, a thing well-nigh incredible in a formation like the Gault of Folkestone, which has been 'the happy hunting-ground' for so many generations of London and provincial geologists, and a spot dear to the name of J. Griffiths, who for the past fifty years or more has been the sole collector and geological guide of Folkestone Cliffs.

The figures give both the dorsal and lateral aspect of the carapace, and show it to be one-fourth longer than broad, very tumid in the centre, having three pairs of rounded sub-central tubercles (three on either side of a median dorsal line), with a central tubercle placed on the posterior metacardiac region. Two rather curved and elongated tubercles occur on the surface of the test outside the hindmost pair of sub-central tubercles and midway between them and the lateral margins of the carapace, just over the posterior branchial region. Five somewhat prominent tubercles mark each lateral margin, the hindmost and most prominent pair being situated on a transverse V-shaped ridge and furrow, which cuts off the posterior fifth of the carapace, and meeting in the centre, where it is marked by the single median posterior tubercle already referred to.[1] The three succeeding pairs of marginal tubercles are about equal in size, and the front pair forms the outer angle of the orbital fossa. The rostrum is subdivided or notched in the centre, having a λ-shaped groove running down it, the base of which is directed forwards, and the diverging points reaching to the first pair of sub-central tubercles which mark the gastric region. The orbits are large and well defined. No nuchal furrow is visible. The carapace is not in the least crushed or distorted, and the surface is well preserved.

Differences and Affinities.—A careful comparison of our Brachyuran with the various species from the Gault and Greensand affords but little assistance in the specific determination of the specimen. In *Necrocarcinus,* when the rostrum is preserved it is not notched or bifurcated, but pointed in the centre; the median line of the carapace is not simple, but divided into distinct gastric and cardiac regions, and an anterior nuchal furrow can be traced; the carapace is broader than long; the marginal tubercles are not prominent, and the posterior or metabranchial furrow is absent.

Turning to *Dromilites* from the London Clay, one is at once struck by many points of resemblance. The carapace (as in our Gault fossil) is longer than broad, is very tumid, the rostrum is bifurcated, there is a median furrow, the tubercles are arranged in pairs; four pairs of marginal tubercles are present, the posterior metabranchial furrow is also seen; the orbits are large and conspicuous.

Unfortunately the other ventral aspect of the carapace is wanting in the Gault fossil.

Prof. Bell ("Fossil Malacostracous Crustacea of Great Britain," Mon. Pal. Soc.: Part ii, 'Crustacea of the Gault and Greensand,' 1862, p. v) remarks:—"The Crustacea of the strata below the Chalk . . . . present several remarkable peculiarities in their forms and affinities. One of the most interesting of these is the existence of analogous or, so to speak, representative species in these beds and in the London Clay" (see part i of same Mon., 'Crustacea of the London Clay,' op. cit., 1857, pls. v and vi). "In some cases this representation is shown in their specific distinction, with the most perfect generic identity, as in the case of *Hoploparia,* of which we have already seen two very distinct species in the later formation, and we have now described no fewer than six species in the earlier deposits. In no instance do any of these locally separated individuals belong respectively to the same species; in every one the specific distinctness is unambiguous, but the generic relation to each other is no less so. Another case of nearly similar import occurs in the anomourous family Dromiadæ; the *Homolopsis* of the Greensand

[1] This line may be defined as the 'metabranchial furrow,' and is seen in *Plagiophthalmus oviformis* from the Greensand of Wilts, and in *Dromilites* from the London Clay.

being represented in the London Clay by two species of *Dromilites*, a very nearly allied form."

The addition of another new species, apparently related to this family in the Gault, is extremely interesting as exemplifying the close family similarity, but very clear specific and (I venture to think) in this case even generic distinctness from its congeners. It is hoped that before long other examples may be obtained, offering fuller details of its structure; meantime I publish this interesting little Crustacean, giving it the name of *Mesodromilites* to define its older geological position and also its probable relationship to *Dromilites* of the London Clay, with the specific name of *Birleyi*, in honour of Miss Caroline Birley, to whom I am indebted for the opportunity of describing this new Gault crab.

NOTICES OF MEMOIRS.

I.—The Red Colour of the Salt Lakes in the Wadi Natroun. By J. Dewitz.[1]

In an article published in the 'Zoolog. Anzeiger'[2] I have given a report on the biology of the Natron Valley, the Wadi Natroun, in the Libyan desert, about 170 kilometers from Cairo. It seems that my remarks concerning the red colour of the water of the salt lakes of the valley have interested readers of the article. I therefore wish to add here some researches I was able to make on the same subject owing to the kindness of Mr. Prochaska, head of the chemical survey of the soda company.

When I came to the Natron Valley the red water of the lakes excited at once my curiosity, and I tried to ascertain the reason for the redness of the liquid. Most people to whom I spoke about the matter told me that *Artemia* lives in the lakes, and that the red colour of this Crustacean is communicated to the water. During my stay in the Wadi the *Artemia salina* was not to be seen, the animal appearing only at certain periods of the year. It is impossible to believe that the coloured mass of these small creatures is sufficient to stain such immense quantities of water as the Wadi Natroun lakes. These lakes, about fourteen in number, lie rather close to each other and extend over a space of about 40 kilometers.

No number of *Artemia salina* would be great enough to give the water the deep purple colour which it has. If there were frogs in the lakes and those frogs were red, and someone should say that the red colour of the water came from the red colour of the Amphibia, this explanation, I think, would not be much inferior to the *Artemia* theory. Besides *Artemia*, there are other red animals in the lakes. I obtained, for example, a red culicid larva. This shows that animals living in the water may take the colour from it, and not the water from the red animals. Finally, *Artemia salina* disappears in

[1] Reprinted from *Science*, N.S., vol. x (1899), No. 240, pp. 146, 147.

[2] "Das Wadi Natroun in der libyschen Wüste und seine niedern Thiere," Bd. xxii (1899), pp. 53–61.

the lakes for the greater part of the year without causing a change in the coloration of the water.

But, if it is not *Artemia salina*, what is it that gives the red colour to the water? In my investigations I treated the red water with different chemicals, among them acetic acid. When the acid is poured into the red water a powerful development of carbonic acid takes place, and at the same time a red soft mass rises to the surface of the liquid, while the latter loses more and more of its colour. From a large quantity of water I collected the soft red mass swimming on the surface, washed it with distilled water, and shook it in a mixture of ether and absolute alcohol. The red colour left the soft mass, being extracted by the ether. The solution of the colour in ether did not keep the purple tint of the soft mass, but showed a fine brownish coloration, the soft mass itself appearing now as a grey yellowish substance, reminding one of blood fibrine. It could be reduced to ashes, and is, therefore, of organic composition. When the lake water was directly exposed to the mixture of ether and alcohol without having passed through acetic acid no result was obtained. Concerning the osmotic property of the red organic mass, it is to be noted that it did not pass through a membrane of so-called parchment paper, such as is used for covering jars.

The experiments show that the water of the lakes contains an astonishingly great quantity of organic red substance, and that it is this which gives the red colour to the water.

The question now arises what the origin of the red organic substance is. My supposition is that the substance must be the product of bacteria. Each drop of water taken from the lakes will be found full of them. The bacteria in all the lakes are uncoloured, but I found that the cocci exhibit a red colour.

According to "Baedeker" (Egypt, French edition, 1898) there existed another spot in Egypt, near Suez, where red salt water is found. On p. 162 of the guidebook I read the following note: "La couleur rouge des marais salants entre des collines des Bédouins et le canal, provient d'une petite écrevisse (de l'ordre des phyllopodes) presque microscopique qui y fourmille à certains moments. Le matin ils exhalent un parfum semblable à celui des violettes." Unfortunately, when I was at Suez I did not visit the 'marais salants,' and I therefore wish to call this note to the attention of the biologists visiting that part of Egypt. It would be very interesting to ascertain whether the water there contains bacteria and the same red organic mass which I found in the lakes of the Natroun Valley.

II.—Notes on the Minerals of Japan. By Kotora Jimbō. (Reprint from Journ. Sci. Coll. Imp. Univ., Tōkyō, 1899, vol. xi, pp. 213–281.)

A DESCRIPTION is given of 128 mineral species found in Japan, and represented in the collections of Mr. T. Wada, of the Imperial University and the Imperial Museum at Tōkyō. The paper is written in English, and so renders information, which previously has only been published in Japanese journals, more easily accessible. The subject-matter is mainly confined to the enumeration of occurrences; and for museum curators, puzzled by Japanese locality names, the paper will be very useful. Longer descriptions are given of quartz, topaz, and felspar, these minerals being represented in Japan by specially fine crystals.

REVIEWS.

I.—Dr. Traquair on Silurian Fishes. Report on Fossil Fishes collected by the Geological Survey of Scotland in the Silurian Rocks of the South of Scotland. By Ramsay H. Traquair, M.D., LL.D., F.R.S. Trans. Roy. Soc. Edinb., vol. xxxix, pp. 827–864, pls. i–v. (December, 1899.)

DR. TRAQUAIR'S new memoir on the Upper Silurian fishes of Southern Scotland is the most valuable contribution to our knowledge of Palæozoic Ichthyology which has been made for many years. It is of fundamental importance not only as describing with tolerable completeness the exoskeleton of several organisms which have hitherto been known only by indeterminable isolated fragments; it also records for the first time a series of well-ascertained facts in reference to the primitive mode of development of the dermal armour of the Vertebrata. Moreover, it is a work which could not have been accomplished, or at least have been done in a thoroughly trustworthy manner, by anyone less skilled in the observation and interpretation of Palæozoic fish remains than Dr. Traquair himself. Most of the fossils are very obscure, and can only be understood after long-continued study and repeated comparisons. Any geologist or biologist who casually examines them will feel gratitude to the painstaking author, whose patience and unwearied zeal have enabled him to obtain so much information from them as is contained in the beautiful memoir now before us.

The specimens in question were discovered by Messrs. Macconochie and Tait, collectors to the Geological Survey of Scotland, in the Upper Ludlow and Downtonian beds in the neighbourhood of Lesmahagow, Lanarkshire. The thin bands in which they occur consist of hard, grey, flaggy shale; and in most cases the actual substance of the fossils seems to be preserved.

The two first genera described are considered to be primitive Heterostraci or Pteraspidians, in which the dermal armour consists of isolated shagreen-like granules, not yet fused into plates. They constitute the family Cœlolepidæ of Pander, which was known only by the detached dermal granules until a year ago, when Dr. Traquair published a foretaste of his results in the description of *Thelodus Pagei* from the Lower Old Red Sandstone of Forfarshire. Two new species of *Thelodus* (*T. scoticus* and *T. planus*), from the Upper Silurian, are now described and figured. The head and trunk are completely covered with a dense layer of the little shining, quadrangular granules, which have long been familiar to collectors from the Ludlow Bone-bed and the Upper Silurian of Oesel. In shape the fossilized organism closely resembles a *Cephalaspis*, and its anterior portion is usually crushed vertically, while its slender caudal region occurs in more or less direct side view. No orbits are distinguishable. There is no clear evidence

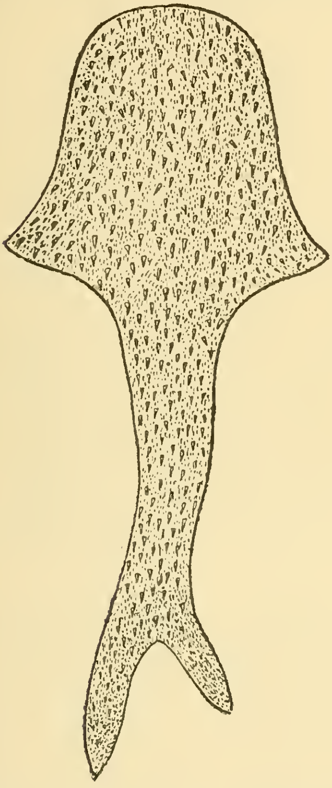


Fig. 1.—Restored outline of *Lanarkia spinosa*, Traq., in the position in which it occurs as a fossil, namely, vertically compressed in front, but the tail twisted round so as to appear in profile.

of paired fins. The heterocercal caudal fin is well preserved, but there is apparently no dorsal fin. *Lanarkia* is a new allied genus, armoured with small, sharp, hollow, conical spines, instead of the comparatively solid quadrangular tubercles. *L. horrida*, *L. spinulosa*, and *L. spinosa* (Fig. 1) are distinguished, the last with the dermal spinelets not uniform in size.

A remarkable new genus and species, *Ateleaspis tessellata*, follows next. The remains on which it is based are rather fragmentary; but Dr. Traquair is inclined to regard the organism as intermediate between the simplest Heterostraci and the Osteostraci, only referring it to the latter because part of the tissue of its armour exhibits true bone-cells. The general form of the body is apparently as in the Cœlolepidæ, but the dermal covering in front consists of small polygonal plates, while in the caudal region it is in the form of flat, rhombic, sculptured scales. The orbits seem to have been close together on the top of the head, as in *Cephalaspis.*

A new order, Anaspida, is established to contain the two last and perhaps most extraordinary new genera treated in the memoir. These comprise small, laterally compressed organisms, without paired fins, but with a single small dorsal fin and a well-developed heterocercal tail. In many respects they are suggestive of *Cephalaspis* and its allies, but there is no continuous head-shield, and the orbits are not clearly distinguishable in the known specimens. The substance of the armour is not sufficiently well preserved to furnish satisfactory sections for microscopical examination. *Birkenia,* with a single species, *B. elegans,* is the first genus placed here. It is completely armoured with small scutes arranged in the strange manner indicated in Dr. Traquair's careful restoration (Fig. 2). On the side apparently of the back of the head there is an oblique series of eight small round holes, which look like branchial openings. The flank-scales of the trunk are disposed chiefly in series which incline forwards and downwards, not backwards and downwards as is usual in fishes. A median series of ventral scutes develops into a formidable armour of spines in the caudal region. The second new genus, *Lasanius,* with two species, *L. problematicus* (Fig. 3) and *L. armatus,* is considered to be closely related to *Birkenia,* differing in the loss of all the dermal armour except a few anterior flank-scales and the median ventral row of spines.

The detailed descriptions of these organisms are illustrated by a beautiful series of five plates, most of the drawings being by Mr. James Green, but the highly magnified details and critical points by the author himself.

In the concluding section of the memoir, which is a general discussion of the results, Dr. Traquair gives for comparison a brief description of the hitherto problematical Lower Devonian genus *Drepanaspis.* Its main features are illustrated in an outline-sketch which he kindly permits to be reproduced here (Fig. 4). In shape it resembles *Thelodus* and *Lanarkia,* but it is covered with well-developed plates and scales, and the orbits seem to have been placed laterally. All the known plates of *Drepanaspis* are too much pyritized for microscopical examination; but Dr. Traquair has shown that the other Devonian plates named *Psammosteus* belong to a closely similar animal, and these contain no bone-cells. The Drepanaspidæ and Psammosteidæ are therefore placed by him in the Heterostraci.

It follows from these researches that the definition of the order Heterostraci must now be slightly modified. We must admit that the armour may consist either of separate granules (each formed round a distinct papilla), or these granules may be more or less fused together in every degree from small polygonal plates to great shields. According to Dr. Traquair the order will therefore include the known families of Cœlolepidæ, Psammosteidæ, Drepanaspidæ, and Pteraspidæ, each exhibiting a progressive modification over the other in the development of the dermal armour.

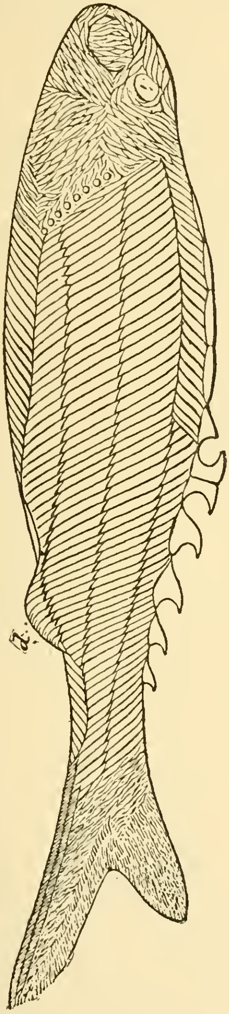


Fig. 2.—Restored outline of *Birkenia elegans*, Traq., one-half larger than natural size. *d.*, dorsal fin.

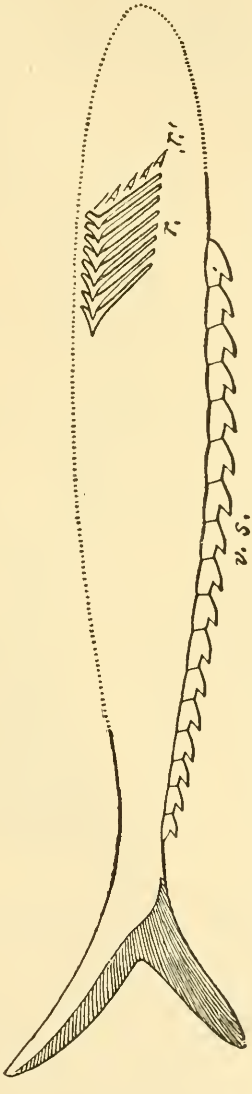


Fig. 3.—*Lasanius problematicus*, Traq., restored outline enlarged. *v.s.*, ventral scutes; *r.*, post-cephalic rods; *r'.*, chain of ossicles.

While the original conception of the Heterostraci is enlarged in this manner, *Ateleaspis* seems to form a link between its lowest family (the Cœlolepidæ) and the order Osteostraci. Dr. Traquair points out that the shape of this organism is like that of *Thelodus*, while its polygonal plates and scales merely represent groups of the dermal tubercles of the latter fused together by the great development of their bases. At the same time some of the basal layers of

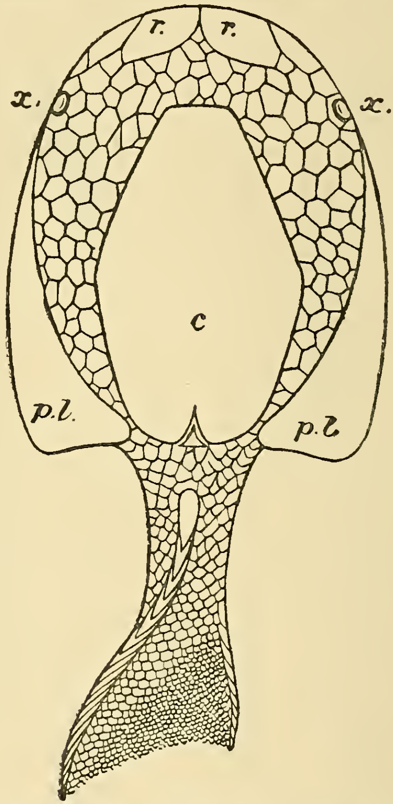


FIG. 4.—*Drepanaspis Gmuendenensis*, Schlüter. Restored outline of the dorsal aspect, the surface ornament omitted, and the tail twisted round so as to show the caudal fin in profile. *c.*, central plate; *p.l.*, postero-lateral plates; *r.*, rostral plates; *x.*, orbits?

the plates contain distinct bone-cells, a peculiarity necessitating the reference of *Ateleaspis* to the Osteostraci. Dr. Traquair is therefore of opinion that Cope and the British Museum Catalogue are correct in regarding the Heterostraci and Osteostraci as closely related orders, while Professor Lankester is no longer justified in maintaining that "there is absolutely no reason" for grouping them together beyond that they "occur in the same rocks."

As might be anticipated, Dr. Traquair also discusses the propriety of admitting the existence of the sub-class Ostracodermi, to which the Heterostraci and Osteostraci have been referred by Cope and the British Museum Catalogue. He concludes that no more satisfactory arrangement can be suggested at present. He accordingly accepts it, and adds the new order Anaspida to include the Birkeniidæ.

The most disappointing feature of the memoir is, that it provides no new facts which will be universally regarded as advancing our knowledge of the affinities of the Ostracodermi. Dr. Traquair is very emphatic in his refusal to believe that they are "Agnatha." Very justifiably, he declares that he has no faith in negative evidence. He must have some positive reason before he can admit that these organisms were destitute of a mandibular arch and paired limbs. On the other hand, he thinks his new discoveries justify a belief that the Ostracodermi are the modified descendants of an early group of Elasmobranchii. He "prefers to consider" the Cœlolepidæ, or lowest Ostracoderms, "as having definitely split off from the [Elasmobranchii], from which they doubtless originally came" (p. 844).

When, however, the arguments for this new interpretation are closely examined, I maintain that they are found to depend just as much on negative evidence as the hypothesis of Cope. So far as I understand them, they are based on two propositions — (i) that the shagreen of the Cœlolepidæ is identical with that of an Elasmobranch, and (ii) that the lappet-like postero-lateral angles of the anterior broad part of the body in the Cœlolepidæ, Drepanaspidæ, and Cephalaspidæ are pectoral fins.

As to the first proposition, I think there is justification for asserting that, in the present state of knowledge, it affords no sure proof of affinity between the Ostracoderms and the Elasmobranchs. We cannot conceive of the dermis of a chordate animal beginning to acquire superficial calcified hard parts by any other process than by the deposition of mineral matter round papillæ. At the remote period when the Chordata were first beginning to develop an exoskeleton, it is extremely probable that these animals were already well differentiated; at least, we cannot explain their diversity and high grade in the early Devonian period unless we admit this probability. When dealing with Silurian fish-like organisms, therefore, a form armoured with tubercles of dentine does not necessarily belong to the Elasmobranchii; it may be a Chordate animal of any kind just beginning to assume a protective covering. The admitted fact that since early Carboniferous times an exoskeleton exclusively of dentinal tissues has persisted only in Elasmobranchii and Chimæroidei, is no proof that any organism similarly armoured in the strange archaic Devonian and Silurian faunas is intimately related to either of these sub-classes.

In short, if Dr. Traquair has discovered that the Cœlolepidæ are closely related to the Heterostraci proper and to the Osteostraci, as seems almost certain, I maintain that he has not helped us towards forming any more plausible theory of their origin. He has merely dealt another blow at the old Agassizian conception of the importance of dermal structures in classification. He has shown that 'placoid scales' are as of little value for taxonomic purposes in the Silurian and Devonian periods as are 'ganoid scales' in the Tertiary and existing faunas.

Dr. Traquair's second proposition that the Cœlolepidæ and Drepanaspidæ possess pectoral fins, seems to me to be much more absolutely an hypothesis than my contrary assertion that *Cephalaspis* is destitute of them. So far as I understand, not a single specimen of *Thelodus* or *Lanarkia* shows the slightest change in texture or arrangement of its armour at the postero-lateral angles of the broad part of the organism, which are described as lappet-like pectoral fins. There is no more appearance of flexibility here than along any other border. There are not the faintest lines of demarcation of any kind. In the remarkable genus *Drepanaspis* the angles in question are indeed strong plates, apparently without any power of motion. Nevertheless, Dr. Traquair still considers them as pectoral fins, believing them to be "rendered utterly functionless as fins by being enclosed in unyielding bony plates." In other words, a motile organ, originally used at least for balancing, if not for progression, is assumed to have lost its function, not by atrophy, but by conversion into a rigid structure continuous with its base of support—a phenomenon for which I have tried in vain to find a parallel in the animal kingdom. Personally, I consider it is less hypothetical to believe that the postero-lateral angles in question are not homologous with the flaps in *Cephalaspis*, but with the hinder end of the branchial chamber of the same. Both hypotheses depend on negative evidence, but I prefer the latter as most reasonable.

With respect to the flexible flap in *Cephalaspis*, which I regard as opercular, but which Dr. Traquair now thinks is really a pectoral fin, I may repeat that we know exactly its relationships. The specimens in the British Museum show that it is a flexible outgrowth from the hinder margin of the roof (perhaps more accurately the outer and partly upper wall) of the branchial chamber, while the external outlet of this chamber is clearly a large oval opening immediately beneath (within) the base of the flap.

In conclusion, I therefore believe that Dr. Traquair's hypothesis of the derivation of the Ostracodermi from an early race of Elasmobranchs with a mandibular arch and paired fins, depends quite as much on negative evidence as does Cope's theory that they are far more primitive and best termed Agnatha. I still maintain that they "are quite of a problematical character"; but of the two theories proposed for their interpretation, I think that of Cope is, for the present, the less beset with difficulties.

A. Smith Woodward.

II. — Geschichte der Geologie und Paläontologie bis Ende des 19 Jahrhunderts. Von Karl Alfred von Zittel. (R. Oldenbourg: München u. Leipzig, 1899.)

History of Geology and Palæontology up to the end of the Nineteenth Century. By Karl Alfred von Zittel. Demy 8vo; pp. vii and 868.

THIS volume forms one of a series of histories of science in Germany in recent times, issued, under the patronage of the King of Bavaria, by the Royal Academy of Sciences at Munich. Its preparation had at first been entrusted to the late Professor Ewald of Berlin, but it remained unfinished at the time of his death, and, in accordance with the terms of his will, the incomplete MS., with his other papers, was destroyed. The task was then undertaken by Professor von Zittel, and the contents of this volume prove that it could not have been allotted to abler hands. The work was intended originally to be limited to a history of geology in Germany only, but the author enlarged the plan so that it should include a history of the science generally, and present a faithful picture of the successive stages in its development wherever they may have occurred. Whilst it may be true that the German literature on the subject has been, in some parts, referred to with greater fulness than that from other countries, no important contribution from other sources has been overlooked, and the author's comments and criticisms on the writings and achievements of past and present geologists are marked by the strictest judicial impartiality. With respect to subjects which are still matters of controversy, the author takes a neutral position, and contents himself with a plain statement of facts and opinions relating to the particular questions in dispute.

The History is treated under four periods of very inequal length and interest: 1st, the geological knowledge of the ancients; 2nd, the early stages of palæontology and geology; 3rd, the heroic age of geology, from 1790 to 1820; and 4th, the later development of geology and palæontology.

With respect to the first period, that of the geological knowledge of the ancients, the author shows that whilst facts relating to the science were of a limited character, hypotheses on the origin and development of the earth were plentiful enough. If any of these latter have perchance been found conformable to modern views, it is due to their being lucky speculations rather than theories based on observation. At the same time, some of the observations made at this period on earthquakes, volcanoes, changes of level of the earth's surface, and on the action of water, are not without importance.

Neither does the second period, which includes from about 800 A.D. to the close of Buffon's career in 1788, present us with any solid or striking advance in geological science. We find that fossils aroused the attention and curiosity of many of the learned in different parts of Europe during the fifteenth to the seventeenth centuries, and many were figured with remarkable fidelity in the works of Lister, Lang, and Knorr and Walch; but their real characters were unrecognized and they were attributed to a certain 'vis plastica,' and considered to have been directly produced in the ground where they were met with. Even when they were seen to be the remains of extinct animals, they were supposed to have reached their position in the rocks through the action of Noah's Deluge! The palæontology of this period did not advance beyond dry, detailed descriptions of fossils, with fantastic speculations as to their origin, and their relation to the sacred scriptures.

Amongst the writers of this period whose observations of geological facts and whose views of the origin and history of the earth are placed before us by the author, we find the names of Leonardo da Vinci, Giordano Bruno, Nicholas Steno, Burnet, John Woodward, Scheuchzer, John Ray, Charpentier, and Guettard; whilst amongst those distinguished for their observations on volcanoes and earthquakes occur the names of Della Torre, Desmarest, Sir W. Hamilton, and Faujas de St. Fond.

In the concluding part of the chapter on this period a summary of the views of Buffon on the theory of the earth is given, with an appreciative reference to the position which this great French philosopher occupies in geological history. As an original investigator and observer his claims were limited, but he understood the significance of facts, and possessed a marvellous capacity of marshalling them in support of his theories. He was incontestably the most genial representative of that speculative movement, held in high repute in the sixteenth, seventeenth, and eighteenth centuries, which set itself to solve its problems in a deductive way. With Buffon there closed a period which had indeed gathered together a large store of materials needful for the earth's history, and had moreover arrived at the conviction that the data for that history might be obtained from the earth itself. But the key for the determination of a chronological succession of events on our planet had not as yet been discovered, no satisfactory insight as to the composition and building up of the earth's crust had been obtained, nor of a regular succession of the fossil remains found within it.

With the third period of the heroic age of geology, placed by the author in the thirty years from 1790 to 1820, there commences an epoch when facts were recognized and sought after as the only sure foundation for theory, and a corresponding appreciation was placed on the investigation and description of the phenomena of the earth's crust which are within the limits of human observation. Amongst the imposing host of geologists of this period whose works are passed under review occur the names of Werner, Pallas, Saussure, Hutton, Playfair, William Smith, Leopold von Buch, Alexander von Humboldt, Alex. Brongniart, and Cuvier. Perhaps the most conspicuous amongst his contemporaries is the celebrated Freiberg Professor, A. G. Werner, of whose teachings and of the wonderful influence which he exercised on his students a very graphic account is given by the author. It is difficult to realize at the present day that the teaching of Werner that all the rocks of the earth's crust had been produced as chemical or mechanical deposits from a watery solution should have been so firmly maintained and strenuously defended, and that it was only overthrown after a lengthened period of violent controversy.

But whilst Werner, with a renown akin to that of a prophet, had drawn to himself a school of ardent disciples from all civilized countries, a simple teacher in Scotland, James Hutton, was preparing his work on "The Theory of the Earth," which was destined to exercise a powerful influence on modern geology long after the Neptunist theory of Werner had exploded. The great merit of Hutton, as the author points out, is that he based his conclusions on inductions from previously observed facts, and explained the phenomena by the action of forces still in operation, so that he had no need to call in the aid of supernatural or imaginary powers. As is well known, many of Hutton's ideas were more fully expanded by subsequent authors, notably by Sir Charles Lyell, and thereby the credit justly due to him has, in a measure, been attributed to others.

To the genius of another of our countrymen of this epoch, William Smith, is due the discovery of the leading principle that the succession of the rocks may be known by their included fossils. A sympathetic account of William Smith's work is given by the author, with an able summary of his character in the following terms:—"William Smith was self-educated, a man of rare originality and unusual penetration. Without academic training, without any guidance, without any material support, and at the beginning without even encouragement from his contemporaries, he succeeded by his tenacious perseverance in tracing out the geological structure of England in so clear a manner that subsequent investigation has not made any important change in the groundwork he laid down. Smith limited himself to the practical study of the geology of his native land, and abstained from all general speculations on the origin and history of the earth. On his work, thus wisely limited, rests his greatness, and to it this modest, unselfish, and open-hearted observer owes the well-deserved appellation of Father of English Geology."

The position occupied by geology in the principal countries of Europe during this heroic period, and the lines of investigation followed by the leaders of the science in each, are passed under review: the various textbooks on geology and geognosy published in this interval are noticed as contrasting favourably by their sober, practical treatment of the subject with the more speculative works of the preceding epoch, and sketches are given of the advances made in the study of petrology and palæontology. Owing to the great influence of Werner's teaching, which did not take much account of fossils, their study did not take so high a position during this period as that of petrology. The great French anatomist, Cuvier, however, dwelt much on the importance of fossil organisms in the study of the earth's history in general, and of organic life specially. In the warm eulogium pronounced on him by Von Zittel it is pointed out that his merit chiefly rests on his achievements in vertebrate palæontology, in establishing a scientific method in the nomenclature of fossil osteology, and in the convincing proof which he gave that fossil mammals belonged to extinct genera and species and that they could not be regarded as mere varieties of forms now living. At the same time he maintained the unchangeableness of species, and denied that there was any genetic connection between the earlier forms of organic life and the present ones. It must be confessed that on some points he stood at a lower level of knowledge than his contemporaries, and that some of his theoretical conclusions tended to hinder rather than forward the advance of geology.

The author's fourth period — the more recent development of geology and palæontology, from 1820 to the present time—is treated at great length, and occupies about three-fourths of the volume. After the close of the last epoch, which might well be termed the spring-time of the science, geology entered on a new phase. Its position as not the least important of the natural sciences had been established, and in most of the great centres of academical learning courses of study were founded and collections of rocks and fossils made for teaching its principles. The period for great discoveries had passed; hasty and superficial observations and wide generalizations were replaced by deeper and more detailed investigation, less brilliant perhaps, but more permanent in its results. The list of eminent professors and teachers of geology in the Universities of Germany during this recent period indicates the high importance attached to the science in that country, in a measure greater than that shown in the corresponding institutions in England and in France.

The value of geology in many departments of practical life, such as mining, agriculture, building, etc., was not long hidden from Government authorities, and led to the establishment of official Geological Surveys for the purpose of investigating and mapping the geological structure of their respective countries. The first to be founded was that of the Geological Survey of the United Kingdom in 1835, and since then Government Surveys with a similar object have been formed in nearly every State in the civilized world. A further notable impulse to the study of geology in recent times has been derived from the societies and associations for the encouragement of independent researches in the science which have sprung up in different countries.

The wide field for observation presented by the diverse aspects of geology in its later developments, and the vast store of materials collected from so many varied sources, naturally led to a division of labour amongst the workers, and hence the science became divided up into a series of special departments, more or less intimately linked to each other and to the sister sciences, though often differing materially from each other in their mode of working. It was therefore impossible to treat the recent development of geology as a whole, and the author has consequently given us a history of the origin, the growth, and the present position of each of the separate branches of the science, which are referred to in as many chapters under the headings of Cosmical, Physiographical, Dynamical, and Topographical Geology, Stratigraphy, and Petrography. It would be beyond our province to refer to the numerous points of importance in each of these subjects, which have been so thoroughly and lucidly stated by the author; their intimate connection with the present generation of geologists will cause them to be scanned with the liveliest interest.

In the concluding chapter, Palæontology, the science with which Von Zittel's name will ever be associated, is treated in a somewhat condensed form, and consists chiefly of short references to the principal groups of fossil organisms and to the authors and works in which they have been described. It would almost seem as if the author's vast knowledge of the subject had restrained him from venturing into details which might have proved overwhelming.

We cannot finish this short notice without expressing our high opinion of the value of this work to all geologists and to others interested in the science of geology who desire to be acquainted with its early history and the various stages it has passed through in the course of its growth up to the present time. The author is heartily to be congratulated on having successfully carried out this arduous undertaking, the character of which can only be appreciated by those who have some knowledge of the enormous literature which has to be studied and digested for its preparation.

III.—Indian Geology.

1. Memoirs of the Geological Survey of India, vol. xxv: Geology of Bellary District, Madras Presidency. By R. Bruce Foote, F.G.S., F.M.U. Superintendent, Geological Survey of India. 8vo; pp. xviii and 218 (1895), with a folding geologically coloured map of the Bellary District (October, 1896). (Calcutta, 1897.)
2. The Geology of Baroda State. By R. Bruce Foote, F.G.S., C.F.E.G.S., Geological Survey of India (retired), and lately State Geologist, Baroda. Published by order of H.H. the Gaekwar. 8vo; pp. x and 194, with 3 folding maps (1897–98). Received December, 1899. (Madras, 1898.)

The author of these memoirs is one of the oldest and most experienced members of the Geological Survey of India, and although he has retired some time from the staff, he has remained resident in India.[1] He has just sent us a copy of his memoir on the Geology of the Bellary District in the Madras Presidency, being the last piece of his official survey work, done some time since. The map which accompanies this memoir is a good specimen of modern chromolithography, well and clearly printed in colours, which define alluvium, laterite-breccia, the Dharwar System and hæmatites, the granitoids and gneisses, the steatite beds, granite veins, trap-dykes, crystalline limestones, etc.

[1] Undertaking the Geology of Baroda and of Mysore States for their respective native Governments.

Bellary District lies between Haidarabad on the north, Mysore on the west and south, and Anantapur on the east. It forms the western division of the Ceded Districts (so-called because ceded by the Nizam by treaty in 1800 to the East India Company); it lies in the centre of the Deccan tableland, and has an area of 5,904 square miles. Nearly the whole area has a general slope to the northward, and is drained by the Tungabhadra River. Thirty-one hills are cited by the author having altitudes varying from 1,674 feet to 3,285 feet.

The rocks of the district are arranged in four principal groups—

IV. Recent and Post-Tertiary.	*Subaerial.* — Talus formation. Cemented Taluses. Pseudo - Lateritic Breccias. Kankar formations. Blown sands. Regur. Red soils. Mixed and white soils.
	Alluvial.—Modern Alluvial deposits (loams and shingle beds) of the Tungabhadra and its tributaries. Fossiliferous Travertine. Consolidated shingles. High-level gravels (old alluvium) of the Tungabhadra. Shingle fans.
III. Tertiary (?).	*Terrace Laterite.*
II. Lower Transition.	*Dharwar System.*—Principal metalliferous rocks of South India.
Azoic. I. Archæan or Metamorphic and Plutonic.	Granitoids and gneisses with associated traps, etc.

The Archæan rocks, which form the fundamental series in the peninsula, are very largely developed in the Bellary District, and occupy fully five-sixths of its area. Their extent alone, therefore, renders them the most important geological series to be treated of; they are deserving of much interest, and of far closer study than could be bestowed upon them, because of their general poverty in minerals of economic importance, to the quest for which much more time had to be devoted.

Taking the district as a whole, it must be described as consisting mainly of granitoid rocks, generally of porphyritic character, the metamorphic or gneissic crystallines playing a very subordinate part in most places, though of such great importance in other parts of the Madras Presidency.

The description of the Archæan or metamorphic rocks occupies the whole of chapter iv, pp. 26–73.

"Very marked and interesting illustrations of the power of weather-action along lines of jointing are to be seen on the top of the Fort Hill in the shape of water-holes which have been utilized as cisterns. In every case the weathering has worked along lines of jointing and produced the remarkable holes which are so useful in holding rain-water, and of which the native builders availed themselves so fully by increasing the water-holding capacity by dams.

"Some people seem to think the constant supply of water in these holes a rather mysterious phenomenon, whereas it is in reality a very simple one. The several catchment-areas which supply the holes are more than large enough to fill them in good rainy seasons, and the larger holes are so deep that their stock of water cannot evaporate more than partially before they get a fresh supply from the skies, and thus they never run dry in a normal succession of seasons. There is, then, no need to appeal to occult causes, such as natural *artesian action, pressure derived from the copper-mountain*, or *subterranean syphons connected with mysterious water stores at unknown depths*, goodness knows where!" (p. 58.)

The lower Transition or Dharwar Rocks, a great system of submetamorphic sedimentary rocks with numerous contemporaneous trap-flows, was first recognized by Foote as distinct from the South Indian gneiss; these rocks were originally deposited over very much larger areas than those they now occupy, and very probably extended across the whole or nearly the whole peninsula.

The Dharwar System was exposed to great contortion and deformation at a very remote geological period, followed by vast denudation, which eroded and cut up the enormous folds, into which they had been previously forced, into the great bands in which they now occur. These transition rocks are richly interbedded with bands of hæmatite, giving them great stability and resistance to denudation, so that they now form most of the hilly country of the district. Many illustrations and geological sections accompany this chapter, pp. 74–175. These are followed by the intrusive rocks in the Archæan area, the Laterite terraces, the alluvial deposits, the subaerial formations, and economic geology. Under this last heading we find that iron, manganese, gold, and copper are met with, the iron alone occurring in any quantity. There are also excellent building stones.

The last chapter is devoted to prehistoric economic geology, and describes the various implements met with of Palæolithic and Neolithic age down to iron axes closely imitating polished stone implements in form.

2. *Baroda State.* — Mr. Bruce Foote introduces his memoir on Baroda as follows:—"The duty of making a geological survey of the Baroda State was entrusted to me early in October, 1891, and occupied the working seasons of 1892, 1893, and 1894. During those three years I visited carefully and examined closely all the important mineral regions lying within the limits of the State, both in Gujarat and Kathiawar. The completion of this memoir has been delayed partly by personal ill-health and by difficulties connected with the preparation of the maps and plates requisite to illustrate the memoir, the work required being of such a nature that all the most important parts had to be done by myself, and did not admit of my being appreciably assisted by anyone else."

The Gujarat divisions of Baroda are separated from each other by intercalated parts of British territory belonging to the districts of Surat, Broach, Kaira, and Ahmedabad, and the political agencies of Rewakanta, Panch Mahals, and Mahikanta.

The southern half of the Baroda territory lies about ten miles inland from the Gulf of Cambay, except in the Nausari taluq between Mindhola and Purna Rivers, where the Baroda territory forms the seaboard; but the State possesses no seaport of any value, while, owing to the silting up of the estuaries of the great rivers, no craft of any size can ascend to any point within the State boundaries.

The northern half of the State lies entirely inland along the valleys of Mahi, Sábarmati, and Sarasvati Rivers.

The drainage of the Gujarat divisions of Baroda State all falls westward into the Arabian Sea, and, excepting that of the most northerly taluqs, which are drained by the Banass and Saraswati Rivers into the Runn of Kach, falls into the Gulf of Cambay, which receives such a vast amount of silt brought down by the larger rivers that it is rapidly being silted up, as shown by the present condition of the harbours of Surat, Broach, and Cambay. Not two centuries ago the seaports were visited by fleets of shipping of the ordinary size of the traders of those days. Now they are with difficulty reached by vessels of as low a tonnage as about 30 tons.

The succession of the rocks met with in the Gujarat divisions of Baroda State are referable to the following groups, which are here arranged in descending order :—

VI. *Recent* (b) *Subaerial Formations.*—Blown sands; soils; the great blown loam or 'Loess' formation; fluviatile and marine alluvia.

(a) *Old Alluvia of the Great Rivers.*—Consolidated grits and ferruginous gravels of the Sábarmati, Mahi, and Tapti Quaternary deposits.

V. *The Eocene* (*Nummulitic*) *System.*—Clays, cement-stones, limestones, conglomerates, and laterites of the Kim and Tapti Valleys. Laterites and sandstones of the Sábarmati Valley. Laterites of Purna and Ambika Valleys.

IV. *The Deccan Trap* (*Cretaceous*) *and Intertrappean Rocks.*—Traps and intertrappean rocks of the Mohar Valley (Atarsumba). Traps and intertrappean rocks of the Mahi Valley (Sauli taluq). Intertrappean rocks in the Vishwamitri. Traps in the Dev River. Traps in the valley of the Heran. Spurs of the Rajpipla Hills north of the Tapti. Spurs of the Sahyadri range south of the Tapti. Dykes traversing the southern trap area.

III. *The Bagh Series.*—Songir conglomerates and sandstones in Sankheda taluq, and conglomerates and limestones in Sauli taluq.

II. *The Champanir System.*—Quartzites forming the hills north of the Orsang River. Quartzites, limestones, calcareous schists, clay schists, and slates in the valley of Heran and Aswan Rivers.

I. *The Archæan Rocks.*—Granite with pegmatite veins of the Upper Sábarmati Valleys. Granites, gneisses, and crystalline limestones of the Orsang and Unch Valleys, Sankheda taluq. Intrusive rocks, pegmatites, quartz reefs, and trap-dykes.

Although so much of the country is masked by deep coverings of alluvium, of sand, loess, and other late deposits, the Eocene (Nummulitic) System, where it occurs, yields some fossils which have been identified by Stoliczka as—*Rostellaria Prestwichi*; *Terebellum*; *Cerithium*; *Cypræa elegans*; *Natica longispira*; *Conus*, sp.; *Trochus*, sp.; *Pholas*, sp.; *Pecten Hopkinsi*; *P. Favrei*; *P. corneus*; *Vulsella legumen*; *Ostrea Flemingii*; *O. lingura*, etc.; *Nummulites perforata*; *N. Brongniarti*; *N. exponens*; and *N. spira*.

Under the head of Economic Geology, the author points to one serious drawback to the development of the country, namely, the want of roads. Owing to the want of construction these lines of would-be traffic are during the rains totally impassable, districts are entirely isolated from one another, and travelling becomes impossible. In dry weather the mud is exchanged for deep ruts and suffocating clouds of dust. The tanga frequently sinks up to the axle-tree. Iron and iron-ores are fairly abundant; gold also is met with, but in very small quantity. Building material can be obtained readily within a reasonable depth below the surface in the western taluqs of the Kari and Baroda Prants.

Part II is devoted to a sketch of the geology of the Gaekwari Districts in the Kathiawar Peninsula. This area is about 1,320 square miles in extent, and largely occupied by rolling plains, which as a rule are treeless and cheerless in aspect. The Gir forest is hilly, and is the last refuge of the Gujarat lion, now reduced to about forty individuals.

The succession of the rocks in the Kathiawar Gaekwari is limited to—

III. Recent.	Alluvium and subaerial deposits. Miliolite.
II. Tertiary.	Dwarka beds. Gaj beds.
I. Cretaceous.	Deccan Trap Series.

The only economic product of importance here seems to be the building stones, principally the miliolite or Porbander stone largely quarried at Porbandar.

It is quite impossible to do justice as we could desire to this valuable memoir in the space at our command. Three large folding maps greatly assist the comprehension of the regions described.

Everyone interested in Indian geology will be grateful to Mr. Bruce Foote for his contributions to a fuller knowledge of these districts, which he has so carefully examined and reported upon. Wherever Mr. Bruce Foote goes he gathers not only geological notes but also ethnological treasures. One of these, which he figures in this volume (pl. v), is a rude Palæolithic axe from the alluvium of the Sábarmati River, and is very remarkable in shape, not unlike an iron adze in form.

IV.—General Report on the Work carried on by the Geological Survey of India for the period from April 1, 1898, to March 31, 1899. Under the direction of C. L. Griesbach, C.I.E., F.G.S. Large 12mo; pp. 91. (Calcutta, 1899.)

AMONG the various materials of this Report there is much interest to be found in the "Lists of Assays and Examinations made in the Laboratory during the past year" (pp. 3–10), including the account of a Stony Meteorite (p. 2) which fell at Gambat in Sind, September 15th, 1897. Dr. A. von Kraaft reports on the Spiti fossils (pp. 11 – 22), collected by Mr. H. H. Hayden, whose report on the geology of Spiti is given at pp. 46–50. Economic inquiries by the Surveyors, beginning with the distribution of mica and the local systems of mining, were made under the superintendence of Mr. T. H. Holland, whose much extended issue of the late Professor Val. Ball's account of Indian Corundum, Ruby, and Sapphire, from Part iii of the "Manual of the Geology of India," 1881, was published in 1898. A preliminary report is given at pp. 28–33. Mr. La Touche's discovery of a coal area in Bikanir is reported (pp. 33–35) as being likely to prove very valuable. Another landslip at Naini Tal is reported at p. 35. Geological Surveys have been carried on in the Central Provinces, Central India, Western Rajputana, Himalayas, and Baluchistan, with good results, often of much interest. A list of additions to the Library is appended as usual. T. R. J.

V. — The Palæontographical Society of London: Annual Volume (LIII) for 1899. Issued December, 1899.

THE volume issued by the Society for the year 1899 contains portions of four monographs; two of these are devoted to the bivalved Mollusca, which, by the way, in one monograph are called Lamellibranchia and in the other Lamellibranchiata.

1. A Monograph of the British Palæozoic Phyllopoda (Phyllocarida), Packard. By Professor T. Rupert Jones, F.R.S., F.G.S., etc.. and Dr. Henry Woodward, F.R.S., F.G.S., etc. Part IV (Conclusion): General Title-page; pp. i–xv, 175, 176 (reprinted), 177–211; pls. xxvi–xxxi.

This forms the concluding portion of this Monograph, the preceding parts of which appeared in the volumes of the Palæontographical Society for the years 1887, 1892, and 1898. The study of the genus *Dithyrocaris*, which was commenced in part iii, is continued and concluded. Two new species, *D. Dunnii* and *D. Neilsoni*, are described from tail-pieces; the former upon specimens found by Mr. John Dunn in the Redesdale Shales, Northumberland, the latter upon examples in Mr. Neilson's collection from East Kilbride. A new genus, *Chænocaris*, is proposed to include McCoy's *Dithyrocaris tenuistriatus* from the Carboniferous Limestone of Little Island, Cork, and a new species (*C. Youngii*) founded upon a specimen from the Upper Limestone group of the Lower Carboniferous series at Robroyston, Lanarkshire. For the unique specimen in the Museum of the Geological Survey of Scotland that was collected from a "'greenish-grey' (now reddish), flaggy, calcareous shale of the Lower Red Sandstone series at the Carmichael Burn, near the Manse, four and a half miles south-east of Lanark," and previously described as *Dithyrocaris striatus*, the new genus *Calyptocaris* is proposed, and into it is placed, somewhat doubtfully, a new species (*C.? Richteriana*) founded upon a single specimen from the "Cypridinen-Schiefer" (Entomis-shales), at Saalfeld, Sachsen-Meiningen.

Then follow descriptions of various tail-pieces belonging to the genus *Dithyrocaris*; some remarks upon the allied genus *Mesothyra* from the Devonian strata of North America, and a note upon F. A. Roemer's *Dithyrocaris Jaschei* from the Hercynian Limestone in the Klosterholz, near Ilsenberg, Hartz, which the authors refer with a query to the genus *Ptychocaris*. There is a short chapter on "The Gastric Teeth of *Dithyrocaris*," with a number of illustrations of these curious little fossils. The part concludes with observations on "Some Allies of *Dithyrocaris*." These are—(i) *Lebescontia ænigmatica*, a new genus and species founded upon two specimens which were collected by M. Paul Lebesconte, of Rennes, from the Lower Silurian rocks of Brittany and neighbourhood, which, although "somewhat obscure on account of imperfection, distortion, and embedment," the authors believe to be "the relics of some kind of bivalved or shield-like Phyllopod, near to but not identical with *Dithyrocaris*"; (ii) *Lebescontia occulta*, a new form from the "Upper Limestone" series at Linn Spout, south-west of Dalry, twenty miles south-west of Glasgow; (iii) *Hibbertia orbicularis*, already described and figured by the authors in the Geological Magazine for September, 1899.

This being the concluding part of the Monograph there are various lists, several pages of "Addenda et Corrigenda," and an index and general title-page to the whole volume. The binder is instructed to "*cancel* the title-pages of parts i, ii, iii, and iv . . . and *substitute* the general title-page given in the volume for the year 1899"; but though the dates of the several parts are given, some workers may prefer to have the volume bound with the title-pages of the several parts in position as issued. We shall certainly do so ourselves.

2. A Monograph of the Cretaceous Lamellibranchia of England. By Henry Woods, M.A., St. John's College, Cambridge. Part I: Nuculanidæ, Nuculidæ, Anomiidæ, and Arcidæ. pp. 1–72; pls. i–xiv.

Mr. Woods has already devoted much attention to the Palæontology of the Invertebrata, and not very long ago contributed to the Geological Society of London an important paper on "The Mollusca of the Chalk Rock" (Q.J.G.S., vol. lii, 1896, pp. 68–98, pls. ii–iv; and ibid., vol. liii, 1897, pp. 377–404, pls. xxvii and xxviii). Mr. Woods doubtless found the nomenclature of the Cretaceous Lamellibranchiata in a sad state of confusion, and this may have led him to commence the present Monograph. The bad state of preservation of many of the Chalk Mollusca renders their study exceedingly difficult; but as the Chalk is now attracting the special attention of not a few geologists, it is very desirable that all the Mollusca, especially the Lamellibranchiata and the Gasteropoda, which have hitherto been in a very unsatisfactory state, should be overhauled, and the nomenclature corrected as far as possible. Mr. Woods' monograph appears, therefore, very opportunely, and he deserves the hearty thanks of all for undertaking to work out this very difficult group. As in every other group, many species have been very differently interpreted by different authors; we are therefore glad to find that whenever possible the type-specimens of the species have been examined, for very often this is the only way to arrive at a satisfactory conclusion.

This first part of Mr. Woods' Monograph deals with the Nuculanidæ, the Nuculidæ, the Anomiidæ, and the Arcidæ. The arrangement of the species of each genus is in the main stratigraphical.

The Cretaceous members of the family Nuculanidæ are comprised in the genus *Nuculana*, H. F. Link, and range from the Crackers and Atherfield Clay of Atherfield, through the Gault and Upper Greensand, possibly into the Chalk Rock. It is found also at several horizons in the Speeton Clay, a new form, *N. Speetonensis,* being described from the Speeton Clay of Speeton, upon specimens in the British Museum (Natural History) and in the Museum of Practical Geology, but their precise horizon is not recorded.

The only representative of the family Nuculidæ is the genus *Nucula*, Lamarck, which occurs in the Speeton Clay, and ranges from the Lower Greensand through the Gault and Upper Greensand, possibly into the Chalk Rock. A new species (*N. Lamplughi*), the types of which are in Mr. Lamplugh's collection, is described from the Speeton Clay (D 4) of Speeton.

The Cretaceous Anomiidæ are comprised in the genus *Anomia*, Linnæus, which ranges from the Lower Greensand through the Gault, Upper Greensand, and Cambridge Greensand, into the Totternhoe Stone.

The family Arcidæ is represented by the genera *Arca*, Linnæus (*sensu stricto*); *Barbatia*, J. E. Gray; *Grammatodon*, Meek & Hayden; *Trigonoarca*, T. A. Conrad; *Cucullæa*, Lamarck, with the new subgenus *Dicranodonta*; *Isoarca*, G. Münster; *Pectunculus*, Lamarck; and *Limopsis*, A. Sasso. The subgenus *Dicranodonta* is proposed for W. Keeping's *Cucullæa Donningtonensis*, the types of which came from the Claxby Ironstone, Benniworth Haven, and are preserved in the Woodwardian Museum, Cambridge; but the species is also recorded from the Lower Greensand of Upware. The author places with a query in this same subgenus the species which W. Keeping described as *Pectunculus obliquus* from the Lower Greensand of Upware; and he considers that the form described by Keyserling and by Schmidt as *Pectunculus Petschoræ* probably also belongs here. A new species of *Pectunculus* (*P. euglyphus*) is founded upon three specimens in Mr. Meÿer's collection from the Chalk Marl (Meÿer's bed ii) of Dunscombe, and a new species of *Limopsis* (*L. albiensis*) upon some specimens from the Lower Gault (zones ii, iii, and vii) of Folkestone, that are preserved in the Museum of Practical Geology, Jermyn Street.

3. A Monograph of the British Carboniferous Lamellibranchiata. By Wheelton Hind, M.D., etc. Part IV: Edmondidæ, Cyprinidæ, Crassitellidæ. pp. 277–360; pls. xxvi–xxxix.

In the present part the author deals with the rest of the Edmondidæ, comprising, in addition to those treated of in part iii, the genera *Sedgwickia*, M'Coy; and *Edmondia*, De Koninck, with the subgenus *Scaldia*, De Ryckholt. *Sedgwickia* is represented by five species, three of which (*S. ovata*, *S. Scotica*, and *S. suborbicularis*) are described as new. In his observations on this genus the author states that "*Venus centralis*, M'Coy, and *Dolabra securiformis*, M'Coy . . . doubtless belong to the genus; unfortunately, however, the type specimen of the former has decomposed, and that name can no longer be retained." If we are to conclude from this statement that when the type-specimen decomposes the name of the species disappears, what a prospect for the names of the Gault and London Clay fossils, which have such a strong inclination to go 'wrong'! The genus *Edmondia*, De Koninck, is represented by about twenty species, six of which are regarded as new, and the subgenus *Scaldia*, De Ryckholt, by two species.

Of the Cyprinidæ the author recognizes among the Carboniferous Lamellibranchiata only the new genus *Mytilomorpha*, the typical Carboniferous form of which he considers to be that described by Phillips as *Cypricardia rhombea*; the only other British Carboniferous species being *M. angulata*, n.sp.

To the Crassitellidæ Dr. Hind refers Hall's genus *Cypricardella*, seven species of which are described in the present part; Fischer and Beushausen placed this genus in the Astartidæ, and the author admits that it really possesses characters intermediate between the two "genera" [families]. He regards *Astartella* and *Cypricardella* as probably identical, and says (p. 347) "the date of the description of *Astartella* is 1858, the same year as that of *Cypricardella*," a statement, however, which does not quite agree with the references to these two genera given on the preceding page.

4. A Monograph on the Inferior Oolite Ammonites of the British Islands. By S. S. Buckman, F.G.S., etc. Part XI. Supplement: ii.—Revision of, and addition to, the Hildoceratidæ. pp. xxxiii–lxiv; pls. v–xiv.

Mr. Buckman continues his revision of this family, dealing chiefly with the forms which were referred in the body of the work to *Lioceras* and *Ludwigia*. He says that "nearly all the specimens inscribed as *Lioceras* in the body of this work must be removed from that position." The genus *Lioceras* is restricted, *opalinus* being the type species of the genus, and "Quenstedt's fig. 10 in pl. vii of his 'Cephalopoden' is regarded as the arbiter of what is *opalinus*." Several new species and not a few new genera are proposed.

VI.—A Treatise on Crystallography.—By W. J. Lewis. pp. 612, with 553 figures in the text. (Cambridge, 1899.)

DURING Mr. Lewis's tenure of the University Professorship, which has extended over nearly twenty years, the subject of Mineralogy (in combination with Crystallography) has been made an independent subject of the Natural Sciences Tripos, and for some time has had a considerable number of students; a textbook of Crystallography at once suited to the requirements of the Tripos and corresponding in its methods and terminology to the professorial lectures will be a great boon to Cambridge men, and the book will doubtless be welcomed in other Universities, both at home and abroad, more especially in America. Among the many good points which we have noticed, we may more particularly mention the lucid descriptions of the methods of crystal drawing and the numerous worked problems illustrating in detail the methods practically adopted in the calculation of the forms of crystals from the measured angles. The methods of projection and the uses of anharmonic ratios are also well explained. In the treatment of the subject great stress is laid on the independence of the thirty-two types of crystalline symmetry, and their deduction and characteristics are illustrated in full detail. Most of the figures have been specially drawn, and there are frequent references to the specimens preserved in the Cambridge Collection. The Cambridge University Press is to be heartily congratulated on this particularly handsome and valuable addition to its series of Natural Science Manuals.

M. F.

VII.—First Appendix to the Sixth Edition of Dana's System of Mineralogy. By Edward S. Dana. pp. 75. (New York, 1899.)

THE usefulness of the well-known Dana's System of Mineralogy, the sixth edition of which was published in 1892, has been increased by the issue of a First Appendix, which includes within a brief compass a description of the more salient characters of the new mineral species discovered during the last seven years, and an account of the results of later research on the species already described in the Sixth Edition itself. For convenience the mineral species are noted in alphabetical order, and full references are given to the original memoirs. The Appendix is brought well up to date, and takes account of researches published very shortly before its own appearance.

M. F.

VIII.—The Geology of the South Wales Coalfield. Part I: The Country around Newport, Monmouthshire. By Aubrey Strahan, M.A., F.G.S. Memoirs of the Geological Survey. pp. vi, 97. (London: printed for H.M. Stationery Office, 1899. Price 2*s*.)

THE resurvey of the great Coalfield of South Wales was commenced in 1891 by Mr. Strahan, and has been carried on with the aid of Mr. J. R. Dakyns (who has now retired from the service), Mr. R. H. Tiddeman, Mr. Walcot Gibson, and Mr. T. C. Cantrill. The present Memoir is the first of a series intended to explain the one-inch geological maps of the district, of which four have now been published. In it we have descriptions of the Silurian rocks of Usk, of the Old Red Sandstone, Carboniferous rocks, Keuper Marl, Rhætic Beds, Lower Lias, Glacial Drifts, and more recent deposits. The Silurian rocks comprise Wenlock and Ludlow Beds, and while they are overlain with apparent conformity by the Old Red Sandstone, it is noted that the plane of demarcation is sharp and that there is no evidence of gradation. This is not as we have usually been taught to believe. Moreover, instead of any break in the Old Red Sandstone, marking a division into Upper and Lower beds, it is stated that the entire group is made up of a conformable series of red sandstones, conglomerates, and marls with cornstones. Of these, three divisions have been traced out and coloured on the map. Remains of *Pteraspis* and *Cephalaspis* occur in the lowermost division.

The Lower Carboniferous rocks rest conformably on the Old Red Sandstone, but they differ from equivalent beds in the Mendip area, inasmuch as the mass of "Lower Limestone Shales" there, is represented in the neighbourhood of Newport by a lower bed of brown, often oolitic, encrinital limestone 50 to 100 feet thick, surmounted by from 40 to 90 feet of shale. Above is the main mass of Carboniferous Limestone, which in the area now described varies from 150 to 700 feet. No particular attention appears to have been given to the fossils of these rocks, and we can hardly wonder that this has been the case. Fossils are not readily to be obtained from the Carboniferous Limestone of Monmouthshire, and the field-geologist can scarcely give the weeks of labour to quarries and other exposures of rock, without which collecting would be of little value.

No distinct division of "Upper Limestone Shales" is recognized. The strata immediately above the Carboniferous Limestone are grouped as Millstone Grit, and they comprise not only the characteristic hard grit with quartz pebbles, but considerable masses of shales. The details relating to the Coal-measures naturally form the most important features in this Memoir, judged from an economic point of view. A study of the various faults and dislocations is most important, and these will be best understood when the map is placed alongside the memoir. Descriptions are given of the Keuper Marls, the Rhætic Beds, and the Lower Lias which are exposed near Newport, in quarries and cuttings at Lis-Werry and at Goldcliff on the Severn shore. Various Glacial drifts, River gravels, and other Alluvial deposits are also described.

IX.—Preliminary Notice of the Etcheminian Fauna of Cape Breton. By G. F. Matthew, LL.D., etc. Bull. Nat. Hist. Soc. New Brunswick, vol. iv, pp. 198–208, pls. i–iv. December, 1899.

THE fossils described in this article were collected from a terrane beneath the Cambrian in Cape Breton Island, in the province of Nova Scotia, Canada. The sections given prove that this terrane is beneath the Cambrian, which overlies it unconformably. They show no 'Lower Cambrian,' as the faunas of *Paradoxides* and *Protolenus* are absent, or, at least, have not been recognized. The beds are therefore assigned by Dr. Matthew to the same level as the beds of similar appearance and position in New Brunswick and Newfoundland (see Geological Magazine, Dec. IV, Vol. VI, pp. 373 and 472, August and October, 1899; see also next notice). The Pre-Cambrian life-period thus revealed has been named Etcheminian by its discoverer. It was a period characterized in this region by much volcanic activity, and by rather humble forms of life: worms in abundance, primitive brachiopods, Capulidæ but few other molluscs, some ostracods but no trilobites. None the less, still a long way from the beginning of things.

The fauna in the Cape Breton Etcheminian is quite different from that found in rocks supposed to be of the same age in Newfoundland; in fact, the genera are all such as occur at the base of the Cambrian in New Brunswick (*Protolenus* zone). A difference of age, however, is to be inferred from the fact that the species are all different and new. Of Brachiopods there are—*Lingulella*, two species; *Leptobolus* (?), two sp.; *Obolus* (subgen. *Palæobolus*, n.subgen.), one sp.; *Acrothele*, one sp.; *Acrotreta*, one sp. Of Ostracods there are—*Bradoria* (n.gen.), three sp.; *Schmidtella*, two sp. Four plates of figures representing these species accompany the article.

X.—Studies on Cambrian Faunas: No. 3, Upper Cambrian Fauna of Mount Stephen, etc.; No. 4, Fragments of the Cambrian Faunas of Newfoundland. Also The Etcheminian Fauna of Smith Sound, Newfoundland. By G. F. Matthew, D.Sc., LL.D. Trans. Roy. Soc. Canada, ser. ii, vol. v (1899), sect. 4, p. 39.

THESE articles on the early Palæozoic faunas of the eastern part of Canada and Newfoundland and on that of Mount Stephen in British Columbia serve to extend and broaden our knowledge of the species of that early time in America. Dr. Matthew, on a careful review of the Mount Stephen fauna, concludes that it may be regarded as equivalent to the *Peltura* fauna of N.W. Europe. Eleven genera of trilobites are recognized,—*Ogygia* (*Ogygopsis*), *Bathyuriscus*, *Zacanthoides*, *Neolenus* (n.gen. with 5 n.spp.), *Ptychoparia*, *Dorypyge*, *Agnostus*, *Corynexochus*, *Dolichometopus*, *Oryctocephalus*, and *Conocephalites*. Two new genera and four new species of Hyolithidæ are described. This problematic group of animals is, in accordance with the views of Pelseneer and Holm, absolutely removed from the Pteropoda or any other Mollusca, and is referred by Dr. Matthew to the Annelida, a conclusion which is at any rate more consistent with their predominance at so low a geological horizon.

Under 'Study' No. 4, a variety of forms from several horizons of the Cambrian of Newfoundland is described. *Raphistoma* (?) *Kelliensis*, n.sp., is an early type of a Pleurotomarioid Gasteropod. Several worm-burrows and trails are described, and a large *Hyolithes*. Among the trilobites is a *Microdiscus*; the Agrauloid forms are represented by *Strenuella* (subgen.); two new species of *Miomacea* are described; one new *Avalonia*, and a fine *Metadoxides*. The Conocoryphinæ are re-classified, *C. trilineatus* as subgen. *Atops*, and *Erinnys venulosa*, Salt., as *E.* (*Harpides*) *breviceps*, Ang.

The third article gives the fauna of a set of beds described by the author as a separate terrane, lying beneath the beds that carry the well-known fauna of *Paradoxides* and the less-known fauna of *Protolenus*, which underlies it. This fauna, to which we have referred in the preceding note, is remarkable for the prevalence of Hyolithidæ and primitive types of Gasteropods and Brachiopods. In this article the new Gasteropod genus *Randomia* is described, and the following new species: *Kutorgina*, one sp.; *Randomia*, one sp.; *Platyceras*, three sp.; *Modiolopsis*, one sp.; *Urotheca*, one sp.; *Helenia*, one sp.; *Hyolithellus*, one sp.; *Orthotheca*, four sp.; *Hyolithes*, one sp.; *Aptychopsis*, one sp.

The articles are accompanied by eight plates of figures.

REPORTS AND PROCEEDINGS.

Geological Society of London.

December 20, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On some Effects of Earth-movement on the Carboniferous Volcanic Rocks of the Isle of Man." By G. W. Lamplugh, Esq., F.G.S., of H.M. Geological Survey.

[Communicated by permission of the Director-General of the Geological Survey.]

The author, since the completion of his survey of the Isle of Man, has studied the coast-section in the Carboniferous Volcanic Series between Castleton Bay and Poolvash, with the result that he has discovered evidence that the strata have undergone much deformation in pre-Triassic times, and probably before the Upper Permian rocks of the island were deposited. In the western part of the outcrop the volcanic material consists almost wholly of tuff, in places bedded and fossiliferous; in the eastern part there exists a chaotic mass of coarse and fine fragmental volcanic material traversed by ridges of basaltic rock and containing entangled patches of dark limestone. The author now considers that the larger lenticles and most of the smaller blocks of limestone have been torn up from the underlying limestone floor during a sliding forward or overthrusting of the volcanic series upon it. Such blocks do not contain ashy material, and the patches of truly interbedded, ashy limestone can be distinguished from them. The sections at Scarlet Point, Poolvash, and between Cromwell's Walk and Close ny Chollagh Point are described and figured. Strips of limestone are found to shoot steeply upwards and become wedged in between the blocks in the agglomerate; they give indications of sliding and disturbance, and their outer surfaces are indurated and chert-like. The ash, which usually rests on black argillaceous limestone flags, in places appears to come into juxtaposition with a somewhat lower horizon, crushed, platy material intervening between the two. Steep domes of the limestone break into sharp crests which shoot up into the ash and are bent over towards the north; and between the crests there are small ragged strips of limestone entangled among the tuff. Bands of vesicular basalt are bent and shattered. A dyke-like mass has had a segment sliced off and thrust forward among the agglomerate, so that its flow-lines of vesicles are sharply truncated along the fractured edge, which is often notched and filled in with ash as though lumps had been torn out of it. The composition of the included masses is influenced by the neighbourhood of the rocks *in sitû*, calcareous near limestone, basaltic near the basalt masses.

The phenomena may be explained as the result of earth-movement on a group of rocks consisting of limestone passing up into tuff, interbedded with lava-flows, and possibly traversed by sills or dykes of basaltic rock. The effects of the disturbance appear to be limited vertically and horizontally, and to have been influenced by the differential resistance of the component rocks. Analogous features occur in the Borrowdale Volcanic Series and in the Silurian volcanic rocks of Portraine.

2. "The Zonal Classification of the Wenlock Shales of the Welsh Borderland." By Miss Gertrude L. Elles. (Communicated by J. E. Marr, Esq., M.A., F.R.S., F.G.S.)

This paper deals with the Wenlock Rocks of Builth, the Long Mountain, and the Dee Valley, and establishes the following sequence in these districts:—

Builth.	Long Mountain.	Dee Valley.		Southern Sweden.
Lower Ludlow.	Lower Ludlow.	Moel Ferna Slates.	Nant-Glyn Flags.	*Cardiola*-Shales.
6. Zone of *Cyrtograptus Lundgreni*, Tullb.	Zone of *C. Lundgreni.*		Slates with very few graptolites.	Zone of *C. Carruthersi*, Lapw. = Zone of *M. testis.*
5. Zone of *Cyrtograptus rigidus*, Tullb.	Zone of *C. rigidus.*		—	Zone of *C. rigidus.*
4. Zone of *Cyrtograptus Linnarssoni*, Lapw.	Zone of *C. Linnarssoni.*		Zone of *C. Linnarssoni.*	
3. Zone of *Cyrtograptus*, sp. nov.	?	Pen-y-glog Grit.		Zone of *M. Riccartonensis*
2. Zone of *Monograptus Riccartonensis*, Lapw.	Zone of *M. Riccartonensis*	Pen-y-glog Slates.	Zone of *M. Riccartonensis.*	
1. Zone of *Cyrtograptus Murchisoni*, Carr.	?		Zone of *C. Murchisoni.*	Zone of *C. Murchisoni.*
(Local Unconformity.) Tarannon Shales? Llandovery Grits.	(Local Unconformity.) Purple Shales (? Tarannon). Llandovery Grits.	(Succession conformable.) Tarannon Shales. Corwen Grit.		(Succession conformable.) Shales with graptolites.

The results obtained by the author completely confirm the work of Tullberg on the Wenlock Shales of Southern Sweden.

Along the Welsh border the Wenlock Rocks do not cover a large area, but are merely a fringe to the Ludlow Rocks. The former are characterized by graptolites of the *priodon-Flemingii* type, the latter by those of the *colonus* type.

The general structure of the Builth district is a syncline towards the north and north-west part of a series of folds whose axes run north-east and south-west. A later set of movements, along east and west axes, and of later date, lifted the district to the north and north-west of Builth, and, combined with the effect of previous movements and subsequent denudation, caused the exposure in the north and north-west of beds which are overlapped to the east. The full six zones in the foregoing table occur to the north-east of Builth Road Station, but some of them are overlapped north-west of Builth; and at Aberedw Hill, east of Builth, only the highest zone is exposed. The entire succession in the north and north-west part of the district is given below :—

Ludlow.		10. Hard light-grey siliceous flags.	
		9. Micaceous sandy shales, with rotten limestone bands.	
Wenlock Shales.		8. Calcareous flagstones, with fossiliferous bands.	
	(*f*)	7. Calcareous fissile shales, with beds of flagstone. = Zone of *Cyrtograptus Lundgreni*.	
	(*e*)	6. Hard grey calcareous shales with graptolites. = Zone of *Cyrtograptus rigidus*.	
		5. Light-coloured flags, unfossiliferous	(400 feet) ?
	(*d*)	4. Grey calcareous flags and shales, with limestone concretions ... ... = Zone of *Cyrtograptus Linnarssoni*.	300 feet.
	(*c*)	3. Soft shales with harder flaggy beds ... ... = Zone of *Cyrtograptus*, sp. nov.	200 feet.
	(*b*)	2. Hard calcareous flagstones ... ... = Zone of *Monograptus Riccartonensis*.	300 feet.
	(*a*)	1. Soft fissile shales alternating with flags. = Zone of *Cyrtograptus Murchisoni*.	

The Wenlock Shale of this area was deposited on the sinking shore-line of the old Llandeilo ridge, resulting in the overlap of higher beds on lower.

The Long Mountain is a syncline with north-east and south-west axis. Here also there must have been deposition on a sinking ridge accompanied by overlap. The lowest beds, exposed near Chirbury, belong to the zone of *Monograptus Riccartonensis* ; but on the north-west side, near Middletown, the lowest beds seen above the Tarannon shales belong to the zone of *Cyrtograptus Linnarssoni*. The relationship of these beds to the Tarannon shales is regarded as an unconformability. The sections in this district confirm those established for the Builth area.

In the Llangollen Basin the general structure is a synclinal fold complicated by many minor folds and faults. The 'pale slates' are covered by darker shales belonging to the zone of *Cyrtograptus Murchisoni*; and in this district the relationship of the lowest zones is clearer than at Builth or the Long Mountain.

The palæontological part of the paper describes several species, some of which are recorded for the first time in the country: *Cyrtograptus Carruthersi*, *C. rigidus*, and a new species of *Cyrtograptus* of zonal value, four varieties of *Monograptus Flemingii*, three of *M. vomerinus*, one variety of *M. testis*, and two new species of *Monograptus* are amongst the forms dealt with.

3. "On an Intrusion of Diabase into Permo-Carboniferous Rocks at Frederick Henry Bay (Tasmania)." By T. Stephens, Esq., M.A., F.G.S.

The relationship of the abundant diabase to the Permo-Carboniferous strata of the island has been long a matter of dispute. Among others, Jukes described sections which appeared to confirm the view that Permo-Carboniferous sediments were deposited round vast masses of igneous rock previously cooled and denuded. The author has identified and visited the sections, and finds in one that, although there is a step-like junction between the sediments and the igneous rocks, it is the result of intrusion of diabase, and not of the deposition of sediment. The sediment, which is fossiliferous, is converted into an intensely hard whitish marble, and the associated shale bands into chert. The diabase, which is ordinarily an ophitic rock, acquires at the junction a finely crystalline-granular structure. Jukes's second section also gives undoubted evidence of intrusion.

Geological Society of London: Medals and Awards, January 10th, 1900.

The Council of this Society has decided to give the Medals and Awards on February 16th, 1900, as follows:—

The "Wollaston Gold Medal" to the American Geologist, Professor G. K. Gilbert, For. Memb. Geol. Soc., of the United States Geological Survey, Washington, D.C., U.S.A.

The "Murchison Medal" to Baron Adolf Erik Nordenskiöld, Ph.D., For. Memb. Geol. Soc., of Stockholm.

The "Lyell Medal" to Mr. J. E. Marr, M.A., F.R.S., F.G.S., of Cambridge (for many years Secretary of the Geological Society of London), Fellow of St. John's College, Cambridge.

The Wollaston Fund to Mr. George Thurland Prior, M.A., F.G.S., of the Mineralogical Department, British Museum (Natural History), S.W.

The Murchison Fund to Mr. A. Vaughan Jennings, F.L.S., F.G.S., Assoc. R.S.M., etc.

The Lyell Fund to Miss G. L. Elles, Woodwardian Museum, Cambridge.

The Barlow-Jameson Fund (1) to Mr. G. C. Crick, Assoc. R.S.M., F.G.S., Geological Department, British Museum (Natural History), Cromwell Road, S.W.; (2) to Professor T. T. Groom, M.A., D.Sc. Lond., F.G.S., of the College, Reading.

CORRESPONDENCE.

THE COLOUR OF GLASLYN AND OF LLYN LLYDAW.

Sir,—Glaslyn and Llydaw are the names of the two chief Snowdonian lakes. Glaslyn has from time immemorial been noted, as its name implies, for the greenish colour of its water; but until this year, 1899, there has not been anything peculiar about the colour of Llydaw. Last summer, however, for the first time within at least the last fifty years, the water of Llydaw has become as green as that of Glaslyn. The cause of this change of colour is not far to seek, for last spring the company that works the Snowdon copper-mine commenced crushing and washing their ore on the bank of Llydaw, so that a large quantity of greenish débris is daily carried into the lake, whose water has thus become turbid and greenish in colour. The rock excavated along the copper veins is of a greenish hue, as anyone may see by looking at the tips at the mouths of the adit levels. The change of colour in Llydaw explains the colour of Glaslyn, about the cause of which there has hitherto been some doubt, for it must now be obvious that Glaslyn owes its green colour to the detritus of green rock washed into t from the adit levels of the mine. J. R. DAKYNS.

PEN-Y-GWRYD, *Nov.* 14, 1899.

CATALOGUE OF THE FOSSIL CEPHALOPODA IN THE BRITISH MUSEUM (NATURAL HISTORY), PART III: A CORRECTION.

SIR,—The woodblocks used in illustrating Part iii of the "Catalogue of the Fossil Cephalopoda in the British Museum (Natural History)," by Dr. A. H. Foord and myself, have just passed through my hands, and on comparing them with the figures in the book I find that there has been a very unfortunate transposition of the figures of the suture-lines of some of the species of *Gephyroceras*. The blocks themselves are numbered correctly, but owing to a printer's error they do not appear in their proper places in the volume. The following corrections are necessary:—For Fig. 33 (suture-line of *Gephyroceras affine*) see Fig. 34; for Fig. 34 (suture-line of *Gephyroceras calculiforme*) see Fig. 36; for Fig. 35 (suture-line of *Gephyroceras æquabile*) see Fig. 33; and for Fig. 36 (suture-line of *Gephyroceras serratum*) see Fig. 35. These four figures, then, with their descriptions, should have been as follows:—

FIG. 33.

Suture-line of *Gephyroceras affine* (Steininger). Copied from Holzapfel and completed.

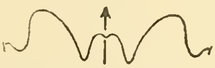
FIG. 34.

Suture-line of *Gephyroceras calculiforme* (Beyrich), enlarged. After Sandberger.

FIG. 35.

Suture-line of *Gephyroceras æquabile* (Beyrich). After Sandberger.

FIG. 36.



Suture-line of *Gephyroceras serratum* (Steininger). After Sandberger.

GEO. C. CRICK.

BRITISH MUSEUM (NATURAL HISTORY).
December 22, 1899.

THE SUB-OCEANIC VALLEY OF THE RIVER CONGO.

Sir, — I have just completed the details of this magnificent submerged river-channel by means of the soundings on the Admiralty chart No. 604. Fortunately they are sufficiently numerous at this part of the African coast to enable me to do so with great accuracy. That the Congo valley is continued under the Atlantic to a great depth has been known for some years, and accompanying the paper by Mr. Edward Stallibrass on "Deep-sea Soundings in connection with Submarine Telegraphy,"[1] there is a plan of this sub-oceanic valley from the mouth of the Congo down to the 1,000-fathom contour, which very closely corresponds with that drawn by myself. The scale of Mr. Stallibrass' map is about half that of the Admiralty chart, or about 25 miles to the inch: the details deserve publication on the full scale. The length of the submerged valley is about 120 miles, and, like those of the West of Europe, it opens out on the abyssal floor at a depth of 1,200 fathoms. The valley is remarkably straight for a distance of about 100 miles, and nearly coincides with the 6th parallel of South latitude, but at this point bends slightly northwards. It is generally narrow, and bounded by walls, in some places precipitous, descending to depths of 2,000–4,000 feet within very short horizontal spaces, and the average fall of the channel is 60 feet per mile. It is unnecessary to point out the significance of the presence of this great submerged river valley as far south as 6° beyond the Equator. It proves beyond question that the western margin of Africa has shared in the great upheaval and subsequent depression by several thousand feet of that of Western Europe and the British Isles, and, let me add, represents on the eastern side of the Atlantic the uprise and depression of the Antillean continent so ably elucidated by Professor Spencer. I hope to treat this subject more fully in a paper to be read before the Victoria Institute this session. Edward Hull.

January 15, 1900.

OBITUARY.

JOHN RUSKIN, M.A., LL.D., D.C.L., F.G.S.

Born February, 1819. Died January 20, 1900.

The great Art-writer and Critic of the century, John Ruskin, passed away peacefully on the afternoon of Saturday, 20th January, his life's work accomplished long since.

Few men have had greater influence on modern thought in matters pertaining to art, pictures, sculpture, and architecture than John Ruskin; he was always an idealist and romantically enthusiastic in his notions, and wholly unworldly, yet no one believed more strongly than he did in his ability to regenerate the world and reform its abuses. His kindness of heart was extreme, and his sympathies were universal. He has been, as such a man naturally would be, severely criticized for his published views on 'Political Economy,'

[1] Journ. Telegraphic Engineers, vol. xvi (1888), p. 479.

and his fierce comments on those manufacturers and merchants who pile up riches by the employment of labour. Doubtless Ruskin forgot for the moment that his own splendid abilities mainly owed the opportunity for their development and sustained energy through life to the accumulated fortune of his father, a partner in the firm of Ruskin, Telford, & Domecq, London.

His success as an art-critic and writer gave him unbounded belief in his power to carry out any matter upon which he had set his heart. Thus, at one time (resenting the intervention of publishers) he determined to print, illustrate, and publish his own works. At another time he started a business as a tea-dealer in order to show that trade might be conducted in an honourable and honest manner. He encouraged the undergraduates at Oxford to dig and repair the roads; and he himself undertook to keep the streets clean between the British Museum and St. Giles', engaging a staff of helpers and setting them an example of their duties.

Everyone who loves Ruskin is, of course, well acquainted with his numerous works—his "Modern Painters," "Stones of Venice," "Seven Lamps of Architecture," "Lectures on Architecture and Painting," "Fors Clavigera," "Ethics of the Dust," "Sesame and Lilies," and some thirty other works, essays and lectures. But how many are aware that he had a strong attachment to geology and mineralogy!

When taken as a boy to Wales by his parents he enjoyed his first sight of really bold scenery; he ascended Snowdon and Cader Idris, and, to his intense delight, found for the first time in his life a real mineral. Ruskin believed if he had been allowed to remain there in charge of the good Welsh guide and his wife they would have made a man of him, and also "probably the first geologist of my time in Europe." Although this youthful dream was never realized, and he devoted his after years to art and architecture, his crossings and recrossings of the Alps in his frequent pilgrimages to his beloved Italy made a powerful impression upon his imagination, as may be seen by his notes and sketches published in the Geological Magazine for 1865, whilst his subsequent papers on Banded and Brecciated Agates, 1867–1870, op. cit., may still be read with intense pleasure for their wonderful word-painting; these, too, being *all illustrated by Ruskin's own hand.* His "Deucalion" on Geology is also most attractive.

Only a few years since he was deeply engrossed in arranging a case of specimens in the Mineralogical Gallery of the British Museum of Natural History, Cromwell Road, to illustrate the structure of Agates, accompanied by a printed description by himself. To this collection he also presented the great South African uncut natural gem, which he named the "Colenso Diamond" after the late Bishop Colenso. The Ruskin Museum, founded by him at Meersbrook Hall, near Sheffield, is a treasure-house of Art, in which minerals also find a place. Of Ruskin's many acts of noble generosity to the world the public Press is now everywhere speaking in most just and appreciative praise; the innumerable kindnesses which he secretly performed will never be known, but they will serve to keep his memory green in the hearts of a large circle, to whom, although occupying quite humble positions, he had endeared himself for all time by calling them *his friends*.

Titles of Prof. Ruskin's Papers printed in the Geological Magazine.

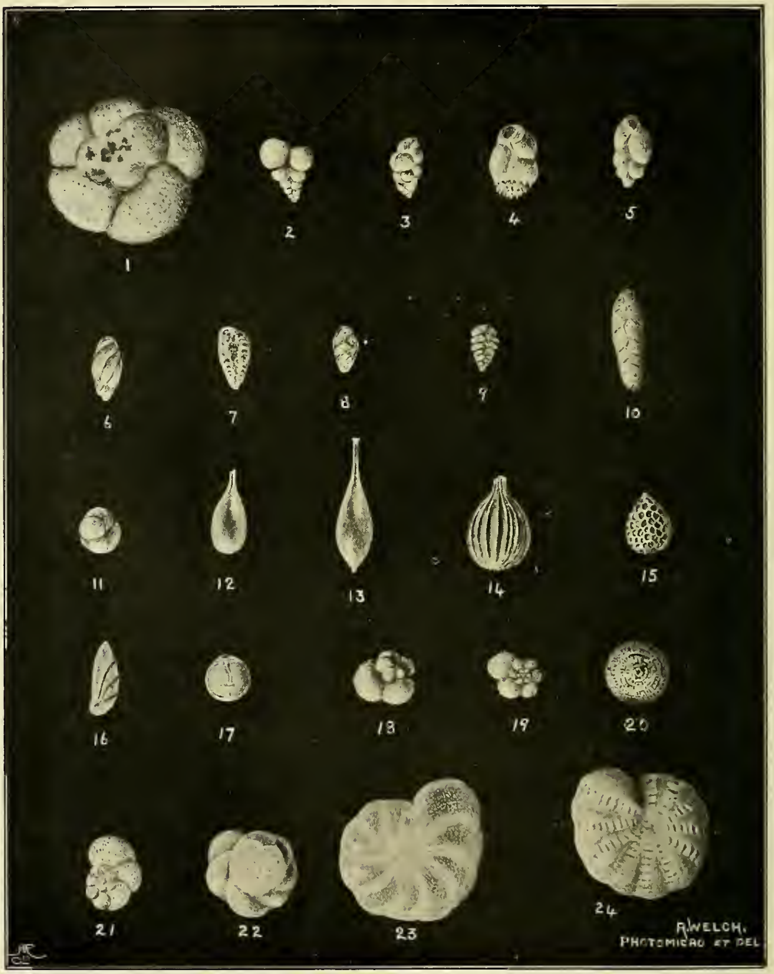
1. "Notes on the Shape and Structure of some parts of the Alps, with reference to Denudation." Vol. II (1865), pp. 49–54 and 193–196, Pl. VI and Woodcuts.
2. "On Banded and Brecciated Concretions." Vol. IV (1867), pp. 337–339, Pl. XV.
3. "On Brecciated Formations." Vol. IV (1867), pp. 481, 482, Pl. XX.
4. "On Brecciated Concretions." Vol. V (1868), pp. 12–18, Pl. III and Woodcuts; pp. 159–161, Pl. X; and pp. 208–213, Pl. XIII and Woodcuts.
5. "On Brecciated Concretions." Vol. VI (1869), pp. 529–534, Pl. XIX and Woodcuts.
6. "On Banded and Brecciated Concretions." Vol. VII (1870), pp. 10–14, Pl. II and Woodcuts.

MISCELLANEOUS.

Presentation of a Testimonial to the Rev. Professor Wiltshire, M.A., D.Sc., F.L.S., F.G.S., etc., Honorary Secretary of the Ray and Palæontographical Societies.—A well-attended meeting of the members of the Palæontographical and Ray Societies was held at the Geological Society's Apartments, Burlington House, on Tuesday, December 19; the Rt. Hon. Sir John Lubbock, Bart.,[1] P.C., M.P., D.C.L., LL.D., F.R.S., President of the Ray Society, in the chair, supported by Dr. Henry Woodward, F.R.S., F.G.S., President of the Palæontographical Society. The object of the joint meeting was to present to the Rev. Prof. Wiltshire, the Hon. Secretary of both the above-named Societies, his portrait in oils, an illuminated address, and a cheque for £138—the balance of the sum subscribed after defraying expenses—in recognition of the services rendered by him to these Societies and to Palæontology and Zoology during a period of more than thirty years. The portrait was executed by Miss Atkinson, the illuminated address by Miss G. M. Woodward. Among those present were—The Right Rev. Bishop Mitchinson, Master of Pembroke, Oxford; Professor T. McKenny Hughes, F.R.S., and Professor W. J. Lewis, of Cambridge; the Rev. R. A. Bullen, the Rev. G. F. Whidborne, V.P. Pal. Soc., the Rev. H. H. Winwood, Dr. W. T. Blanford, F.R.S., Mr. John Hopkinson, Professor T. Rupert Jones, F.R.S., Sir Owen Roberts, Dr. D. H. Scott, F.R.S., Mr. F. W. Rudler, F.G.S., and Mr. A. Strahan; many ladies were also present. The presentation address was delivered by Sir John Lubbock, and the Rev. Professor Wiltshire responded. Speeches were also made by Dr. Woodward, Professor T. McKenny Hughes, Rev. G. F. Whidborne, and the Rev. H. H. Winwood; 132 subscribers took part in the testimonial.

Corrigenda.—In Mr. F. Chapman's paper on *Patellina*-limestone, which appeared in our last issue, the following corrections should be made: pp. 11, 12, and 17, for *Patellina Egyptiensis* read *Patellina Ægyptiensis*; pp. 13 and 17, for *Polytrema papyracea* read *Polytrema papyraceum*. — Also on p. 40, line 20 from foot, for "Applied Geology," read "Applied Geography."

[1] Now "Lord Avebury."



FORAMINIFERA

FROM THE FORMBY AND LEASOWE POST-GLACIAL BEDS.

Magnified 40 diameters.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VII.

No. III.—MARCH, 1900.

ORIGINAL ARTICLES.

I.—A Contribution to Post-Glacial Geology.

By T. Mellard Reade, C.E., F.G.S., F.R.I.B.A.

(PLATE V.)

Foraminifera of the Formby and Leasowe Marine Beds.

IN 1871 I read a paper before the Liverpool Geological Society describing the extensive and interesting submarine forests and associated Post-Glacial beds that occur fringing the coasts of Cheshire and of South-West Lancashire.[1]

The first known description of these fossil forests was in the *Gentleman's Magazine* for 1796.[2] Since then they have been described by Mr. G. H. Morton in his "Geology of the Neighbourhood of Liverpool," by the late Mr. Charles Potter, and others, and by Mr. C. E. De Rance in the Memoirs of the Geological Survey; and have formed the theme of vigorous controversy on many occasions at the meetings of the Liverpool Geological Society.

In the paper referred to it was my endeavour to describe and map out the relations of the various beds over the whole area from the mouth of the Dee to the mouth of the Ribble, and to show that they were only a part of an extensive series of beds of the same age extending round the British Isles and the opposite coasts of France and Belgium.

Since the paper was written I have had many opportunities of checking the accuracy of the work and of testing the conclusions

[1] "The Geology and Physics of the Post-Glacial Period, as shown in the Deposits and Organic Remains in Lancashire and Cheshire": Proc. Liverpool Geol. Soc., Session 1871–72, pp. 36–88, illustrated with four coloured plates of maps and sections. See also Geol. Mag., Vol. IX, pp. 111–119.

[2] Since writing the above I have found an earlier mention of them in Dr. Aikin's "Description of the Country from Thirty to Forty Miles round Manchester," published in 1795. In describing Sephton parish he says: "Along the sea-shore, and near the Grange land-mark, are the stumps of several large trees, which, by being in a line and at equal distances, were undoubtedly planted: whence it would seem as if formerly either the climate was not so rough, or the sea did not advance so far, since there would now be no possibility of raising trees in the same situation. It appears, however, as if the sea had formerly overrun a good deal of this country, from the strata of sea-slutch, moss, sand, and shells found in various parts; and the sea now again seems retiring."

arrived at. Though I might add further illustrations and facts to those already given, as indeed I purpose doing in this paper, there is very little in the original work that needs correction or alteration.

In 1897, with Professor A. Renard, of Ghent University, I had an opportunity of seeing the excavations of the new Bruges Canal near Heyst in Belgium, which resulted in my reading a paper before the Geological Society of London, in which the Microzoa, especially the Foraminifera in the silty beds overlying an extensive peat bed, are dealt with in considerable detail.[1]

So much struck was I with the similarity of these Belgian Post-Glacial deposits to those I had mapped out and sectioned in Lancashire and Cheshire, that for microscopical comparison I took the first opportunity that occurred to get specimens of the shelly blue clays underlying the Peat-and-Forest Bed in Cheshire. Mr. Joseph Wright, F.G.S., of Belfast, with his usual kindness, has examined them for me, and, I am pleased to add, extracted a most interesting assemblage of Foraminifera which form the subject of this paper. It will be observed that the Belgian beds referred to occur above the main bed of peat, whereas those in Cheshire and Lancashire occur below the superior peat bed. The synchronism of the beds will be discussed later on.

The Superior Peat-and-Forest Bed is exposed in a continuous section along the shore from the west end of the old Wallasey Embankment to a spot between Dove Point and Hoylake. Many stools of trees rooted in the clay and silt below are still to be seen, but the whole bed has been much reduced in area by the denudation of the sea since my survey of 1871 was made. The peat has also been stripped off, so that where formerly it was several feet thick it is now reduced sometimes to one foot or less. Underlying this Upper or Superior Peat-and-Forest Bed is a blue silty clay, which is now nowhere exposed for a greater depth than from two to three feet. It is this clay which I have classed with a similar bed in Lancashire under the name of the Formby and Leasowe Marine Beds, and from which the specimens yielding Foraminifera were taken. At places there are still some exposures of a second bed of peat underlying the Formby and Leasowe bed. This bed is known as the Lower or Inferior Peat-and-Forest Bed, and it in turn rests upon the Boulder-clay which is also exposed in the western end of the series of beds described. I may add that this series is the thinned-out shore margin of these Post-Glacial deposits.

Description of Specimens.

Specimen No. 1 was taken about a quarter of a mile east of Dove Mark from the blue silt lying between the Superior Peat-and-Forest Bed, which is here about 1 foot thick, and the Inferior Bed, here only a few inches thick. The blue silt (Formby and Leasowe Marine Beds) was only 2 feet thick, and contained much vegetable matter in the shape of traversing fibres. Below the Inferior Peat

[1] "Post-Glacial Beds exposed in the Cutting of the New Bruges Canal": Q.J.G.S., vol. liv (1898), pp. 575–581.

was a bed of bluish clay about 7 inches thick, full of pebbles, many of which were glacially facetted. This was evidently the redistributed Boulder-clay derived from the brown Boulder-clay on which it rested, which was only exposed about 6 inches in depth.

Specimen 2 was taken from this brown Boulder-clay, but it was only a surface specimen, much perforated by rootlet tubes.

It will be seen from this description that the paucity of Foraminifera in specimens Nos. 1 and 2 is not surprising.

Specimens Nos. 3 and 4 were taken from the blue clay (Formby and Leasowe Marine Beds) a little west of the west end of the old Wallasey Embankment, at a depth of 18 inches below the Superior Peat and horizontally about 20 feet apart. Here were found numerous specimens of *Scrobicularia piperata*, vertical as in life, with both valves united but in a very chalky condition. This was a good representative of the *Scrobicularia* Clay of the Formby and Leasowe Marine Beds, and yielded Foraminifera in profusion.

No. 5 is a specimen of brown Boulder-clay taken between Dove Point and Hoylake at a greater depth than specimen No. 1; the capping of redistributed blue clay and pebbles and Inferior Peat and Forest Bed was more developed, and good-sized roots traversed them, striking into the Boulder-clay below. This was an outlier of the Inferior Peat-and-Forest Bed, the Superior Peat and Formby and Leasowe Beds appearing on a higher level of the shore immediately opposite the outlier. Mr. Wright's report shows that notwithstanding the shallow depth at which the specimen of Boulder-clay was taken it contained eleven species of Foraminifera. The relations between these Glacial Foraminifera and the Post-Glacial forms will be discussed later on.

Report by Mr. Joseph Wright, F.G.S.

No. 1, from between upper and lower peat beds, Leasowe Shore. Weight of clay, 15·8 oz. troy. After washing, ·8 oz. fine; no coarse. Clay very fine and containing a large quantity of vegetable matter. Only one Foraminifer was obtained; it was a weak specimen of *Trochammina inflata*.

No. 2. Brown Boulder-clay, under lower peat. Weight of clay, 18·4 oz. troy. After washing, 2·8 oz. fine; ·6 coarse. Most of the stones more or less rounded, one of them showing faint striæ. Clay containing a large quantity of vegetable matter. Foraminifera very rare, only three specimens of *Polystomella striato-punctata*.

No. 3. Blue clay with *Scrobicularia in situ*. Weight of clay, 17·8 oz. troy. After washing, ·56 oz. fine; ·01 coarse. Fragments of shells only. Clay containing a quantity of vegetable matter. Foraminifera most abundant.

FORAMINIFERA.

* *Miliolina seminulum* (Linné). One specimen.
Cornuspira involvens, Rss. One specimen.
* *Trochammina inflata* (Montag.). Very common. (Pl. V, Fig. 1.)
* *Textularia globulosa*, Ehr. Frequent. (Pl. V, Fig. 2.)

* *Bulimina pupoides*, D'Orb. Common. (Pl. V, Fig. 3.)
,, *marginata*, D'Orb. Rare. (Pl. V, Fig. 4.)
,, *fusiformis*, Will. Frequent. (Pl. V, Fig. 5.)
* ,, *elegantissima*, D'Orb. Very common. (Pl. V, Fig. 6.)
* *Bolivina punctata*, D'Orb. Very common. (Pl. V, Fig. 10.)
* ,, *plicata*, D'Orb. Very common. (Pl. V, Fig. 7.)
,, *lævigata* (Will.). Very rare.
,, *difformis* (Will.). Rare.
,, *dilatata*, Rss. Frequent.
* ,, *obsoleta*, Eley. Very rare. (Pl. V, Fig. 8.)
,, ,, var. *serrata*, Nov. Frequent. (Pl. V, Fig. 9.) This form differs from *B. obsoleta* in the segments being more obliquely set, and in the marginal ends projecting, especially in the later segments; specimens very small.
* *Cassidulina crassa*, D'Orb. Very common. (Pl. V, Fig. 11.)
* *Lagena globosa* (Montag.). Rare.
* ,, *lævis* (Montag.). Frequent. (Pl. V, Fig. 12.)
* ,, *clavata* (D'Orb.). Frequent. (Pl. V, Fig. 13.)
* ,, *sulcata* (W. & J.). Very rare. (Pl. V, Fig. 14.)
,, *semistriata*, Will. Frequent.
* ,, *hexagona* (Will.). Rare. (Pl. V, Fig. 15.)
* ,, *squamosa* (Montag.). One specimen.
* ,, *lævigata* (Rss.). Very common.
* ,, *lucida* (Will.). One specimen.
* ,, *Orbignyana* (Seg.). Very rare.
* ,, *marginata* (W. & B.). Very common. (Pl. V, Fig. 17.)
* *Nodosaria communis*, D'Orb. Rare, fragments.
,, *pyrula*, D'Orb. Rare, fragments.
Rhabdogonium tricarinatum, D'Orb. Very rare.
Cristellaria rotulata (Lamk.). Rare.
* ,, *crepidula* (F. & M.). One specimen. (Pl. V, Fig. 16.)
* *Polymorphina lactea* (W. & J.). Very rare.
Uvigerina Canariensis, D'Orb. Very rare.
* ,, *angulosa*, Will. Very common.
* *Globigerina bulloides*, D'Orb. Very common. (Pl. V, Fig. 18.)
* ,, *cretacea*, D'Orb. Very common. (Pl. V, Fig. 19.)
* *Orbulina universa*, D'Orb. Very common.
Spirillina vivipara, Ehr. Very rare.
* *Patellina corrugata*, Will. Very rare. (Pl. V, Fig. 20.
* *Discorbina globularis* (D'Orb.). Rare. (Pl. V, Fig. 21.)
* ,, *rosacea* (D'Orb.). Very common.
* ,, *Wrightii*, Brady. Very common.
* *Truncatulina lobatula* (W. & J.). Frequent.
* *Pulvinulina*, sp. near *P. auricula* (F. & M.). Rare.
* *Rotalia Beccarii* (Linné). Very common. (Pl. V, Fig. 22.
* *Nonionina depressula* (W. & J.). Most abundant. (Pl. V, Fig. 23.)
,, *pauperata*, B. & W. Frequent.
,, *turgida*, Will. (?). One broken specimen.
* *Polystomella striato-punctata* (F. & M.). Most abundant. (Pl. V, Fig. 24.)
Ostracods common.

In this clay medium-sized specimens both of *Nonionina depressula* and *Polystomella striato-punctata* are in great profusion and in fine preservation, the other Foraminifera being for the greater part small or very small in size. The Arenacea are represented only by *Trochammina inflata*, some of the specimens being large in size; and only two specimens of the Porcellanea were obtained, viz., one each of *Miliolina seminulum* and *Cornuspira involvens*.

No. 4. Blue clay with *Scrobicularia in sitû* taken 18 inches below upper peat. Weight of clay, 31·2 oz. troy. After washing, ·8 oz.

fine; ·008 oz. coarse fragments of shells only. Clay containing a quantity of vegetable matter. Foraminifera most abundant.

FORAMINIFERA.

* *Miliolina seminulum* (Linné). One specimen.
Reophax scorpiurus, Montf. One small specimen.
Haplophragmium Canariense (D'Orb.). One specimen.
Trochammina squamata, J. & P. One small specimen.
* ,, *inflata* (Montag.). Very rare.
* *Textularia globulosa*, Ehr. Common.
Gaudryina filiformis, Berth. One specimen.
* *Bulimina pupoides*, D'Orb. Very common.
,, *marginata*, D'Orb. Frequent.
,, *fusiformis*, Will. Common.
* ,, *elegantissima*, D'Orb. Very common.
Virgulina Schreibersiana, Cz. Very rare.
* *Bolivina punctata*, D'Orb. Very common.
* ,, *plicata*, D'Orb. Very common.
,, *lævigata* (Will.). Rare.
,, *difformis* (Will.). Common.
,, *dilatata*, Rss. Frequent.
* ,, *obsoleta*, var. *serrata*, Nov. Frequent.
Cassidulina lævigata, D'Orb. Rare.
* ,, *crassa*, D'Orb. Very common.
* *Lagena globosa* (Montag.). Common.
* ,, *lineata* (Will.). Frequent.
* ,, *lævis* (Montag.). Common.
* ,, *clavata* (D'Orb.). Common.
* ,, *sulcata* (W. & J.). Common.
* ,, *Williamsoni* (Alcock). Very rare.
,, *striata* (D'Orb.). Rare.
,, *semistriata*, Will. Rare.
* ,, *squamosa* (Montag.). One specimen.
* ,, *hexagona* (Will.). Frequent.
* ,, *lævigata* (Rss.). Very common.
,, *lucida* (Will.). Frequent.
,, *quadrata* (Will.). Very rare.
* ,, *marginata* (W. & B.). Very common.
* ,, *bicarinata* (Terq.). One specimen.
* ,, *Orbignyana* (Seg.). Rare.
,, *lagenoides* (Will.). Very rare.
,, *clathrata*, Br. Elongate pyriform variety. One small specimen.
Nodosaria radicula (Linné). Very rare.
,, *calomorpha*, Rss. Very rare.
,, *pyrula*, D'Orb. Very rare.
* ,, *communis*, D'Orb. Very rare.
,, *obliqua* (Linné). Very rare.
Rhabdogonium tricarinatum, D'Orb. Rare.
Cristellaria rotulata (Lamk.). Very common.
* ,, *crepidula* (F. & M.). Rare.
* *Polymorphina lactea* (W. & J.). Rare.
Uvigerina Canariensis, D'Orb. Very rare, specimens broken.
* ,, *angulosa*, Will. Very common.
* *Globigerina bulloides*, D'Orb. Very common.
* ,, *cretacea*, D'Orb. Very common.
* *Orbulina universa*, D'Orb. Very common.
Spirillina vivipara, Ehr. One small specimen.
* *Patellina corrugata*, Will. Rare.
* *Discorbina globularis* (D'Orb.). Rare.
* ,, *rosacea*, D'Orb. Very common.
* ,, *Wrightii*, Brady. Very common.

Discorbina tuberculata, B. & W. Very rare.
* *Truncatulina lobatula* (W. & J.). Very common.
Pulvinulina Karsteni (Rss.). Rare.
* ,, sp. near *auricula* (F. & M.). Rare.
* *Rotalia Beccarii* (Linné). Very common.
* *Nonionina depressula* (W. & J.). Most abundant.
,, *pauperata*, B. & W. Common.
,, *turgida*, Will. Very rare.
,, *stelligera*, D'Orb. Rare.
* *Polystomella striato-punctata* (F. & M.). Most abundant.

Ostracods very common.

The Foraminifera in this gathering are very similar to those obtained from the previous sample (No. 3). Medium-sized specimens of *Rotalia Beccarii, Nonionina depressula,* and *Polystomella striato-punctata* occur in great profusion, the other species being for the greater part small or very small in size.

No. 5. Boulder-clay. Weight of clay, 28 oz. troy. After washing, 2·6 oz. fine; ·65 oz. coarse. The greater portion of the stones more or less rounded. Foraminifera frequent.

FORAMINIFERA.

Miliolina seminulum (Linné). One specimen.
Bolivina plicata, D'Orb. Very rare.
Cassidulina crassa, D'Orb. Very rare.
Lagena sulcata (W. & J.). One specimen.
,, *lævigata* (Rss.). Very rare.
Cristellaria rotulata (Lamk.). One specimen.
Globigerina bulloides, D'Orb. One specimen.
Discorbina rosacea (D'Orb.). One specimen.
Rotalia Beccarii (Linné). One specimen.
Nonionina depressula (W. & J.). Common.
Polystomella striato-punctata (F. & M.). Frequent.

The species marked with an asterisk occur in one or other of the Heyst deposits of the new Bruges Canal, viz. the "Argile des polders supérieure," the "*Cardium* Sand," or the "*Scrobicularia plana* (*piperata*) Clay." Some of the Boulder-clay forms also occur in the Heyst deposits, but these are not marked, as it is wished to confine the comparison to beds of the same age.

A comparison of this list of Foraminifera, consisting of 68 species in all, with that of the Bruges beds already referred to, shows that there are 34 or half of the species in common. *Globigerina cretacea*, a notable form which is common to both, does not occur as a recent species in the British Isles, and in consequence Mr. Wright thought that those in the Bruges silts were not native to the deposits, but derived from Cretaceous beds in the neighbourhood. The discovery of *Globigerina cretacea* in abundance in the Leasowe under-clay shows that the species are here indigenous, as there are no Cretaceous beds in Cheshire or adjoining counties from which they could be derived.

Mr. Wright also observes that the interiors of Foraminifera from our Chalk are filled with silica, so that when placed in muriatic acid the tests of the shells only are affected by it, the casts being unaltered. On placing some of the Leasowe specimens in the acid they all effervesced away, showing that they could not have been derivative from the Chalk, and must have lived where now found. On testing the Bruges specimens with acid the same thing happened with no siliceous remainder, so that I think Mr. Wright is justified in now thinking that this species was living where found in the Bruges sand and silt.

Textularia globulosa is a form very rare in British waters, but common in the Chalk, occurs in abundance in the Leasowe Beds, and also in the Bruges silt. *Globigerina cretacea* was found rare in the Boulder-clay at Riverside, Seacombe, Cheshire, and *Textularia globulosa* very rare in the Crosby Boulder-clay. (See Proc. Liverpool Geol. Soc., vol. viii, session 1898–99, p. 361, and ibid., vol. vii, session 1895–96, p. 389.)

The Post-Glacial Deposits represent a well-marked Geological Episode.

As I have proved in many previous papers,[1] these marginal beds around our Island contain records of several oscillations of the level of the land, cumulatively giving evidence of a well-marked period of time between the dying out of the Glacial epoch and the incoming of historic time.

It is well worthy of note that the deposits bear a characteristic physical resemblance to each other, whether found in England, Scotland, Ireland, or Belgium, being evidence of the widespread and persistent nature of the conditions under which they were laid down. The fauna and flora are analogous, and we further find the silts associated with *Scrobicularia piperata* are distinguished by the presence of *Globigerina cretacea*, a species of Foraminifera not now found living in the British Isles. The peat-and-forest beds show that our Island was covered with forest trees, of which this marginal band has been preserved by being covered up with a growth of peat and deposits of silt, sand, and blown sand. There is good evidence that the climate of this period was milder and more continental than the present one.

It may be noted as interesting that the royal fern, *Osmunda regalis*,[2] is found in the superior peat at the Alt mouth, and also what is not uncommon in peat beds, viz. the wing

[1] See papers previously referred to; also many minor papers in the Proceedings of the Geological Society of Liverpool, and the following: "A Problem for Irish Geologists in Post-Glacial Geology," Journ. Roy. Geol. Soc. Ireland, N.S., vol. ii, pt. 4, pp. 255–258; "Oscillations in the Level of the Land as shown by the Buried River-Valleys and Later Deposits in the Neighbourhood of Liverpool," Geol. Mag., 1896, pp. 488–492. As bearing upon the same subject, see also an excellent paper by Mr. A. Strahan, "On Submerged Land Surfaces at Barry, Glamorganshire," with notes on the Fauna and Flora by Mr. Clement Reid: Q.J.G.S., vol. lii (1896), pp. 474–496.

[2] I showed this fern embedded in the peat to the members of an excursion party of Section C at the twenty-fourth meeting of the British Association at Liverpool, 1896.

cases of beetles. When the Post-Glacial deposits rest on Boulder-clay, as is commonly the case, and a section displays both, the difference of the deposits are so striking that a novice may at once pronounce upon them. It is noticeable that the surface of the Boulder-clay under the Post-Glacial deposits is deeply eroded by subaerial action, indicating that the land was at that time at a higher level than now with respect to the sea. The silt and *Scrobicularia* clays containing the profusion of Foraminifera detailed in the preceding lists are equally a sign of the subsequent submergence of this Boulder-clay surface to a depth marked generally by the 25 feet contour-line. The Superior Peat-and-Forest Bed is again a sign of following subaerial conditions succeeded by a depression, for much of it is now washed over by the tides.

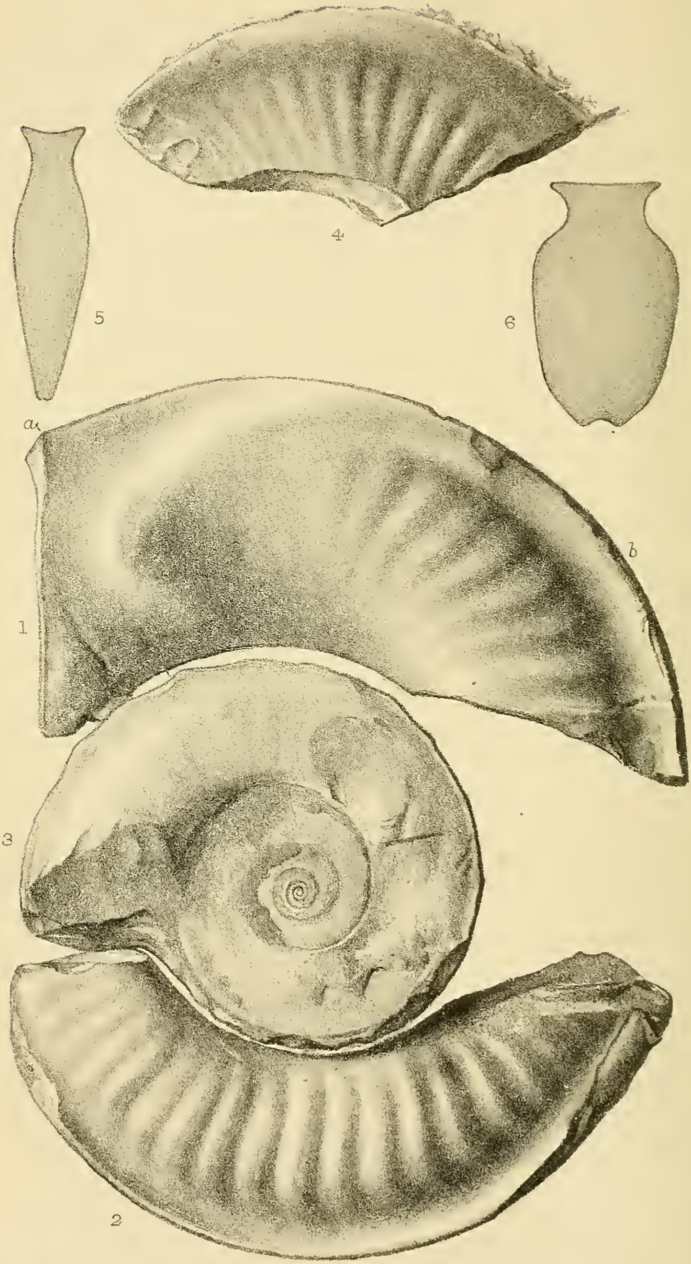
The last movement of the land was downwards at Formby and Leasowe, and it appears to me to have been the same in Belgium. As I have before observed, the Bruges Canal or Heyst silts lie above the peat, whereas the Leasowe silts lie below. If the Heyst peat is of the same age—and it is certainly not older than the Superior Peat-and-Forest Bed at Leasowe—the Belgian silts I have described are not so old as those at Leasowe, but they nevertheless belong to the same series of beds.[1] This group of beds is a geological object-lesson of a comparatively recent date, showing that geological periods are records of a similar kind, but on a larger scale of widely prevailing physical conditions.

Relative to these conditions it is interesting to find that the Boulder-clay on which the group rests, though so markedly different in physical constitution, possesses a foraminiferal fauna of much the same character, though of a more stunted growth. Even in this little surface exposure one of the specimens of Boulder-clay yielded eleven species of Foraminifera, and if it were possible to get specimens from a depth of 10 or 20 feet it would no doubt yield them in the same profusion as the Boulder-clay at Great Crosby, Lancashire, or Riverside, Seacombe, Cheshire.[2] The species found in the Leasowe Beds have doubtless lived through the Glacial seas, nevertheless the two periods or episodes are so physically different that no geologist could mistake one for the other.

The artistic figures given in the Plate accompanying this paper are by Mr. Robert Welsh, of Belfast, and I am greatly indebted to him and Mr. Wright for enabling me to illustrate the leading species in such a satisfactory manner. Being photographs of the actual specimens obtained from the Leasowe deposit, they are instructive as showing the relative sizes of the different species as they occur in the deposit.

[1] There is a very good engineering description of the works of the new Bruges Ship Canal by Mr. Vernon Harcourt in the Minutes of Proceedings of the Institute of Civil Engineers, vol. cxxxvi (1899), pp. 283–295, with plans and sections.

[2] "The Gypsum Boulder, Great Crosby": Proc. Liverpool Geol. Soc., 1898–99, pp. 347–356. "Foraminiferal Boulder-clay, Riverside, Seacombe, Cheshire": ibid., pp. 357–364.



G. M. Woodward del. et lith.

West, Newman imp.

Pleuronautilus? scarlettensis. *sp. nov.*
Carboniferous, I. of Man.

EXPLANATION OF PLATE V.

Fig. 1. *Trochammina inflata* (Montag.).	Fig. 13. *Lagena clavata* (D'Orb.).
,, 2. *Textularia globulosa*, Ehr.	,, 14. „ *sulcata* (W. & J.).
,, 3. *Bulimina pupoides*, D'Orb.	,, 15. ,, *hexagona* (Will.).
,, 4. „ *marginata*, D'Orb.	,, 16. *Cristellaria crepidula* (F. & M.).
,, 5. ,, *fusiformis*, Will.	,, 17. *Lagena marginata* (W. & B.).
,, 6. ,, *elegantissima*, D'Orb.	,, 18. *Globigerina bulloides*, D'Orb.
,, 7. *Bolivina plicata*, D'Orb.	,, 19. ,, *cretacea*, D'Orb.
,, 8. ,, *obsoleta*, Eley.	,, 20. *Patellina corrugata*, Will.
,, 9. ,, ,, var. *serrata*, Nov.	„ 21. *Discorbina globularis* (D'Orb.).
	,, 22. *Rotalia Beccarii* (Linné).
,, 10. ,, *punctata*, D'Orb.	,, 23. *Nonionina depressula* (W. & J.).
,, 11. *Cassidulina crassa*, D'Orb.	„ 24. *Polystomella striato-punctata* (F. & M.).
,, 12. *Lagena lævis* (Montag.).	

The figures are magnified 40 diameters.

II.—Woodwardian Museum Notes: A new Carboniferous Cephalopod, *Pleuronautilus? scarlettensis*, sp. nov.

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

(PLATE VI.)

FOUR fragments of a large cephalopod (from the Carboniferous Limestone) were collected by Professor Hughes' party in 1892 at Scarlett Quarry, Isle of Man. On fitting three of these together they were found to compose nearly the complete shell, and in a sufficiently good state of preservation to warrant description. The fourth fragment is a cast of a portion of the external surface. Mr. G. C. Crick has expressed his opinion that they represent a new species and probably a new subgenus or genus.

Diagnosis.—Shell discoidal, compressed; whorls in contact, but not overlapping; umbilicus wide, shallow, exposing all the whorls; no central vacuity; volutions rapidly increasing in width. Whorls eight in number, laterally compressed and flattened, twice as high as broad. The two outer whorls form nearly four-fifths the diameter of the shell, and have steeply sloping walls to the umbilicus. The outer whorl has its sides weakly convex for the inner two-thirds of its width and crossed by about thirty transverse rounded plications, which are strongest about the middle portion of the whorl, but become gradually weaker towards the beginning of the second whorl, and also towards the aperture, dying out completely a short distance from it. The outer fourth of this whorl is not crossed by these plications, but is deeply excavated into a broad marginal groove bordered by the sharp edge of the ventral side. Ventral (peripheral) side rather less in width than diameter of whorl, flattened or slightly concave with projecting edges overhanging the marginal groove on the sides. Dorsal side narrow, about one-fourth the width of ventral side, marked by shallow groove where in contact with next whorl. Second whorl with very weak or obsolete transverse plications, and the marginal groove very shallow and gradually dying out. Inner whorls poorly preserved, but with nearly flat sides, devoid of transverse plications and marginal groove. Aperture vertical, narrow, lanceolate, with sides produced obliquely forwards to ventral rostrum. The sides of the outer whorl near the aperture become slightly swollen, and then are suddenly depressed to the level of the marginal groove, the ventral side at the same time considerably narrowing and losing its overhanging edges and being produced apparently into a pointed rostrum. Septa, sutures, and siphuncle not preserved.

Measurements.—Diameter of shell, 13″–15″; height of mouth, $4\frac{1}{2}''$; width of ditto, $1\frac{1}{4}''$.

Remarks.—The only species which has a general resemblance in possessing transverse plications and an overhanging concave ventral side is *Gyroceras* (*Trigonoceras*) *aigoceras* (Münster),[1] but as it consists of only two whorls, which are not in contact, are of much greater breadth, and have a sharp keel-like dorsal side, the resemblance is not very close. Moreover, so far as we know, the mouth did not possess the important features which we find in the Manx form. There is no species of *Gyroceras* with which I am acquainted exhibiting these characteristics, and it seems impossible to attribute our new form to this genus or to *Discites*. *Pleuronautilus* has a closely coiled shell with transverse ribs; but, on the other hand, a rather large central perforation is present. Mojsisovics[2] has remarked on the relations between *G. aigoceras* and *Pleuronautilus*, and it seems advisable for the present to place our new form in the latter genus, though probably a subgenus or genus will have to be made to contain it (which might appropriately receive the name of *Eubonioceras* from the ancient name of the Isle of Man). Until we know the suture-lines, septa, and siphuncle it will, however, be wiser to associate it with *Pleuronautilus*.

EXPLANATION OF PLATE VI.

Pleuronautilus ? scarlettensis, sp. nov. Carboniferous Limestone: Scarlett Quarry, Isle of Man. One-third nat. size.

1. Body-chamber of shell.
2. Part of outer whorl.
3. Inner whorls of shell.
4. Cast of surface.
5. Transverse section of Fig. 1 near the mouth at *a*.
6. Transverse section of Fig. 1 at *b*.

III.—On some Minor British Earthquakes of the Years 1893–1899.

By Charles Davison, Sc.D., F.G.S.

During the seven years 1893–1899, 42 earthquakes have been felt in Great Britain—28 in England and Wales and 14 in Scotland.[3] All of the latter number visited areas which are thinly populated, and it has therefore been impossible to draw the boundaries with the accuracy that is to be desired. In the English earthquakes this

[1] Münster, "*Cyrtoceera aigokeros* (1838)": Beitr. r. Petrefact., 2nd ed., Heft i (1843), p. 56, t. i, figs. 7*a*, 7*b*; t. ii, fig. 1. Foord: Cat. Foss. Ceph. Brit. Mus., pt. ii (1891), p. 72, and references.

[2] "Die Ceph. d. Medit. Triasprov.": Abhandl. d. k. k. geol. Reichs., Bd. x (1882), p. 73.

[3] The cost of investigating all these earthquakes was defrayed from grants which I had the honour to receive from the Government Research Fund.

difficulty is seldom encountered, and the failures are generally due to the confusion caused by the rather rapid succession of the shocks.

The number of earthquakes more or less briefly described in this paper is 19, and, with few exceptions, I have not been able to correlate them with known faults. It should not be inferred from this that the shocks owe their origin to some other cause than fault-slipping; for, in nearly every case, the epicentral region is one in which it is difficult to detect faults. It is possible, indeed, that the careful study of an earthquake may form a useful supplement to the methods which are at the disposal of the field-geologist.

Explanation of Map-Symbols.—In a weak earthquake, every place of observation can generally be marked on the map; and, without making use of a wide range of symbols, it is convenient to employ signs to represent the perception of the shock and sound. In all but one of the following maps, a square indicates that the shock was felt, a triangle that no mention is made of the shock or that its perception was doubtful, and a circle that no shock was felt. A figure entirely filled in denotes that the sound was heard, one half-filled in that no mention is made of the sound or that its perception was doubtful, and one not filled in at all that no sound was heard.

List of Earthquakes, 1893–1899.

1893, Jan. 2, 7.20 p.m. Glen Garry.
Aug. 3, 6.41 p.m. Leicester.
Nov. 2, 5.45 p.m. Pembroke (principal earthquake).
,, 6.1 p.m. Pembroke.
,, about 6.15 or 6.20 p.m. Pembroke.
Nov. 3, about 1 a.m. Pembroke.
Dec. 11, about 3 p.m. Glen Garry.
Dec. 30, 11.20 p.m. Somerset.
Dec. 31, 12.28 a.m. Somerset.
,, about 4 a.m. Somerset.
1894, Jan. 12, about 11.55 p.m. Fort William.
Jan. 23, about 9 a.m. Exmoor.
Jan. 25, 1.7 p.m. Glen Garry.
March 8, about midday. Annandale.
May 14, in the afternoon. Annandale.
July 12, about 11 p.m. Comrie.
Sept. 18, 10.10 a.m. Glen Garry.
1895, Jan. 9, about 5.45 a.m. Fort William.
July 12, about 7.40 a.m. Comrie.
Aug. 27, about 12.30 p.m. Cornwall.
1896, Jan. 26, 6.50 a.m. Cornwall.
May 29, 4.47 a.m. Annandale.
June 5, early in the morning. Glen Nevis.
Dec. 16, about 11.0 or 11.30 p.m. Hereford.
Dec. 17, ,, 1 a.m. Hereford.
,, ,, 1.30 or 1.45 a.m. Hereford.

1896, Dec. 17, about 2 a.m. Hereford.
„ „ 3 a.m. Hereford.
„ „ 3.30 a.m. Hereford.
„ „ 4 a.m. Hereford.
„ „ 5 a.m. Hereford.
„ „ 5.20 a.m. Hereford.
„ 5.32 a.m. Hereford (principal earthquake).
„ about 5.40 or 5.45 a.m. Hereford.
„ „ 6.15 a.m. Hereford.
1897, July 19, 3.49 a.m. Hereford.
1898, Jan. 28, about 10.5 p.m. Rutland.
Mar. 29, about 10.25 p.m. Cornwall.
Apr. 1, 9.55 p.m. Cornwall.
Apr. 2, about 3 p.m. Cornwall.
Aug. 22, about 7.15 a.m. Comrie.
1899, Dec. 18, about 6.50 a.m. Glen Garry.

The more important of these earthquakes have been described in the following papers, etc. :—

"On the Leicester Earthquake of August 4, 1893": Roy. Soc. Proc., vol. lvii, 1895, pp. 87–95.

"On the Pembroke Earthquakes of August, 1892, and November, 1893": Quart. Journ. Geol. Soc., vol. liii, 1897, pp. 157–175.

"On the Exmoor Earthquake of January 23, 1894, and on its Relation to the Northern Boundary Fault of the Morte Slates": Geol. Mag., Vol. III, 1896, pp. 553–556.

"On the Comrie Earthquake of July 12, 1895, and on the Hade of the Southern Boundary Fault of the Highlands": Geol. Mag., Vol. III, 1896, pp. 75–79.

"The Hereford Earthquake of December 17, 1896." (Cornish Brothers, Birmingham, 1899.)[1]

"On the Cornish Earthquakes of March 29th to April 2nd, 1898": Quart. Journ. Geol. Soc., vol. lvi, 1900, pp. 1–7.

[1] Since this report was written, several papers have been published on the Hereford earthquake. The following is a complete list of those which I have seen:—

W. Cole, "The English Earthquake of December 17th, 1896": Essex Nat., vol. ix, 1896, pp. 258–259. (Records from Essex.)

H. G. Fordham, "The Earthquake of the 17th December, 1896, as it affected the County of Hertford": Herts. Nat. Hist. Soc. Trans., vol. ix, 1897, pp. 183–208. (Records from Hertfordshire and adjoining counties.)

E. Greenly, "The Hereford Earthquake of December 17, 1896, considered in relation to Geological Structure in the Bangor-Anglesey Region": Edin. Geol. Soc. Trans., vol. vii, 1898, pp. 469–476.

J. Lomas, "The Earthquake of December 17th, 1896": Liverpool Geol. Soc. Proc., 1896–1897, pp. 91–98. (Records from the neighbourhood of Liverpool chiefly.)

H. C. Moore, R. Clarke, & A. Watkins, "The Earthquake of December 17th, 1896": Woolhope Field Club Trans, 1898 (?), pp. 1–8. (A detailed account of the damage to buildings in Herefordshire.)

G. J. Symons, "The Earthquake of December 17th, 1896": Meteor. Mag., vol. xxxi, 1896, pp. 177–185. (An analysis chiefly of newspaper reports.)

Rev. H. H. Winwood, "Notes and Observations on the Earthquake of December the 17th, 1896," contributed by members of the Cotswold Club: Cotswold Nat. Field Club Proc., vol. xii, 1896–1897, pp. 187–196. (Records from Gloucestershire.)

Glen Garry Earthquake: Jan. 2, 1893.

A slight shock, accompanied by a noise as of a carriage passing very rapidly, was felt by Mr. Duncan Grant at Glenquoich at 7.20 p.m. The noise was also heard by another observer about three miles higher up the Glen.

Glen Garry Earth-Sound: Dec. 11, 1893.

A low rumbling sound, resembling that which accompanies an earthquake, was heard at about 3 p.m. at Glenkingie, Glenquoich, and Lochournhead. There was no perceptible movement of the ground.

This note is founded on a paragraph in the *Oban Times* for Dec. 15 (?).

Somerset Earthquakes: Dec. 30–31, 1893.

The number of earthquakes that should be included in this series is somewhat uncertain. The most important are those which occurred on Dec. 30 at 11.20 p.m. and on Dec. 31 at 12.28 a.m., and these were followed at about 4 a.m. by a third but much weaker shock. There may also have been four others in the early morning of Dec. 31, but the times are only roughly recorded, and they ought, I think, to be regarded as doubtful earthquakes. They are as follows:—

a. Shepton Mallet, shortly after the shock at 12.28; and Draycot, 12.45 or 12.50 a.m.

b. Shepton Mallet, between 1 and 2 a.m.; and Wedmore, about 1.30 a.m.

c. Croscombe, about 2.30 a.m.; and Wookey, about 2.15 a.m.

d. Street, 2 or 3 minutes after the shock at about 4 a.m.

The times of the two principal shocks were determined by a signalman at Masbury station, and, as they agree with those given by several other witnesses, they are no doubt correct to the nearest minute.

For convenience, the isoseismal lines of both earthquakes are shown upon one map (Fig. 1), and the symbols referred to above are therefore not employed. Also, as it would be difficult to represent all the places of observation on so small a figure, I have only marked those which are of importance or which are mentioned in the following pages. The broken lines refer to the first earthquake, the continuous lines to the second.

First Earthquake: Dec. 30, 11.20 *p.m.*—The number of records is 45, coming from 27 places. There are also negative records from 20 places; and, in addition, two observations from Frome and Whatley, the connection of which with the present shock is doubtful.

The intensity of the shock was certainly not less than 4, and at Wells may have been as high as 5. The disturbed area is 15½ miles long, 13¼ miles broad, and contains 159 square miles. Owing to the absence of negative records towards the north-west, it is uncertain whether the boundary should not extend a little further outwards on this side. The direction of its longer axis is W. 30° N. and E. 30° S. Its centre lies ½ mile S. 37° W. of Wells.

The isoseismal 4 is an elongated oval, 9½ miles long, 5 miles broad, and 38 square miles in area. The direction of its longer axis is W. 30° N. and E. 30° S.; and its centre is one mile N. 35° W. of Wells. The distance between the two isoseismals is 3 miles on the north-east side and 5 miles on the south-west side.

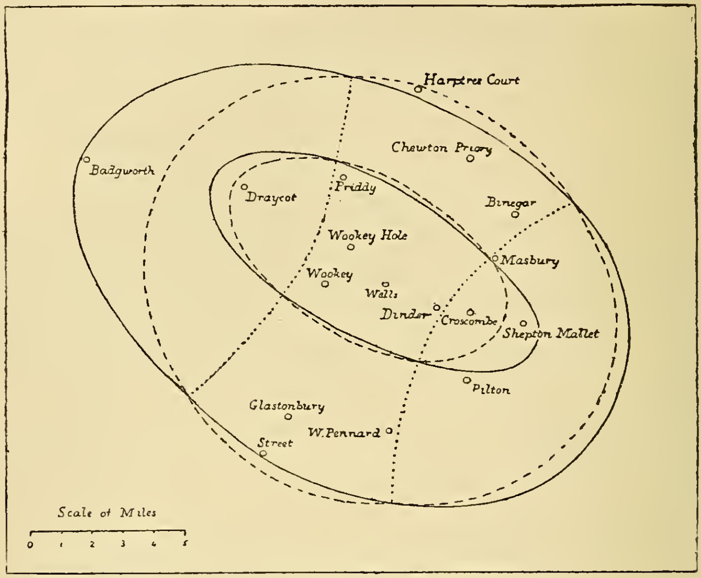


Fig. 1.—Somerset Earthquakes: Dec. 30–31, 1893.

So far as I can learn, the shock was in all parts a continuous series of vibrations, like that felt in an upper room when a heavy waggon or train passes. Its mean duration was 4 seconds.

The sound was compared by different observers to that of a waggon passing over loose stones, the dragging of a heavy weight or a heavy piece of furniture along the floor, a rolling peal of thunder, a stack of wood or coal tumbling down, the fall of an avalanche of snow, a terrific explosion, etc. As a rule, the beginning of the sound either preceded or coincided with that of the shock, while the end of the sound either coincided with or followed that of the shock.

Second Earthquake: Dec. 31, 12.28 *a.m.*—Of this earthquake, there are 41 records from 25 places, and negative records from 20 places, the latter being the same as for the first earthquake.

The intensity of the shock at Wells and one or two other places was about 5. The disturbed area is more elongated than the former. It is 19¾ miles long, 12½ miles broad, and contains 180 square miles. Its longer axis runs from W. 27° N. to E. 27° S.; and its centre is ¾ mile W. 6° S. of Wells.

The isoseismal 4 is $11\frac{1}{2}$ miles long, $4\frac{3}{4}$ miles broad, and includes 43 square miles; the direction of its longer axis being W. 30° N. and E. 30° S. Its centre is $\frac{3}{4}$ mile W. 27° N. of Wells, and $\frac{1}{4}$ mile from the corresponding centre for the first shock, the line joining the two centres being parallel to the longer axis of both curves. The distance between the isoseismals is nearly 3 miles on the north-east side, and nearly 5 miles on the south-west side.

In nature and duration the second shock resembled the first. It was again a continuous series of vibrations, like that felt in a house built directly over an underground railway, according to one observer. The mean recorded duration was slightly less than 4 seconds, but most of the observers were awakened by the shock and may have missed the earlier tremors.

The sound is also compared to similar types. Among them may be mentioned a goods train passing over an iron bridge, a deep peal of thunder, a rushing wind, the fall of boxes on a floor, and tremendously heavy blasting but prolonged.

In estimating the frequency of comparison to different types, the small number of descriptions renders it advisable to do so for the two shocks together, especially as there are several other accounts in which the particular shock is not distinguished. The sound is compared to passing waggons, etc., in 26 per cent. of the records, to thunder in 11 per cent., to wind in 5, loads of stones falling in 13, heavy bodies falling in 11, explosions in 26, and to miscellaneous sounds in 8 per cent. These are about the usual proportions for a slight earthquake, except for the rather frequent references to explosions. The exception is in reality only apparent, for, in all but three cases, the reference is to an explosion prolonged or else to an explosion in the midst of an undescribed rumbling sound; the three places are Wells, Wookey, and Wookey Hole, and these are close to the epicentre. Again, the comparison to passing waggons implies that the sound was of long duration and gradually increased to a maximum and then died away; but this is not the case with the dragging of heavy boxes along the floor, which I have included in the same type. Comparisons to the latter sound come from Priddy, Street, and West Pennard, places which are not far from the shorter axis of the disturbed areas. The general result is, as we should infer, that the sound is of long duration near the ends of the longer axis, and of short duration near the ends of the other.

Relation between the two Earthquakes.—The relation between the isoseismal lines of these two earthquakes is somewhat peculiar. They are almost concentric. Yet both isoseismals of the second shock overlap those of the first towards the east and west, and are overlapped by them towards the north and south. Moreover, though the second shock had the larger disturbed area yet its intensity was not everywhere the greater. The first shock is reported to have been the stronger at Binegar, Chewton Priory, Coxley, Dinder, Priddy, Street, West Pennard, Wookey, and Wookey Hole; and the second shock at Croscombe, Draycot, Masbury, Pilton, Shepton Mallet, and Wells. Now, at the points where the isoseismals intersect, the intensities of both shocks were the same, and, if curves (represented by dotted lines on the map) be drawn through the four points of intersection on both the west and east sides of the disturbed areas, the intensities of both shocks at any point of these curves should be the same. These lines divide the whole area into three districts. In the central district lie all the places where the first shock was regarded as the stronger, and in the terminal districts those where the second was the stronger, with one exception, that of Wells. This city lies near the centres of both disturbed areas, and, according to a newspaper report, the second shock was severer than the first. Too much stress should not be laid upon this exception, for there is always some variation in the estimates of the relative intensities of two shocks where these do not differ greatly.

The explanation of the peculiarity is simple enough. The more elongated form of the isoseismal lines of the second shock implies that it had a longer focus. The overlapping towards the north and south of the second disturbed area by the first shows that the initial intensity of the first shock within a given area of the focus was greater than that of the second. Thus, the second earthquake owes its larger disturbed area simply to the greater length of its focus.

Third Earthquake: Dec. 31, *about* 4 *a.m.*—A slight shock was felt at Priddy, Street, Wells, and Wookey. At Street and Wells it was accompanied by sound. So far as we can judge from the distribution of these places it would seem that the epicentre lay to the west of the epicentres of the two first shocks.

Origin of the Earthquakes.—It has been suggested that the shocks were not of seismic origin, but were caused by the fall of large masses of rock in underground channels. If this were so, the disturbed areas and isoseismal lines would have been approximately circular and the sound would have been compared almost exclusively to explosions or the fall of heavy bodies. The elongated forms of the isoseismal lines and the general character of the sound are therefore conclusive against such an explanation.

On the other hand, all the phenomena known to me are in complete accordance with the view that the shocks were caused by slips along a fault, running W. 30° N. and E. 30° S., hading towards the south-west, and passing through a point between one and two miles north-east of Wells and between Wookey Hole and Priddy. The Geological Survey map contains no fault in this position, but it will be noticed that the direction assigned to the earthquake-fault is roughly parallel to that of the Mendip Hills in this district. The focus of the first shock must have been about 4 miles and that of the second about 6 or 7 miles in length.

Fort William Earthquake: Jan. 12, 1894.

Owing to its time of occurrence (about 11.50 or 11.55 p.m.) and to the small number of villages within the disturbed area, I have only been able to obtain 17 records from 14 places, in addition to negative records from 5 places. I regret my failure especially in this case, as the earthquake appears to be unique in one respect among British earthquakes of the last eleven years.

So far as the accounts may be trusted, the disturbed area appears to consist of two detached portions—one in the neighbourhood of Fort William, the other in Moidart and Arisaig in the extreme west of Inverness-shire. Eleven of the places of observation lie in the former area and three in the latter, while between them there are three places (Kinlochiel, Duisky, and Kingairloch) at which, I am told, the earthquake was not observed. Much reliance should not of course be placed on so small a number of negative records, especially for an earthquake which occurred at midnight; but there is also distinct evidence that, in the eastern area, the shock was much weaker on the west than on the east side of Loch Linnhe.

In a country district, time-records are naturally liable to considerable error, but those in both parts of the disturbed area agree in giving the time as nearly midnight. If there were two separate impulses, there is therefore no evidence to tell us which occurred first.

Of the places in the eastern area, four (Ardgour, Banavie, Carpach, and Trislaig) are on the north-west side of or close to the great Highland fault, and the remaining seven (Achintore, Blarmacfoldach, Carnach, Fort William, Glencoe, Nether Lochaber Manse, and North Ballachulish) are on the south-east side. The boundary of the area cannot be determined satisfactorily from these places, but it is about 17 miles long, its longer axis is roughly parallel to the great fault, and it extends to a much greater distance on the south-east than on the north-west side of the fault. If the shock felt in the eastern area were due to a slip of the fault, or of one of the system of faults, it is clear that the fault concerned must hade to the south-east. This is also shown by the intensity of the shock; for the only places where it attained the degree 4 (Blarmacfoldach, Carnach, and Nether Lochaber) are on this side.

As a rule, the shock resembled the tremors felt in a house when a heavy conveyance is passing. At Nether Lochaber Manse, however, the movement was stronger and more distinct, being like that felt in a heavy carriage in rapid motion on a rough road, and culminating in a severe vibration. The sound was compared by three observers to the rumbling of a cart or a heavy loaded waggon on a rough road, and by three to distant thunder.

Very little can be ascertained with regard to the western part of the disturbed area. The shock was felt only at three places, namely, Arisaig, Glenmoidart, and Roshven; at the second of these places the intensity was 4. The sound was described by one observer as like distant thunder, and by another as like the explosion of a large quantity of gunpowder at a great distance. The observer at Glenmoidart informs me that a second and weaker shock was felt there in the daytime some days afterwards, and a third at night.

It seems to me probable from the above evidence that there were two distinct shocks, each disturbing a separate area; and that the shock felt in the neighbourhood of Fort William was due to a slip of the great Highland fault. With regard to the origin of the other shock nothing can be ascertained, nor is there any evidence to show whether the proximity in time and place between the two shocks was other than accidental.

Glen Garry Earthquake : Jan. 25, 1894.

A shock, of intensity 4, was felt by Mr. M. Matheson and at least four other persons at Ardochy at 1.7 p.m. The vibration was like that produced by a carriage passing over a wooden bridge; it was followed by a distant roar.

Annandale Earthquakes : March 8 *and May* 14, 1894.

My only authorities for these two shocks are the accounts given in the local newspapers.[1] I was unsuccessful in my attempts to obtain further information, but houses are widely scattered in the district. I see no reason for doubting the seismic character of the shocks.

The first earthquake occurred about midday on March 8, and was most marked in the central district of Corrie.

The second occurred during the afternoon of May 14 in the upper valley of the Milk. It was distinctly felt at Corrie Bridge, Corrielaw, and Rosebank (about two miles east of Lockerbie), and possibly also in the district about Eskdalemuir. The intensity was at least 4 in the first three places mentioned. At Corrie Bridge, the shock was accompanied by a noise resembling the distant firing of cannon.

Comrie Earthquake : July 12, 1894.

A very distinct trembling (of intensity 3) was felt at about 11 p.m., and was accompanied by a dull rumbling sound lasting about 6 seconds. So far as I know, the earthquake was only observed at Comrie and Dalginross, which is about $\frac{1}{4}$ mile south-east of Comrie; and I have six negative records from places in the vicinity. The disturbed area must therefore have been very small, and the epicentre may be regarded as coincident with the village of Comrie.

Glen Garry Earthquake : Sept. 18, 1894.

Mr. Matheson informs me that this shock was not so strong at Ardochy as that felt on Jan. 25. It occurred at 10.10 a.m., and was followed by a loud noise. It was also felt on the opposite (or south) side of Loch Garry.

Fort William Earth-Sound : Jan. 9, 1895.

The occurrence of this earth-sound was noticed in the daily papers, but for the details given below I am indebted to Mr. Angus Rankin of the Ben Nevis Observatory.

The noise was heard between 5.45 and 5.50 a.m. by many persons, some lying awake in bed, others preparing to go to work; but it was not loud enough to waken sleepers. It is described by all as a rumbling noise resembling distant thunder, and to one observer at Fort William it appeared to travel in a north-easterly direction. No

[1] *Annandale Herald* (Lockerbie), May 17; *Dumfries and Galloway Courier and Herald* (Dumfries), May 19; and *Eskdale and Liddesdale Advertiser* (Langholm), May 23.

shock or tremulous motion was felt by anyone, and the seismograph at the Low-level Observatory at Fort William showed no sign of any movement. The noise was heard also at Blarmacfoldach and Lundavra, which are respectively 3 and 5 miles to the south of Fort William; all three places being close to the northern boundary fault of the Highland district. As to the seismic origin of the sound, there can be little doubt, for the district is one where slight shocks are occasionally felt, and all the observers agree that it was an 'earthquake-noise.' So far as our knowledge of the earth-sound goes, its evidence confirms the conclusion that the great fault, or one of the system of faults, hades to the south-east.

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

IV.—Report on the Drift at Moel Tryfaen.[1] Drawn up by the Secretary, E. Greenly, F.G.S.

Introduction.—In August, 1898, it became known that what is perhaps the clearest and most instructive section in the famous high-level drift deposits at Moel Tryfaen must in a short time be swept away in the course of the quarrying operations. There are two slate quarries on Moel Tryfaen, the "Alexandra" and the "Moel Tryfaen" Quarries, excavated in the same line of strike of the slates. Gradually expanding, they had approached each other so nearly as to leave a narrow bank between them with no more than a yard or two of uncut turf upon it. Now the drift sections

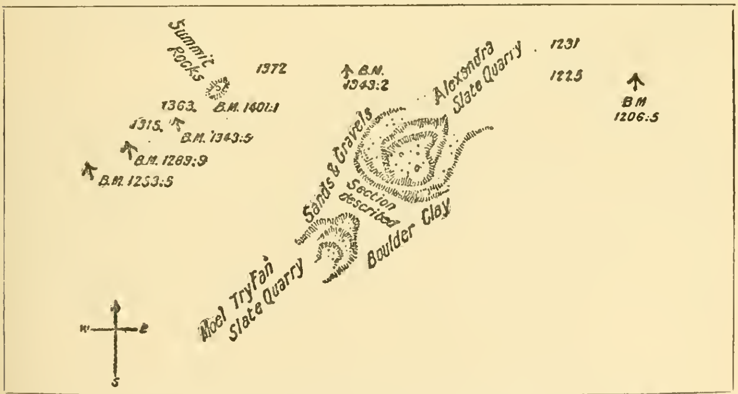


Fig. 1.—Map of part of Moel Tryfaen from Six-inch Ordnance Map.

thus in danger of destruction are exceedingly important for the following reasons: (1) They are at right angles to the strike of the slates, and thus display the character of the underlying rock

[1] Report of the Committee, consisting of Dr. H. Hicks (Chairman), deceased, Mr. E. Greenly (Secretary), Professor J. F. Blake, Professor P. Kendall, Mr. G. W. Lamplugh, Mr. J. Lomas, Mr. T. Mellard Reade, Mr. W. Shone, and Mr. A. Strahan, appointed to make photographic and other records of the disappearing drift section at Moel Tryfaen (spelt Tryfan in New Ordnance Survey Maps). Reprinted from the British Association Report, 1899 (1900), pp. 414–423.

surface; (2) they show the nature and position of the junction of the shelly sands and gravels with the overlying Boulder-clay; (3) the false bedding and other structures in the sands and gravels are best seen along them; (4) they have been more accessible than the other sections in the quarries. A Committee was therefore appointed to preserve, by photography, supplemented by a written report, an impartial record of the phenomena displayed in these sections. The Committee have much pleasure in acknowledging their obligations to Mr. Menzies, the manager of the Alexandra Quarry, who, with a large-minded appreciation of scientific work for which geologists cannot be too grateful, offered to suspend operations in that part of the quarry for three months, besides showing the Committee every hospitality and facilitating their work by all means in his power.

Photographs.—Six whole-plate and five half-plate photographs were taken by Mr. John Wickens, F.R.P.S., photographer, of Bangor.

The views taken are:—

1. General view of section from W.N.W. end.
2. General view of section from E.S.E. end.
3. General view from W.N.W. of Moel Tryfaen Quarry, including neighbourhood.
4. Boulder-clay by engine-house at E.S.E. end section.
5. Sands seen below Boulder-clay.
6. Junction, wedge of Boulder-clay in sand and gravel.
7. Base of sands and terminal curvature near W.N.W. end of section looking S.S.W.
8. Duplicate, showing a little more of slate.
9. Similar phenomena on N.E. side of quarry (third gallery) looking N.N.E.
10. Duplicate, a little nearer.
11. Rocks on summit of hill from N.W.

Description of Section. — The Chairman, the late Dr. Hicks, F.R.S., visited the section on September 26, 1898; and on November 5, 1898, Messrs. Kendall, Lamplugh, Lomas, Mellard Reade, Shone, and the Secretary examined it and recorded the facts embodied in this report. On July 1, 1899, the Secretary added items 1, 2, and 9.

As there have been serious differences of opinion as to the interpretation of the Moel Tryfaen phenomena, the Committee wish to emphasize the statement that this report is intended to be a record of observed facts only, without reference to any conclusions that may be drawn from these facts.

The observations are here arranged under thirteen heads. All the details were examined from the side of the Alexandra Quarry, which was the better and more accessible section of the two.

1. *Bearing and Distance of Section from Hilltop.*—About 800 feet E.S.E. to the middle of the section.

2. *Length of Section.*—From 700 to 750 feet.

3. *Direction of Section.*—The sections are in curves concave to N.N.E. and S.S.W. in the "Alexandra" and "Moel Tryfaen" Quarries respectively, so that a tangent to both curves at their nearest point, about the middle of each section, is about W.N.W.–E.S.E.

4. *Height of Rock Surface.*—The floor of Gallery "No. 1," the highest in the Alexandra Quarry, is at 1,281 feet above sea-level. The surface of the rock emerges from below drift in the floor of this gallery a few yards E.S.E. of the edge of the Boulder-clay, and rises gradually to W.N.W. The angle measured by Abney Level from the opposite side of the Alexandra Quarry is from 2°·5 to 6°·0 (average 4°·25) to E.S.E. (Photographs 1, 2, 3). But the surface undulates (Photographs 7, 8).

5. *Slope of Surface of Drift along Section* (Photograph 3).

6. *Strike and Dip of Cleavage of Slates.*—N. 30 E., 95°–98° to S. of E. *Dip of Bedding of Slates.*—25°–30° S.S.E. or S., but undulating.

7. *Thickness of Drifts along Section.*—25 feet maximum, thinning toward hilltop (Photographs 1, 2, 3, 4, 11). The sections which will remain at present will show the varying thicknesses in the quarries.

8. *General Nature of the Drifts.*—Their general characters have been often described. Towards the N.W. are sands, sandy loam, and gravel, with shells, Boulder-clay coming on above them towards the S.E. (Photographs 1, 2, 3).

9. *Position of Boundary of Sandy Group and Boulder-clay.*—The junction at the surface between the quarries is about 1,000 feet from the hilltop.

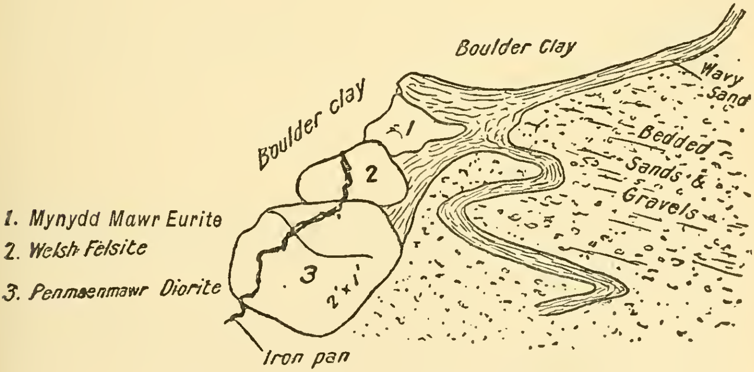


Fig. 2.—Contortions in Sands below Boulder-clay.
(Section at x in Fig. 3 on Elevation.)

10. *Character of the Sandy Group.*—The beds may be described as sand and yellow loam with gravelly streaks and pockets containing shells. The shell fragments were found on November 5 only in the gravel, none but the finest crumbs having been seen in the sand and loam (a, p. 120). The bedding is very irregular, and even here and there curved (Photograph 1), but contortion has only been observed near the junction with the overlying Boulder-clay (β, p. 120).

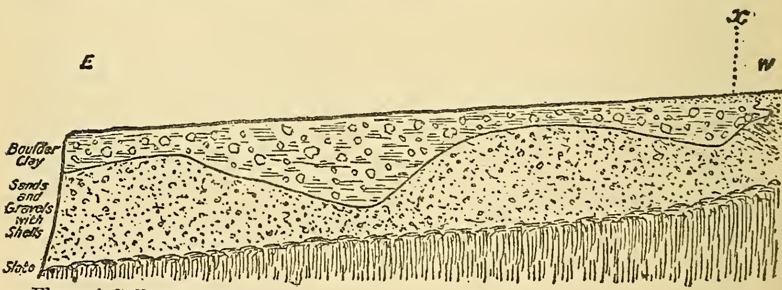
11. *Characters of the Boulder-clay.*—This is a good typical, tough, strong, unstratified till, such as is mostly found in mountain

districts, dark grey in colour and full of stones (Photograph 4). The stones are for the most part of moderate size, but some up to $3\frac{1}{2}$ and 3 feet (the visible part) occur. They are subangular and well striated. There seems to be a general slight upward inclination of the longer axes of the stones to E.S.E. or E. The longer axis of the large boulder mentioned pointed W. 20 S. — E. 20 N., and its eastern end was a little lifted. Nearly all the stones observed were of North Welsh origin, the riebeckite eurite of Mynydd Mawr being very abundant, but one pebble of a granite foreign to North Wales was obtained on November 5 (γ, p. 120). Extensive sections will remain, in which all points not depending upon orientation can be observed.

12. *Nature of Junction of Sandy Group and Boulder-clay* (Photographs 5, 6).—In a general way the sandy group passes under the Boulder-clay to the E.S.E., as described by previous writers. The sandy beds in places dip W. at the junction, and are also contorted, a string of loamy sand two inches thick being bent into sharp folds (Fig. 2). These contortions,[1] however, were not very clearly displayed on November 5 on account of slipping.

The Boulder-clay rests upon an uneven surface of the sandy beds, as shown in the annexed section (Fig. 3), which was measured, and is drawn to scale.

The photograph No. 5 is taken close to the E.S.E. end of this section. The Boulder-clay is "good typical stony till," and the underlying beds the usual sand and yellow loam with gravelly streaks and pockets containing shell fragments. In the lowest layers are angular fragments of slate, below which is broken slate



Floor of Gallery No. 1.

FIG. 3.—Junction of Boulder-clay and Sandy Beds.

(Scale 1 inch = 36 feet; length of section 144 ft. 6 in.)

mixed with a small quantity of clayey matter resting on slate with terminal curvature.

Evidence has been adduced by previous writers to show that the sandy group overlies as well as underlies the Boulder-clay, so that the two groups interdigitate. The section as seen on November 5 could not be said to be conclusive on this point; but it is shown

[1] Very well seen on September 26.—H. H.

in Photograph No. 6, of which Fig. 4 is an explanatory diagram: (*a*) is very stony Boulder-clay, stones mainly of Welsh origin; (*b*) yellow loam and sand bedded and contorted; (*c*) bedded sand and gravel, 1 foot to 2 feet; (*d*) soil 6 inches. The lower edge of the Boulder-clay dips downward into the exposed face rather steeply. BBB are boulders with angular ends projecting from the clay into the sand, the largest being apparently of Penmaenmawr diorite, and the other two of riebeckite eurite of Mynydd Mawr. There is no distinct evidence that the shelly sand and gravel anywhere overlie the Boulder-clay. A close examination showed a distinct line, probably of erosion, between that which passes above and that which passes beneath the Boulder-clay, in which last only were shell fragments found. The sand and gravel above the Boulder-clay may be altogether newer than that in the lower part of the section containing the marine shells, and may possibly be merely hill-wash.

13. *Base of the Drifts and Nature of Underlying Rock Surface* (Photographs 7, 8).—The surface of the slate is seen in contact with the sandy group only, the Boulder-clay not reposing directly upon the rock in any part of the section. The surface of the slates is exceedingly shattered, the shattering affecting them to the depth of a foot or two. The shattered edges are, with (δ, p. 120) certain local exceptions, bent over in an E.S.E. direction, i.e. to the left of an observer looking along the strike of the cleavage to the S.S.W., the displaced laminæ retaining generally their original direction of strike. The displacement usually goes down to the first horizontal joint below the surface, and is a 'displacement' rather than a true curvature.

These terminally disturbed slates pass up into a band of slate breccia or rubble, composed of angular fragments (ε, p. 120). This forms a well-marked band all along the section, and is from

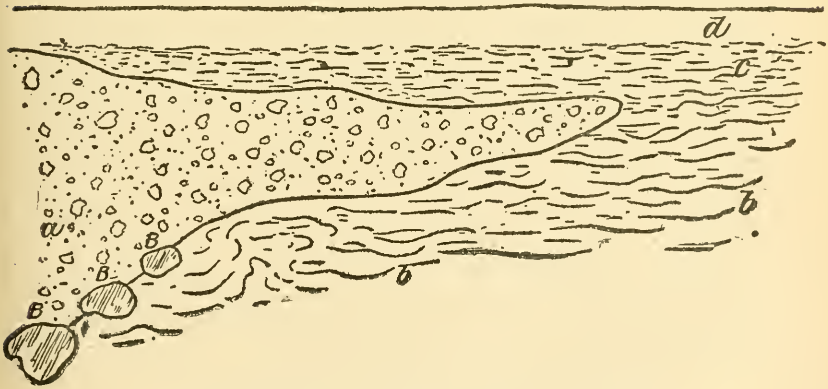


Fig. 4.—North-west termination of Boulder-clay in Section.

1 to 3 feet thick. The fragments become smaller towards the top, and have at first a slight inclination upwards to the E.S.E., the upper layers, however, becoming horizontal. Where not obscured

by slipping, the junction with the sandy drift above is usually well marked, but angular and subangular débris is mixed with the lowest layers of the gravel.

Conclusion.—The above description is not intended to be exhaustive, though the description of the section about to be destroyed has been made as full as seemed possible at the time. Incidentally certain details in other parts of the quarries were observed, and have therefore been included; but these form only a subsidiary and unessential portion of the report, and are therefore placed in a separate appendix,[1] because the sections in which they are displayed are in no danger of destruction. Generally, moreover, it will be observed that the report is confined to questions of structure, physical relations, and measurements; and that many matters of the highest importance, such as species, distribution, and state of preservation of the shells, the nature of the boulders in the sands and the clay, the character of the fine material of the drifts, are not dealt with. These are points which can be investigated as well as ever in extensive sections, which the quarrying will keep clear and open.

It must not be supposed that the Moel Tryfaen sections are being destroyed as a whole. It is the part specified only that is perishing; and the drifts of the quarries will continue to furnish ample scope for research into many matters of great importance to glacial geology for many years to come.

Note A.—*By Chairman and Members.*

(α) § 10.—Some of the best preserved specimens sent to me by Mr. Menzies from the drift in the Alexandra Quarry have adhering to them a fine loamy sand, and it is in such a material, interstratified with sand and gravels, that I have usually obtained the best specimens of shells in the Welsh sections.—H. H.

(β) § 10.—In addition to boulders of North Welsh rocks, they are full of far-travelled erratics from the Lake District and the South of Scotland.

(γ) § 11.—This deposit, therefore, differs widely in regard to its included stones from the underlying sandy group, which contains many far-travelled erratics, as before stated; as it does also in the apparent absence of marine shells and of Foraminifera.

(δ) § 13.—P. F. Kendall and J. Lomas would prefer to say that the general direction of displacement had only a few individual exceptions, which might indeed be due to quarrying operations.

(ϵ) § 13.—This material was not observed by the Committee to contain any glacially striated fragments or any foreign stones—no fragments, indeed, but of the underlying slates.

Note B.—*By T. Mellard Reade, F.G.S.*

Specimens of the drift were taken by me at the meeting on November 5, 1898, in the positions shown on the following sections

[1] See Appendix C.

(Figs. 5 and 6), and submitted to Mr. Joseph Wright, F.G.S., of Belfast.

He very kindly examined them for Foraminifera, and in all discovered twenty-three species. The results seem to show that the Foraminifera occur in the most abundance in the shelly sand. None were found in the overlying Boulder-clay (Specimen 4), and a few only in Specimens Nos. 1 and 2. In No. 3 the Foraminifera were more plentiful and of species common to the low-level Boulder-clay of Lancashire, Cheshire, and the Vale of Clwyd. As usual, *Nonionina depressula* was common, and far outnumbered the other species.

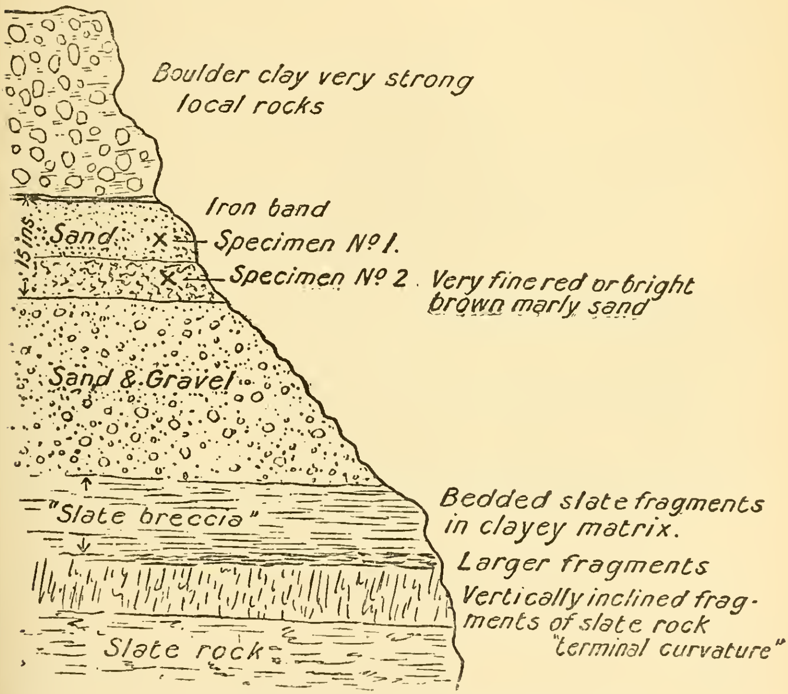


FIG. 5.—Section showing position of Foraminiferal beds.

The high-level drift generally does not appear to have been searched much for Foraminifera. The only other published list from Moel Tryfaen that I can find is that given by Miss Mary K. Andrews.[1]

This list was also the result of Mr. Wright's examination of specimens collected by Miss Andrews. In all twelve species are

[1] Annual Report, Belfast Naturalists' Field Club, 1894–95, pp. 209, 210.

enumerated, those common to this list being marked with an asterisk, and being eight in number.

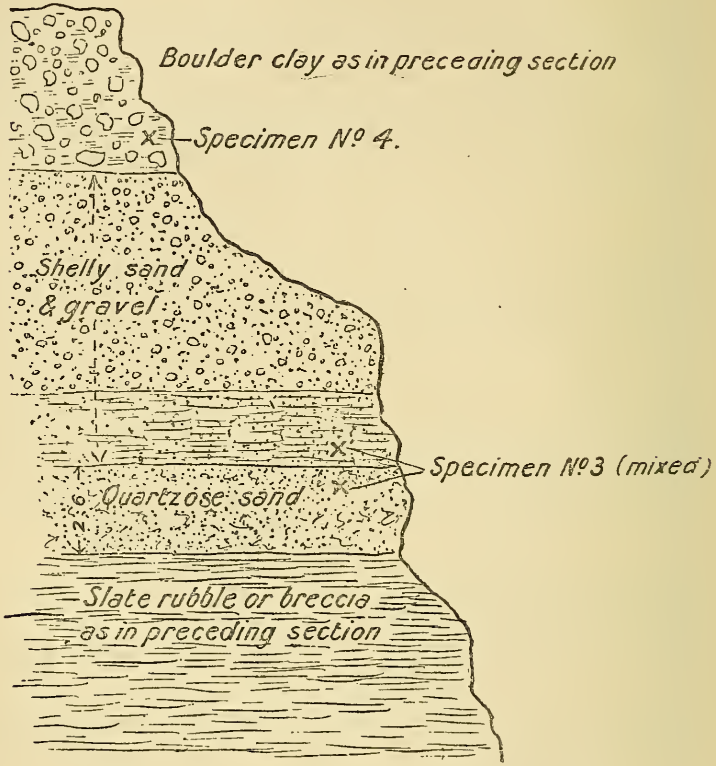


Fig. 6.—Section showing position of Foraminiferal beds.

Note C.

List of Foraminifera of Pleistocene Beds of Moel Tryfaen.

By Joseph Wright, F.G.S.

No. 1.—Weight of sand, 1 lb. 1·7 oz. troy. After washing, fine 10·8 oz.; coarse 1·5 oz. In this sample, as well as in all the others which I examined, the greater portion of the stones were more or less rounded, the others being angular.

Lagena semistriata (Will.). Very rare.

**Nonionina depressula* (W. & J.). Very rare.

No. 2.—Weight of sand, 1 lb. 2·7 oz. troy. After washing, fine 7·3 oz.; coarse 2·2 oz. Very fine bright brown sand.

Lagena lineata (Will.). Very rare.

No. 3.—Weight of sand, 2 lb. 3·5 oz. troy. After washing, fine 1 lb. 8·2 oz.; coarse 5·4 oz. Fragments of shells.

Miliolina seminulum (Linn.). Rare.
Bulimina pupoides (D'Orb.). Very rare.
Bolivina punctata (D'Orb.). Frequent.
* ,, *plicata* (D'Orb.). Common.
**Cassidulina crassa* (D'Orb.). Common.
Lagena sulcata (W. & J.). Very rare.
,, *Williamsoni* (Alcock). Very rare.
,, *semilineata* (Wright). Very rare.
* ,, *squamosa* (Montg.). Very rare.
,, *marginata* (W. & B.). Rare.
,, *quadrata* (Will.). Very rare.
,, *clathrata* (Br.). Very rare.
,, *Orbignyana* (Seg.). Very rare.
,, *quadricostulata* (Rss.). Rare.
Uvigerina angulina (Will.). Very rare.
Globigerina bulloides (D'Orb.). Very common.
Orbulina universa (D'Orb.). Frequent, very small.
**Discorbina rosacea* (D'Orb.). Very rare.
,, *Wrightii* (Br.). Common.
**Pulvinulina Karsteni* (Rss.). Rare.
**Nonionina depressula* (W. & J.). Most abundant.
**Polystomella striato-punctata* (F. & M.). Very rare.

203 specimens of *Nonionina depressula* were obtained from this gathering, whilst the other twenty-one species numbered only 102.

No. 4.—Weight of sand, 2 lb. 6·7 oz. troy. After washing, fine 6·6 oz.; coarse 1·3 oz. Sand very dirty, and having a large proportion of stones in it.

No Foraminifera.

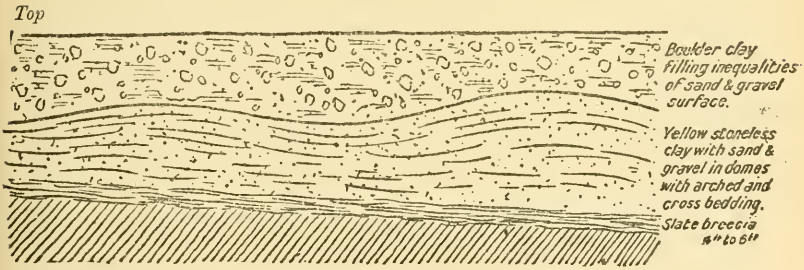


Fig. 7.—Diagram at north-east side of Alexandra Quarry, showing dome-like arrangement of sand and gravel beneath Boulder-clay.
(Length 50 to 60 yards; height about 60 feet.)

Note.—Much of the middle series consists of fine plastic reddish-yellow clay or silt without stones, the kind of material common in the stratified drifts of the Isle of Man. Shell fragments rather plentiful in the gravelly streaks, but none seen in the clay or sand.

P.S.—For the sake of those interested in the drifts of Moel Tryfaen, it may be mentioned that copies of the photographs alluded to in this Report may be seen in the collection belonging to the British Association (at Jermyn Street Library); and of the more important of them also at the Museums of Science and Art in Edinburgh and Dublin. Copies have also been sent to Chicago and Ottawa.—E. G.

REVIEWS.

I.—An Estimate of the Geological Age of the Earth. By J. Joly, M.A., B.A.I., D.Sc., F.R.S., F.G.S., M.R.I.A., Hon. Sec. Roy. Dublin Soc., Professor of Geology and Mineralogy in the University of Dublin. Scientific Transactions of the Royal Dublin Society, ser. ii, vol. vii (1899); 4to, pp. 44.

THE paper consists of an introduction and these nine sections:—

I. The estimate of geological time.
II. The original condition of the ocean.
III. The supply of sodium by the rivers.
IV. The saline deposits.
V. The alkalies of the rocks.
VI. The potash of the rivers.
VII. Uniformity of denudation by solution.
VIII. The alkalies of sediments, and the geological age of the latter.
IX. The solvent denudation of the ocean.
And two appendices.

Appendix 1 is generally useful. It contains a list of numerical quantities adopted in the calculations. Appendix 2 is a list of sources of error which may modify the conclusions.

The matters treated of in the nine sections are epitomized in the introduction.

The first point argued is, that so much of the removal of the land surface as is due to solution may be accepted as a uniformitarian process; and this being granted, if we take the one element of sodium, which is dissolved out of the rocks and enters the ocean through river discharge, and if we assume that there was no sodium in the primæval ocean, the amount of sodium in the ocean divided by the amount annually brought down by rivers will give the length of time during which the accumulation has been going on, and will be a measure of the age of the world.

Professor Joly claims that the amount of sodium in the ocean agrees very well with that which must have been lost by the crystalline rocks in the process of their being converted into the existing volume, as usually estimated, of the sedimentaries. This would decidedly support his view that the sodium of the ocean has been derived from the crystalline rocks, and that the primitive ocean was devoid of that element.

I. The data upon which the calculations are made are as follows: "The absolute masses of the ingredients of the ocean" are:

	Tons.
Sodium chloride	$35,990 \times 10^{12}$.
Magnesium chloride	$5,034 \times 10^{12}$.
Magnesium sulphate	$2,192 \times 10^{12}$.
Lime sulphate	$1,666 \times 10^{12}$.
Potassium sulphate	$1,141 \times 10^{12}$.
Magnesium bromide	100×10^{12}.
Lime bicarbonate	160×10^{12}.

"Of the sodium chloride 39·32 per cent. is sodium. In the sea, there is therefore a mass of sodium amounting to $14,151 \times 10^{12}$ tons."

The materials in tons per cubic mile of nineteen of the principal rivers of the world (after Sir J. Murray) are next given, and from these it is calculated that they contain 24,106 tons of sodium per cubic mile. "The total volume [of water] discharged by the rivers *into the ocean* is 6,524 cubic miles per annum."

The mass of sodium in the ocean divided by the mass annually brought down by the rivers gives the length of time in which. at the present rate, the mass in the ocean can have accumulated. The result is 89,565,000 years. But Professor Joly prefers to use a later estimate of the volume of the ocean, which would lengthen the "period of geological denudation to 94,800,000 years nearly."

The foregoing gives the pith of Professor Joly's very ingenious theory of the age of the earth. The remaining sections are subsidiary to it, and are apparently intended to meet possible objections, and to render the first estimate more accurate.

II. "On the Original Condition of the Ocean." This is a necessary inquiry; for unless it can be premised that there was no sodium in it, the argument clearly fails, and the earth's age will be proportionately shorter by an unknown amount. The author assumes that the earth was once molten, and considers that, upon cooling, "the upper part of what is now the earth's crust must have contained as silicates, in the form of slag, lava, or rock, the alkaline earths now appearing chiefly as carbonates, the alkalies now distributed between the salts of the sea and the alkali silicates of the rocks, along with iron and alumina. The early hydrosphere must for want of other known alternative be supposed to have contained a quantity of hydrochloric acid, roughly represented by the chlorine now in the ocean."

We next find speculations as to the sequence of events preceding and following the first condensation of water on the surface; and it is considered improbable that a uniform ocean ever covered the entire globe; and the author inclines to the opinion that the sub-oceanic crust is more dense than the continental, and that ocean basins have been permanent. This part of the essay is of much interest, but does not very closely concern the main question of the age of the earth.

We have here quoted an important analysis by Mr. F. W. Clarke (Bull. U.S.A. Geol. Surv., 1897), "which may fairly represent the composition of the older crust of the earth."

" SiO_2	59·77	Na_2O	3·61
Al_2O_3	15·38	H_2O	1·51
Fe_2O_3	2·65	TiO_2	0·53
FeO	3·44	P_2O_5	0·21
CaO	4·81		
MgO	4·40		99·14
K_2O	2·83		

"Such a rock, or lava, attacked by a heated solution of hydrochloric acid, must ultimately yield its iron, calcium, magnesium, potash, and soda as chlorides. The atomic percentages of Clarke's average are given by himself as follows :—

Iron	4·71	take up units of chlorine	9·0
Calcium ...	3·53		6·3
Magnesium ...	2·64		7·6
Potassium ...	2·35		2·14
Sodium ...	2·68"		4·1

Having given the composition of the crust, the author next considers how the chlorine of the heated hydrochloric acid, which he supposes then to have been in the ocean, would have been distributed among the bases.

It is evident that any sodium which was obtained by rock solution from the floor of the primæval ocean must be deducted from that supplied by the rivers, otherwise the age of the world will be reckoned too long. Professor Joly proposes to estimate the former by considering the chlorine in the ocean. Of whatever chlorine there was in the primitive ocean the sodium would take 14 per cent. (reckoning from the proportion of sodium to the other bases in the crust). But some chlorine is also supplied by the rivers, and by rain upon the land. He allows for this at a guess 10 per cent. Deducting this, the total supply by rivers is $97·8 \times 10^6$ tons of sodium chloride per annum. There are other chlorides (lithium 16×10^6, ammonium $6·5 \times 10^6$) in the rivers. Thus we find 76×10^6 tons of chlorine discharged into the ocean annually by rivers.

"If we assume that the final result as to the duration of denudation will not be far from 86×10^6 years. we arrive at a total deduction of $6,536 \times 10^{12}$ tons [of chlorine] as a correction on the amount of chlorine contained [at present] in the sodium chloride of the ocean." This, however, seems to *postulate* the period of 86×10^6 years, which is the thing to be found. The calculation will be—

	Tons.
Chlorine in the sod. chl. now in the ocean	$24,155 \times 10^{12}$
Chlorine in the mag. chl. now in the ocean	$4,161 \times 10^{12}$
	$28,316 \times 10^{12}$
Deduct chlorine introduced by rivers in 86×10^6 years ...	$6,536 \times 10^{12}$
	$21,780 \times 10^{12}$

"The result is $21,780 \times 10^{12}$ tons" of chlorine in the original ocean. Of this, 14 per cent. will have been combined with sodium as already explained, the remainder combining with the other bases of the magma. This gives $1,972 \times 10^{12}$ tons of sodium in the original ocean. Hence we have—

Tons of sodium in the present ocean	$15,627 \times 10^{12}$
Tons of sodium in the original ocean...	$1,972 \times 10^{12}$
Difference given as brought in by rivers	$13,655 \times 10^{12}$

This, divided by the annual supply of sodium by rivers, viz. $15,724 \times 10^4$ tons, gives as a final result $86·8 \times 10^6$ years for the age of the world.

III. In this section some slight modifications of the supply of sodium by rivers to the ocean are considered. The estimate of 89·3 millions of years is finally arrived at as "based on the most complete estimates of probabilities."

IV. We next have a short geological discussion on the origin of beds of rock salt; but the author concludes that these have scarcely any bearing upon his theory.

V. In this section the rates of percentages of soda and potash in igneous and sedimentary rocks respectively are considered. Seeing that the sedimentaries have been ultimately derived from the igneous, the difference needs to be accounted for. The difference is considerable; for while in the igneous the percentages are of potash 2·83 and of soda 3·61, in the sedimentaries they are of potash 2·49 and of soda 1·47. "If now the inference is right that the missing alkalies [i.e. the deficiency of soda in the sedimentaries] were supplied to the ocean, we should expect to find, on a rough approximation of the bulk of sedimentaries, and hence of the original rocks giving rise to them, that such a mass of parent rock would be adequate to supply the sodium in the ocean." This the author claims to be the case, allowing for the sodium retained in beds of rock salt. The weight of this argument clearly depends upon what reliance we can place upon the estimate of the bulk of the sedimentaries, which is taken from Mr. Mellard Reade.[1] Professor Joly accepts his estimate of a layer 2 miles thick over the land area, which on deducting the calcareous rocks is reduced to 1·6 miles. This, however, is reduced still further by a course of somewhat complicated reasoning to 1·1 miles, and the conclusion, accentuated by italics, is thus stated:—

"*Hence it appears that, if a thickness of* 1·1 *mile of rock spread over the land area represent the bulk of the entire detrital siliceous sedimentary rocks, inclusive of submarine detritus, and this constitutes* 67 *per cent. of the entire sedimentaries of the earth, including matter in solution in the sea, the sodium contained in the sea, added to what is left over in the detrital sediments, would suffice to restore to the entire mass a soda percentage almost equal to that in the eruptive, igneous, and crystalline rocks*; the deficiency, about 0·4 per cent., exists partly in rock-salt deposits."

The bearing of this section upon the general argument is, that the sodium in the ocean may be regarded as having been all of it derived from the original rock magma.

VI. The ratio of potash to soda in the ocean is 1 to 31 nearly, whereas in the river discharge it is 1 to 2·8, that is, there is about eleven times as much potash compared to soda in the rivers as there is in the ocean. It is therefore clear that at this rate the present ratio of these alkalies in the ocean could not have been contributed by the rivers. "We must then suppose that the rivers are now supplying more potash relatively to soda than formerly; *or* that some process of abstraction of the potash from the ocean is in continual progress." The author comes to the conclusion that there is no reason to suppose that the ratio of the alkalies in the river supply differed in

[1] Geol. Mag., Dec. III, Vol. X (1893), p. 97.

times past from what it is now, but attributes the deficiency of potash in the ocean to a continual abstraction of that alkali in deposits which have always been, and still are, going on upon the sea bottom, especially in the form of glauconite. Moreover, while the soda brought by rain from the ocean is returned to it again, much of the potash is retained by vegetation, and finally deposited in the strata.

[Is it certain, however, that the primæval ocean did not contain soda? If it did, the excess would be at once explained.]

VII. The uniformity of denudation by solution throughout geological time is a first requisite of Professor Joly's calculation. The objection which would be probably made is, that the sodium supply by rivers will have been greater in early times. To meet this he first argues for a nearly equable distribution of land and sea all along, so that there would not have been formerly much larger areas exposed to denuding agency than now. This portion of the present section is very interesting from a geological point of view, and is well reasoned. No claim is made to settle definitely the ratios of rainfall during successive epochs.

In the next place the author meets the possible objection, that it might be thought that formerly greater areas of the land surfaces were occupied by crystalline rocks, which, containing a larger percentage of sodium than the sedimentaries, would have supplied that element at a quicker rate. In later times the sedimentaries would occupy a larger proportion of the exposed surface, but the balance of supply would, he thinks, be rectified by the greater ease with which the sedimentaries, aided by disintegration into soils, yield up the alkalies they contain.

VIII. In this section "a very interesting but difficult line of enquiry is suggested in the probable facts of geological denudation" referred to in the previous section. The object in view appears to be to support the theory of uniformity of sodium supply.

IX. By "the solvent denudation of the ocean" is meant its action upon the coastlines. This is believed by the author to be small compared with what goes on upon land surfaces. Moreover, experiment has shown that sea-water has little effect in decomposing felspars, and similarly the volcanic products which are so abundant in deep-sea deposits have the alkali ratio of igneous, not of sedimentary rocks—"a plain proof that the waters of the ocean do not affect them as would terrestrial rain and rivers." The correction on the world's age on account of the solvent denudation of the ocean will be sufficient if half a million years is allowed. The final conclusion is that "*our present knowledge of solvent-denudation of the earth's surface points to a period of between eighty and ninety millions of years having elapsed since water condensed upon the earth,* and rain and rivers and the actions continually progressing in the soils began to supply the ocean with materials dissolved from the rocks."

As Major Dutton has somewhere remarked, "If we enquire of Mother Earth her age her face is the face of a sphinx." Has

Professor Joly read her riddle aright? The suggestion of some criticisms may be excused.

In the first place, it does not appear safe to take the intensities of actions now going on as a measure of those in past ages, because the earth has been losing energy; and, as Professor Darwin has pointed out in his book on "The Tides," meteorological agencies must have formerly been more powerful than they are now. In the writer's opinion, in dealing with events of long past ages the interaction of the moon upon the earth ought not to be lost sight of. This is inversely proportional to the cube of her distance, which distance was once much less than it is now, if, indeed, the moon was not once a portion of the earth suddenly detached. If such was the case, the primæval condition of the earth's surface may have been profoundly modified by the stupendous event.

The assumption made that the primitive ocean did not contain alkalies appears to require that the alumina in the original magma was exactly proportioned to the alkalies, so that when the felspathic minerals were formed there was neither alumina left nor alkalies, as there certainly was silica in abundance, still uncombined. If this proportion did not hold, there would have been either alumina uncombined in the crystalline rocks, or alkalies over to combine with the acids in the ocean—presumably the latter, seeing that alkaline salts abound in it at present. That this due proportion should have existed does not seem probable. If there was soda in the primæval ocean, that would shorten Professor Joly's estimate of the earth's age.

The various sodium salts in the rivers are in the proportion of sulphate 32, nitrate 27, chloride 17, nearly. The decomposition of iron sulphide would supply the sulphuric acid. Bacteria in the soils would supply the nitric. But whence came the chlorine? The amount of 0·01 per cent. stated to occur in crystalline rocks seems insufficient. Sodium occurs as carbonate rather abundantly in some rivers and artesian wells, which, Sterry Hunt remarks, "has its source in the decomposition of felspathic minerals."[1] This shows that the direct product of these rocks is the carbonate rather than the chloride. Is it not probable that the chlorides of sodium, and to a small extent of lithium, are derived from sedimentary rather than from crystalline rocks; not from the decomposition of these rocks, but from what Sterry Hunt calls the "fossil sea water still to be found imprisoned in the pores of the older stratified rocks,"[2] and presumably in the younger as well?

This idea had occurred to the writer before referring to Sterry Hunt's book, and he had already begun to examine a specimen of the Silurian rock (Wenlock shale) obtained from the depth of 880 feet in the New River Company's borehole at Ware; for it seemed probable that this rock has never yet been exposed to atmospheric influences, so that it would contain all the salts which were present in the mud of the very early ocean from which it was

[1] "Chemical and Geological Essays," p. 85.

[2] Ibid., p. 41.

consolidated. And it is distinctly salt to the taste. On submitting a fragment of this rock for examination to Mr. Purvis, of the Cambridge University chemical laboratory, he found that it contained 0·568 of soluble matter, of which 0·042 per cent. consisted of chlorine calculated to sodium chloride. Now the specific gravity of this rock is 2·59. Consequently, since a cubic foot of water weighs 1,000 ounces, there are 1·08 ounces of chlorides in a cubic foot of the rock and 2·27 ounces of other soluble salts. In like manner a piece of Devonian shale from Meux Brewery in Tottenham Court Road at the depth of 1,070 feet was found to yield 1·11 per cent. soluble in water, but the amount of chlorine was too small to determine.

It is interesting to compare these old rocks with such as we might suppose would now be forming. Accordingly it was found upon squeezing dry some mud from Southampton Water that the matter soluble in water was 0·495 per cent., and of "chlorine calculated to sodium chloride 0·074 per cent." This mud was derived from Middle Bracklesham sands, and yielded a soft sandstone rock when consolidated in a hydraulic press.

Some mud from the Fleet near Weymouth, when treated in the same manner, yielded 0·9 per cent. of soluble matter, of which chlorine calculated to sodium chloride gave 0·29 per cent.

It is remarkable that the total amount soluble in these hypothetical recent rocks is closely analogous to that in the ancient rocks examined, and also that the proportion of sodium chloride in both cases is comparatively small; whereas in sea-water it is very much greater than that of any other salt. Mr. Purvis adds: "This pressed mud also contains probably mixed sulphates, such as magnesium sulphate, sodium sulphate, potassium sulphate, and calcium sulphate." It is natural to conclude that the decomposition of iron sulphide in the original sands may have converted much of the chloride into sulphate. Sulphuric acid is also a product of the combustion of coal, which would account for the presence of a certain amount in localities like those from which these muds were obtained. But the point of interest is the probable substitution of sulphates for chlorides, from whatever source the acid may have come. This consideration shows that there may have been originally more sea salt in a sedimentary rock than is indicated by the quantity of sodium chloride it now contains.

Another point to be noticed is, that the amount of salts in the ancient rocks being so near that in rocks now presumably being deposited, shows that the ocean was about as salt then as it is now, and consequently not much additional sodium can have accumulated in it during the long ages since Silurian times.

In the 18th annual report of the U.S.A. Geological Survey[1] upwards of sixty analyses of well waters are recorded in Indiana and Ohio. In the artesian wells sodium chloride is very abundant, to the amount of 1,000 to 3,000 grains to the U.S.A. gallon. These waters appear to be found in sedimentary rocks. In the 19th report[2]

[1] 1896–7, pt. iv, p. 500.
[2] 1897–8, p. 650, "Rock Waters of Ohio."

we read: "Water from a greater depth [not specified] holds dissolved chlorides as well. Chloride of sodium is by far the most common, but chlorides of magnesium and calcium are often added. Such waters are usually called saline. The presence of chlorides is seldom shown in waters at less than 100 feet in depth. . . ." "It is very rare that the drill descends to 300 feet without encountering saline water." These waters are from Silurian beds.

The conclusion to be drawn from these remarks is, that some of the sodium found in river waters may probably be derived from the "fossil waters" of old sea muds, and if that is the case, it is in circulation from the ocean to the stratified rocks and back again. No doubt much sodium may find its way into rivers immediately from the felspar of rocks, but we are not justified in crediting all the sodium conveyed to the ocean as having been supplied *de novo* in that manner. This consideration would lengthen Professor Joly's estimate of the world's age by an unknown period.

An enquiry not without interest may be made as follows:—Supposing the whole of the land area to consist of granite; for how many years would a foot thickness of the land supply the sodium as carried down by the rivers at the present rate? Mr. Merrill's book supplies the data to answer this question.[1] He describes a section where solid granite occurs at the bottom, and, after passing through an intermediate stage of weathering, is disintegrated into sand at the surface. It appears legitimate to assume that this process of disintegration keeps pace with the denudation of the surface. Mr. Merrill says that the solid granite, in the process of disintegration into the residual sand, loses 28·62 per cent. of its soda. Now the weight of the sodium is the weight of the soda *minus* the weight of the combined oxygen, so that it will be 23/31 the weight of the soda. Also he tells us that the weight of the soda is 2·68 per cent. of the solid granite; and according to Mallet a cubic foot of granite weighs 198·34 pounds.

With these data it appears that the weight of the sodium in a cubic foot of granite is 0·00047029 of a ton.

Accepting Professor Joly's figures, the land area in square feet will be $55{,}814{,}000 \times (5{,}280)^2$, which gives us the volume of a layer a foot thick covering the land area; also the weight of the sodium annually discharged by the rivers is 157,267,544 tons. Dividing this by the volume of the one foot layer multiplied by the weight of sodium in a cubic foot, we get 1/5000 of a foot of granite as competent to supply the sodium of the rivers in the annual process of disintegration.

We may hence conclude that, if the land area consisted of granite, the rate of denudation would be one foot in 5,000 years. Sir A. Geikie, in his "Text Book of Geology" (p. 444), accepts one foot in 6,000 years as a probable mean for the rate of denudation. It is certainly remarkable that the result we have obtained comes near this. But when we remember that but a small portion of the land surface consists of crystalline rocks, and that the mean

[1] "On Rocks and Rock Weathering," p. 209.

percentage of soda in sedimentary rocks is only 1·47 (p. 44), it is obvious that a much higher rate of denudation would be required to yield annually by decomposition of such rocks the amount of sodium carried down by the rivers. The conclusion will be that, if one foot denuded in 6,000 years is near the truth, the sodium in the rivers must have some further source than the soda which forms a mineral constituent of the surface rocks, and that this additional soda is probably derived, as already suggested, from "fossil" sea-water. Ought not also some allowance to be made for the soda introduced into rivers by human agency?

The style of the paper leaves here and there a little to be desired in respect of clearness; for instance (p. 47), "We can apply to the mean analysis of the sedimentaries on the one hand, and to that of the original crust on the other, to arrive at a rough estimate of the loss of entire rock by solution in the process of formation of the former." Again (p. 46), "We accept one mile deep of these [detrital sediments] on the land, and confining ourselves to purely detrital siliceous sediments, assume that as much as 10 per cent. of what is on the land is in the sea [!], or say a total of 1·1 mile deep over the land area."

In this important essay Professor Joly has opened up an entirely new line for the investigation of geological time. It is too soon to pronounce whether his numerical estimate is fully to be relied upon, until it has been a little while before the scientific world. His period of between 80 and 90 million years will perhaps satisfy geologists as being sufficient. The leading physicists, on the other hand, are disposed to grant us a good deal less time.

O. Fisher.

Harlton, Cambridge.
January 22, 1900.

II.—The Fauna of the Silurian of Podolia.

Fauna sīluriīskīkh otlozhenīĭ podol'skoĭ guberniī. Die Fauna der Silurischen Ablagerungen des gouvernements Podolien. By P. N. Venyukov (Wenjukow). Mater. Geol. Russlands, XIX, pp. 21–266, pls. i–ix; November, 1899.

Podolia, which lies to the south-west of Kiev, is bounded on the south by the Dniester and on the west by Galicia, and is drained by a river beloved of every schoolboy—the Bug. The Silurian rocks are all in the south-west of the province, adjoining the similar formations of Galicia. The present work by Professor Venyukov of Kiev describes the fauna of these rocks, unfortunately for us, in Russian; but the broad results may be gathered from the short abstract in German, while the new species, of which there are not a few among corals, brachiopods, molluscs, and ostracods, may to some extent be identified from the plates. The Silurian geologist will certainly have to read the abstract, and the specialist in palæontology must get the Russian descriptions translated for him. Here we give only the main conclusions.

The Silurian rocks of Podolia consist chiefly of limestone, and may be divided into three series (*Horizonte*), each characterized by a more or less independent fauna, which developed and altered during the deposition of the series. The lowest series, which occurs in the south-east of the Silurian area, near Studenitza, is very poor in corals and gasteropods, but rich in brachiopods, especially Atrypidæ and Leptænidæ. Among the characteristic species are *Strophomena antiquata*, *Atrypa cordata*, *A. imbricata*, *A. Barrandei*, *A. Thisbe*, *Pentamerus linguifer*, and *Glassia compressa*. This is correlated with the Wenlock Shale, and with bed *c* of Lindström's Gotland scale. The middle series has a wider extent, and is exposed along the north bank of the Dniester. It is very rich in corals, such as *Cyathophyllum articulatum*, *Ptychophyllum truncatum*, *Rhizophyllum gotlandicum*, while gasteropods of the genera *Oriostoma* (esp. *O. discors*, *O. globosum*), *Murchisonia*, and *Pleurotomaria* are characteristic and abundant. The brachiopods are represented chiefly by Rhynchonellidæ and Pentameridæ. The series is clearly capable of further subdivision, but in the main is correlated with the English beds from Wenlock Limestone to Aymestry, and with *d*, *e*, *f* of Gotland. The uppermost series occurs towards the north of the area, near Dumanov and Kamenez-Podolsk. Brachiopods preponderate, and among the species may be noticed *Spirifer Thetidis*, *S. robustus*, *Rhynchonella nympha*, *R. Hebe*, and *Atrypa sublepida*. There are scarcely any mollusca and few trilobites; but there are some ostracods and the characteristic *Eurypterus Fischeri* and *Scaphaspis obovatus* (?). As local developments are beds of crinoid-limestone, in which *Crotalocrinus rugosus* is the only recognized species. A similar occurrence is characteristic of the Gotland horizons *g* and *h*, with which this is correlated. Its English representatives are the Upper Ludlow and Passage Beds.

It is clear that for the greater part of Silurian time the Podolian area formed a part of the great northern basin in which the rocks of England, Gotland, and North-West Russia were deposited. It was, however, connected with the Bohemian basin, and this connection increased until in Lower Devonian time the Podolian sea formed a link between Bohemia and the Ural basin. F. A. B.

III.—Beiträge zur Kenntniss des Sibirischen Cambrium. Von Eduard von Toll. Mémoires de l'Académie Impériale des Sciences de St. Pétersbourg. Série viii, vol. viii, No. 10, 1899.

Contributions to a Knowledge of the Siberian Cambrian. By E. von Toll. 4to; pp. iv + 57, with 9 woodcuts and 8 plates.

In this memoir Baron von Toll records the discovery of beds of sandstone, shale, and limestone, with Cambrian fossils, in several localities in Eastern Siberia widely separated from each other, which seem to indicate the existence in this region of an extensive basin of Cambrian deposits. The rocks have previously been regarded, owing to an erroneous determination of some imperfect fossils, as of Devonian, Carboniferous, and Triassic age. The strata are principally exposed in the banks of the great rivers, and fossils have been found in the following localities: (1) Torgoschino, near Krasnojarsk on the Yenesei, 56° N. lat., 93° E. long.; (2) on the right bank of the Vilyui, 63° N. lat., 115° E. long.; (3) on the Olenek, in 70° N. lat., 120° E. long.; and (4) on the Lena, between Oleminsk and Yakutsk, in 64° N. lat., 128° E. long.

From limestones on the Lena the author describes two species of *Ptychoparia* related to forms in the *Olenellus* zone of North America; three new species of *Microdiscus*, two of which approach closely to American forms; *Agnostus*, sp.n.; fragments of a doubtful *Olenellus*; *Kutorgina cingulata*, Billings; an *Obolella* related to *O. chromatica*, Bill.; and an undetermined *Hyolithes*.

The beds on the Olenek contain *Bathyuriscus Howelli*, Walcot, a Middle Cambrian species found originally in Nevada; *Agnostus Czekanowskii*, Fr. Schmidt; and some worm tracks. From the Vilyui Fr. Schmidt has already described *Anomocare Pawlowskii* and *Liostracus*? *Maydelli*.

From limestones at Torgoschino on the Yenesei two species of Trilobites, *Proetus Slatkowskii* and *Cyphaspis Sibirica*, had been described by Fr. Schmidt: the former of these is now determined by the author to belong to the Cambrian genus *Dorypyge*, Dames, and the latter with some doubt to *Solenopleura*, Angelin.

The Yenesei rocks likewise contain numerous representatives of the widely distributed Cambrian family of the Archæocyathinæ. The author describes six species of *Archæocyathus*, Bill., three of which are new, and three considered to be identical with species from the Cambrian rocks of Sardinia. Of the allied genus *Coscinocyathus*, Bornemann, seven species common to the Sardinian rocks and one new are recognized, and there is also a doubtful form of *Protopharetra*, Bornemann. The Yenesei examples of this family, like those from Sardinia, appear to be enclosed in a very hard limestone, so that they can be studied only in sections; consequently the recognition of specific characters is very difficult, and complete identification of species, as the author acknowledges, is hardly to be expected.

A new genus, *Rhabdocyathus*, is also proposed: it agrees, in the laminate character of the wall, with *Spirocyathus*, Hinde, but it possesses neither septa nor dissepiments, and the space between the inner and outer wall layers is traversed by tubes which open on the exterior surface as rows of pores. The author considers that this form represents a simpler type of the family than any hitherto known, and, further, that it furnishes a clue to the systematic position of the group, which, as is well known, is not as yet by any means settled. The Archæocyathinæ have been in turn referred to siliceous sponges, foraminifera, and perforate corals, but their resting-place in any one of these divisions has not received the general support of palæontologists. Von Toll puts forward a fresh suggestion, namely, that they are possibly Calcareous Algæ, whose nearest relations are to be found in the Tertiary genus *Acicularia*, D'Archiac, and the existing *Acetabularia*, Lamx. Whatever may be the final conclusion respecting the nature of the Archæocyathinæ, their significance as characteristic fossils of Cambrian strata is further manifested by their occurrence, in association with *Dorypyge*, in Eastern Siberia.

It may be hoped that the author's anticipations of fresh discoveries of fossils in these ancient rocks in the works for the great Siberian railway, now in progress, will be fully realized.

G. J. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—January 10, 1900.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On a Particular Form of Surface, the Result of Glacial and Subaerial Erosion, seen on Loch Lochy and elsewhere." By Dr. W. T. Blanford, F.R.S., Treas. G.S.

This form of surface, first noticed by the author on Lake Como, was afterwards observed in the Great Glen of Scotland and in British Columbia. It consists of an almost even plane sloping at a moderate or high angle, and cut at intervals by small ravines or channels. The sides of the Great Glen have been planed by glacier-action to a greater extent than usual, and between Loch Lochy and Loch Oich, near Laggan, the sides of the Glen have a regular and flat slope of over 35° up to about 1,000 feet above sea-level. Numerous stream-cut channels draining down this slope are, on an average, not more than 10 to 15 feet deep, but some quite exceptional examples may be 50 feet deep; these channels occupy less than a fourth of the surface. In addition there are larger glens which, although they run out into shallow ravines where they cut the sloping side of the Great Glen, are frequently 500 feet in depth among the hills. If these were ordinary stream-valleys before the Glacial Period, the cutting away of the ridges separating them to the extent of at least 250 or 300 feet must be attributed to glacial erosion on the sides of the Great Glen. The erosion of the small ravines in the glacial slope must have been effected by streams in post-Glacial times, and the measurement of their rate of erosion might be expected to throw light on the amount of time which has elapsed since the Glacial Period in this district. "The general effect produced by the whole evidence is . . . . the small amount of denudation that has taken place since the Great Ice Age, and the necessary deduction that no great period of time, measured in years, can have elapsed between the Glacial Epoch and the present day."

2. "On the Geology of Northern Anglesey." Part II. By C. A. Matley, B.Sc., F.G.S.

The present paper deals in the first place with the stratigraphy of the Northern Complex. The following table shows the succession of the rocks in descending order:—

C. The Llandeilo Strata.

		Feet.
C *d*.	Black argillaceous shales	40; top not seen.
C *c*.	Ironstone, in part oolitic	20
C *b*.	Grey quartzose shales or slates, striped by thin, black laminæ	150
C *a*.	2. Pale conglomerates and grits	500
	1. Red-purple conglomerate	180

B. The Llanbadrig Series, about 1,000 or 1,500 feet; apparent order:—

B *f*. Quartzite.
B *e*. Pebbly slates.
B *d*. Slates with grit and quartzite bands.
B *c*. Quartzites, shales, and some limestone (Porth Padrig, etc.).
B *b*. Limestone (as at Trwyn y Parc).
B *a*. Grits and slates, usually smashed to a crush-conglomerate.

A. The Green Series.

Greenish and bluish slates (of the Northern Complex).

The rocks strike east-south-east, and dip usually at a high angle northward; a well-marked transverse fault divides the complex into western and eastern portions. The Llandeilo rocks occupy four strips of ground in the west and three in the east, but the full succession does not occur in any one of these outcrops. The effects of compression are much marked in the purple conglomerate; the matrix is dragged out along small shear-planes, and the pebbles are stretched into phacoids, slip-faulted, and their extremities tailed out. A deceptive appearance of unconformity is also produced at the junction of grits and shales. Fossils are found in some of the rocks. The Llandeilo rocks are of importance, as they reveal the existence of at least four shattered synclines, usually faulted, and probably all overthrust on their northern boundaries.

No fossils have been found in the Llanbadrig rocks, and no more definite assertion of their age is possible than that they are pre-Llandeilo. They are newer than, and their base may be conformable with, the Green Series; but as fragments almost certainly derived from the latter series have been found in the highest zones, the relation between the two series is more likely to be that of an unconformity. The Llandeilo rocks contain fragments of limestone and pieces of quartzite; but in spite of this evidence in favour of unconformity between the Llanbadrig and Llandeilo rocks, the basal beds of the latter are found to cling closely to the highest quartzite of the Llanbadrig Group.

The quartzites are remarkable in the fact that they frequently contain patches of limestone, apparently deposited with them, and that they vary rapidly in thickness from about 30 to 200 feet at Craig Wen, where this variation is correlated by an inverse variation in the conglomerate. Although earth-movement may be partly responsible for this variation, some further explanation appears requisite, and this may possibly be furnished by erosion of the quartzite. The overthrusting force appears to have come from a direction somewhat east of north.

The igneous rocks are dealt with in two groups: those older and those newer than the earth-movement. To the former belong granite, serpentine, and its associates, and basaltic dykes. In each area where they occur the serpentines are associated with masses of a peculiar purple limestone not known elsewhere; they also contain bands of ophicalcite, and schistose structures are common in the rocks. The later dykes belong to an acid and a basic set; the latter show some evidence of a minor movement, such as faulting and a little shearing. The acid dykes are microgranites, granophyres, and quartz-porphyries. In some cases the dykes are composite, the acid material being the older and the basic the later constituent. As a rule, the basic material invades the edge of the dyke; but in one case it has invaded the joints and cracks and caught up fragments of the acid rock.

3. "The Formation of Dendrites." By A. Octavius Watkins, A.R.S.M., F.G.S.

If two plane-surfaces be separated by a film of suitable plastic material, and one surface be rotated slowly on the other through a small arc, the plastic material collects into branching forms similar to the structure of dendrites. The dendritic form starts from the part farthest from the axis, and the flow of material is from the smaller to the larger branches, the smaller uniting to form the larger. The author explains dendritic structure by the formation of a fissure in rock which becomes filled with a thin film of dendritic material; if the fissure is slowly widened, the dendrite starts where the widening commences, coinciding dendrites being formed on each wall. This theory is in accordance with many of the characters of dendrites, such as their method of occurrence, the nature of the material, and their uniformity in thickness.

II.—January 24th, 1900.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "Fossils in the University Museum, Oxford. II. On two New Genera and Species of Crinoidea." By W. J. Sollas, M.A., D.Sc., LL.D., F.R.S., V.P.G.S., Professor of Geology in the University of Oxford.

The first genus and species are founded on two calyces in the University Collection and three in the British Museum; all the specimens come from the Carboniferous Limestone. The arms and stem are at present unknown. The genus in general character and structure recalls *Platycrinus*, but the incorporation of the costal and distichal plates in the calyx affords a very obvious distinction. The analysis of the calyx, however, suggests the Melocrinidæ, from the members of which it is chiefly distinguished by the comparatively small size of the costal and distichal plates. The new genus is a truly annectant form uniting the Melocrinidæ and the Platycrinidæ, and may be indifferently associated with either.

The second genus and species are founded on a specimen in the Grindrod Collection, obtained probably from the Silurian rocks, but from a locality not known, possibly Dudley. In general appearance it resembles an elongated form of *Pisocrinus*, particularly in its calyx, but the arms are those of a Heterocrinid. This conjunction of characters, though rendering necessary a revision of the definition of the Pisocrinidæ, cannot be regarded as bringing this family appreciably nearer to the Heterocrinidæ, which are fistulate, while the Pisocrinidæ, so far as known, are not.

2. "Fossils in the University Museum, Oxford. III. A New Worm-track from the Slates of Bray Head, Ireland; with Observations on the genus *Oldhamia*." By W. J. Sollas, M.A., D.Sc., LL.D., F.R.S., V.P.G.S., Professor of Geology in the University of Oxford.

The curious markings known as *Oldhamia* have not been hitherto recorded from other than the lower Palæozoic rocks, although they have a wide distribution in space, being found in Ireland, in the Ardennes, in Brabant, in America, and possibly in Norway. While the organic nature of *Oldhamia* was scarcely a matter of doubt in the minds of the earlier writers, there existed a great diversity of opinion as to its place in the organic world, and it was placed by different observers among polyzoa, hydrozoa, and plants, respectively. The microscopical observations made by the author prove that *Oldhamia* is not the remains of an organism, but merely a marking in the rock, though one which might be, nevertheless, of organic origin. Certain markings formed in the mud at Portishead, by the feeding habits of a small burrowing crustacean, bear a considerable resemblance to specimens of *Oldhamia*; but a stronger resemblance to the new species described in this paper is found in Nathorst's figures of the impressions made by one of the two recent worms *Glycera alba* or *Gonidia maculata*. Professor Joly's observation that markings of *Oldhamia antiqua* always occur in relief, while those of *O. radiata* are depressions, might suggest that while one set of markings was produced by the animal when feeding, the other was connected with its castings of excrementitious matter. This explanation is open, however, to several objections, and the author is inclined to believe that these species of *Oldhamia* are the traces of some kind of siphonaceous alga: the cavities left by their decay were subsequently filled in by sediment under pressure. If the upper surface of *O. antiqua* were more resistant than the lower, this might account for its preservation in relief. The microscopical examination of slate containing *Oldhamia* affords evidence of original and secondary structures which have an important bearing on this question.

3. "Contributions to the Geology of British East Africa. Part II: The Geology of Mount Kenya." By J. W. Gregory, D.Sc., F.G.S.

The three main zones of Kenya are characterized by different geological features. The long slope of the forest-belt consists in the main of volcanic ash, though the remains of secondary parasitic craters occur in it. The Alpine zone consists of coarser ash, agglomerates, and tuffs, interbedded with lava-flows and traversed by numerous dykes, with the remains of some secondary centres of eruption. The third zone, or central peak, consists of the plug which choked the central vent, of beds of agglomerate, and the thick proximal ends of the great lava-flows.

The rocks of the central core comprise an olivine-anorthoclase-nepheline-syenite with ægyrine, and a black glassy lava with numerous white phenocrysts of anorthoclase; this rock is allied in some respects to the pantellerites, but receives a special name both here and in its occurrence in lava-flows.

The dyke-rocks fall into two categories—a series of phonolites, and one of basalts and dolerites. One, at least, of the dykes is compound, including both these rock-types. The basic group ranges from basalts with little olivine to coarsely crystalline dolerite rich in that mineral.

The lavas belong to three main groups: (1) those of the nepheline-syenite series, (2) the phonolites, and (3) the basalts. The oldest lavas appear to be the phonolites, but they and the first group of lavas seem to have overlapped in age; the olivine-basalts, which reach the surface from a zone of secondary craters in the Alpine zone, are the latest in date. The first group of lavas are rhyolitic in aspect, and consist of a brown or green glass in which are embedded phenocrysts of anorthoclase, and green needles which show the optical characters of ægyrine. As these rocks do not conform to Rosenbusch's definition of pantellerites, a new name is proposed for them; the author considers that the pantellerites may be liparitic equivalents of the dacites, while these Kenya rocks correspond with the nepheline-syenites. The structure of the phonolites is trachytic, the groundmass including abundant small, lath-shaped plagioclases; nepheline is not very abundant, and occurs in larger crystals than the other constituents, the chief of which is ægyrine. The basalts are often vesicular and columnar, and contain olivine, augite, magnetite, and apatite often in a glassy groundmass.

The pyroclastic rocks vary in texture from coarse to fine; they contain blocks of all types of the lavas, and also large crystals of anorthoclase.

The nepheline-syenite is the most deeply-seated, holocrystalline rock found on Kenya; and the mountain appears to represent a single, ancient, dissected, volcanic mass, with a shorter geological history and a narrower range of rock-types than its great companion volcano, Kilima Njaro. The author gives reasons for considering that all the different rock-types present may have resulted by differentiation from the olivine - anorthoclase - nepheline - syenite magma, although this involves the conclusion that in some cases the basic materials must have concentrated in the glass and solidified after the formation of the felspars.

4. "Contributions to the Geology of British East Africa. Part III: The Elæolite-Syenite and Fourchites intrusive in the Coast Series." By J. W. Gregory, D.Sc., F.G.S.

The rocks described in this paper were given to the author by Mr. C. W. Hobley. Mount Zombo, situated in long. 39° 13′ E. and lat. 4° 26′ S, and 1,519 feet high, is a massif of coarse-grained elæolite-syenite, consisting of anorthoclase, elæolite, usually allotriomorphic, and ægyrine. The rock must occur in the belt of Duruma Sandstone, unless the fossiliferous Jurassic shales run westward up the low valley of the Umba River. Associated with this massif is a series of dykes belonging to the olivine-less variety of monchiquites known as fourchites. Their phenocrysts consist of plagioclase, probably oligoclase, hornblende, and ægyrine, but augite and ilmenite are also present; the groundmass contains a certain amount of analcite.

Unfortunately there is some doubt as to the exact age of the Duruma Sandstone into which the fourchites are intrusive. The author gives an account of the different opinions as to the age of these rocks; the evidence at present available is only sufficient to prove that they are post-Carboniferous and pre-Callovian. The sedimentary series on the coast-lands of British East Africa and Usambara, in his opinion, may be previously arranged as follows:—

5. Pleistocene reefs, limestones, alluvium, and laterites.
4. Jurassic shales and sandstones; Kimeridgian, Oxfordian, and Callovian.
3. Possibly a pre-Jurassic part of the Duruma Sandstone.
2. Magarini sandstones; ? Triassic.
1. Sabaki shales; Upper Carboniferous.

It is therefore probable that the igneous rocks are not older than the early Mesozoic, and may be Jurassic or post-Jurassic.

III.—February 7, 1900.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "Foraminifera from an Upper Cambrian Horizon in the Malverns." By Frederick Chapman, A.L.S., F.R.M.S. (Communicated by Prof. T. T. Groom, M.A., D.Sc., F.G.S.)

The foraminifera described in this paper were found in a shaly limestone which Professor Groom obtained "from the débris of a small ridge composed of black shales, with intercalated basalts, which forms a spur on the north-west side of Chase End Hill. The rock belongs to the well-known and widely-spread zone of *Sphærophthalmus*, *Peltura*, and *Ctenopyge*, which in Britain forms the upper half of the Dolgelly Beds or Upper *Lingula*-Flags." The specimens have been sliced, and have yielded a few forms other than *Spirillina*; sections of echinoderm-spines, ostracod-tests, and occasionally sponge-spicules (?) are also to be seen in the slides. The tests of the foraminifera are infilled with a crystalline substance.

The following species are mentioned: *Lagena lævis*, Montagu, *L. apiculata*, Reuss, *L. ovum*, Ehrenberg, *Nodosaria pygmæa* (?), Terquem, *N. abnormis* (?), Reuss, *Marginula soluta* (?), Reuss, *Cristellaria acutauricularis* (?) (Fichtel & Moll); and a new species of *Spirillina* is described. The *Spirillinæ* are in a good state of preservation; and the valves of mollusca, cut through in section, are sometimes seen to be quite filled with the tests of this genus.

A record is given of some of the earliest known foraminifera, including the somewhat doubtful forms described by Cayeux from pre-Cambrian rocks in Brittany, those by Ehrenberg from the so-called 'Silurian Clay' near St. Petersburg, by W. D. & G. F. Matthew from the rocks bearing the *Protolenus*-fauna in New Brunswick, by Keeping from the shells above the Bala Limestone near Welshpool, by Blake from the Llandovery of Cwm Symlog, by Brady from the Woolhope Limestone of the Malverns, and by Terquem from the Upper Silurian rocks of Indiana. The author has also frequently met with *Lagena* in the Wenlock Limestone of Shropshire.

2. "Bala Lake and the River-System of North Wales." By Philip Lake, M.A., F.G.S.

In this paper the author begins by showing that topographically Bala Lake belongs to the same valley as the River Wnion—the valley of the Bala Fault; and he believes that the whole drainage of the valley flowed originally south-westward, and entered the sea near Barmouth.

He then examines the possible outlets, and shows that the lake is probably rock-bound in all directions except towards the south-west, where there is no conclusive evidence.

He describes the faults which occur near the watershed that separates the Wnion from the streams flowing into Bala Lake, pointing out that they are closely related to the form of the valley, and that the watershed coincides with a transverse line of fault. From this he infers that the formation of the lake is possibly due to earth-movements.

The watersheds of several other similar valleys are examined, and are shown to lie in one straight line; whence it is concluded that they must have been produced by some general cause, probably a slight differential movement.

The general drainage-system of North Wales is next discussed. Attention is drawn to the existence of a series of long and nearly parallel valleys running from north-east to south-west, which divide the region more or less completely into a number of strips. The drainage of each strip is now independent, and flows in most cases into the long valley lying south of it. But from the fact that the chief streams in each strip have their representatives (flowing in the same line) in the adjacent strips, it is concluded that before the formation of the long valleys the streams were continuous.

The centre from which these streams radiate lies in the high ground near the sources of the Conway; and the author believes that this was the centre of an original radial system of drainage, and that this radial system was subsequently broken up into sections by the formation of the long valleys which now run from north-east to south-west—each of these long valleys carrying away the drainage of one of the sections. He attributes the formation of the long valleys to faulting.

CORRESPONDENCE.

RAILWAY SECTIONS IN AYRSHIRE AND LANARKSHIRE.

Sir,—At present there are some railway sections through Drift in the line being constructed from Darvel, in Ayrshire, to Strathavon, in Lanarkshire, which, I think, show features *demonstrative* of a depression of the land, and the marine origin of at least part of the Drift beds. Lately, with two friends (it was my fourth visit to the locality), I examined minutely one of these sections, 500 to 600 feet above sea-level (estimated from a bench-mark). This cutting is to be a deep one, and is being taken in two 'lifts'; about 200 yards of the upper lift can at present be examined, but it is much longer, part of the slope being already pick-dressed. The section is almost horizontal for the above-mentioned distance, and very regular—not at all twisted or disturbed, as is the case with many parts of the Drift. It is about two miles east of Darvel. The following beds are exposed:—

1. Sand and gravel, stratified	15 feet.
2. Stony Boulder-clay with large blocks	6 ,,
3. Laminated clay with few stones and large blocks ...	5 ,,
4. Stony clay	3 ,,
5. Sharp sand, not cut through.	

In bed 1, I observed a long boulder of Matstone Hill granite, quite in a vertical position. In beds 2, 3, and 4, long boulders were obtained during the progress of the cutting, in a similar position. In the laminated bed 3, a large striated boulder of white sandstone is at present to be seen, measuring four feet in diameter. It has clearly *fallen into the clay* when the latter was in a *soft state*, as the laminæ at the bottom corners of the block *are bent down under it*, showing that the block in falling has made a small indent in the laminated clay. They (the laminæ) also curved over the top of the block.

Another interesting feature was the depressions or ruts in the stony clay bed 2, these being invariably filled more or less with laminated clay. A number of shell-fragments *with the epidermis* were picked out by us from the stony clay, and from the laminated bed we secured a perfect valve of *Leda parvula*. (I may say that in this district marine shells are frequent in certain parts up to 700 feet above sea-level. See suppl. to vol. xi, Trans. Geol. Soc. Glasgow, p. 59.)

The boulders in the sections of the railway at this part are a variety of porphyrites (igneous rocks with conspicuous felspar, a 'Survey' term), amygdaloids, felstones (igneous fine-grained rock, a 'Survey' term), sandstones, dolerites, a few limestones; Matstone Hill granite, a moderately coarse-grained reddish granite, being not infrequent, the parent rock occurring fully two miles to the south and on the opposite side of the Irvine Valley to the railway sections.

Not only the Boulder-clay, *but a sharp grey sand bed* also shows very distinct *jointing*. The joints in a *sand-pit* 200 yards north of the railway were very conspicuous, and had attracted the attention of the workmen in the pit, who called them *water-backs*. Workmen's terms are generally pretty expressive. In solid rocks water often issues from joints.

We went on to Londoun Hill. This hill is not named on Sheet 23; it is just above the house named Backhill on the western edge of the map. It is composed of large vertical columnar felstone.

To the east and south-east of this hill the 'Survey' have shown a 'terrace of marine drift' and an 'old sea beach.' Lately I observed that the talus of large blocks from the hill had *fallen down upon the top of the* 'marine *drift*,' so that the great vertical cliff on the south side of the hill was very likely *the work of the waves*, assisted perhaps by shore-ice, for much of the 'felstone' in the drift may have come from this hill, it being the only felstone rock within many miles of this district.

The 'marine terrace' is 700 feet, and the top of Londoun Hill 1,034 feet, above sea-level.

The facts given in this letter speak, I think, pretty plainly. The Drift beds here are clearly *water deposits*, and that 'water' was the sea. The blocks and stones in both the stony and laminated clay were clearly dropped into the clay from floating ice. In bed 2 (the stony Boulder-clay), there are frequent indications of *stratification*, and those lines have a steady, *gentle* dip of five to ten degrees towards the east, or up the Irvine Valley. This long section has been exposed to the weather for about six months; the clay has not slipped, and the rain-washed face of the drift can be read like a book. There are many well-striated stones and boulders *lying in all directions*, long ones even vertical, but quite as many which show no striations. The ruts in the stony clay bed 2 were probably produced by floating ice grating on the sea bottom, and these have formed *sheltered hollows* in which laminated clay has been deposited.

J. Smith.

Monkredding, Kilwinning.

SOME SNOWDON TARNS.

Sir,—Will you permit me to correct a mistake in my paper on "Some Snowdon Tarns." The depression at 250 yards from the present outlet of Llyn Llydaw is in a N.N.E. direction therefrom, not N.N.W. as I had erroneously written. J. R. Dakyns.

Snowdon View, Nant Gwynant,
Beddgelert, Carnarvon.
February 19, 1900.

OBITUARY.

GEHEIMRATH PROFESSOR DR. GEINITZ,

For. Mem. Geol. Soc. Lond.

Born October 16, 1814. Died January 28, 1900.

Dr. Hans Bruno Geinitz was born at Altenburg, Saxony, where he passed a happy boyhood in his father's home. The political troubles of 1830 affected the family prosperity, so that the youthful

Geinitz had to serve for four years in the shop of the Court chemist, but this did not prevent him from spending his spare time in the study of botany, chemistry, and modern languages. In 1834 a way opened for him to go to the University of Berlin, and in 1836 to that of Jena, where he graduated in 1838. Under the influence of Quenstedt, Geinitz directed his attention more particularly to the study of mineralogy and palæontology, and the subject of his graduation thesis was the Muschelkalk in Thuringia. In the same year, 1838, he went to Dresden and accepted the post of assistant-tutor in the Technical High School, with the modest salary of 150 thalers (about £22) per annum. In 1850 he became Professor at the same institution, and he occupied this position until 1894, when, owing to increasing deafness, he was obliged to resign. From 1863 to 1878 he was one of the editors of the *Neues Jahrbuch*; in 1857 he was appointed Director of the Royal Mineralogical Museum at Dresden, which may be said to owe its present flourishing condition mainly to his zeal and energy, and also the founding of the Prehistoric Museum in 1874.

Professor Geinitz was a very prolific writer on geological and palæontological subjects, and his published papers date from 1837 to nearly the latest years of his life. Though to a large extent they refer to the rocks and fossils of his native country, they yet include matters of general and permanent importance to geological science. Amongst his principal memoirs are his descriptions of the fossils in the Grauwacke formation of Saxony, which appeared in 1852; the monograph of the animal remains of the Dyas formation, 1861–62; and that on the "Elbthalgebirge," 1871–75, which contains the results of his long-continued researches into the stratigraphy and palæontology of the Cretaceous rocks of Saxony and adjoining countries. He also wrote on the fossil flora of the Hainich-Ebersdorf Coal Basin, and on that of the Coal formation in Saxony. A commendable feature in Geinitz's palæontological memoirs is the admirable manner in which they are illustrated.

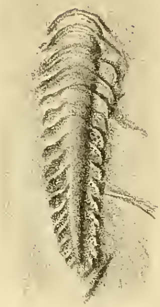
Professor Geinitz was deservedly esteemed and honoured alike by the geologists of his own country and by those of other lands. He became a Foreign Member of the Geological Society of London in 1857, and was the last of those elected to this position directly without passing through the subordinate stage of Foreign Correspondent. In 1878 he received the Society's Murchison Medal.

Professor Geinitz died at Dresden on the 28th January in the 86th year of his age, and his remains were interred on the 31st, in the presence of a numerous gathering of his old students and colleagues.[1]

G. J. H.

The Honorary Degree of Doctor of Laws has just been presented by the Senate of the University of Glasgow to Mr. Arthur Smith Woodward, F.L.S., F.G.S., of the British Museum (Natural History), Cromwell Road, London.

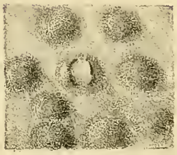
[1] Many of the facts in the above notice are taken from the *Dresden Anzeiger*, a copy of which was kindly forwarded by Miss Agnes Crane of Brighton.



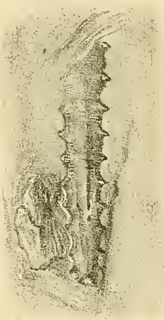
1. *nat. size.*

3. × 3

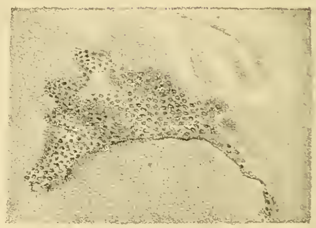
2. *nat. size.*



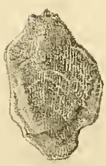
6. × 10.



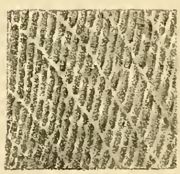
4. *nat. size.*



5. *nat. size.*



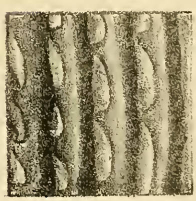
7. *nat. size.*



8. × 5

11. *nat. size.*

9. *nat. size.*



10. × 5

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

Fossils from the Devonian Rocks of the North Coast of Cornwall.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VII.

No. IV.—APRIL, 1900.

ORIGINAL ARTICLES.

I.—Notes on the Geology and Fossils of some Devonian Rocks on the North Coast of Cornwall.

By Howard Fox, F.G.S.

(PLATE VII.)

During the past year I had the pleasure of spending some weeks on the north coast of Cornwall, south of the Camel, examining the rocks exposed in the cliffs and on the foreshores of the various coves, some of which I had not previously visited. A part of my notes were communicated to the Annual Meeting of the Royal Geological Society of Cornwall last November, and with the permission of the Society I propose to reproduce these and additional observations obtained since, with the view more particularly of calling attention to some of the fossils which, though fragmentary, appear to me to yield not unimportant evidence on the stratigraphical horizon of the rocks along certain parts of the coast.

It had been my intention to visit the various islands lying off the north coast, but during my holiday month, September, there was not a single day in which it would have been prudent to attempt a landing either on the Quies Group or the Bull Rock off Trevose Head. I did, however, make a brief visit to Gulland Island, which is, rightly, coloured greenstone on the Geological Survey Map. The entire surface of this island is covered with angular weathered fragments, which have been disjointed off from the massive rock, a process still rapidly going on. The lower cliff on the south side of the island is composed of a coarse-grained felspathic rock, whilst higher up the rock is of the same kind but much finer grained. The exposed rock surfaces, within reach of the waves and spray, weather nearly black, whilst the rocks beyond are of a rusty-brown appearance.

Padstow Harbour.—In the rocks both to the north and to the south of the River Camel, simple cup-corals and fragmentary crinoidal remains occur, but for the most part they are unfavourably preserved.

Trevone.—An account of the fossils present at several distinct horizons in the shales at this place, and more especially on the foreshore, has already appeared in the Trans. Roy. Geol. Soc.

Cornwall, vol. xi, 1894, pp. 634–644. The following, amongst others, were noted: fragmentary plates of *Pteraspis*; *Orthoceras*; *Bactrites*, including *B. Budesheimensis*, Ferd. Roemer; *Goniatites*; G. (*Tornoceras*) *simplex*, Von Buch; *Euomphalus*; *Cardiola retrostriata*, Von Buch; *Centronella*, *Phacops*, *Tentaculites*, *Styliola*, *Amplexus*, *Favosites*, and *Pachypora*. According to Mr. G. C. Crick the majority of the Cephalopod remains indicate the same geological horizon as the Budesheim Beds, that is, the lower portion of the Upper Devonian, but with these there are some small forms resembling *Anarcestes latiseptatus*, Beyr., and *Mimoceras compressus*, belonging to the Wissenbach (Nassau) Beds, of Lower and Middle Devonian age. On visiting the locality again, after an interval of six years, I was disappointed at not finding any new forms exposed by the ceaseless scour of the waves and sand on the rocks.

West of Newtrain Bay.[1]—The shales here contained some fragmentary crinoidal arms, which were determined by Mr. F. A. Bather to be of a nearly similar character to those of *Scaphiocrinus*, Hall, as figured by the Rev. G. F. Whidborne from the Pilton Beds near Barnstaple (see "Dev. Fauna S. of England": Pal. Soc., 1898, vol. iii, pt. 3, pp. 228–232, pls. xxxi, xxxiii–xxxviii).

Mother Ivey's Bay.—A shelf of blue shale is exposed at the east end of the beach at this place, near high-water mark, which contains fragmental crinoidal stems, pyritized examples of *Tentaculites*, and *Centronella* similar to those occurring at Trevone, and, in addition, a specimen of *Hyolithes*.

Porthcothan Cove.—This picturesque cove is about three miles south of Trevose Head. The rocks are of a bluish, non-calcareous shale, showing a general dip E.N.E. at 15–20°. Fossils do not appear to have been previously noticed in them, but they contain a fair number, though for the most part in poor preservation. The following have been recognized:—*Petraia*, in casts showing the outlines of the cup and septa, are not uncommon. Two species appear to be represented; one may be *P. celtica*. *Pleurodictyum*, sp., described below, fragments of *Conularia* similar to those from Constantine Bay (Trans. Roy. Geol. Soc. Cornwall, 1894, p. 643), imperfect pygidia of Trilobites,[2] and obscurely shown examples of *Orthoceras* and *Goniatites*.

Porth Mear.—This cove is about half a mile south-west of Porthcothan, and the rocks enclosing it are of the same character. On the foreshore several distinct fossiliferous bands are exposed; one of these can be traced for a distance of 40 yards nearly due east from the north end of the island; numerous specimens of *Pleurodictyum* are weathered out of its surface.

Lower Butter Cove.—The same kinds of rocks and fossils noted from Porthcothan and Porth Mear are likewise found in this cove, which is about half a mile south-west of the last-named place. The fossiliferous beds are visible at low-water, at the base of the eastern

[1] At the Bay itself I have since found two species of Favosite corals.

[2] A Trilobite minus the head, which I have recently obtained here, has been determined by Dr. H. Woodward to be a species of *Phacops*.

cliff of the southern inlet. Huge blocks of rock fallen from the cliffs above likewise contain numerous fossils.

Bedruthan Steps.—The fossiliferous character of the claret and bluish shaly or slaty beds of this locality has long been known. Mr. S. R. Pattison states that they contain crinoidal remains, a bivalve shell, and impressions of a Trilobite (Trans. Roy. Geol. Soc. Cornwall, vol. vii, 1848, p. 48); and in the same volume (p. 391) the late Mr. W. Pengelly notes the occurrence in them of the plates of *Steganodictyum*, McCoy (*Pteraspis*), then supposed to be a fossil sponge. The fossils are present, in great abundance, in the lower part of the cliff and on the foreshore, and in the large fallen rock masses. Some years since I obtained here fragments of fish-plates, principally of *Pteraspis*; *Orthoceras*?; the basal plate of a crinoid resembling *Sphærocrinus*, and fragments of crinoid stems which may have belonged to *Rhodocrinus* or *Melocrinus*; simple cup-corals, apparently zaphrentoid in character; *Pleurodictyum* and *Aulopora*? Last autumn I further obtained *Petraia*; a fragment of a Monticuliporoid; crinoidal fragments, one of which has been determined by Mr. Bather as the anal tube of a dicyclic adunate crinoid; and specimens of the peculiar form described below as *Pteroconus mirus*.

Watergate or Tregurrian Bay or Beach.—This range of beach and cliff extends about 2¼ miles north of St. Columb Porth, and it is noted for the variegated colouring of its slates. Similar rocks occur between Fowey and Polperro, and according to Mr. W. A. E. Ussher they are also present in South Devon, where they are known as the Dartmouth - Kingswear Slate group. Professor Sedgwick states (Quart. Journ. Geol. Soc., 1852, vol. viii, p. 4) with respect to these rocks, that he found a highly fossiliferous group extending from New Quay to Mawgan Porth and Padstow, and thence to Tintagel; not merely ranging near the coast, but running far up the interior of the country until, in some instances, it approached a central boss of granite.

On close examination I found indications of fossils throughout the whole series of the variegated slates or shales of the Bay, though they are, as a rule, so poorly preserved that only occasionally can the nature of the organism be recognized. Fragments of *Pteraspis* plates are not infrequent in satiny grey soft shales exposed on both the north and south banks of the small stream running into the sea north of the noted Watergate Elvan; and also in a bed of soft blue shale the *Pteraspis* plates, though fragmentary, are in great abundance.

The fossils mentioned above, which I have obtained from these north coast rocks from time to time, have been submitted to various authorities at the British Museum (Natural History), to whom I am greatly indebted for their efforts to decipher the characters of the forms usually very imperfectly preserved. Dr. A. Smith Woodward, F.L.S., has determined the fish remains, Mr. F. A. Bather, M.A., the Crinoids, and Mr. G. C. Crick, F.G.S., the Cephalopods, etc. Further, Dr. G. J. Hinde, F.R.S., has examined the Corals and doubtful forms. On the accompanying plate some of the fossils, which appeared to be of sufficient interest to justify figuring, have been skilfully represented by Miss G. M. Woodward, and the following notes are appended in explanation of them, beginning with the fish remains.

Pteraspis Cornubica, McCoy, sp. (Pl. VII, Figs. 7, 8.)

This species is represented by irregularly shaped, flattened fragments of the dermal plates, which are scattered, sometimes singly, sometimes in close juxtaposition, and even occasionally overlapping each other, on the exposed surfaces of the bluish-grey shales at Watergate Bay. The plates are black, sometimes glossy in appearance, and their exterior surfaces are ornamented with fine ribs or striæ running parallel to the length of the plate. The striæ are in places interrupted so as to look like a series of minute tubercles, only visible under a lens, and in some instances they are crossed transversely by lines of growth. The plates vary from 0·5 to 1 mm. in thickness, and there are about four of the surface striæ in a millimetre. These fragmentary plates have been identified by Dr. Smith Woodward as similar to those of *Pteraspis Cornubica* which occur in the Devonian rocks of Lantivet Bay, South Cornwall, and of which he has lately given an interesting account (Trans. Roy. Geol. Soc. Cornwall, vol. xii, 1899, p. 229).

These fragments are found at Bedruthan Steps as well as at Watergate Bay. According to Dr. S. Woodward the genus *Pteraspis* is characteristic of the Lower Devonian or Lower Old Red Sandstone in Western Europe, and does not descend below this horizon (Catalogue of Fossil Fishes in the British Museum, vol. ii, 1891, pp. 160–169).

Phlyctænaspis, sp. (Pl. VII, Figs. 5, 6.)

The only specimen referable to this genus is a thin plate, part of which is shown on the surface of a light-grey shale and part still enclosed in the rock. The plate is not entire; in one direction it is shown for a distance of 55 mm., and it is about 0·5 mm. in thickness. The upper surface, nearly of the same grey tint as the matrix, is furnished with numerous small depressed tubercles, rounded or oval in outline, and about 0·5 mm. in diameter. They are arranged alternately in rows, between three and four in the distance of 2 mm. The summit of these tubercles is often wanting, and the rounded dome is replaced by a minute crater.

Dr. Smith Woodward states that owing to the incompleteness of the plate it is not possible definitely to identify it with *Phlyctænaspis*, but the tubercular surface is approximately similar to that of the plates of *P. acadica*, Whit., sp. (see Geol. Mag., Dec. III, Vol. IX, 1892, p. 5, Pl. I, Figs. 7, 8), from the Lower Devonian at Campbellton, New Brunswick. The Canadian fossil, of which a specimen is in the British Museum (Nat. Hist.), has stouter tubercles with striæ radiating from their bases, and they are more deeply hollowed out than in the present form.

The specimen is from Watergate Bay. The genus *Phlyctænaspis* is characteristic of the Lower Old Red or Lower Devonian.

Climatius, sp. (Pl. VII, Figs. 9, 10.)

The only example is a fragment of a compressed spine, 9 mm. in width and 2 mm. in thickness; the exposed surface is jet-black; it shows stout, straight, longitudinal ribs, of which there are eight in the width of the spine. The upper edge of the ribs is, in places, tuberculate, and on one side of each there are, at intervals, blunted processes which reach across the interspace between the ribs so as to form elongate hollows, now filled with matrix. According to Dr. Smith Woodward the structure of this spine resembles that of the spines of the genus *Climatius*, Ag., which has a dermal spine in front of each fin except the caudal.

The specimen figured is from Watergate Bay. The genus occurs in the Lower Old Red of Forfar, Hereford, and Worcester, and in the Lower Devonian of New Brunswick.

The occurrence of the remains of *Pteraspis*, *Phlyctænaspis*, and *Climatius* in the same series of shaly strata at Watergate Bay and Bedruthan Steps derives significance from the fact, brought to my notice by Dr. Smith Woodward, that in other regions of Western Europe and Eastern North America where these three genera are present, they characterize the geological horizon of the Lower Old Red Sandstone or the Lower Devonian. It may therefore be reasonably assumed that the rocks on the North Cornish coast in which they are found likewise belong to the same geological period.

The following descriptions of *Pteroconus mirus*, n.sp., and *Pleurodictyum*, sp., have been contributed by Dr. G. J. Hinde, F.R.S.:—

Family HYOLITHIDÆ, Nicholson.

Genus PTEROCONUS, Green (= NEREITOPSIS, Green).

Pteroconus mirus, sp. nov. (Pl. VII, Figs. 1–4.)

Shell conical, compressed, straight; in transverse section round or elliptical, on both sides with small shelly flap or fin-like extensions disposed at regular intervals from the basal point to the summit aperture. A longitudinal rod or thickening of the shell enclosed within the cone. The outer surface with an ornamentation of transverse lines of growth following the contour of the summit, and at intervals with stronger raised lines connected with the lateral processes. No operculum has been observed.

This description is based on the characters shown by a number of specimens collected by Mr. Howard Fox at Bedruthan. The fossils are exposed on the surface of a bluish or claret-tinted shaly rock as they have been naturally weathered out; in some the shelly exterior of the test with its ornamentation is visible, whilst in others the interior of the cone has been laid bare. The forms are to some extent compressed in the shaly rock, and only the surface weathered in relief can be studied. The test is now of a brownish or reddish-brown tint, owing to the replacement of the original shell by some compound of iron; the interior is now generally filled with the shaly matrix. Only exceptionally are perfect specimens met with;

as a rule the summit apertures are defective, but on the whole these fossils are better preserved than other organic remains in the same rock.

The specimens are variously elongate, gradually tapering cones, ranging from 30 mm. to 72 mm. in length and with a summit breadth of 7–9 mm. The most complete example (Pl. VII, Fig. 1) is a cone, 35 mm. in length, showing the outer surface of the test, but the ornamentation is only distinguishable in its upper portion. The upper margin, apparently perfect, has a gently convex outline, and including the lateral processes is about 9 mm. in breadth. The surface of the central cone exhibits delicate arched growth-lines following the contour of the aperture, and at intervals of about 2·5 mm. it is crossed by stronger raised lines, which on either side of the cone are prolonged downwards to form the anterior margins of small flattened or slightly concave processes or flaps, which extend obliquely for a distance of 1·5–2 mm. from the cone. There are in this specimen sixteen of the ear-shaped processes; they are disposed so that the posterior margin of each dips slightly under the front edge of the one next below it in the series. The three or four processes on either side of the lower part of the cone appear to have coalesced together so as to form a narrow continuous plate, which extends round and slightly beyond the point of the cone. In another specimen, 72 mm. in length, there are about thirty-four pairs of processes, which are somewhat triangular in outline. A transverse section of a specimen similar to Fig. 1 is distinctly elliptical in outline.

In the form represented in Pl. VII, Figs. 2 and 3, the cone has been weathered so as to expose the interior longitudinal rod or thickening of a portion of the interior of the test. The specimen is imperfect, and a joint in the shale has divided it into two parts. Above the fracture, the exterior of the test is shown crossed by striæ with a slightly concave curve, whilst below the line of fracture the interior of the cone is laid bare by weathering, and a central rod-like body, unequally thickened at intervals and bordered by depressions on either side, projects slightly above the bordering wall of the test (Pl. VII, Fig. 3). The lateral flaps or processes are very distinctly striated, and in contrast with those of the specimen mentioned above (Fig. 1) the processes and the striæ have a slightly upward direction. This difference may perhaps be explained by supposing that the side of the shell exposed in this example is the reverse of that shown in Fig. 1. Owing to the fact that only one side of a specimen can be examined, it is not practicable to determine if the characters of the dorsal or ventral side in this form are similar or not.

Another aspect of the interior rod is seen in the middle half of a specimen (Pl. VII, Fig. 4) in which the striated shelly exterior has been weathered away. It here appears as a straight, slender, nearly smooth, cylindrical rod, just within the wall of the cone. In the short length of it exposed there is no connection with the lateral processes apparent. The nature and function of this interior rod are problematical. At first it suggested the idea that it might indicate a siphuncle, but there is no evidence that it was a hollow tube. Mr. G. C. Crick, who has most carefully examined these fossils, is unable to recognize in them any genuine Cephalopodan characters.

The real nature of these forms has been a subject of much speculation alike to the writer and to other palæontologists who have examined them. They present several points of resemblance to the Hyolithidæ in their general form, size, the character and ornamentation of the shell, and even the peculiar flaps or lateral processes may be looked upon as analogous to the winged expansions in *Pterotheca*, Salter, and *Pterygotheca*, Novak. I am unable to say at present whether any structure occurs in known Hyolithidæ which can be compared with the interior rod-like body in *Pteroconus*. On the whole there seems sufficient justification for regarding this genus as belonging to the Hyolithidæ. The systematic position of this family is still a matter of debate, and its relations to the Pteropoda have not been certainly proved.

Whilst working at the specimens sent to me by Mr. Howard Fox, my attention was called to the figures of some casts of fossils from Polruan, etc., by Mr. Upfield Green, in the Trans. Roy. Geol. Soc. Cornwall, vol. xii (1899), pt. 4, pl. F, p. 227. Through the kindness of Mr. Green and Mr. J. H. Collins, I had an opportunity of seeing the originals of the figures which are preserved in the Museum of that Society at Penzance, and at once recognized them as casts of organisms similar to those discovered by Mr. Fox. Mr. Green did not describe the forms, but limited himself to giving the figures and naming "the fossil *Nereitopsis cornubicus*, from its somewhat distant resemblance to some of the species of the genus *Nereis* (Cuvier) of the dorsibranchiate order of Annelids." I pointed out to Mr. Green that the fossils themselves, as distinct from the casts, precluded the idea that they could in any way resemble any species of *Nereis*, and that consequently the name he proposed was misleading and should be changed. Mr. Green accepted my suggestion and desired to substitute *Pteroconus* for *Nereitopsis*, and I have adopted his fresh name as that of the genus. Mr. Green states that the larger of his specimens (fig. 1, pl. F) "differs from the others, being terminated posteriorly by a tuberculated extension," and this may properly be considered as the type of *Pteroconus* (*Nereitopsis*) *Cornubicus*. Whether the other forms represented in his figures are new species or will prove to be the same as those described and figured in this paper must remain at present undecided.

The specimens of *Pteroconus mirus* were collected by Mr. Howard Fox in the claret-tinted and bluish shales, probably of Lower Devonian age, exposed in the cliffs and foreshore at Bedruthan Steps, North Cornwall. Mr. Fox has announced his intention to present the specimens figured to the British Museum (Natural History), Cromwell Road, South Kensington.

Pleurodictyum, sp. (Pl. VII, Fig. 11.)

Corallum discoidal, thickness inconsiderable, the upper surface depressed convex, diameter from 25 to 34 mm. There are about ten large corallites in what appears to be a full-sized corallum, with smaller corallites in the angles between the larger. The corallites range from 5 to 9 mm. wide, their average diameter is 7 mm. They are polygonal or rounded in outline, shallow, the walls are relatively thick and apparently vesicular, showing small irregular interspaces on their weathered margins. There are indications of pores passing through the walls near the base of the corallites and communicating with the exterior, but it is uncertain if the corallites were directly connected with each other by mural pores. A few blunt spines are present in the lower portion of the corallites, but there are no indications either of tabulæ or septal striæ.

Examples of this form are by no means rare, but they are all very poorly preserved, and but little more than their upper surfaces, slightly projecting from the bluish shaly rock, can be distinguished. Their walls have been replaced by a mineral which gives a very slight reaction with acid. So far as comparison is possible, the form to which they are nearest allied is *P. granulifera*, Schlüter (Anthoz. d. rhein. Mittel-Devon. Abhandl. der geol. Landesanst., vol. viii, 1889, p. 361, pl. iv, figs. 5–8), from the Middle Devonian of the Eifel. According to Mr. C. W. Peach, *P. problematicum*, Goldf., also occurs in abundance at Polruan and other localities in Cornwall (Trans. Roy. Geol. Soc. Cornw., vol. ix, p. 52), but I am unaware if this determination has been confirmed.

It seems desirable not to give a specific name to the present form until better preserved specimens have been obtained. It is found at Porthcothan, Porth Mear, and Lower Butter Cove.

EXPLANATION OF PLATE VII.

Fig. 1.—*Pteroconus mirus*, Hinde, sp.n. Showing the exterior surface of a fairly perfect specimen, weathered out on the surface of a shaly rock. Natural size. Lower ? Devonian: Bedruthan Steps, North Cornwall.

Fig. 2.—The same. An imperfect specimen from the same locality, the exterior surface shown in the portion above the line of jointing, and below this the interior of the cone with the lateral processes are exposed. Natural size.

Fig. 3.—The same. A part of Fig. 2, enlarged three diameters, showing the longitudinal rod within the cone and the striation of the lateral processes.

Fig. 4.—The same. An imperfect specimen showing in the middle portion the inner rod, exposed by the weathering away of the shell. Natural size. From Bedruthan.

Fig. 5.—*Phlyctænaspis*, sp. A fragment of a plate weathered out on a surface of shale. Natural size. From the Lower Devonian of Watergate Bay, North Cornwall.

Fig. 6.—The same. A portion of Fig. 5, enlarged ten diameters to show the tubercles, one of which is hollowed out.

Fig. 7.—*Pteraspis Cornubica*, McCoy, sp. An imperfect shield-plate, showing the striæ and lines of growth. Natural size. From the Lower Devonian at Watergate Bay.

Fig. 8.—The same. A portion of Fig. 7, enlarged five diameters.

Fig. 9.—*Climatius*, sp. A fragment of a spine, showing the strongly marked ribs with their lateral processes. Natural size. From Watergate Bay.

Fig. 10.—The same. Part of Fig. 9, enlarged five diameters.

Fig. 11.—*Pleurodictyum*, sp. The upper surface of a specimen, partly weathered out of bluish shale. Natural size. From the Lower Devonian at Porthcothan, North Cornwall.

II.—Notes on *Drepanaspis Gmündenensis*, Schlüter.

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

THIS most remarkable fish, from the Lower Devonian Roofing Slate (Hunsrückschiefer) of Gmünden, in Western Germany, was named, but very imperfectly described, by Schlüter in 1887, as his material was at that time of a very fragmentary nature. He apparently considered the creature to be allied to *Cephalaspis*. In Dr. Smith Woodward's "Catalogue" (pt. ii, 1891, p. 311) it is only mentioned by name along with a number of other imperfectly known forms (*Aspidichthys*, *Anomalichthys*, etc.) which he considered as "perhaps for the most part" referable to the Coccosteidæ.

In 1890 I began to obtain specimens, at first very fragmentary, through the agency of Mr. Stürtz in Bonn, and in exhibiting these before the Royal Society of Edinburgh, I expressed the opinion that the affinities of *Drepanaspis* lay rather with the Pteraspidæ (*Nature*, vol. liv, p. 263). Finally, having got together a considerable amount of more perfect material, I incidentally described the fish in my recently published memoir on the Silurian Fishes of Scotland, giving a restored figure of its dorsal aspect, which Dr. Smith Woodward has reproduced in his critical notice of that memoir which appeared in the Geological Magazine for February last. The conclusion I came to was that *Drepanaspis* formed the type of a distinct family, related not only to the Pteraspidæ but also to the Psammosteidæ and Cœlolepidæ, and which must consequently along with these three families be included in the Heterostraci, of which the Cœlolepidæ appear to form the starting-point.

But beyond the fact that *Drepanaspis* possessed a large median ventral plate as well as a dorsal one, and that the two could readily be distinguished by their shape, my knowledge of the topography of the inferior surface of the carapace was still imperfect. Nor had I ascertained the position of the mouth, though I said that "as it is impossible to conceive of the absence of a mouth, we must conclude that it was placed exactly at the anterior margin."

However, since that memoir was published, I have received from Dr. Krantz, of Bonn, a specimen of the carapace of *Drepanaspis* (Fig. 2), which not only clears up previously unsettled questions regarding the arrangement of the plates on the ventral surface, but also shows the mouth itself *in situ*.

But before describing the ventral surface, I may as well recapitulate the facts already known regarding the configuration of the fish.

The carapace (Fig. 1) is broad, depressed, very obtusely rounded in front, and terminating behind in a prominent though rounded angle on each side. There is on the dorsal surface a large median plate (*m.d.*) of an ovate-hexagonal shape, the anterior margin being short and nearly straight, while the still shorter posterior one is acutely notched. Each postero-lateral angle of the carapace is formed by a narrow, elongated, somewhat falciform plate (*p.l.*), the postero-lateral or cornual, which tapers to a sharp point in front and forms most of the external margin of the shield. The rest of the surface is formed by small polygonal plates, reminding us of the tesselated surface of many Psammostean shields, while we sometimes find a few larger *rostral* ones (*r.*) just at the anterior margin; and external to these just at the edge of the carapace we find a plate showing a small round depression or pit (*x.*) which in my Silurian memoir I have supposed might possibly represent an orbit. But to this I shall again refer further on.

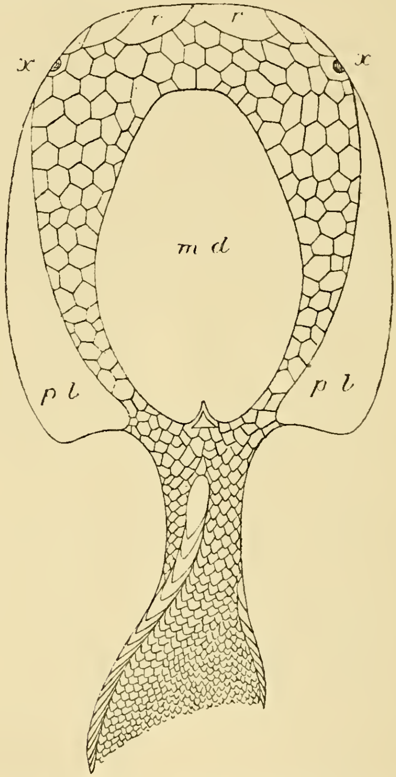


FIG. 1.—*Drepanaspis Gmündenensis*, Schlüter; restored outline of the dorsal aspect, the surface ornament omitted, and the tail twisted round so as to show the caudal fin in profile. *m.d.* median dorsal plate; *p.l.* postero-lateral plates; *r.* rostral plates; *x.* sensory plate. Slightly altered from the figure previously given.

The surface ornament of all these plates consists of small and tolerably closely set stellate tubercles, and it is to be noted that on the small polygonal ones we often find a tubercle of larger size at or near the centre, as is commonly the case on the polygonal areas of *Psammosteus Taylori*.

The tail, springing from the middle of the posterior margin of the carapace, is comparatively short, and terminates in a heterocercal though scarcely bilobed caudal fin, but there is no trace of any other fins or appendages, paired or unpaired. These parts are covered on the sides by rhombic tuberculated scales, and bordered above and below respectively by a single row of narrow imbricating median scales or 'fulcra.' Nothing resembling *fin-rays* can be seen, nor is there any definite line of demarcation between the scales of the body prolongation and those of the fin-membrane, though the latter become gradually smaller.

Turning now to the ventral surface of the animal, I have in Fig. 2 given an accurately reduced sketch of the plates as seen in the new specimen to which I have alluded, while Fig. 3 represents a restoration in which the oblique distortion due to slaty cleavage

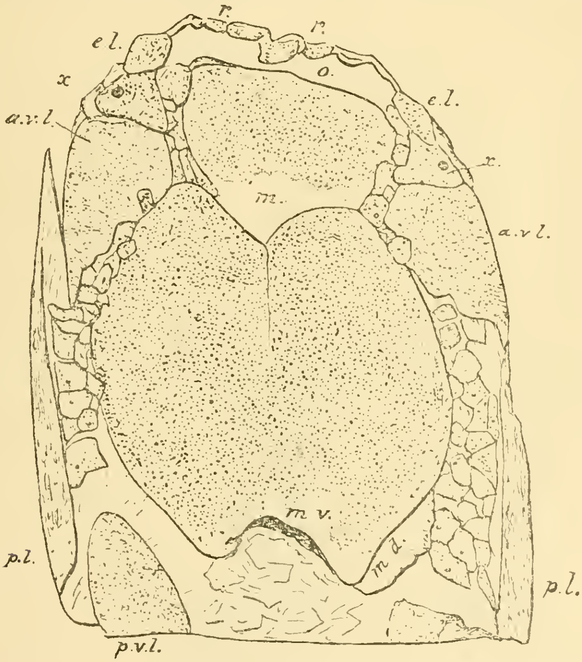


Fig. 2.—Sketch of a specimen of the carapace of *Drepanaspis Gmündenensis*, Schlüter; one-third natural size; distorted by slaty cleavage, and somewhat imperfect behind. *o.* mouth; *r.* rostral or upper labial plates; *e.l.* external labial plate; *m.* mental plate; *x.* sensory plate; *a.v.l.* anterior ventro-lateral; *m.v.* median ventral; *m.d.* portion of inner surface of median dorsal; *p.v.l.* posterior ventro-lateral; *p.l.* postero-lateral or cornual plate.

has been corrected. We may now see that the mouth (*o.*) is placed exactly where I had expected to find it, namely, at the anterior margin of the carapace. It is a transverse slit, the upper margin of which is formed by the anterior edges of the *rostral* plates (*r.*) already mentioned, while at each outer corner there is a small *external* labial plate (*e.l.*), the tubercles on which are rather larger than those elsewhere. The lower boundary of the oral slit is formed by the lower margin of a broad pentagonal plate (*m.*), which we may call *mental.* The anterior or oral margin of this plate, which is also the longest, is, however, not quite straight, as it shows a very obtuse angle in the middle; the two lateral margins are shorter and slightly convergent posteriorly; the postero-lateral margins follow, each at an obtuse angle to its respective lateral one, and they meet each other behind also at an obtuse angle, which fits into the wide anterior notch or excavation of the plate next to be described.

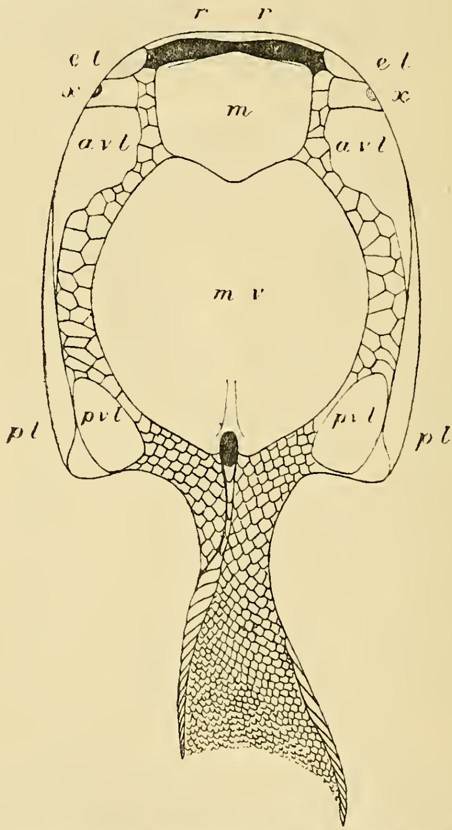


Fig. 3.—Restored outline of the ventral aspect of *Drepanaspis Gmündenensis,* Schlüter; surface ornament omitted, and the tail twisted round so as to appear in profile. Lettering as in Fig. 2, but the mouth in front and the supposed cloacal opening behind are represented in black.

This, the great *median ventral* plate (*m.v.*), is of a broadly oval form, having a widely open notch or indentation in front which, as aforesaid, receives the posterior angle of the mental plate. In the specimen of which Fig. 2 is a sketch, the hinder extremity of this plate is broken off, but in Fig. 3 I have restored its contour from other specimens, whence it will be seen that it presents a narrow median notch, the direction of which is continued for a little way in front by a longitudinal fold-like elevation of the surface.

Returning now to the front, we find on each margin of the carapace, immediately behind the small external labial plate of the mouth, another and rather larger element of a trapezoidal shape (*x.*), transversely placed, with a short external margin, a longer internal one, while the posterior is the longest and is directed nearly at a right angle to the middle line of the creature. In the outer extremity of this plate is a small rounded depression, which in the specimen sketched in Fig. 2 and in some others is seen on the ventral aspect of the fossil; but as it also appears in some on the dorsal aspect it appears to me to have been marginal, and that the outer extremity of the plate on which it occurs must have been reflected upwards when in an uncrushed condition. In my "Silurian" Memoir above quoted, I have designated this depression as an orbit with a query, and it certainly occupies a position singularly analogous to that of the supposed orbit in *Pteraspis*, which is also very small in proportion to the size of the animal. But in some examples before me it seems to have a floor furnished with tubercles similar to those of the rest of the surface, so that its orbital nature can hardly be maintained. However, from its constant occurrence on the same plate and in the same position it must have a meaning, and doubtless it marks the place of an organ of sense of some sort, which can hardly be a nostril, and as the plate itself must have a name we may call it the *sensory* plate.

Immediately behind this 'sensory' plate is another and larger one (*a.v.l.*) of an approximately triangular form, a long irregularly scolloped side internally, a gently convex outer one, and an acutely pointed posterior angle. The outer margin of this plate, which we may call *anterior* ventro-lateral, fits on below the anterior pointed extremity of the great postero-lateral plate (*p.l.*), so extensively seen on the dorsal surface (Fig. 1), but which appears on the ventral aspect simply as a rather narrow thickened margin, marked with wavy ridges instead of tubercles, and is obliquely bevelled off just at the postero-lateral angle (Figs. 2 and 3). These lateral elements on the ventral surface are on each side separated from the mental and median ventral plates by a series of small polygonal ones, as represented in Figs. 2 and 3, but just behind there is an ovate-oblong one of a considerable size (*p.v.l.*), which may be called *posterior ventro-lateral.* The space between this and the postero-external angle of the plate *p.l.* (left empty in the figures) seems in one specimen to be covered by another smaller one; any way, I think that in this region the branchial aperture must have been placed, though its position is as yet not exactly determined.

In a specimen in the collection of the Geologische Landesanstalt in Berlin, the posterior notch of the median ventral plate seems to form, along with an elevated median scale just behind it, a narrow opening, which I take to be the orifice of the cloaca (see Fig. 3). This is succeeded in the backward direction by four similar scales which pass into the median fulcra of the ventral margin of the tail and caudal fin; these fulcra being at first very stout and prominent, but becoming further back proportionally more slender and oblique.

The above is a sketch of the configuration of *Drepanaspis* and of the parts forming its exoskeleton, so far as I have been able to elucidate the subject after ten years' careful hoarding up of material.

Observations.—It will, I think, be acknowledged that *Drepanaspis* is a creature, the details of whose structure as described above form an important addition to our knowledge of the extinct Ostracodermi of the Silurian and Devonian periods. Its resemblance to the still imperfectly known Psammosteidæ cannot be gainsaid, nor can its affinity to the Cœlolepidæ on the one hand and to the Pteraspidæ on the other be doubted, and consequently I have in my memoir on the Scotch Silurian fishes included all four families in a new and enlarged conception of the Heterostracous division of the Ostracodermi.

Looking at *Drepanaspis* by itself we have a creature whose hard parts are entirely dermal, and in which no traces whatever of any endoskeleton can be found.

The mouth is a transverse slit, which shows no teeth, nor any jaws properly so called, and therefore affords an apparent support to the agnathous theory of the Ostracodermi. But, I repeat, we know nothing of the original cartilaginous endoskeleton, and consequently to believe that the fish while living had no cartilaginous representative of the Meckelian element is surely an assumption, while to argue therefrom any special affinity to the Lampreys, so utterly different in form, seems to me to be a *non sequitur*. Here it may be observed that the condition of the nasal organ does not afford us any help in this question, as no external nostril, either single or double, has been observed in *Drepanaspis* or in any other Ostracoderm. The only Palæozoic fish which is apparently monorhinal like the Lampreys is *Palæospondylus*.

There is certainly no shoulder girdle in *Drepanaspis*, nor are there paired fins, at least from the functional standpoint. But the prominent postero-lateral angles of the carapace are obviously equivalent to the lateral expansions in the Cœlolepidæ, which I have interpreted as pectoral fin-folds. If this idea is right, we have the parts representing the pectoral fins in *Drepanaspis* replaced by unyielding plates.

Dr. Smith Woodward, in his review of my Silurian memoir, disagrees with this view on two grounds.

First, because there is no line of demarcation between the fin-like expansions of *Thelodus* and the rest of its body, no change in the character of the dermal armature at that part, and no signs of flexibility.

But the very same things may be said of the *caudal fin* of *Thelodus* and of *Drepanaspis*, and surely no one would deny that *it*, at least, is a fin. In *Drepanaspis*, as we have seen, the expanse of the caudal fin is covered with scales precisely similar in shape and in sculpture to those of the body prolongation, between which and the fin membrane no abrupt line can be seen, though the scales tend to diminish in size distally. And in a specimen of the recent Angel-fish (*Rhina squatina*) now before me, I see no sudden change in the character of the shagreen granules as they pass from the surface of the body on to that of the broad pectoral fin. As regards evidence of flexibility, the Silurian specimens of Cœlolepidæ are all crushed absolutely flat, but in the case of the large *Thelodus Pagei* from the Forfarshire Old Red, which has not been subjected to such an extreme degree of compression, it does seem to me that there is decided evidence of flexibility, as well as thinness, at the posterior external angles of the parts which I have supposed to represent fins.

Secondly, Dr. Smith Woodward objects to the idea of "a motile organ, originally used for balancing, if not for progression, losing its function, not by atrophy, but by conversion into a rigid structure continuous with its base of support," a phenomenon for which he has "tried in vain to find a parallel in the animal kingdom."

It is perhaps a bold idea, and I may be wrong, but let us look for one moment at the case of the Asterolepids (Antiarcha of Cope). Dr. Smith Woodward thinks it improbable that the pectoral members of *Pterichthys* are homologous with those of the 'Class Pisces,' but there they are, organs which must have been used for progression, enclosed in rigid plates, though provided with two joints, one at the junction with the body and another about the middle of the appendage itself. Dr. Smith Woodward maintains, however, that the *fixed* pectoral spines of *Acanthaspis*, which he considers to be an Asterolepid or Antiarchan, are homologous with the moveable 'arms' of *Asterolepis* or *Pterichthys*. If he is right in this, would there not be something of a parallel here, unless we believe that the fixed spine has been the original condition from which the complex moveable limb of *Pterichthys* has been evolved, which is not very probable? This, of course, is not an argument upon which I can insist, seeing that I personally consider *Acanthaspis* to be, not an Asterolepid, but a Coccostean, closely related to *Phlyctænaspis*, Traq., the very similar pectoral spine of which Dr. Smith Woodward was himself the first to observe.[1]

It is, however, not the object of the present communication to enter into an exhaustive discussion of the disputable questions raised in my 'Silurian' Memoir and in Dr. Smith Woodward's comments thereon,—*that* I must defer to another time and another place. My purpose has been to complete the description of the remarkable Heterostracan genus *Drepanaspis*, according to light thrown on the subject by material acquired since the publication of the memoir to which I have so often referred.

[1] In *Coccosteus* itself the pectoral spine is so small that in my description of the skeleton of *C. decipiens* (Ann. Mag. Nat. Hist., Feb., 1890) I described and figured it merely as a process of the interlateral plate, from which it is, however, quite distinct. There certainly is a 'Bruststachel' in *Coccosteus*, but as it is not only very small, but absolutely fixed, it can hardly be called a 'Ruderorgan.'

III.—On the Age of the Later Dykes of Anglesey.

By Edward Greenly, F.G.S.

The existence in Anglesey of a series of dykes later than most of the rocks of the island has long been known. Some of the more conspicuous ones were described by Henslow, many more appear on the map of the Geological Survey, and petrological descriptions were given some years ago (Geol. Mag., 1887–88) by Mr. Harker.

They have been hitherto regarded as of Post-Carboniferous but Pre-Permian age, on the ground that, while traversing the Coal-measures of the Malldraeth Marsh, one of them has been observed to terminate at the base of the overlying red strata. Sir A. C. Ramsay distinctly states that this evidence is derived entirely from the old coal-workings, and that at the time he wrote the red beds, regarded by him as Permian, were nowhere visible at the surface. ("Geol. N. Wales," 2nd ed., p. 266.)

Now, however, some of the red beds in question are exposed in the bottoms of the railway cuttings on either side of Holland Arms Station. The sections are shallow, the cuttings being grassed over to within a few feet of the bottom, but are tolerably clear where visible. The rocks seen are variable red sandstones and marls, often green-mottled with occasional thin beds of harder yellow and white sandstone and grey shale. While some of the types are such as elsewhere occur in the true Coal-measures, others are of well-known 'New Red' aspect, and might, as far as lithological characters go, be even of Triassic age.[1] They closely resemble the rocks seen on the old pit spoil-banks, among which I have found red sandstones with secondary outgrowths of quartz showing crystal facets, like the well-known rocks of Penrith and other localities. There are beds, moreover, containing fragments of chert in a dolomitic matrix, and some with rolled fragments of limestone; and due weight must still be attached to the statement that certain faults fail to traverse these red beds in the old coal-mines.

It appears, then, that while the question of the age of these rocks cannot be regarded as settled, there is no fresh evidence to upset, and some to support, the view of Sir A. C. Ramsay that they are of Post-Carboniferous age.

Now, in the cutting south-west of the station, these beds are seen to be traversed by two dolerite dykes, one on each side of the Holyhead Road, that on the north-east being about 50 feet and that on the south-west side about 110 feet in width. Their intrusive relations are clear, and one of the grey shales shows small spots and is perceptibly indurated near the dyke. They break up spheroidally, and although the bulk of the material of both dykes is quite decomposed, yet the spheroidal cores are not only hard but remarkably fresh and well preserved. The dyke on the

[1] Some of my former colleagues of the Geological Survey, who have lately had much experience of the Red Rocks of South Wales and the Midlands, kindly examined some specimens for me.

north-east side of the road is seen only in the cutting, but that on the south-west side (which I will call the Holland Arms dyke) has been traced to the E.S.E. for a distance of more than a quarter of a mile, retaining all its peculiar characters. In this short distance it passes from the red rocks of the cutting across a faulted belt of Carboniferous Limestone, then across a narrow belt of Ordovician shales, and from these into mica-schists belonging to the old complex. It traverses, indeed, nearly all the great rock groups of Anglesey, and passes, unaffected so far as can be seen, across two, if not three, main faults. Moreover, the two faults in question must be at least of Post-Carboniferous, and if Sir A. C. Ramsay's view be correct, of Post-Permian age.

It appears, therefore, that the dykes must be of much later date than has been hitherto supposed. The negative evidence of the old pit-workings, that they belong to a period between Carboniferous and Permian, loses its value in face of the positive evidence from the railway cutting,[1] and certainly no volcanic episode of that date is known elsewhere in Britain. It is conceivable, indeed, that they might belong to the Permian period itself, but this is very unlikely, even should the red rocks prove to be Carboniferous. No such regular system of N.W.–S.E. dykes is known in the Permian volcanic groups, and in any case we should hardly expect Permian dykes to pass across main faults of Post-Carboniferous date. Now the next period of volcanic activity within the British area is that of Tertiary time (Geikie, "Ancient Volcanoes of Great Britain," vol. ii, p. 107); and to that period, therefore, these dykes most probably belong.

In addition to the stratigraphical considerations above set forth, there are others that lend support to this view.

The petrological characters of the dykes are on the whole favourable to it rather than otherwise. While the majority are somewhat sub-basic dolerites, with andesitic selvages, there are a certain number of typical ophitic olivine-dolerites, of which the Holland Arms dyke is one. I have compared a slide of it and of one of the less basic dykes a short distance away, on the south side of the Holyhead Road, near the old Jerusalem Inn, with a number of slides of Tertiary dykes in the Jermyn Street collection, and there is no difficulty in matching them. The Holland Arms dyke itself resembles a dyke from Goat Island, Raasay, to mention a particular instance.

Mr. Harker, who has described these dykes (Geol. Mag., 1887, p. 409; 1888, p. 267; also "Bala Volc. Series Carnarv.," pp. 106–109, and "Petrology for Students," 2nd ed., p. 129), and who has had exceptional opportunities for studying the Tertiary dykes of Skye, writes me:—"Petrographical analogies would seem rather to support than to debar such a conclusion [viz., *as to their Tertiary age*]. The Menai Straits dykes are for the most part andesitic dolerites and augite-andesites, not rocks of very basic composition,

[1] It may be remarked in passing that the statements as to certain *faults* in the coalfield, if true, lose none of their importance as evidence.

and olivine is of exceptional occurrence. Dykes and other intrusions of the Carboniferous-Permian set elsewhere in Britain seem to be in general decidedly basic, and usually carry olivine. They might be matched among the Tertiary rocks of the Western Isles, which have a very considerable range of composition, basic and sub-basic; but the Tertiary dykes of the North of England are, as Teall has pointed out, mainly of andesitic nature."

On p. 215 of "British Petrography," Mr. Teall remarks on a rock from Holyhead Island as "a wonderfully fresh ophitic olivine dolerite. In its composition and state of preservation it differs so markedly from the 'greenstones' and approaches so closely to many of the Carboniferous and Tertiary dolerites that one is inclined to regard it as a rock of much later date."

The Holland Arms dyke presents two opposite extremes with regard to state of preservation. Much of the rock is decomposed to a sand,[1] and yet in the cores of the spheroids even such a mineral as

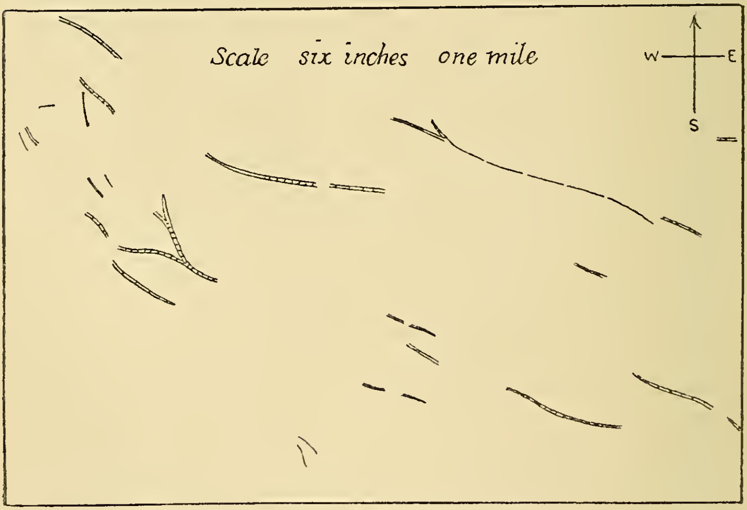


Fig. 1.—Group of dykes in Mynydd Llwydiarth.

olivine remains intact and unserpentinized to a degree almost unknown in Pre-Tertiary rocks. Mr. Barrow tells me that this condition is characteristic of the Cleveland dyke when traversing certain beds in East Yorkshire. The less basic dolerites are also in general very well preserved.

In their strike and general behaviour in the field these dykes closely resemble those of the West of Scotland; and certain parts of the maps can hardly fail to at least suggest to the mind that they belong to the same age and series of intrusions, the type of volcanic action being identical. (Fig. 1.) The average strike is about N.W.–S.E., a large number ranging W.N.W.–E.S.E., and a few in a more N.–S.

[1] Denudation along this soft friable material probably initiated the transverse ravine on the south side of the Holyhead Road at Holland Arms.

direction. The 'solitary' and 'gregarious' habits may both be said to be represented. The Plas Newydd dyke is a good example of the solitary, and the group shown in Fig. 1 of the gregarious type.

Most of them are short, or at any rate are traceable for short distances only, the longest yet mapped being the large dyke that runs from Menai Bridge village to Castellor, about a mile and three-quarters. The widest is the Holland Arms dyke itself, 110 feet, but the larger dykes of Menai Bridge, which average about 50 feet, are more typical of the larger dykes of the island. One of these last has been quarried for road-metal in several places, and the abandoned quarries remain as very striking trench-like chasms, one of which is visible from the Suspension Bridge among the houses on the north-east side. It may be observed, moreover, in this connection, that these dykes furnish the principal material for road-metal in the district.

The discontinuity of the dykes at the surface is not wholly due to concealment by drift, but can in certain cases be shown to be due to failure to reach the existing surface of the ground. Thus, the Menai Bridge dyke can be seen to be interrupted by a space of country rock near the Church, reappearing after a few yards. A small dyke (about 2 feet wide) at Cadnant Creek can be seen to terminate upwards in cross section (Fig. 2), while a large one on the coast

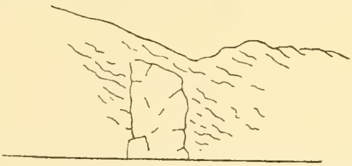


Fig. 2.—Upward termination of dyke at Cadnant.

near Careg Onen, sufficiently inclined to be of the nature of a sill (a somewhat rare mode of occurrence) is partly overlain by schist (Fig. 3), and disappears wholly underground before reaching low-

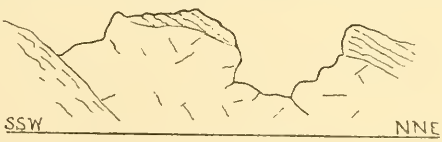


Fig. 3.—Sketch section through dyke near Careg Onen.

water mark. These characteristics were observed by Henslow, and are illustrated by him in some longitudinal sections. The Castellor dyke actually stops short at the brow of the hill overlooking the village of Menai Bridge, instead of, as might have been expected, being still better exposed in the lower ground. It is curious, though perhaps accidental, that the Cleveland dyke is known to behave in a similar manner (see Geikie, "Ancient Volcs. Gt. Brit.," vol. ii, pp. 147–150). Yet, in spite of phenomena like these, dykes cross the summit of Mynydd Llwydiarth at a height of 500 feet above the sea.

If the views advocated in this paper be adopted, considerable interest will attach to these rocks. The only igneous rock hitherto recognized as Tertiary in this country to the south of the Cleveland dyke is a solitary dyke which traverses the red rocks of Staffordshire.

But these Anglesey dykes are a large and important system, much more important than has been generally supposed. They do not give rise to conspicuous features of any kind, and easily escape notice, so that few of them have been hitherto recorded, except on certain parts of the coast. But within the space comprised in the one-inch sheets 94 and 106 (i.e. east of a line drawn from Pentraeth to near Plas Newydd) I have met with no less than 131. A large group also occurs about Holland Arms itself; and though they are less numerous in the centre of the island, a good many still appear, and of the same general type as those near the Straits; while Mr. Teall's remark above quoted shows that they also occur in the Holyhead area.[1] They are most numerous of all in the rocky tract known as Mynydd Llwydiarth (in Sheet 94), where 47 occur within a space of a square mile. But there is good reason to believe that they are as plentiful in the drift-covered areas as elsewhere, for the number of boulders they have furnished to the drift is out of all proportion to the known exposures, even allowing for their durability. Without supposing, however, that they are everywhere as numerous as on Mynydd Llwydiarth, it is not improbable that they average as many as ten to the square mile in Sheets 94 and 106, which estimate is as high as that given by Necker for the island of Arran (Geikie, op. cit., p. 124).

Volcanic activity thus appears to have been exerted in Tertiary times not only in North but in certain parts also of South Britain, and this serves to bring the British phenomena perceptibly nearer to those of the Continent. And if the phonolite of the Wolf Rock be, as would seem most probable, of Tertiary age, yet another link is added to carry us, in Tertiary time, across the tract of quiescence which still separates, though now even more widely than then, the volcanic regions of Northern from those of Central and Southern Europe.

IV.—On some Minor British Earthquakes of the Years 1893–1899.

By Charles Davison, Sc.D., F.G.S.

(*Concluded from the March Number, p.* 115.)

Cornwall Earthquake: Aug. 27, 1895.

THIS slight, though not uninteresting, earthquake was of intensity 4, and occurred at about 12.30 p.m. I have 20 records from 19 places, and negative records from 2 places.

The earthquake is chiefly remarkable for its small, but elongated, disturbed area (Fig. 2), which is 6 miles long, nearly 2 miles broad,

[1] Some basic dykes recently described from the north of the island do not appear to belong to the same series. (See C. A. Matley, Abstract Proc. Geol. Soc., Jan. 10, 1900, and discussion.)

and contains only 9 square miles. The direction of its longer axis is E. 5° N. and W. 5° S. The centre of the area is ½ mile north of Blisland.

The shock was felt at 13 places. The sound was heard at all of these, and at 6 other places, 4 of which lie outside the disturbed area. The sound-area overlaps the disturbed area both to the north and south, but whether towards the east and west as well is doubtful; for, owing to the scarcity of observations, it is impossible to trace the boundary of the sound-area.

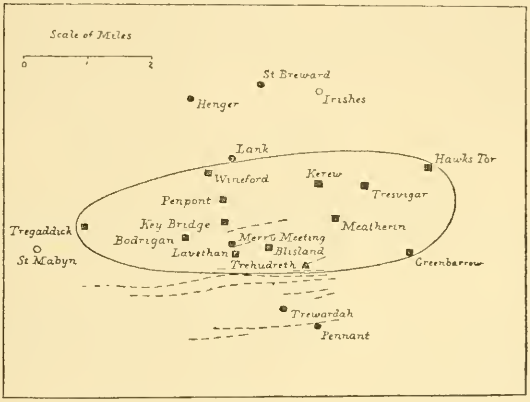


Fig. 2.—Cornwall Earthquake: Aug. 27, 1895.

In all parts of the disturbed area, the shock was merely a slight tremor, a shaking like that experienced on a bridge when a heavy weight is passing over it. At Greenbarrow, the earthquake was noticeable first as a low rumbling sound, growing louder until it resembled an explosion of gunpowder, causing a slight trembling of the floor and a little shaking of the furniture in the room.

The sound is described in 15 records, the comparisons being to passing trains, etc., in 33 per cent. of the number, to thunder (a long low peal of thunder) in 47 per cent., and to explosions in 20 per cent. The beginning of the sound generally coincided with that of the shock, and the end of the sound either coincided with, or followed immediately, the end of the shock. The epochs of maximum intensity of both sound and shock coincided, as is the rule in weak earthquakes. Several observers noticed a change in the character of the sound at the time when it was loudest. This is shown in the record from Greenbarrow quoted above. The evidence of an observer at Tregaddick is also worth giving. "The sound," he says, "was like that of an artillery waggon being trotted up to the house, and, when it apparently had arrived at the house, there was a noise as if two large stones were crunched against each other."

Origin of the Earthquake.—The only element of the originating fault that can be determined is its average direction, which is E. 5° N. and W. 5° S. The Geological Survey map shows no fault anywhere near the disturbed area. Not far distant, however, there are several series of elvan dykes which have almost this direction. The broken lines on the map represent one of these series, and if one of the dykes, especially either of those which nearly coincide with the southern boundary of the disturbed area, should happen to run along a fault hading towards the north, it would satisfy all the conditions required by the seismic evidence.

The seismic focus must have been about 4 miles in length, and the displacement throughout extremely small. That the part from which the more prominent vibrations came was a narrow band is evident from the small breadth of the disturbed area. The extension of the sound-area on both sides of the disturbed area shows, I think, that the sound-vibrations came from the lower, as well as from the upper, margin of the focus; in other words, that the displacement died out downwards as well as upwards and laterally.

Cornwall Earthquake: Jan. 26, 1896.

The earthquake was a very slight one, of intensity 3 or nearly 4. It was felt at 6.50 a.m. The number of records is 36 from 30 places, in addition to which there are negative records from 20 places.

The disturbed area is 12 miles long and $8\frac{3}{4}$ miles broad, and contains 86 square miles. The direction of the longer axis is east and west, and the centre of the area lies $1\frac{1}{2}$ miles S. 42° E. of Launceston.

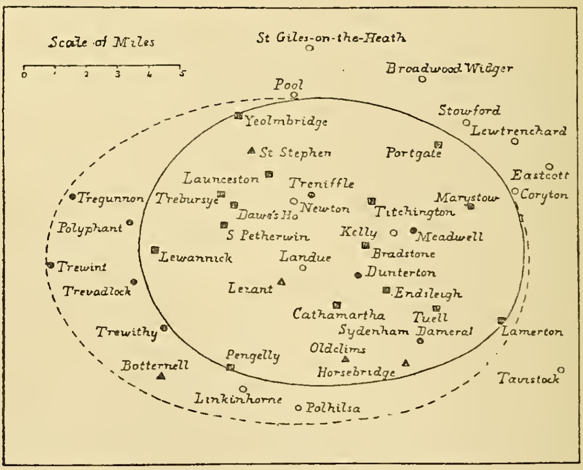


Fig. 3.—Cornwall Earthquake: Jan. 26, 1896.

The shock was felt at 14 places. At all of these the sound was heard, as well as at 10 places where the shock was not felt, and at 6 others where no mention of the shock is made. The sound-area is 15 miles long and 10 miles broad, and includes 124 square miles. Its longer axis is directed east and west, and is thus parallel to that of the disturbed area. The centre is $1\frac{1}{2}$ miles S. 12° E. of Launceston, and, as will be seen from the map (Fig. 3), the sound-area overlaps the disturbed area by 3 miles towards the west and by $1\frac{1}{4}$ miles towards the south.

Very few observers describe the shock. It was clearly a mere tremor, a dull shiver according to one, and a movement such as is produced in a building by a heavy peal of thunder according to another.

The sound was, as usual, a far more prominent feature of the earthquake. Comparisons to well-known sounds are made in 30 cases, in 27 per cent. of these to passing waggons, etc., in 57 per cent. to thunder, and generally distant thunder, and in 17 per cent. to explosions, which were, however, either prolonged or followed by a rumbling noise. Thus, the sounds must in all parts have lasted several seconds.

Origin of the Earthquake.—The longer axis of the disturbed area and sound-area agree in assigning an east and west direction to the originating fault. Its hade must be to the north, for the disturbed area is overlapped by the sound-area towards the south. The fault-line must therefore pass a short distance to the south of the centre of the disturbed area, possibly not very far from Dunterton, Landue, and Lezant.

The horizontal length of the seismic focus must have been about 5 miles, but the extension of the sound-area towards the west shows that the western margin of the focus was much longer than the eastern margin. The displacement throughout the whole focus was very small, and not much greater than that which will produce the sensation of sound.

In this case, again, the Geological Survey map provides no fault in the required position; but the early date of the survey should be borne in mind. To the south of the disturbed area there are, however, numerous mineral veins and elvan dykes, all of which run east and west, and therefore parallel to the earthquake-fault. If the district were to be carefully re-surveyed, a fault would no doubt be discovered that would satisfy all the seismic conditions.

Annandale Earthquake: May 29, 1896.

The disturbed area of this earthquake occupies a more populous part of Annandale than those of the shocks felt on March 8 and May 14, 1894. The number of records which I possess, is, however, small, only 15 from 14 places; but there are several other places from which negative records have come. The time of occurrence, as determined by a signalman at Castlemilk station, was 4.47 a.m.

The shock was distinctly felt at 7 places which lie within an area roughly circular in form and about 6 miles in diameter. The centre of the area is in lat. 55° 6′ N. and long. 3° 17′ W., and is equally distant (3 miles) from Lockerbie, Ecclefechan, and Minsca. The sound alone was observed at several places outside the boundary; at Craighouse close to the boundary on the south-east side, Dormont $1\frac{1}{2}$ miles to the south-west, and Corsegreen 3 miles to the west.

Also at Castleo'er, 6 miles to the north-east, the sound was heard by two persons, and a faint tremor was felt by one of them. Probably all of these observations refer to the earthquake.

The shock lasted about 3 seconds, and was a mere quiver of intensity 4 at places close to the boundary above mentioned, which may therefore be regarded as an isoseismal of that intensity. Six observers compare the sound to some well-known type—three to distant thunder and three to the rumble of a passing cart or waggon.

On the Geological Survey map of the district, there is no fault marked anywhere near the required position. If the earthquake were due to a fault-slip, the approximate circularity of the disturbed area and the short duration of the shock show that the length of the seismic focus was small.

Glen Nevis Earthquake: June 5, 1896.

A slight shock was felt at an early hour in the morning, being strongest at Achreach. No mention is made of any sound accompanying the shock, but the account is very brief (*North British Daily Mail*, Glasgow, June 6). One of the seismographs at the Low-level Observatory at Fort William is said to have shown a very doubtful indication of the shock. The earthquake may have been due to a slip of the Highland fault, but there is no proof whatever of such an origin. If there were, it would of course furnish another indication that the hade of the fault in this district is to the south-east.

Rutland Earthquake: Jan. 28, 1898.

A slight shock of intensity 3 was felt about 10.5 p.m. over nearly the whole of Rutland and in small portions of the adjoining counties of Lincoln, Leicester, and Northampton. I have received 40 records of the earthquake from 26 places. For more than half of these accounts I am indebted to Mr. F. Coventry, of Duddington, who very kindly made many inquiries and distributed a number of my forms in different parts of the disturbed area.

In the map of the earthquake (Fig. 4), the boundary of the disturbed area is represented by a continuous line and that of the sound-area by a dotted line. Of the two the latter is probably the more accurately drawn, but it is impossible to feel much confidence in either, on account of the small number of determining places and the want of negative records. I made many inquiries, however, in the surrounding district, and the absence of replies is probably equivalent to non-observance of the shock or sound.

The disturbed area, as mapped, is 15 miles long, $12\frac{1}{2}$ miles broad, and contains 142 square miles. Its longer axis is directed N. 27° W. and S. 27° E. The sound-area overlaps the disturbed area by about a mile towards the south and three-quarters of a mile towards the east; its linear dimensions being 16 miles and $13\frac{1}{4}$ miles, and its area 165 square miles. The centre of the disturbed area is $1\frac{3}{4}$ miles E.N.E. of Oakham and coincides nearly with the village of Burley.

Wherever the earthquake was observed the sound was a far more prominent feature than the shock. The movement, when felt, was merely a faint vibration in the middle of the rumbling noise. In a few places it made glasses and crockery jingle slightly.

FIG. 4.—Rutland Earthquake: Jan. 28, 1898.

With the exception of one village, in which the omission is probably accidental, the sound was heard at every place where the earthquake was observed. Its gradual rise and fall in intensity are perhaps responsible for the frequent references to the passing of a heavy carrier's van, a train rushing over a long iron bridge, or heavy barrels rolled on pavement underneath the house. The sound is also compared to thunder or the continued tipping of a cartload of bricks. Every one of the ordinary types of earthquake sound is, however, employed, reference being made to passing waggons in 40 per cent. of the records, to thunder in 34 per cent., wind in 3, the tipping of a load of stones in 11, the fall of a heavy body in 3, explosions in 3, and to miscellaneous sounds in 6 per cent. The average duration of the sound appears to have been about 5 or 10 seconds; that it was not inconsiderable is evident from the frequent use of the longer types of comparison.

Origin of the Earthquake.—It is difficult to locate the originating fault with precision. Its general direction would appear to be about N.N.W. and S.S.E. The overlapping of the sound-area towards the east indicates that the fault hades to the west, as the sound-vibrations in the protruding part would come chiefly from the upper margin of the focus. Thus, the fault-line should traverse the district between the centre of the disturbed area and its eastern boundary.

The faults of the district have been mapped by Professor Judd and described in his well-known memoir.[1] The more important ones have a W. by N. and E. by S. direction, with throws in some places of not less than 150 feet towards the north. The two chief faults are the Billesden and Loddington fault (traced for about 7 miles) and the Tinwell and Walton fault (about 14 miles in length), and between them are several others which have a parallel direction. Running transversely to these east and west faults are a number of others of smaller throw and with a general north and south direction, apparently representing cross fractures. A group of these is shown in the south-east corner of the map; one of which, passing by Ketton and Duddington, can be traced for a distance of 8 miles. Its throw seems to be greatest in the central part of its course, to the west of Collyweston; near Duddington it probably amounts to about 40 or 50 feet. At its north end it bends round to a north-westerly direction, and in this part its hade is evidently towards the west. The most easterly fault of the group runs about N.N.W. and S.S.E.

"That the faults mapped and described include all which traverse the area," Professor Judd remarks, "is by no means probable. Over considerable areas clays of enormous thickness prevail without any well-defined hard beds, and among these it would be impossible to detect dislocations while running the geological lines; other large areas are hopelessly concealed from our observation by thick masses of Boulder Clay, and of some of the faults actually detected it is not possible to trace more than a small part of their course, owing to the same causes." (p. 259.)

Possibly this may account for the termination on the map of the Ketton and Duddington fault towards the north, just after it crosses the river Wash and enters a mass of Lincolnshire Oolite. If the fault does not really end at this point, but is continued roughly in a N.N.W. direction, it would satisfy all the conditions implied by the seismic evidence. Whether it be to a slip of this fault, or of another transverse fault not shown on the Survey map, that the earthquake was due, it is clear that the displacement must have been very small to produce so slight a shock. The horizontal length of the focus may have amounted to two or three miles, and the displacement probably died out more slowly towards the south, giving rise to a broader lateral margin, and thus causing the sound-area to overlap the disturbed area in that direction.

Comrie Earthquake: Aug. 22, 1898.

To the seismologist, the recent Comrie earthquakes are of interest as members of a long series of shocks and sounds, now perhaps drawing for the present to a close. To the geologist, they may be of

[1] "The Geology of Rutland": Geol. Surv. Mem., 1875, pp. 256–259.

value from the evidence they furnish with regard to the hade of the great fault which forms the southern boundary of the Highlands. The study of a slight shock, which occurred on July 12, 1895, led to the inference that, in the neighbourhood of Comrie, the fault hades to the north-west;[1] and the still feebler shock of Aug. 22, 1898, supplies additional evidence in favour of this conclusion.

Many persons in the Comrie district seem inclined to refer the recent shocks to a desire to keep up the historic reputation of the village; and the exaggerated reports which have appeared in several newspapers certainly offer some excuse for this scepticism. Moreover, the weather on the last occasion was warm and sultry, the sound-area is very small, and it is therefore natural that many, who did not hear, or only just heard, the sound, should regard it as due to a peal of distant thunder. The seismic character of the disturbance cannot, however, be doubted after a careful study of all the evidence. The shock itself was felt by several persons (by two, as a vertical movement), the sound was evidently of underground origin, and other observers who are well acquainted with the tremors and earth-sounds of the district felt no hesitation in ascribing the sound to that of an earthquake too slight to be felt in all parts of the area affected.

The following account is based on 14 records from 8 places, and on statements that, at 12 other places, no sign of the earthquake was perceived.

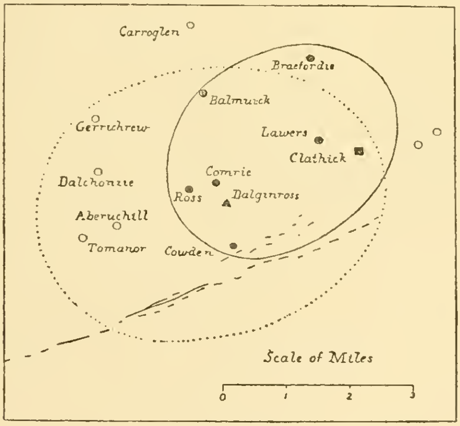


Fig. 5.—Comrie Earthquake: Aug. 22, 1898.

The earthquake occurred at about 7.15 a.m. The shock, which was of intensity 3, was felt only at Clathick, by three or four persons, and possibly by one person on the adjoining estate of Lawers. At Clathick, three distinct movements upwards and downwards were felt, as of heavy blows struck on the ground immediately beneath, lasting about 3 seconds. The sound was compared by four

[1] Geol. Mag., Vol. III, 1896, pp. 75–79.

persons to distant thunder, and by one each to a cart coming up the road, to coals turned out of a cart, and to a distant quarry-blast.

The boundary of the sound-area is represented on the map (Fig. 5) by the continuous line; but, on account of the small number of observations, it cannot be regarded as very accurate, especially to the east of Clathick. The area, as drawn, is 3¾ miles long, 3 miles broad, and contains 9 square miles. Its centre is one mile E. 27° N. of Comrie.

Connection with the Earthquakes of 1894 *and* 1895.—The epicentres of all three earthquakes lie on the north-west side of the great fault, whose course is indicated by the broken lines on the map. The dotted line represents the isoseismal 3 of the earthquake of 1895. As we have seen, the epicentre of the 1894 earthquake was close to Comrie; in 1895, the epicentre must have been a mile or more in length, with its middle point a quarter of a mile south-west of Comrie. Thus, while the first two earthquakes originated in nearly the same region of the fault, the slip which caused the earthquake of 1898 took place at a spot about a mile further to the north-east, and apparently just outside the focus of the preceding shock.

As the epicentres must lie on the side towards which the fault hades, the three earthquakes agree in showing that, near Comrie, the hade is to the north-west.

Glen Garry Earthquake: Dec. 18, 1899.

As the records for these and preceding years have shown, slight earthquakes are not uncommon in the west of Inverness-shire, in Glen Garry and the tributary glens, but none seem to have been felt for more than five years, between Sept. 18, 1894, and the above date, when a stronger shock than usual occurred. It was felt at about 6.50 a.m. at Glenquoich, Glenkingie, Lochournhead, Carnich, and even as far as Corran (Arnisdale, in Glenelg), but the limits of the disturbed area cannot be ascertained owing to the scanty population of the district. On the south side of Loch Quoich the intensity of the shock was about 5. At Glenquoich a sound was heard like distant thunder, getting louder till the house trembled, and then the sound died away as if a carriage had passed; the sound lasted fully 17 seconds. In a neighbouring part of the glen, the sound was compared to a chimney on fire and afterwards to a very heavy carriage passing over an iron bridge, and at Glenkingie to a flock of sheep rushing over hard ground.

For the notices on the Glen Garry earthquakes described in this paper I am indebted to the kindness of Mr. D. Grant, of Glenquoich, Mr. A. M. G. Foster, of Glenkingie, and Mr. M. Matheson, of Ardochy, three very careful observers, who for many years have paid close attention to the subject. The value of their work can hardly be overestimated.

Doubtful and Spurious Earthquakes.

Monmouthshire, etc.: Jan., 1893. — In two letters in *Nature* (vol. xlvii, 1893, pp. 247, 270), Mr. E. J. Lowe, F.R.S., describes a series of slight shocks. On the 3rd inst. he was sitting in a railway carriage placed in siding at Severn Junction station. At 2.15¼ p.m. he felt a sensible upward movement of the seat (as if pushed from below) and saw the carriage sway. The movement was from south to north, i.e. at right angles to the railway, and was repeated four times in about six seconds. At 2.17 p.m. there were two weaker movements. There was no train at the station, and the air was calm. Ice in the neighbourhood was said to have been cracked at the time. On Jan. 4, at 11 a.m., a heavy plant stage in a greenhouse at Itton Court, near Chepstow, was seen by two gentlemen to move four times. On Jan. 5, between 2 and 3 (?) p.m., and again on the 6th a little earlier, a rumbling noise was heard on the Black Mountains near Llanthony Monastery. On Jan. 14, at 6.55 p.m., a shock, lasting more than a second, was felt at Colesford (in Gloucestershire, a few miles from Monmouth) by a gentleman who had had experience of earthquakes in Japan.

Much fuller evidence than is here given would be required to establish the seismic character of these disturbances. An earthquake-shock strong enough to cause a sensible upward movement like that felt on Jan. 2 would be noticed over an area of many square miles, and could not fail to have attracted the attention of other persons. The rumbling noises near Llanthony may have been due to other natural or to artificial causes. It is clear that they cannot be placed in the same category as the Glen Garry earth-sound of Dec. 11, 1893, or the Fort William earth-sound of Jan. 9, 1895. In only one case were there two observers, and they were in the same house. I think, therefore, that the evidence is insufficient to enable us to regard them as other than doubtful, if not spurious, earthquakes.

Isle of Man: May 5–6, 1893.—A number of shocks were felt at nearly regular intervals on the days noticed, but there can be little, if any, doubt that they were due to the firing of heavy guns from H.M.S. "Neptune" (see *Nature*, vol. lx, 1899, p. 139).

Comrie: Feb. 27, 1894.—Reports of an earthquake on this day appeared in several daily papers, but were at once contradicted in the two journals published in Crieff. It is certain that an earthquake felt also, as alleged, at Ardoch and Buchanty (more than 8 and 10 miles, respectively, from Comrie) would have been widely observed. The weather, moreover, was stormy, and several peals of thunder were heard at the time at Comrie.

West Cornwall: May 29, 1896.—According to a paragraph in the *Standard* for the following day, a slight earthquake-shock was felt in West Cornwall at 6.55 a.m., and men on their way to work at the Camborne Mines felt the vibrations distinctly. I made many inquiries in the district, but none of my correspondents had met with, or heard of, any observer of the supposed earthquake. I do not think, therefore, that any reliance can be placed upon the report.

Through the kindness of several correspondents I have received reports of supposed earthquakes, but as I have been unable to obtain corroborative evidence, I have confined myself to noticing those which are recorded in journals that future seismologists would be likely to consult.

Earth-Shakes in Mining Districts.

Under this heading are included several shocks which, it is possible, may be of artificial origin, and, if so, ought to be regarded as spurious earthquakes. Formerly, I should have so considered them, but another explanation has recently occurred to me; and, if it be correct, it will be evident that they are partly artificial and partly natural in their origin. It therefore seems desirable to consider them separately.

Rhondda Valley.—The shocks referred to are frequently felt in the Rhondda Valley in Glamorganshire. One occurred on June 22, 1889,[1] and there have been at least three others within the period embraced by this paper, on April 11 and May 2, 1894, and October 16, 1896. Judging, however, from the expressions used by several of my correspondents, it is probable that these are the dates of only the more important movements.

The shock which occurred on April 11, 1894, at about 2.40 a.m., is described as one of the severest recently felt in the district; and making every allowance for exaggeration in the accounts,[2] there can be no doubt as to its intensity. At one or two places it cannot have been less than 5, that is to say, it must have been the strongest shock considered in this paper. Two loud reports, like those of cannon, were heard in quick succession, and at the same moments, or immediately afterwards, sharp vibrations were felt. They seem to have been almost equally distinct underground, for in several pits the miners rushed to the bottom of the shaft, thinking that a violent explosion had occurred. Notwithstanding the strength of the shock, however, the disturbed area was very small. So far as I have been able to ascertain, its boundary is almost exactly circular, about 5 miles in diameter, and with its centre $\frac{3}{4}$ mile east of Porth.

The second shock took place about noon on May 2, 1894, and seems to have originated in the same district. At the surface it must have been much slighter than the preceding shock; but underground it produced similar effects, miners in the same pits again leaving their work to escape from what appeared to be an explosion.

On October 16, 1896, the district affected was a very small one, not more than a mile in diameter, including Ystrad-y-fodwg, Pentre, Ton, and Gelli. At about 11 p.m. a loud boom, like the muffled sound of blasting, was heard, followed by a brief shaking. The sensation is described by most as like that experienced in a room immediately beneath another in which a heavy article of furniture had fallen. Miners at work rushed from one pit to

[1] Geol. Mag., Vol. VIII, 1891, p. 371.

[2] Houses are said to have rocked like cradles, etc. "Sir," said Dr. Johnson, when Boswell told him of the earthquake of Sept. 14, 1777, "it will be much exaggerated in public talk: for, in the first place, the common people do not accurately adapt their words to their thought: they do not mean to lie: but, taking no pains to be exact, they give you very false accounts. A great part of their language is proverbial. If anything rocks at all, they say *it rocks like a cradle*: and in this way they go on."

another, thinking an explosion had occurred. One informed me that a severe shaking was felt, the tools sprang from the floor and the dust rose in clouds off the bottom. Indeed, the shock seems to have been distinctly stronger underground than on the surface.

Kilsyth: Feb. 16, 1898.—Kilsyth lies in the valley of the Kelvin, 11 miles N.E. of Glasgow, and the same distance from Falkirk and Stirling. The supposed earthquake occurred at 1.33 p.m. It was felt and heard by hundreds of people in the town, but, though I have made many inquiries, I have received nothing but negative records from the surrounding country. It is therefore certain that the area affected must have been very small. All the accounts from Kilsyth are in agreement as to the nature of the shock and sound. There was a single movement, which immediately died away, lasting about a second; a dull heavy thud, as if some heavy article had fallen on the ground shaking all around. It was strong enough to make windows and crockery rattle, in one house to ring bells, and in others to throw down crockery from the shelves. The sound, which accompanied the shock, is said to have resembled the tipping of a load of coals, the fall of some heavy body, the slamming of a door, etc. Men working in the mines below were so alarmed that they ran to the bottom of the shaft.

Pendleton (*near Manchester*) : *Feb.* 27, 1899.—With one exception, I am indebted for all the records which I possess of this supposed earthquake to the kindness of Mr. Mark Stirrup, F.G.S.[1] The shock was felt shortly after 10 p.m., according to one observer at exactly 10.1 p.m. The places at which the shock was felt are all within a small area, approximately circular in form, and about 4 or 5 miles in diameter. The centre of the area is about ½ mile north of Pendleton, and lies a short distance on its downthrow side from the Irwell Valley fault. Even if we disregard the evidence of some observers as possibly exaggerated, there can be no doubt that the intensity of the shock was not less than 4, and it may have been as great as 5. A booming sound, like that of a gas explosion, accompanied the shock. In the Pendleton Colliery some falls of rock took place, and raised a cloud of dust which put some workmen's lamps out.

Origin of the Earth-Shakes.—There are certain features which are common to all the earth-shakes here considered, and which distinguish them from most ordinary earthquakes. They are:—

(1) The disturbed area is small; in the strongest, it is not more than about 5 miles in diameter.

(2) The intensity of the shock is very great for so small an area, and dies away rapidly from the centre towards the boundary.

From these facts, we conclude that the depth of the centre of disturbance is very small, and the inference is supported by the obviously great intensity of the shocks as felt in mines. Again:

(3) The shock and sound are of very short duration. The brevity of the sound is strikingly illustrated by the type of comparison

[1] See a paper by Mr. Stirrup on "The Earthquake of February 27th, 1899": Manchester Geol. Soc. Trans., vol. xxvi, 1899, pp. 174–178.

usually employed in describing it. Taking the four earth-shakes together, we find that 6 per cent. of the sound comparisons are to thunder, 12 to a load of stones falling, 35 to the fall of a heavy body, and 47 to explosions. Now, in the slightest earthquakes, such as those described in this paper, the corresponding percentages are 31 to passing waggons, etc., 35 to thunder, 3 to wind, 8 to a load of stones falling, 5 to the fall of a heavy body, 14 to explosions, and 4 to miscellaneous sounds. But it is only in isolated earthquakes that this is the case. The earth-sounds following a great earthquake or the sounds which accompany the weakest after-shocks resemble those caused by explosions or the fall of a heavy weight.[1]

It follows from this that the centre of disturbance must have been very small in the case of every one of the earth-shakes; and this conclusion is confirmed by the small size and the approximate circularity of the disturbed areas.

These two conclusions regarding the small depth and size of the centre of disturbance are strongly in favour of a local origin of the shocks. In the Rhondda valleys they are generally, I believe, attributed to rock-falls in old mine-workings; and this is no doubt the origin of some of the shocks, for such falls from the roof are known to occur and to lead to a subsidence of the ground above. The chief difficulty in accepting this explanation for the recent disturbances arises from the absence, so far as known, of any fallen masses.[2] The Kilsyth earth-shake was referred without hesitation by one of my correspondents to a blast in one of the whinstone quarries in the town; but, as another points out, the blasts have occurred daily for twelve years without any suggestion of an earthquake. Others, including several miners, consider that the shock was caused by a fall of rock in one of the old pit-workings by which the ground below is honeycombed. The shock at Pendleton is apparently, though not distinctly, ascribed by Mr. Stirrup to a slip of the Irwell Valley fault, and the proximity of the fault to the centre of disturbance is a point in favour of this theory.

But this, of course, is not a peculiarity of the Pendleton coal-mines. The beds about Kilsyth are cut up by a series of faults, and in the Rhondda Valley faults pass close to the centres of the disturbed areas of the earth-shakes. Perhaps a more significant fact is that the coal-seams are generally worked right up to the fault. This is certainly the case, as Mr. Stirrup informs me, at Pendleton, and it is probably so at Kilsyth and in the Rhondda valleys.

Now, by the withdrawal of the coal, the rock above is deprived to a great extent of its support, and tends gradually to sink down and close up the worked-out seam. Nowhere can this tendency be greater than where the rock is severed by a fault from that which adjoins it. Here the sinking would take place by a series of fault-slips, each of which might give rise to a rather strong shock on the surface of the ground above. But, as the slip would only affect

[1] Phil. Mag., vol. xlix, 1900, p. 58.
[2] *Nature*, vol. lx, 1899, p. 140.

a small region of the fault-surface and would occur at a slight depth, the intensity of the shock would rapidly fade away from the epicentre; the disturbed area would therefore be small and circular in form; and the shock and sound would be of brief duration, and in many ways resembling those produced by the fall of a heavy mass of rock.

If this is a correct explanation of some of the earth-shakes which occur in mining districts, it follows that such cannot be classed either with true or with spurious earthquakes. They are of natural origin in so far as they are produced by fault-slips, but artificial in that the slips are brought about by human labour and not by the slow and gradual cooling of the earth.

NOTICES OF MEMOIRS.

Note on *Belinurus grandævus*.[1]

IN a review of a paper by Professor T. R. Jones & Dr. Henry Woodward on *Belinurus grandævus*, a new species of Palæozoic[2] Limuloid Crustacean from the 'Eo-Carboniferous' of Riversdale, N.S., it is stated on p. 208 of this journal that *Belinurus* has not been found in rocks of earlier age than the Coal-measures. In Geikie's Text Book of Geology, however, this genus is mentioned as occurring with *Pterygotus*, *Bothriolepis*, *Coccosteus*, *Pterichthys*, *Glyptolepis*, and other typical Lower Devonian and Silurian forms in the Kiltorcan Beds of Ireland. Thus the inference drawn in the conclusion of this article that these rocks are Carboniferous does not seem to be sustained. May it not, on the other hand, be assumed that "The faunæ of the seas of the Lower Carboniferous, Coal formation, and Permian periods, both in Europe and America, present so great similarities that they may, in a broad view of the subject, be regarded as identical;"[3] while for 'Lower Carboniferous,' according to correlations of the fossils from these strata in New Brunswick and Nova Scotia made recently by Professor Kidston and Dr. David White, as recorded by Mr. J. F. Whiteaves in his "Address on the Devonian System in Canada,"[4] must we now say 'Lower Devonian'? R. W. E.

REVIEWS.

I.—Geological Survey of Canada. G. M. Dawson, C.M.G., LL.D., F.R.S., Director. Annual Report (New Series), Vol. X. Reports A, F, I, J, M, S, 1897. 8vo; with plates and maps. (Ottawa: Dawson, 1899.)

THE present volume, like its predecessors, contains within its pages many proofs of the excellent organization as well as the enterprising spirit which controls and animates the operations of all branches of the Survey, and testifies once again to the

[1] From *The Ottawa Naturalist*, January, 1900, vol. viii, No. 10, p. 256.
[2] Geol. Mag., September, 1899, p. 388.
[3] Acadian Geology, p. 283.
[4] Section E, American Association, Columbus, Ohio, August, 1899.

wonderful resourcefulness and the scientific attainments so happily blended in the Canadian geologist.

The Summary Report (A) by the Director, Dr. G. M. Dawson, dated January, 1898, contains a brief record of the executive and office work of the department and of the organization and main results of the field-work up to the end of the year 1897. The reports which follow have, as usual, all been issued separately, prior to the completion of the general report.

The Director refers especially in his report to the rich discoveries of placer gold on the Klondike and its tributary streams in the Yukon District, verifying his forecast as to their great value published in 1889. More detailed geological investigations must be made before the question of the origin of the gold can be solved. A prolonged and uninterrupted wearing down, from a very early period in the Tertiary, of rocks containing auriferous veins may, in part, account for the great quantities of residuary gold now contained in the placers.

The operations of the field parties (to the number of fifteen) embraced the following widely extended regions, viz., British Columbia (2), North-West Territories, boring operations (2), Ontario (4), Quebec (1), New Brunswick (1), Nova Scotia (3), and Hudson Strait (2).

Experimental borings in petroleum - bearing rocks were undertaken in Northern Alberta (N.W. Territories) with results which pointed to the existence of an oil-field of great extent in that region.

Following the account of this work, which is given in much detail, are the reports of the officers responsible for the Museum, Herbarium, and Library of the Survey.

The first field report (F) is that of Mr. W. McInnes, on the geology of the area covered by the Seine River and Lake Shebendowan map-sheets, comprising portions of Rainy River and Thunder Bay Districts, Ontario. After describing the physical characters of the region, its principal rivers, lakes, waterfalls, wild animals, forest growth, etc., the author deals with its geology. The geological formations are as follows, in descending order :—

Surface deposits of glacial and lacustrine origin.
Animikie.
Steep Rock.
Keewatin.
Coutchiching.
Laurentian.

The most widely distributed of these is the Laurentian, which occupies more than three-fourths of the entire area. It is made up of granite-gneisses, which vary in composition according to the presence or absence of hornblende, and in the distinctness of their foliation. The typical rock is a biotite-granite-gneiss made up of quartz, orthoclase, plagioclase, and biotite, generally distinctly foliated and banded with finer and coarser layers. The non-foliated, central portion merges gradually, at varying distances from the edge of the area, into well-marked gneiss, the latter evidently a phase of the granite produced by stress and incipient flow. The prevailing aspect of the rocks of the Coutchiching series in this section is that of stratiform, fine and coarse gneisses, the coarser intrusive through the finer. The finer gneiss is identical with the Coutchiching series of Rainy Lake and probably represents its eastward extension. The Keewatin is made up of a number of rock types varying from extremely basic, igneous masses and their derived schists, to acid quartz-porphyries and the schists produced by their shearing. The Steep Rock Series, occurring about Steep Rock Lake, are believed to be of later age than the greater mass of the Keewatin strata, as they overlie unconformably the rest of the Archæan, occupying a position below the Cambrian and above the great bulk of the Keewatin. The Animikie rocks, which occupy a limited area in the south-eastern corner of the region, overlie unconformably the Archæan rocks wherever they have been seen in contact. From their stratigraphical relations to the overlying formations further east on Lake Superior, they are believed to represent the lower beds of the Cambrian. They consist of black and green slates with calcareous and cherty bands.

The glacial geology and economic geology of the region are described, the minerals including iron, gold, and silver, with others in insufficient quantities to be commercially valuable.

Report I, by Mr. A. E. Barlow, deals with the geology and natural resources of the area included in the Nipissing and Temiscaming map-sheets, comprising portions of the district of Nipissing, Ontario, and the county of Pontiac, Quebec. It is accompanied by two maps, each on a scale of four miles to one inch. The area represented in each map measures seventy-two miles in length from east to west, and forty-eight miles from north to south, thus embracing an area of 3,456 square miles, or a combined area of 6,912 square miles. The several geological systems and formations represented in the region subjacent to the Pleistocene superficial deposits are as follows, in descending order:—

Palæozoic.	Silurian: Niagara.
	Cambro-Silurian: Trenton; Birdseye and Black River.
Archæan.	Huronian.
	Laurentian: Diorite-gneiss and granite-gneiss.

The Archæan rocks of the region may be separated into two great subdivisions, that of the so-called Lower Laurentian and the Huronian. The Laurentian is composed of a series of massive or schistose, and usually evenly foliated, crystalline rocks, the latter being commonly referred to as 'gneisses.' The latter are separable into two divisions according to the prevalence of orthoclase or plagioclase as the felspathic constituent. Of the two types, granite-gneiss and diorite-gneiss, the former is by far the most abundant, and often passes by insensible gradations into massive, reddish granite in which little or no trace of foliation can be detected.

The Huronian rocks are generally clastic in composition, appearance, and microscopic structure, in marked contrast to those of the Laurentian. The breccia or breccia-conglomerate which lies at the base of the Huronian is the rock referred to by Logan and Murray as 'slate-conglomerate' or 'chloritic slate-conglomerate.' It is composed of angular, subangular, or rounded fragments of various plutonic rocks, of which a coarse, red granite is the most abundant. Diabases and diorites are also present. Throughout the area the Huronian, where fully represented, is separable into three distinct subdivisions, which are, in ascending order, as follows: (1) Breccia or Breccia-conglomerate, (2) Greywacke shale or slate, (3) Felspathic sandstone or quartzite.

The Palæozoic rocks contained in this area consist of outlying patches of the following formations: (1) Birdseye and Black River, (2) Lower Trenton, (3) Niagara. Some excellent illustrations of the scenery of the region surveyed, and plates of microscopic sections, accompany this voluminous report, to which two appendices are added, the first consisting of tables of elevations calculated in feet above mean tide water at Quebec, the second containing tables of Cambro-Silurian and Silurian fossils, with remarks upon them, drawn up by Dr. H. M. Ami.

Report J, by Mr. R. Chalmers, is on the surface geology and auriferous deposits of South-Eastern Quebec. It contains the results of observations made during the seasons of 1895, 1896, and 1897. The district included in the report extends from Lake Champlain and the Vermont boundary north-eastward to Montmagny county, and from the province line along the New Hampshire and Maine border north-westward to the plain of the St. Lawrence. A general study of the superficial deposits of the region was made, with special reference to the auriferous alluviums of the 'Eastern Townships.' To carry this out thoroughly the whole of the St. Lawrence Valley was examined in some detail, the glaciation and the distribution of the Boulder-clay were investigated, and the origin of the latter and of other superficial deposits traced out. The pre-Glacial, decayed rock materials, 'sedentary' and 'transported,' lying beneath the Pleistocene series, were also studied in the gold-bearing districts, as it is chiefly in these that the precious metal is found in workable quantities.

Gold was first discovered in South-Eastern Quebec on the Gilbert River about the year 1823. Many years afterwards (1866) a report by an expert employed by Sir W. E. Logan, at that time Director of the Geological Survey of Canada, was drawn up relative to the distribution of gold in the gravels and clays and gold-bearing quartz veins; since that time gold-mining has gone on intermittently and with varying success in the valleys of the Gilbert and Chaudière rivers and other parts of the district referred to in the report. Although the gold-bearing alluviums of South-Eastern Quebec have been worked and studied for more than half a century by geologists, mining engineers, and others, yet very little is known concerning the true source of the gold. Logan and Sterry Hunt regarded its origin as traceable to the materials derived from the disintegration of the oldest rocks of the region, viz., the crystalline schists of the

Notre Dame Range, belonging for the most part to the Quebec Group. Little progress has been made in a knowledge of its derivation since the time of these geologists, as practically no quartz-mining has yet been carried on. The author finally concludes that "the primary source of the gold of the 'Eastern Townships' seems to be the crystalline schists of pre-Cambrian or Huronian age, which were invaded by diorites and other intrusives and yielded material to the basal Cambrian conglomerates, and were also probably traversed by quartz veins. In the removal and transportation of sedimentary material by drainage waters, whatever gold was in the quartz veins, and in the products of rock decay, would be concentrated in channels or river-bottoms in the gravels in which it is found at the present day."

Dr. L. W. Bailey's Report (M) relates to the mineral resources of the Province of New Brunswick. Among metallic ores are included iron, in the forms of hæmatite, magnetite, etc.; copper, as native copper, and various sulphides; lead, as galena, usually slightly argentiferous; zinc, as blende; antimony; nickel sulphide, bismuth; and gold. To these are added, among substances affording combustible products, bituminous coal, anthracite, cannelite, albertite, petroleum, and peat. Among materials for construction are granite, freestone, slate, limestone and marble, gypsum, clays and sands, besides graphite, salt, infusorial earth, fireclay, etc. Many of these substances, especially the metallic ores, occur only in small amounts. The geological formations represented in the province include all the divisions of the geological scale from the earliest Archæan to the Trias; those formations, such as the Laurentian, Huronian, and Cambrian, which elsewhere usually produce metallic ores, and the Carboniferous formation yielding coal and related products, occupy the largest areas.

Referring to gold, Dr. Bailey says that its existence in profitable quantities remains to be proved, and that this can only be done by a prolonged and systematic prospecting of the areas in which it is likely, if anywhere, to be found. The question of the occurrence of coal is to be made the subject of a special report. There is no dearth of materials used in construction and of deposits of gypsum, limestone, clay, sand, and probably bog manganese. This is doubtless a valuable report, especially from the economic point of view; but our space does not admit of more than this bare outline of its contents. It is accompanied by a map of the province on a scale of 10 miles to 1 inch.

Mr. E. D. Ingall, assisted by Messrs. Denis and McLeish. contributes his annual report (S) on mineral statistics and mines, thus adding to the steadily increasing classified system of mining records. Noting some features of progress of mineral development in the country as a whole, Mr. Ingall says the grand total of 1897, as compared with 1896, shows an increase of nearly 27 per cent., and as compared with 1895 of over 30 per cent. This is almost altogether due to the metallic minerals, and amongst these gold, silver, copper, and lead are those showing the most marked advance, due chiefly to the continued expansion of the mining industries of British Columbia, that province dividing the honours with the Yukon District in the matter of gold.

With this voluminous report the volume concludes, and we have only now to congratulate Dr. Dawson and his able staff on the results of their labours as set forth with so much completeness and wealth of detail. Arthur H. Foord.

II.—Contributions to Canadian Palæontology. Vol. IV, Part 1. A Revision of the Genera and Species of Canadian Palæozoic Corals. The Madreporaria Perforata and the Alcyonaria. (Geological Survey of Canada.) By Lawrence M. Lambe, F.G.S. Pages 1–96, plates i–v. (Ottawa, 1899.)

A REVISION of the Palæozoic Corals has long been a desideratum. Since the great works of Milne-Edwards and Haime, no comprehensive treatise has been produced, though the labours of De Fromentel, Lindström, Duncan, Hinde, Koch, and others in Europe, and Hall, Billings, and Rominger in America, and Nicholson on both sides of the Atlantic, have greatly extended our knowledge of many groups. It need scarcely now be maintained that to Nicholson science is deeply indebted for the initiation of methods of study in this complicated group of organisms whereby a fuller and more exact comprehension of their structure has been acquired than was possible to the earlier workers in this field of study. His work on the Palæozoic Tabulate Corals laid the foundation upon which all subsequent investigators have built, and the fact of his having made use of much American material gives a peculiar value to his writings for those who have to deal with the Palæozoic Corals of that continent.

In the work before us the genera and species of the Canadian Palæozoic Corals are redescribed, and "it is attempted to show that some forms hitherto considered of little value as regards the determination of the age of the deposits in which they occur, on account of their wide range in geological time, are capable of indicating definite horizons through the possession of distinctive structural peculiarities." Thus, as Rominger has observed ("Fossil Corals of Michigan," 1876), Cambro-Silurian (Ordovician) and Silurian species of *Favosites* have spiniform septa, while those of the Devonian have squamulæ. Again, it is found that the forms of *Halysites* of different geological horizons have distinctive characteristics which are apparently constant. A table (at p. 74) shows the distribution in time (from the Niagara to the Trenton), with the physical characters—shape of corallites, size of their tubes, septation, tabulæ, etc.—of *Halysites catenularia* and six varieties, illustrating this point.

With respect to distribution in time *Favosites Gothlandica* has a very wide one in Canada. It is recorded as occurring at many localities in the Niagara, Guelph, and Lower Helderberg formations, in divisions 2, 3, and 4 of the Anticosti Group, and in rocks of supposed Hudson River age at Stony Mountain, Manitoba. Its regional distribution is also very considerable: it extends from the shores of the Gulf of St. Lawrence to the Saskatchewan River. Another species, widely distributed in time and space, is *Lyellia affinis*, occurring in the "Hudson River and Niagara formations, in the four divisions of the Anticosti Group, and in the Lower Helderberg Group," and ranging from the Island of Anticosti to the Saskatchewan River.

The detailed descriptions of the species and their mutual relations, distribution, and synonymy are all worked out by the author with great care, and he seems to have sounded his authorities at all points.

Though in respect to the classification of the Palæozoic corals we are, and perhaps shall ever be, on very debatable ground, yet it may not be amiss to take a survey of our present position in the light of the more recent attempts made in this direction. Haeckel ("Systematische Phylogenie der Wirbellosen Thiere") includes in his class Scyphopolypi the fossil Cnidarians, such as the Favositidæ, Chætetidæ, Auloporidæ, Halysitidæ, etc., which built the coral reefs of the Silurian, Devonian, and Carboniferous seas, and are generally assigned to the Tabulata. Nicholson, discarding the latter group as originally constituted, as containing an incongruous assemblage of forms, places the Favositidæ, Syringoporidæ, and Thecidæ in the Madreporaria Perforata, while the Helioporidæ, Heliolitidæ, Halysitidæ, Chætetidæ, and Auloporidæ are referred to the Alcyonaria ("Manual of Palæontology," Nicholson & Lydekker, vol. i). Von Zittel, in his "Grundzüge der Palæontologie," while affirming that the greater number of the typical Tabulata (Favositidæ, Syringoporidæ, Halysitidæ) show close relationship to the Hexacorallia, concludes that any definite decision as to their systematic position seems to be unattainable. On this ground, though retaining them as a suborder of the Madreporaria, he relegates them as an appendix to the Hexacorallia, and places *Heliolites* in the Octocorallia (Alcyonaria), its generally accepted position.

The uncertainty regarding the zoological status of the various groups enumerated above (excepting perhaps the Heliolitidæ) is not likely to be dispelled, unless evidence is forthcoming in the shape of a living reef-building coral whose affinities with the fossil reef-builders of the favositoid and other kindred types will satisfy the most searching investigation. Even the remarkable discovery by Mr. J. J. Quelch [1] of a living coral (*Moseleya*) of Cyathophylloid affinities does not seem to have carried with it evidence of such a convincing character as to shake the position of the Rugosa (or Tetracorallia) as a distinct group.

Much light is thrown upon the structure and affinities of the Heliolitidæ in a recent and valuable contribution to the subject by Professor Lindström (Kong. Svenska Vetenskaps-Akad. Handl., Bd. xxxii, No. 1). It is noticeable that the genus *Lyellia*, M.-E. & H., is rejected by Lindström on account of its similarity to *Propora*, M.-E. & H.

[1] Ann. Mag. Nat. Hist., vol. xiii (1884), p. 293; "Challenger" Reports, vol. xvi (1886), p. 110; see also Nicholson, in "Manual of Palæontology," Nicholson & Lydekker, vol. i (1889), p. 274.

In the present work the author's suppression of certain species is, we trust, done with sufficient justification. It is a proceeding which should be carried out with the utmost caution, because, however inconvenient a multitude of species may be to the systematist, their presence is a lesser evil than that which may result from the loss of information respecting the mutations which groups of individuals undergo, and which are best recorded and stereotyped under a specific or varietal name. The disadvantage of burying such records, so to speak, is of course very much lessened when there is abundance of material at the disposal of the palæontologist, in which case transition forms may be found to bridge over the gaps and to unite what had before been mistaken for independent forms. The following genera are included in this Revision:—

Favosites.	Syringolites.	Heliolites.
Alveolites.	Romingeria.	Plasmopora.
Cœnites.	Fletcheria.	Lyellia.
Cladopora.	Nyctopora.	Lyopora.
Michelinia.	Syringopora.	Protarea.
Striatopora.	Cannapora.	Stylarea.
Trachypora.	Halysites.	Tetradium.
Calapœcia.		

The illustrations are few, and though excellent, considering the mode of reproduction adopted, are more suitable for the text than for plates. The details, doubtless most faithfully rendered in the original drawings, are in some instances reproduced on too small a scale to give satisfactory results. Moreover, we miss representations of the entire corallum, which is inserted only in one instance (pl. v, fig. 4, $\frac{1}{2}$ nat. size). Apertures of corallites, sketched in outline, with the tubular parts from which they proceed omitted, have a strange and unnatural appearance (plates i and iii).

We cannot commend the practice adopted by the author of employing two terms of measurement—one for the corallum, in inches; the other for the individual corallites, in millimetres.

This work will be of especial value to students of the Palæozoic corals of North America, while other palæontologists may learn much that is interesting respecting variations in structure, both external and internal, so minutely and carefully recorded by Mr. Lambe from the rich material at his command.

Arthur H. Foord.

REPORTS AND PROCEEDINGS.

Geological Society of London.

February 16th, 1900.—W. Whitaker, B.A., F.R.S., President, in the Chair.

Annual General Meeting.

The Secretary read the reports of the Council and of the Library and Museum Committee for the year 1899. In the former the Council referred to the continued increase in the number of Fellows and the steadily maintained financial prosperity of the Society.

During 1899 the number of Fellows elected was 52 (exactly the same number as in 1898): of these 45 qualified before the end of the year, making, with 11 previously elected Fellows, a total accession of 56 in the course of the twelve months under review. During the same period, the losses by death, resignation, and removal amounted to 51, the actual increase in the number of Fellows being therefore 5.

The total number of Fellows, Foreign Members, and Foreign Correspondents, which on December 31st, 1898, was 1,336, stood at 1,344 by the end of 1899.

The balance-sheet for the year 1899 showed receipts to the amount of £3,991 14*s.* 4*d.* (including a balance of £1,076 0*s.* 8*d.* brought forward from the previous year), and an expenditure of £3,029 14*s.* 6*d.* (omitting the sum of £541 6*s.* 0*d.* invested in India 3 per cent. Stock). Among the items of non-recurring expenditure were £200 contributed by the Society, at the request of H.M. Office of Works, towards the cost of the improved lavatory accommodation at the Society's apartments; and £73 16*s.* 5*d.* expended in the publication of vol. iii of Hutton's "Theory of the Earth." The balance remaining available for the current year is £420 13*s.* 10*d.*

The Council announced that it was proposed to complete the extension of the electric lighting to the whole of the Society's apartments at an estimated cost of £250, and the Fellows were requested to sanction this expenditure.

The bequest made by Sir Joseph Prestwich of the sum of £800 had now become payable to the Society, owing to the lamented death of Lady Prestwich. An extract from Sir Joseph's will was read, citing the purposes to which this sum is applicable, but it was pointed out that, in common with other legacies, that to the Society will have to be to some extent abated and moreover will have to bear its own legacy duty.

Reference was made to the issue of the third volume of Hutton's "Theory of the Earth," and gratitude was expressed for the minute and reverent care with which the work had been edited and annotated by Sir Archibald Geikie.

The completion of vol. lv and the commencement of vol. lvi of the Society's Quarterly Journal was mentioned, and it was stated that the Council had decided to discontinue, for the present, the issue of index-slips.

In conclusion, the awards of the various Medals and proceeds of donation funds in the gift of the Council were announced.

The report of the Library and Museum Committee enumerated the increasingly extensive additions made to the Society's Library, and announced the completion by Mr. C. Davies Sherborn of the work of labelling and registering the type, and other important specimens in the Museum.

After the reports had been read, the President invited those to speak who wished to make any comment on the management of the Society. Dr. G. J. Hinde said that owing to the action of the Council in rejecting a motion which he had made to it, "that an invitation be extended to Miss Elles to be present at the Annual General Meeting to receive the award which has been made to her by the Council," he had, as a protest, resigned his position on the Council and withdrawn his nomination to the new Council, then being elected. He contended that the giving of the Medals and Awards was not an official part of the business of the Annual Meeting, and that in refusing to invite a recipient of an honour to be present to receive it, solely on the ground of sex, the Council had acted against the custom of the Society.

The reports having been adopted, the President handed the Wollaston Medal, awarded to Professor G. K. Gilbert, F.M.G.S., of Washington, to Mr. Henry White, Secretary of the American Embassy, for transmission to the recipient, addressing him as follows:—Mr. White,—

For many years Professor Gilbert has contributed to several American publications papers of a most varied kind, some dealing with important subjects appertaining to the Geology of the United States and some with matters of still wider interest.

The same may be said of his series of reports, etc., to the Geological Survey of the United States, beginning with the well-known "Geology of the Henry Mountains," in which the volcanic structure known as a laccolite was first described, and a masterly summary of the principles of erosion was given. The Essay on the Topographical Features of Lake-shores, descriptive of the work of waves, of streams, and of ice, of the formation of deltas, of cliffs, and of terraces, naturally led up to the great monograph on Lake Bonneville, the tracing out of a former feature—whereof the present Great Salt Lake is the diminished representative, written in such a way as to make one almost feel that the old lake is there still.

Nor has Professor Gilbert neglected those more practical matters that press themselves on officers of a Geological Survey, for he has written also on the Underground Water of the Arkansas Valley; but the lake fever keeps with him, and has led him to take up the question of recent earth-movements in the region of the Great Lakes, on which we had an elaborate essay in 1898, leading to the conclusion that change is still going on, and pointing out the results that will occur if it continues.

We feel that Professor Gilbert is an honour to the Survey of which he has long been an officer, and a worthy successor of his countrymen, James Hall and J. D. Dana, as our Wollaston Medallist, for his work is not only American, but for the world at large.

Mr. White replied in the following words:—Mr. President,—

It has given me great pleasure, Sir, to attend this interesting meeting to-day, and to receive on behalf of my fellow-countryman, Professor Gilbert, the Wollaston Medal which has been awarded to him by the Council of this Society for important researches concerning the mineral structure of the earth—an honour which, as you have just pointed out, has hitherto been conferred upon two other Americans only, the late James Hall and the late J. D. Dana.

Particularly gratifying has it been to me, as I am sure it will be to all who know Professor Gilbert, to hear, from the statement which you have just read, how highly his work is appreciated by the Geological Society of London. He deeply regrets that it should not have been possible for him, owing to engagements of a pressing nature at home, to come here to-day and to receive this Medal himself, but I shall not fail to inform him of the very kind manner in which its presentation has been made, and of the applause which has greeted each mention of his name at this meeting.

I beg to thank the Council of this Society most sincerely, on Professor Gilbert's behalf, for the honour which has been conferred upon him, an honour which he highly appreciates, as does the United States Geological Survey, of whose staff he has been a distinguished member since its foundation in 1878.

Perhaps I may be permitted, as one who has been closely connected for many years past with the diplomatic relations between the United States and Great Britain, to add that I always welcome with especial pleasure occasions of this kind, on which marks of appreciation are conferred by scientific Societies of one country upon eminent men of the other, as they not only tend to draw more closely together the people of Great Britain and America, but they demonstrate to the rest of the world that the two nations are working together for the furtherance of science, and consequently for the advancement of civilization.

The President then handed the Murchison Medal, awarded to Baron Adolf Erik Nordenskiöld, of Stockholm, to His Excellency, Count Carl Lewenhaupt, Minister for Sweden and Norway, for transmission to the recipient, addressing him as follows:—Your Excellency,—

Baron Nordenskiöld has given much of his time to the arduous work of Arctic exploration, having visited Spitsbergen twice, the first time in 1858, with Torell. Again, in 1868 he organized and started another Arctic expedition, and in 1872 he discovered the great masses of native iron of Ovifak, originally described to our Society as meteorites, and also brought home a large collection of fossil plants, from which we learnt much as to the long-past climatic conditions of the Arctic regions.

In 1875 he went up the Yenisei from the Kara Sea; three years later he first doubled the northernmost point of the Old World, and reached Japan in the latter part of 1879, making what is known as the North-East Passage.

In 1883 he undertook a second voyage into the interior of Greenland, adding largely thereby to our knowledge of its glacial conditions.

Among the records of these expeditions, his book entitled "The Voyage of the *Vega*," which has been translated into English, and from which we derive much information as to inland ice, glaciers, and icebergs, and his work on "The Second Swedish Expedition to Greenland," are notable.

We have also to thank him for giving us an English version of some of his work, chiefly in the pages of the GEOLOGICAL MAGAZINE, in vol. ix of which is a set of papers on the Expedition to Greenland in 1870, while in vol. ii of decade II we find the Lecture on the Former Climate of the Polar Regions, and in vol. iii a set of papers on the Geology of part of Spitsbergen and a discourse on the distant Transport of Volcanic Dust.

Both as an observer and as an organizer of expeditions of discovery has Baron Nordenskiöld earned our gratitude, of which this Murchison Medal is a sign.

His Excellency replied in the following words:—Mr. President,—

On behalf of Baron Nordenskiöld, I beg to express his deep gratitude for the great distinction conferred upon him by the Council of the Geological Society. I shall not fail to transmit the Medal at once, but I may perhaps be allowed to mention that I have been asked to present the accompanying cheque as a donation from Baron Nordenskiöld to the British Antarctic Fund. It is a great pleasure for Baron Nordenskiöld to have this opportunity of proving his good wishes for the success of this expedition.

The President then presented the Lyell Medal to Mr. John Edward Marr, F.R.S., addressing him as follows:—Mr. Marr,—

From 1876 onwards you have contributed fourteen papers to our Journal, most of them on the Geology of the Lake District and its borders, but two being on Welsh and two on European geology. Of these one may specially note those on the pre-Devonian Rocks of Bohemia, on the Stockdale Shales (done in conjunction with our lamented friend Nicholson), on the Shap Granite and its Associated Rocks (done with Mr. Harker), and on Limestone-knolls.

These papers that you have given us are enough to prove your power as an observer and a reasoner both in the field and at home; but you have also contributed much to the GEOLOGICAL MAGAZINE, often in association with other workers, and I may remark that the frequent coupling of your name with other names shows how your aid is valued and how well you can work with others. Nor is this all; other journals have been enriched by your pen, and you have added the following books to the literature of Geology: "The Classification of the Cambrian and Silurian Rocks," "The Principles of Stratigraphical Geology," and "The Scientific Study of Scenery."

Undoubtedly your long continuous service on the Council (from 1885 to 1899) has alone hindered us from thus acknowledging the value of your work until now.

The award of the Lyell Medal may bring an additional pleasure to you in that it has been given to Nicholson, with whom you have so often worked, and to Hughes, whom you have so greatly assisted in the teaching of geology at Cambridge.

We are proud to add your name to the list of Lyell Medallists.

Mr. Marr, in reply, said:—Mr. President,—

In thanking the Council for the very gratifying and unexpected honour which they have conferred upon me, I feel that they must have been influenced in their choice by personal considerations, as I have been so long among them. The Founder of the Medal stated that the recipient must have "deserved well of the science," which in the present case could only be so in that I have tried to do my best; I will endeavour, however, by working in the future, to "justify the honour."

You have mentioned, Sir, original work and teaching as qualifications. As regards original work, I have been singularly fortunate in the co-operation of the late Professor Nicholson, and in that of Mr. Harker and Mr. Garwood. As a teacher, I am glad to see two of my old pupils receiving awards on this occasion, as it shows how happy I am in the nature of my classes. But I feel that the teacher's influence must count for something, and I know it by experience, as a pupil of the Woodwardian Professor. I am glad to take the present occasion to bear testimony to Professor Hughes's guidance of his pupils' work—a guidance by no means exercised solely in the lecture-room.

As one who was brought up in Lyellism, and am still being brought up in it, I am unaffectedly glad that the Lyell Medal has been awarded to me. I do not use the term Lyellism in a narrow sense, as a crystallized set of tenets, which will ever retain the form in which they were left at the Founder's death. I regard it rather as possessing vitality, and as ever growing and spreading its seed, like a goodly tree.

In conclusion, while thanking you, Sir, for the kind words which you have used in presenting the Medal, I beg to call your attention to the fact that it is 25 years since you have shown me your first kindness, and that kindness has continued ever since. I am especially glad to receive the Medal from your hands.

In presenting the balance of the proceeds of the Wollaston Donation Fund to Mr. George Thurland Prior, M.A., of the Natural History Museum, the President addressed him as follows:—Mr. Prior,—

In the course of the last thirteen years you have contributed a number of papers to the Mineralogical Society, either alone or in conjunction with other observers, in which you have described minerals from various parts of the world. In the case, indeed, of one of the late numbers of the Mineralogical Magazine, there would be little left were the five papers wholly or partly written by you taken out. In three cases you have done us the service of showing that certain minerals had been christened more than once. You have, moreover, strayed from the path of pure Mineralogy into the ways of Petrology, and have always been ready to let geologists have the advantage of that valuable help which your position in the Natural History Museum enables you to give them.

We are glad to find that our great National Museum continues to keep to the front in Mineralogy, and that we may look forward to the continuance of able observers among its officials. The Wollaston Fund is most fittingly awarded to this end.

Mr. Prior replied in the following words:—Mr. President,—

I wish to express my heartfelt thanks to the Council for the honour which they have done me in conferring this award. That it should be connected with the name of Wollaston is to me an additional pleasure, since my work has been mainly of a chemical and mineralogical character.

Mineralogists are perhaps rather apt to pay too little attention to the modes of occurrence and mutual associations of the minerals that they study. To try in future to make my mineralogy more geological in its character, I feel, will be the best way for me to show my high appreciation of this generous recognition from the Council and of the kind words with which you, Sir, have accompanied it.

The President then handed the balance of the proceeds of the Murchison Geological Fund, awarded to Mr. A. Vaughan Jennings, F.L.S., to Professor J. W. Judd, C.B., LL.D., F.R.S., for transmission to the recipient, addressing him as follows:—Professor Judd,—

Mr. Vaughan Jennings has done much work in Physical Geology and in Petrology, especially in the papers which he has given us on the country around Davos in Switzerland, and he has done this despite long and serious illness. Driven abroad by that illness, he has used the opportunity thus afforded to investigate the geological structure of the district in which he has had to live and to unravel the geological history of the great valley of the Engadin.

We hope that this award may not only show him that his work, done under such disadvantage, is appreciated by us, but may also cheer him in time of trouble and encourage him to continue his labours.

Professor Judd, in reply, said:—Mr. President,—

I wish to express my great regret that the state of Mr. Vaughan Jennings's health and the illness of a near relative prevent him from being present to receive the award in person, and therefore beg to read the following words of acknowledgment of the honour done to him:—

"In endeavouring to express my thanks to the Council of the Geological Society for the honour which they have conferred upon me, I feel that my remarks must be of an apologetic character. Though much of my time for many years has been devoted to geological matters, my contributions to original research in that science have been far less than I wished and hoped.

"The reason—or, perhaps, I should say, the excuse—for this, lies in an unfortunate interest in the sister sciences of Zoology and Botany, and in the fact that most of my time has been devoted to teaching. While most of the Fellows of this Society doubtless recognize, in theory, the value of an equal study of the three branches of Natural History, it must be difficult for many to realize the difficulty of putting the theory into practice, and the limitation which such an attempt must impose on one's efforts to do special work in any particular branch.

"The consciousness that I have been led astray into the mazes of Invertebrate Anatomy and the devious paths of Cryptogamic Botany, makes me feel still more grateful that geologists have recognized some slight value in my contributions to our knowledge of the earth.

"My first attempt in Alpine geology is almost certainly my last; but the Council may rest assured that their kind recognition of my efforts will encourage me to work, as long as I am able, for the advancement of our science in whatever way is possible. That I have been capable of accomplishing anything in this direction is chiefly due to my studentship at the Royal College of Science, and to the kindly help of those connected with that institution.

"Perhaps I may be allowed to express also my great regret that, by accident (as I was travelling during the final revision), no acknowledgment was made in my last paper of the kind and constant assistance vouchsafed to me by Professor Bonney during the progress of the work."

In handing the balance of the proceeds of the Lyell Geological Fund, awarded to Miss Gertrude L. Elles, of Newnham College, to Professor T. McKenny Hughes, F.R.S., for transmission to the recipient, the President addressed him in the following words:—Professor Hughes,—

After some stratigraphical work in the Lake District and in North Wales, done with Miss E. M. R. Wood, Miss Elles gave special attention to the Graptolites, and we have had from her a paper on the subgenera *Petalograptus* and *Cephalograptus*, adding much to our knowledge of the characters and range of those fossils, followed by the still more important paper on the Graptolite fauna of the Skiddaw Slates, in which, after a mass of descriptive details, the phylogeny of the group is treated of at some length.

This has been followed by a paper, as yet unpublished, in which her knowledge of the Graptolites is applied to the zonal classification of the Wenlock Shales of the Welsh Borderland. We hope that this award from the Lyell Geological Fund will show her that her work is valued and will encourage her to continue it.

Professor Hughes replied as follows :—Mr. President,—

I am glad to have been asked to receive the award from the Lyell Fund for transmission to Miss Elles, who is debarred by circumstances over which she had no control from standing here to receive for herself this mark of recognition which the Council of the Society have bestowed upon her.

The research by which she has won for herself a prominent place among geologists might seem of limited scope to all but a few who know the difficulty and the importance of the group of organisms to which she has chiefly devoted her attention.

I am much pleased, therefore, to be here to-day to testify that Miss Elles, who is Assistant Demonstrator in my Department at Cambridge, has shown herself to be a clear-sighted stratigraphist and an astute palæontologist over a much wider field than might appear from the mention of the work for which this award has been made, and that she is, besides, accomplished in other and altogether different branches of culture.

Miss Elles has asked me to communicate her thanks in the following terms :—

"Please convey to the Council of the Geological Society my warmest thanks for the great honour which they have so unexpectedly conferred in awarding to me the Lyell Fund for this year.

"I have been able to do so little as yet, that I am bound to regard it as an incentive to future work, rather than as a reward for anything accomplished. I can only add, that I will strive my very utmost to make the work which I may do in the future worthy of the confidence which such an award seems to imply."

The President then handed to Mr. George C. Crick, A.R.S.M., of the Natural History Museum, a moiety of the proceeds of the Barlow-Jameson Fund, addressing him as follows :—Mr. Crick,—

In the course of the last ten years you have made yourself an authority on Fossil Cephalopoda, and have contributed several papers on various branches of this subject to the Geological Magazine and other journals, among which one may note, as of high general interest, your long and well illustrated essay on the muscular attachment of the animal to the shell, published in the Transactions of the Linnean Society in 1898: a subject which had escaped the attention of palæontologists until you drew attention to it.

Your official work at the Natural History Museum has included the making of the List of Types and Figured Specimens of Fossil Cephalopoda and the preparation of vol. iii (in conjunction with Dr. A. H. Foord) of the Catalogue of Fossil Cephalopoda in that Museum, and you have kept up the high character of that public establishment for readiness to impart information to the inquiring geologist.

Mr. Crick replied in the following words :—Mr. President,—

I beg to express my sincere thanks to the Council of the Geological Society for the great and unexpected honour that they have conferred upon me; and to you, Sir, for the kind words with which you have accompanied the award. Considering the many privileges that pertain to my official connection with the British Museum, the amount of work which has been done by me is comparatively so small that I regard the award as an encouragement to continue my work, rather than as a recognition of that already accomplished.

In presenting to Professor Theodore Thomas Groom, M.A., D.Sc., the other moiety of the proceeds of the Barlow-Jameson Fund, the President addressed him as follows :—Professor Groom,—

While at Cambridge you gave us two papers on palæontological and petrological subjects, and since then we have had from you, together with Mr. Lake, a paper on the Llandovery Rocks of Corwen, in which special reference is made to the structure of the district. Carrying out this line of research, you have contributed two elaborate papers on the Geological Structure of the Malverns, one of which is but lately published; and in these you have shown your knowledge of some of the latest methods of stratigraphical research, and your power of applying them to the elucidation of important problems in a somewhat difficult district. I trust that this award may be an encouragement to you to continue your good work.

Professor Groom replied in the following words:—Mr. President,—The scientific investigator has many and varied sources of pleasure: among the greatest of these must be reckoned the sympathies of his fellow-workers, and the appreciation of his efforts by those best qualified to judge. It is therefore with peculiar satisfaction that I understand from your kind words, and from the honour which the Council of the Geological Society have conferred upon me, that my work has met with approval.

The President then proceeded to read his Anniversary Address, in which he first gave obituary notices of several Foreign Members, Foreign Correspondents, and Fellows deceased since the last annual meeting, including Professor R. W. Bunsen (elected F.M. in 1856), Professor H. B. Geinitz (F.M. in 1857), Dr. Franz Ritter von Hauer (F.M. in 1871), Charles Brongniart (F.C. in 1888), Professor Louis Lartet (F.C. in 1882), Sir J. W. Dawson (elected a Fellow in 1854), G. Dowker (el. 1864), Sir William Flower (el. 1866), Sir Douglas Galton (el. 1848), T. M. Hall (el. 1865), Dr. H. Hicks (el. 1871), Sir Frederick McCoy (el. 1852), J. B. Redman (el. 1882), and John Ruskin (el. 1840). He also gave obituary notices of Major Lambart Brickenden, formerly for many years a Fellow of the Society, and of Lady Prestwich.

He then referred to the great advance in Geological Science in his own time, an advance that consisted largely of the arising of new lines of work and not merely of progress in old ones; thus Petrology was a new branch of the science. Palæontology had been affected by the growth of the Theory of Evolution. In Physical Geology such subjects as metamorphism, mountain-structure, and erosion had entered into new phases. In Stratigraphy the geological series had been extended downward below the Cambrian, and at the other end of the scale our knowledge of the Drift had greatly developed, largely owing probably to geological discoveries connected with the Antiquity of Man.

He then treated of the advance in our knowledge of Underground Geology, especially in the South-East of England, a subject in which comparatively little was known 45 years ago; and he described in some detail the underground extension and thickness of various formations, particularly of those below the Chalk, under the heads Upper Greensand, Gault, Lower Greensand, Wealden and Purbeck, Jurassic, Lias and Trias, and Older Rocks; referring to the amount of knowledge which we possess in the London Basin, and its southern border in the Wealden district, as compared with the Hampshire Basin.

He concluded that, as in the past such great progress had been made, so in the future would progress continue, with the development of new ideas and fresh methods of work, so that our younger geologists would have plenty of work before them.

The ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—*Council*: W. T. Blanford, LL.D., F.R.S.; Professor T. G. Bonney, D.Sc., LL.D., F.R.S.; Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S.; E. J. Garwood, Esq., M.A.; Alfred Harker, Esq., M.A.; F. W. Harmer, Esq.; R. S. Herries, Esq., M.A.; Rev. Edwin Hill, M.A.; William Hill, Esq.; Professor J. W. Judd, C.B., LL.D., F.R.S.; Lieut.-General C. A. McMahon, F.R.S.; H. W. Monckton, Esq., F.L.S.; E. T. Newton, Esq., F.R.S.; G. T.

CORRESPONDENCE.

THE GEOLOGICAL SURVEY OF EGYPT.

Sir,—In No. 427 of the Geol. Mag., January, 1900, p. 46, Mr. H. J. L. Beadnell, in a letter entitled "The Geological Survey of Egypt," refers to an abstract report (in *Zeitschrift für praktische Geologie*, Berlin, November, 1899) of my lecture, "Neues zur Geologie und Paläontologie Aegyptens" (Allgemeine Versammlung d. Deutsch. geol. Ges., 1899, in München).

From this abstract report he concludes that I claim to have myself "discovered the existence of rocks of Cenomanian age in Baharia Oasis," which, in fact, I never visited. I never did claim such a thing in any way, as shown by the manuscript of my lecture, *not yet printed*, and I cannot possibly be made responsible for an abstract report, which, as everyone sees from its title and its contents, is not written by me but by Mr. Dieseldorff, the reporter of the *Zeitschrift für praktische Geologie*. In this paper the names of the geologists mentioned in my lecture have been left out in order to shorten it, and there are other mistakes besides which I am sorry I could not correct, because a proof was not sent to me for correction. The authentic words of my lecture will be published soon.

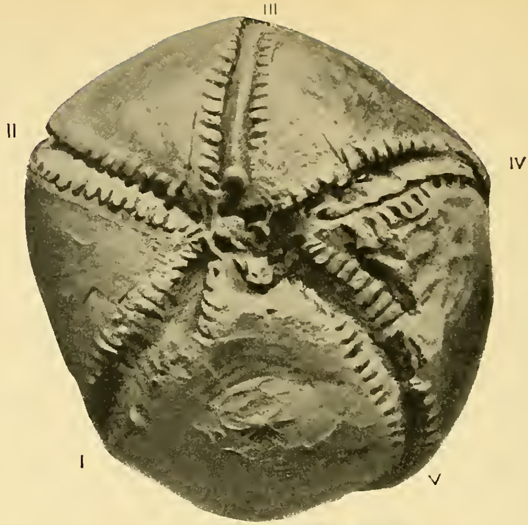
I desire to mention the following facts:—Although I did not myself find the fossils in the Cretaceous formation of the Baharia Oasis, yet I was the first to examine and recognize them as Cenomanian, and thus to prove the Cenomanian age of Baharia. Mr. Beadnell himself, who did not at all know the meaning of his fine fossils, was surprised by my discovery. This he will certainly not deny.

But as Mr. Beadnell justly sets a great value upon being named as discoverer of the fossils, I must claim the same right for myself with respect to the publication of notes in this Magazine on the Palæontology of Egypt. In the January number there is an essay, "On a New Species of Chelonian (*Podocnemis ægyptiaca*) from the Lower Miocene of Egypt," by C. W. Andrews, who describes some fossils collected by me at Moghara without anywhere mentioning my name.

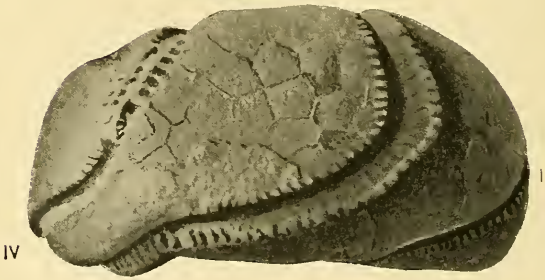
I wish to act in the interests of my former colleagues in Egypt also by asking the palæontologists of the British Museum to mention in each instance the name of the discoverers of the fossils referred to. M. Blanckenhorn.

Berlin.

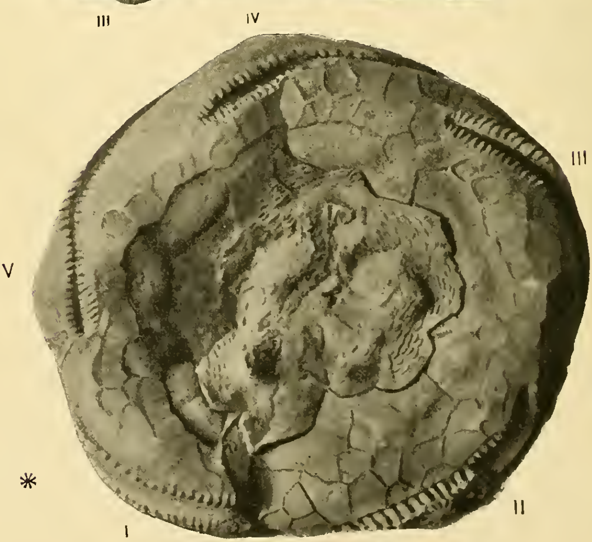
[*Unavoidably delayed in publication.*—Edit. Geol. Mag.]



1



2



3

J. GREEN PHOTO., F.A.B. DEL.

SWAN ELECTRIC ENGRAVING CO.

EDRIOASTER BUCHIANUS.

ERRATUM.

Page 147 (April Number), line 14 from bottom: *for* "on both the north and south banks," *read* "in cliffs both north and south."

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VII.

No. V.—MAY, 1900.

ORIGINAL ARTICLES.

I.—Studies in Edrioasteroidea. II. *Edrioaster Buchianus* Forbes sp.

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

(PLATES VIII, IX, and X.)

IN 1848, under the name *Agelacrinites Buchianus*, Edward Forbes introduced to science "one of the most remarkable Cystideans as yet discovered in British strata." His description and figures, published in his memoir "On the Cystideæ of the Silurian rocks of the British Islands" (Mem. Geol. Surv. Gt. Brit., II, pt. ii; see pp. 519–523, and pl. xxiii), have not proved fully intelligible to subsequent workers, even to those who have had the fossil before them. Unfortunately J. W. Salter, in his "Appendix. On the Fossils of North Wales," to "The Geology of North Wales" by A. C. Ramsay (Mem. Geol. Surv. Gt. Brit., III, 1st ed., 1866), criticised a little, but illuminated less; while the same Appendix in the second edition, 1881, though "greatly enlarged and partly rearranged by Robert Etheridge, F.R.S.," merely introduced verbal alterations into Salter's account.

Allusions to this fossil by writers who have not themselves examined it serve chiefly to show the need that exists for a fresh description. Through the kindness of the Director-General of the Geological Survey and of Mr. E. T. Newton, to whom my sincere thanks are here offered, the original specimens were placed at my disposal for several months. About two years ago the first draft of this paper and some of the illustrations were sent to Dr. Otto Jaekel in Berlin, and have been utilised on pp. 44–46 of his splendid volume "Stammesgeschichte der Pelmatozoen. I. Thecoidea und Cystoidea" (1899). Thanks to Mr. J. F. Whiteaves and the Director of the Canadian Geological Survey, I subsequently learned the true structure of *Edrioaster Bigsbyi*, which was unknown to Dr. Jaekel when he wrote the pages referred to. Hence some interpretations in the present account differ from those given by Dr. Jaekel. They agree, however, with the statements in chapter xii—The Edrioasteroidea—of "A Treatise on Zoology, Part III, The Echinoderma," edited by Professor E. Ray Lankester

(London, 1900). Some of the points will be better understood after publication of Study III, which will deal with *E. Bigsbyi.*

The terms used and the arrangement followed in the present account are the same as those in Study I. *Dinocystis Barroisi.*[1]

Horizon and Locality.

The specimens preserved under this name in the Museum of Practical Geology, V $\frac{3}{77}$, were obtained during the summer of 1847 from the Caradoc beds, two miles west of Ysputty Evan; that is to say, about two miles south of Pentre Voelas, and therefore in Denbighshire and not in Caernarvonshire as stated by J. W. Salter (op. cit., 1866, p. 262) and by R. Etheridge, sen. (op. cit., 1881, pp. 395 and 407). Mr. Etheridge informs me that the specimens were not found *in situ*, but were collected by Mr. Gibbs from a wall of loose stones, all of the same material. There seems, however, no reason to doubt that they came from the Caradoc beds of some quarry in the immediate vicinity, for they have the well-known characters of those beds. The matrix is an indurated sandstone, hardly to be described as "schistose" in any modern sense of the word. It contains remains of crinoid stems, brachiopods, and corals; the calcareous portions of these have been dissolved from the outer portions of the stone, and the same is the case with the edrioasteroid.

Description of the Type-Specimen.

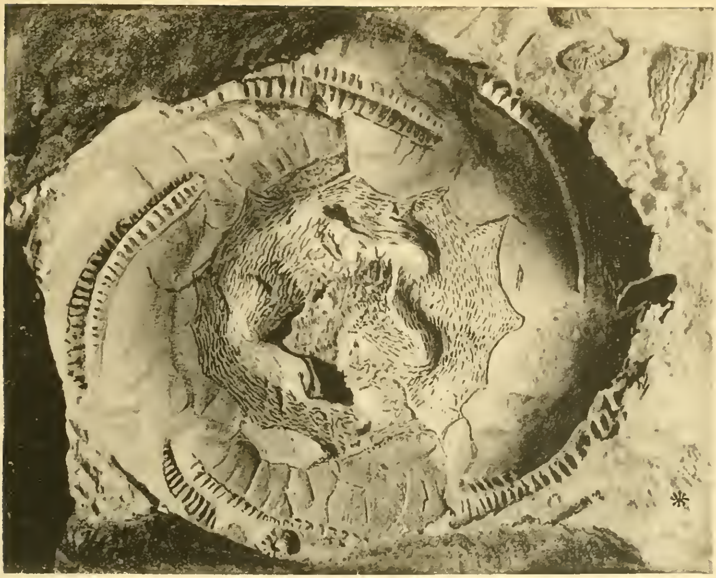
This consists of an *internal cast* of the whole individual (Pl. VIII) and an *external impression* of its abactinal surface (Pl. IX). There is also preserved, in the central region of the abactinal surface of the cast (Pl. VIII, Fig. 3), a small portion of the original theca. Except when said to be otherwise, the statements refer to the internal cast.

The periphery is subpentagonal; the sides of the pentagon correspond to the interradial areas, and are slightly convex. The length along the sagittal plane is 36 mm. The transverse diameter is 32 mm.[2] The greatest width of each side is about 20 mm.

From the periphery, the theca rises rather steeply, then curves gently over to a slight depression around the actinal pole; towards the under surface it bends more suddenly. Seen from the side (Pl. VIII, Fig. 2) the theca looks like a round cap squashed in at the top. If the fossil be placed on a flat surface, it reaches a height of 18·5 mm.; but the actinal pole is about 3·5 mm. below this. The under surface is excavate to about 5 mm., so that the length of the polar axis is about 10 mm. The specimen does not appear to have undergone more compression along this axis than it was capable of effecting spontaneously during life.

[1] Geol. Mag., n.s., Dec. IV, Vol. V, pp. 543–548, pl. xxi; Dec., 1898.

[2] To dispel possible perplexity, it may be said at once that Forbes' measurements are very inaccurate, sometimes inexplicably so.



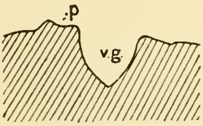
J. GREEN PHOTO., F. A. B. DEL. MORGAN & KIDD COLLOTYPE

EDRIOASTER BUCHIANUS.

On the Upper Surface (Pl. VIII, Fig. 1), five Radial Grooves proceed fairly straight to a distance of 13 mm. from the actinal pole. They then rather suddenly bend in a dextral or solar direction, and, at about 34 mm. from the actinal pole, pass on to the under surface of the theca (Pl. VIII, Figs. 2 and 3); here they continue along the edge until they have attained a distance of about 46 mm. from the actinal pole, when they terminate. The width of a groove in the proximal half of its course is 5·5 to 6 mm.; where it bends over to the underside, the width is about 5 mm., and gradually tapers to 2·5 or 2 mm., after which it is rapidly rounded off.

Of the five grooves, the anterior is the most perfectly preserved. In its proximal half it forms a rather deep V with slightly concave sides, as shown in section, Fig. 1. On the sides are ridges, passing outwards from the median line at an angle that varies with the curvature of the groove, but is never far from a right angle (Pl. X, Fig. 6). These ridges represent the sutures between the flooring-plates. Each ridge passes up to a prominence of somewhat ovoid outline, broader at the end next the groove; the side of the prominence towards the actinal pole has a gentler slope than the side away from it, so that the prominence as a whole seems to pass outwards in an abactinal direction. The depression between adjacent prominences is continued as an exceedingly slight concavity down the side of the groove to the middle line; slight though it be, it is observable in some parts where the sutural ridges on either side cannot be detected. The prominences, and consequently the sutural lines, on the two sides of the groove do not actually alternate; neither do they quite correspond. Therefore the ridge that may, in places, be seen at the bottom of the groove, representing the suture between the flooring-plates of the two sides, bends alternately to either side; in the tract figured (Pl. X, Fig. 6), a long stretch towards the right (of the figure) is followed by a short stretch towards the left.

Fig. 1.



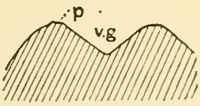


Fig. 2.

Sections across the internal cast of the anterior groove, both as seen from the oral side; × 4 diam. *v.g.* impression left by flooring-plates of subvective groove. *p.* matrix rising up into the pore between adjoining flooring-plates.

Fig. 1, from proximal region of groove.
Fig. 2, from more distal region, just on the periphery or ambitus of the fossil.

The distal region of any groove deviates from the structure just described only in the proportionately less depth of the groove, in the more pronounced alternation of the plates, and in the relative elongation of the prominences, which here merge more gradually into the sutural ridges. (See section of cast, Fig. 2).

A wax squeeze taken from the impression of the distal region of a groove (e.g. the left posterior, Pl. X, Fig. 7) restores the appearance formerly presented by the now vanished test as seen from the outside. In this region we see the flooring-plates rising slightly above the interradial areas, then presenting a narrow flat surface, then dipping down in a slightly convex curve to the middle line of the groove. The groove is less deep than in the internal cast, which means that the flooring-plates were thicker in the middle of the groove than at its margins. Between the flooring-plates, where they bend downwards, are elongate slits, wider towards the margins of the groove; these correspond to the prominences of the internal cast.

The right anterior and left posterior grooves are still filled in places by portions of matrix; and the hollows between this matrix and the internal cast enable one to reconstruct a section of the groove based on actual measurement. Fig. 3 is taken from the left

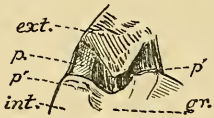


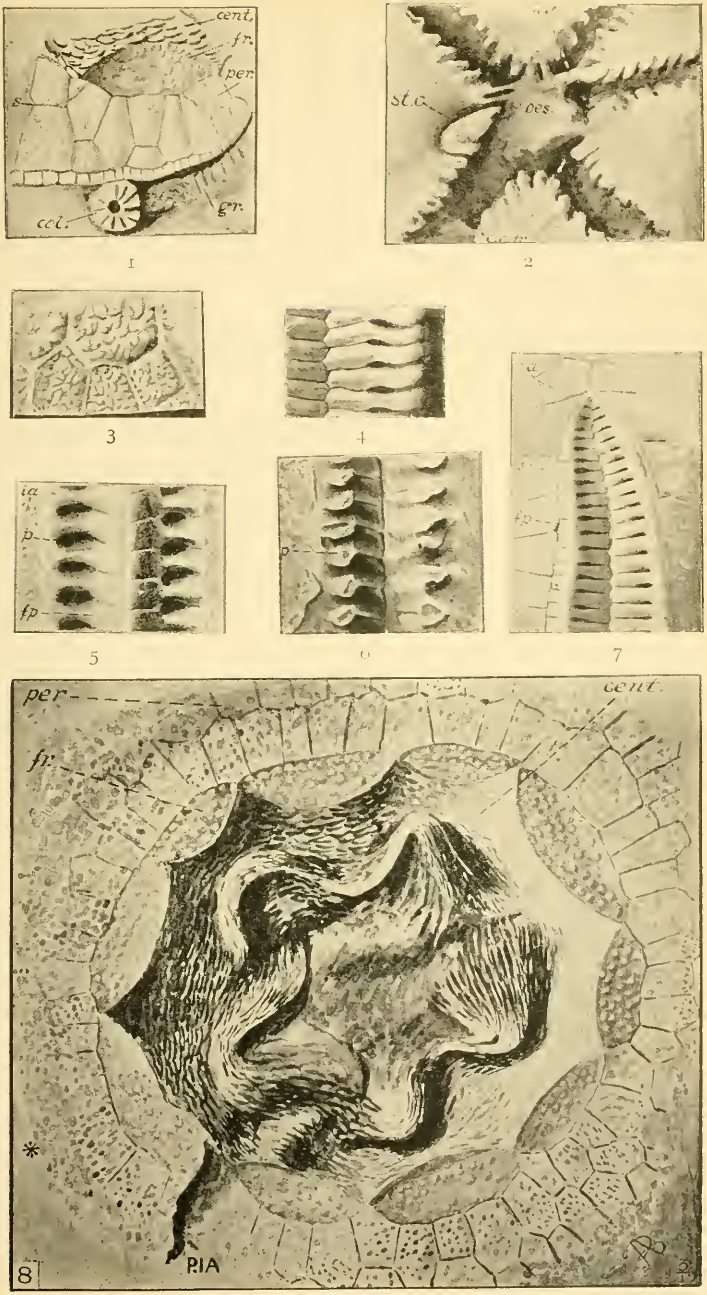
Fig. 3.—View of the left posterior groove, as preserved in the fossil. × 4 diam. *ext.* matrix filling the exterior of the groove. *int.* matrix filling the interior of the test. *gr.* groove on the surface of the latter. *p.* matrix filling pores between the flooring-plates. *p'.* scars where the same has been broken away.

posterior groove, at 5·5 mm. from its distal end. Here the plates are about 1 mm. thick at the edge of the groove, but thin considerably towards the middle line.

A good idea of the appearance of the groove as seen from the inside of the test is obtained from a wax squeeze of the internal cast (Pl. X, Fig. 5).

Forbes describes the "margin of the" grooves as composed of "areal or interambulacral plates bearing 2–3 short elevated transverse ridges, each of which points to the origin of an ambulacral plate, short and oblong; a double series of these ambulacral plates form the canal." It is hard to believe that Forbes did not understand he was dealing with an internal cast; yet this seems to have been the case, for he proceeds to describe the external impressions of the grooves as triangular arms "composed of two rows of dove-tailing joints, with ridges at the articulations to lock into the furrows bordering the arm-canal." From this truly remarkable misconception arose an extraordinary theory as to the nature of the radial grooves and as to the homologies of the ambulacral areas in Echinoids. After half a century one need not linger over mere errors of fact in the first sentence quoted. The present description and figures will enable readers to make the corrections themselves.

Piecing all this evidence together as in Fig. 4, we see that each radial groove was composed of a double row of flooring-plates, more or less alternating, and meeting in a median zigzag line. In the proximal half of the groove the long axis of each of these plates, nearly at right angles to the middle line of the groove, measured 3–3·5 mm., and the short axis, parallel to the middle line, ·9 mm. The total number of plates along one side of a groove was about 60



F. A. B. DEL.

MORGAN & KIDD PHOTOTYP.

EDRIOASTER BUCHIANUS.

(certainly more than the 50 which Forbes counted). The thickness of the plates towards their outer margins was about 1 mm. The plates were continuous with the interradial thecal plates, but rather thicker; at a little distance from the edge, they bent downwards at a rather sharp angle, so as to form a V-shaped trench with slightly convex sides. Seen from the inside the plates formed a ridge, with sides at first steep, then gradually rounding over.

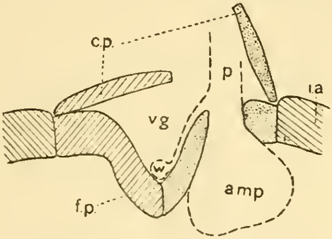


Fig. 4.—Reconstructed section across a subvective groove. × 6 diam. Compare with Fig. 1 on p. 195, and Fig. 3 on p. 196. The relations of the covering-plates are inferred from *Edrioaster Bigsbyi*. The position of the perradial water-vessel and its branch to the podium is deduced from the remains of *E. Bigsbyi* and the present species. Natural suture-surfaces are dotted; cut surfaces are ruled diagonally; supposed soft parts are in broken outline. *v.g.* subvective groove. *c.p.* covering-plates. *f.p.* flooring-plates. *i.a.* interambulacrals. *w.* perradial water-vessel, connected by a branch with the podium, *p.* *amp.* ampulla connected with the podium through the pore.

The adjacent sides of the plates were excavate so that pores were formed between them. Thus the groove was fringed with a row of pores on either side. These pores lay, not at the extreme margin, but just where the plates bent downwards; they passed outwards at an angle sloped away from the actinal centre; they were wider in the proximal portion of the groove, and more elongate in the distal portion. We may infer from the as yet undescribed structure of *Edrioaster Bigsbyi*, that the groove was roofed by covering-plates, which rested on the flattened border. But these covering-plates must have been detached and washed away before the theca was imbedded, since no traces of them remain.

Around the Actinal Pole the form of the internal cast is rather complicated (Pl. X, Fig. 2). The grooves curve down towards the pole, and at 2 or 3 mm. from the pole itself they bend downwards sharply. The central region is occupied by an irregularly shaped mass of matrix, with a broken surface about 3·5 mm. below the highest point of the cast. This mass probably represents the œsophagus. It is surrounded by a channel or, as it were, a moat, into which the down-bent grooves lead. At certain points, however, this moat is bridged by matrix, and in the two rays of the left side the extreme proximal ends of the grooves are similarly bridged. These bridges look like continuations of the prominences or infillings of the proximal pores. In the posterior interradius is a similar lump of matrix, mistakenly alluded to by Forbes (op. cit., p. 522) as "the projection which bore the anus." This is separated from the œsophageal matrix by the moat, and is itself bordered on its outer side by a semicircular channel, which dips down on each side to join the moat; just at those points, this channel is very nearly bridged by projections from its enclosed matrix almost joining the proximal prominences of the adjacent rays. Owing to the bridging and overhanging of the matrix, it is impossible to obtain a satisfactory wax squeeze of the channels; but, translating the appearances into the original stereom structures, we infer that the mouth was central and roughly five-lobed, widest on the posterior side, and that it was surrounded by a stout ring of stereom, over which the food-grooves passed. This latter structure may possibly be that described by Salter (op. cit., p. 291) as "a great thickening of the oral ossicles, just within the mouth." The proximal or adoral pores were connected with one another above this stereom ring, but below the outer theca, so as to form a closed ring-canal (hydrocircus) around the mouth. In the posterior interradius was a madreporite or hydropore-plate, the inner surface of which formed a semicircular projection for the attachment of the upper end of the stone-canal. This was more or less directly connected with the ring-canal. The existence of pores along the radial grooves almost certainly implies the presence of podia, as well as of perradial water-vessels connecting the latter with the ring-canal. But the specimen does not afford satisfactory evidence as to the position of the perradial vessels.

The shape of the Interradial Areas has been figured by Forbes (op. cit., pl. xxiii, fig. 5), but the arrangement of the plates thus represented, though not ridiculous, is imaginary so far as details are concerned. His drawing, however, presents a certain resemblance to the left anterior interradial area, here refigured (Fig. 5). This

Fig. 5.

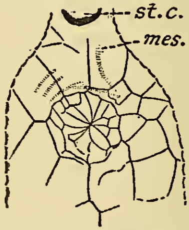


Fig. 6.

Fig. 5.—Arrangement of plates in left anterior interradius. Nat. size.
Fig. 6.—Arrangement of plates in upper part of posterior interradius. Nat. size. *st.c.* depression caused by stone-canal. *mes.* depression perhaps caused by mesentery.

shows the marks left by the plates pretty clearly, and indicates that they were irregular polygons of various sizes, apparently not imbricate. The only regularity visible in their arrangement here is a band of plates bordering the right side of the area, and passing across it at the lower edge of the theca, while another less regular band runs parallel to, and on the inner or left side of, this outer one. Down to and including these bands, there were 36 plates in the left anterior interradial area. The greatest width of this area is 13·75 mm.; that of the posterior area is 16·5 mm. The latter also tapers less rapidly towards its actinal end, where the hydropore was situated.

The greater width of the posterior interradial area (Fig. 6 and Pl. VIII, Fig. 1) is due to the anal opening, which lay in this area about half a millimetre to the left of its middle line and at 11 mm. from the actinal pole. The anal pyramid ("ovarian pyramid" of Forbes) was not a regularly constructed pyramid surrounded by a definite rim, but was a roughly circular area of about 6·25 mm. in diameter, the plates of which appear to have risen from under the edges of the surrounding interradials. The plates contained within this circle seem to have been irregularly disposed in two circlets. The plates of the outer circlet were not so long as those of the inner. These latter were roughly triangular and met in a central point, where doubtless was the anus; the sutures indicate their number as 11, although Forbes estimated them at only 5. The anal pyramid can hardly be described as raised; but above it, and half surrounding it, is a semicircular depression with three concentric wrinkles plainly marked on its left side. Immediately on the right of the anus, the test is not depressed. In the adjacent (r. post.) interradius there is a slight elevation of the theca at this level, clearly shown in the side-view (Pl. VIII, Fig. 2). The wrinkled depression in the anal interradius may be ascribed to the contraction after death of some internal structure, presumably the mesentery attaching the stone-canal to the theca. The slight swelling that curves round from the anus may indicate the course of the rectum; and this would imply that the gut had a dextral coil. Jaekel also has expressed this view (op. cit., p. 46).

The Under or Abactinal Surface of the theca (Pl. VIII, Fig. 3, and Pl. IX) is partly bounded by the dextrally curved ends of the radial grooves, which, as seen from below, of course appear sinistral. The excavate space included by these may be divided into three regions, which, proceeding from without inwards (i.e. from oral to aboral), are as follows:—

(1) Peripheral Area.—A closed ring formed by small polygonal plates like the interradials, with which they are in fact serially homologous. These plates are roughly arranged in rows continuing the spiral twist of the grooves. They are a little smaller than the majority of the interradials, and their long axes are directed more or less radially to the vertical axis of the theca.

(2) The Frame.—A closed ring of 11 thicker and larger plates, with their long axes tangential to the vertical axis of the theca. Their outer margins are slightly scolloped by the sutures with the plates of the peripheral area; the inner margin of each forms a curve, convex towards the aboral pole. These plates seem to alternate in size, a smaller plate corresponding to each interradius and a larger to each radius. Two plates go to the wider posterior area. Too much stress, however, must not be laid on this slight appearance of regularity. These plates were ornamented with small tubercles, the traces of which are seen on both the cast and

the impression, more pronounced than those left by the interradials of the actinal surface.

(3) Central Area.—The whole space within the frame is still covered in the cast by what appears to have been a flexible

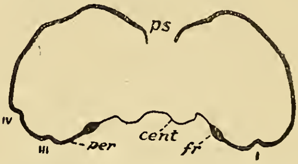


Fig. 7.—General section across the theca of *Edrioaster Buchianus*, about in the transversal plane. Natural size. i, iii, iv, three subvective grooves (compare Plate VIII). *ps.* peristome, the thickening of the circumœsophageal ring not shown. *per.* peripheral area of the abactinal surface. *cent.* central area of same. *fr.* frame surrounding the latter.

integument, in which were deposited minute, loosely calcified, imbricating plates. The imbrication is such that the outer edges of the plates are directed away from the abactinal pole. The exact arrangement of this, and its relation to the surrounding plates, are, however, best made out from a wax squeeze (Pl. X, Figs. 1 and 8) of the impression (Pl. IX).

Forbes speaks of this central portion as a "tough membrane," over which "from the centre radiating lines, with the appearance of having been caused by vessels, proceed, dividing in their course . . . The markings . . . resemble those of *Ischadites.*" There can be no doubt, now that we know the structure of other Agelacrinidæ so much better than Forbes could, that these lines are merely the edges of imbricating plates. This was fully recognised by Salter (op. cit., p. 291).

Forbes' view is here mentioned in order to explain his next sentence. "The plates immediately bordering it [the membrane] are rather larger than the others, and all the plates of the base are marked with twin pore-like dots, connected by a groove." By "all the plates of the base" we must understand, not the minute imbricating plates of the membrane, but the 11 plates forming the frame, and the smaller plates of the peripheral area. Forbes' pl. xxiii, fig. 7, shows these diplopores on one of the frame-plates, but not on the membrane, while the peripheral plates are only drawn in outline. I have been quite unable to distinguish any structure at all resembling the diplopores so clearly described and figured by Forbes; there is nothing more than the tuberculation already referred to. Salter says, "The surface of the plates [in general] is granular, but I can see no trace of spines; nor can I see the chain-like pairs of pores on the puckered membrane, as figured by Forbes in his fig. 7. I think the artist has been deceived by the imbrication of the small calcareous plates which covered this surface." The chief conclusion to be drawn from these bewildering remarks is that Salter did not take the trouble to understand the clear description and figure of his predecessor. Salter's statement, however, was repeated in modified language by Etheridge (op. cit., p. 482), and it may therefore be considered that two palæontologists of repute were, as I am, unable to see the diplopores described by Forbes and drawn by C. R. Bone.

The most important features of the abactinal membrane are 5 prominences or evaginations of it. They form a fairly regular pentagon, each corresponding to an interradius, but they bear no evident relation to the angles of the central area. Each evagination has a rounded U-shaped margin, the apex directed away from the thecal axis. The raised margins are not absolutely continuous. Within the margins the membrane is again depressed, and just in the middle, about the actinal pole, it cannot be traced in either cast or impression. Possibly it was here very thin and contained no imbricating calcareous plates. There is, however, no evidence that there was either a stem-attachment, as Forbes thought, or any opening from the gut or the body-cavity to the exterior.

These evaginations of the aboral membrane, alluded to by Forbes as "prominences" (p. 522) and "peduncles" (p. 538), received another explanation from Wyville Thomson.[1] He writes (p. 110): "In the specimen of Agel. Buchianus (Forbes), in Jermyn Street, there is a rudely pentagonal stamp on the apical surface, which is probably the impression of the wide base of a pyramid of jaws like that of Echinocystites, on the inside of the coriaceous integument." This is very incorrectly expressed, and were it not for some remarks by Salter (op. cit., pp. 290, 291), would be unintelligible. By "the pentagonal stamp," Thomson seems to have meant, as Salter says, "the five indentations figured by Forbes, fig. 6," i.e. indentations not on the apical surface, but on the impression of that surface, and therefore not really indentations but prominences. Salter, attempting to improve on Thomson, speaks of them as "large buccal teeth . . . which must, I suppose, represent the 'lantern' in the *Echinus*."

To this interpretation of the prominences there are objections of three distinct kinds. First, the specimen, though it shows traces of the circumoral ring plainly enough, shows within or below this ring no traces whatever of jaws or teeth. Secondly, the buccal armature of *Palæodiscus* would not make an impression of this nature or in this position, while that of *Echinocystis* is not large enough to make any such impression at all.[2] Thirdly, it is inconceivable that an Echinoderm of distinctly pelmatozoan type, with mouth upturned and with deep subvective grooves, can have had any use for stout biting jaws; even if descended from a gnathostomatous Echinoid (a quite absurd supposition) it would have lost its jaws before attaining its present habit and structure.

The meaning of these five extrusions of the aboral membrane must be sought among other Pelmatozoa. They must have been

[1] C. Wyville Thomson, "On a new Palæozoic Group of Echinodermata": Edinburgh New Phil. Journ., N.S., vol. xiii, pp. 106–117, pls. iii, iv: Jan., 1861.
[2] See W. J. Sollas, "On Silurian Echinoidea and Ophiuroidea": Quart. Journ. Geol. Soc., vol. lv, pp. 692–715; Nov., 1899.

made by some system of organs that had undergone division into five, and had the pentameres interradial. The stomach, gonads of Echinoid type, and water-vascular system seem therefore to be excluded, while the chambered organ of crinoids is forcibly suggested.

It is clear that the frame of 11 large plates gave some rigidity to the base, while within this the membrane was very flexible, capable of extension and contraction. These arrangements may have served a twofold purpose. If the theca were compressed by any external agent, the soft parts and the fluid contents of the cœlom would have been squeezed out into this extensile sac, which thus acted as a safety-valve. Or the vertical mesenteries of the cœlom may have been attached to it, and, developing muscles as in Echinothuridæ, may have been able to withdraw it within the frame; if the outer edge of the theca were closely apposed to the ground, the effect of this would be to create a vacuum and so hold the creature in its position like a limpet. In the dead animal, when the tissues shrank, the aboral membrane was naturally pulled upwards, and at the same time other parts of the theca were pulled inwards. Hence arose the stretching of the membrane over the internal (? chambered) organs, in the same way as the wrinkled depression already noticed in the posterior interradius. Jaekel's opinion that the central area of the abactinal surface was fixed (*aufgewachsen*) on a not quite hard bottom, does not seem in accord with the shape of the theca or with the sharp definition of these five lobes.

Other Specimens.

The various stem-fragments ascribed by Forbes to this species can, as already noted by Salter and Etheridge, have had nothing to do with it. They were found in the same stone wall, but not in juxtaposition with the theca. Neither can the 4-rayed impression so badly represented in Forbes' pl. xxiii, fig. 14, be regarded as "the impression of the base, probably of a similar cystidean."

There was found, however, one other fragment, which I am unable to fit on to the type-specimen, and therefore regard as indicating the existence of another individual. It is an impression of part of an ambulacrum, 16 mm. long, and of portions of the adjacent interambulacra, one of which shows very clearly the markings produced by the ornament of the plates (Pl. X, Fig. 3).

No other specimen of this species is known.

Systematic Position.

Forbes called this species *Agelacrinites Buchianus*, comparing it first with the specimen discovered by Bigsby, and described and figured by G. B. Sowerby in the Zoological Journal (vol. ii, pp. 318–320, pl. xi, fig. 5, 1826), and afterwards named *Agelacrinites Dicksoni* by E. Billings (1856); and secondly with *Agelacrinites hamiltonensis*, Vanuxem, which is the type of the genus. Forbes considered it as a Cystid, allied to the Echinoidea.

Salter (op. cit., p. 290), while retaining the species in *Agelacrinus*, considered it as more allied to the species described by Billings as

Edrioaster Bigsbyi, 1858. In the list on p. 262 of the same work it is actually called "*Edrioaster Buchii* (*Agelacrinus*, Forbes)." The same is the case in Etheridge's revision of Salter (pp. 481 and 395).

Salter's opinion is abundantly justified not only by the details of the present paper, but by the new facts concerning *Edrioaster Bigsbyi*, which will form the subject of the next study. To that it is better to postpone the diagnoses of the genus and of the present species.

EXPLANATION OF PLATES VIII, IX, and X.

Edrioaster Buchianus.

[All the figures are from the type-specimen in the Museum of Practical Geology, except Pl. X, Fig. 3, which is from a fragment associated with it. Plates VIII and IX are based on photographs by Mr. J. Green; the figures of Plate X are drawn directly from the specimens or from wax squeezes thereof. The figures of Plates VIII and IX are magnified two diameters; those of Plate X are enlarged to the extent stated under each. Difficulties of lighting have rendered impossible a rigorous maintenance of the standard orientation; where doubt might have arisen the position of the anal interradius has been marked by a *.]

Plate VIII.—The internal cast.

Fig. 1.—Actinal surface, showing peristomial and anal areas clearly, and the subvective grooves here occupying an almost strictly radial position and marked i–v from left posterior to right posterior.

Fig. 2.—Side view, showing the curvature of the subvective grooves. The anterior groove (iii) passes across the middle of the figure. The plates of the right anterior interradius (between iii and iv) are fairly distinct.

Fig. 3.—Abactinal surface, showing in its central area a portion of the original test (compare Pl. X, Fig. 8). The numbers i–v here correspond to those of Fig. 1, and mark the radii, while the subvective groove corresponding to each number is now seen to have passed through fully one-fifth of the circumference away from it: e.g. the anterior groove (iii of Fig. 1) now comes into the right anterior radius (iv). Close to number ii some matrix fills the groove, and on this is the impression of a columnal of some crinoid or cystid.

Plate IX.—The external impression of the abactinal surface. The upper figure is lit from the right hand, the lower figure from the left hand. These figures, with Fig. 3 of Pl. VIII, give the evidence on which Pl. X, Fig. 8 is based.

Plate X.—Enlarged details.

Fig. 1.—A wax squeeze from a portion of the impression of the abactinal surface, showing accurately the relations of the plates; × 3 diameters. Compare Forbes, pl. xxiii, fig. 7. *cent.* small plates of the central area. *fr.* a frame-plate. *per.* plates of the perradial area. *s.* suture between two of the latter, apparently crenulate. *gr.* portion of left anterior subvective groove. *col.* columnal lying on matrix that fills a part of this groove.

Fig. 2.—The peristomial region of the internal cast, slightly diagrammatised, and seen from right posterior interradius; × 2 diam. *st.c.* a depression where a semicircular ridge on the inside of the test is supposed to have supported the stone-canal; the matrix within this would thus have underlain the madreporite. *oes.* matrix filling the œsophagus. *c.o.fr.* hollow space surrounding the latter and presumed to have been occupied by a circumœsophageal frame of plates (modified flooring-plates). *w.v.* strands of matrix bridging over the space just mentioned; they seem to be serially homologous with the podial or pore scars, and may represent water-vessels connecting the adoral podia with a circumoral water-ring.

Fig. 3.—Interambulacrals showing vermiculate ornament and raised, slightly crenulate suture-margins. From a wax squeeze of a fragment associated with the type. $\times \frac{5}{2}$.

Fig. 4.—Flooring-plates in the distal region of the left anterior groove, drawn from a wax squeeze of the external impression. × 6 diam.

Fig. 5.—Portion of the anterior groove as seen on the inside of the test, drawn from a wax squeeze of the internal cast; × 5 diam. *ia.* interambulacrals. *p.* pores for the passage of the podia or of the ampullæ from the podia. *f.p.* flooring-plates. The proximal end is uppermost in the drawing.

Fig. 6.—The internal cast of part of a subvective groove; the complement of Fig. 5. × 5 diam. *p'.* projecting scars of matrix that filled the podial pores.

Fig. 7.—The distal end of the left posterior groove, from a wax squeeze of the external impression; × 4 diam. Lettering as in Fig. 5.

Fig. 8.—The central part of the abactinal surface, from a wax squeeze of the external cast (Pl. IX), slightly diagrammatised, since details are often obscure in the specimen; × 3 diam. *per.* peripheral area. *fr.* frame. *cent.* central area, with its flexible plated membrane, raised in five interradially situate lobes. * position of posterior (anal) interradius. P.IA. the meridian in which plates of the posterior interradius (i.e. posterior interambulacrals) pass from the actinal to the abactinal surface and merge with the peripheral plates of the latter.

II.—Bala Lake and the River System of North Wales.

By Philip Lake, M.A., F.G.S.

Introduction.

The evolution of rivers and the origin of lakes have recently attracted a considerable share of attention; and the principles which should guide us in tracing the development of a drainage system have been expounded by several authors, both in England and in America.

Little, however, has been written on the lakes and rivers of North Wales. In 1876 Ramsay,[1] who was one of the pioneers in questions of this kind, endeavoured to decipher the history of the Dee and of Bala Lake; and subsequently he performed a similar office for the Clwyd.[2] More recently Mr. Strahan and Mr. Morton[3] have dealt with the latter river.

A few papers,[4] also, have been written on the tarns or 'Llyniau' of Caernarvonshire; but with these we are not directly concerned.

In the following pages an attempt is made to explain the origin of Bala Lake, and to show how the river system of North Wales was established and was subsequently modified; but the formation of the Vale of Clwyd is barely touched in this investigation.

It is scarcely necessary to point out how deeply I am indebted to the writings of Mr. Marr, to which, in fact, whatever there may be of value in my labours is primarily due. For although the present drainage system of North Wales differs greatly from that of Cumberland and Westmoreland, yet in some respects the resemblance is so close that it is Mr. Marr's work in the Lake District which has enabled me to attempt an interpretation of the river

[1] Quart. Journ. Geol. Soc., vol. xxxii (1876), pp. 219–229. See also Mem. Geol. Surv., vol. iii (1881), 2nd ed., pp. 314–323.

[2] Mem. Geol. Surv., vol. iii (1881), 2nd ed., pp. 306–313.

[3] G. H. Morton: Proc. Liverpool Geol. Soc., vol. viii (1897–98), pp. 32–65, 181–204. A. Strahan: Geol. Mag., 1899, pp. 111–117.

[4] W. W. Watts: Brit. Assoc. Reports, 1895, pp. 683, 684. W. A. Brend: Geol. Mag., 1897, pp. 404–407. J. E. Marr & R. H. Adie: Geol. Mag., 1898, pp. 51–61.

system of North Wales. Mr. Marr, however, finds no evidence of the differential movements which seem in Wales to have played so important a part in modifying the original drainage system.

My thanks are also due to Mr. A. L. Hall, of Caius College, Cambridge, and to Mr. J. B. Scrivenor, of Hertford College, Oxford, for invaluable assistance in sounding Bala Lake; and I am, besides, under obligation to Mr. Hall for help in other portions of the work.

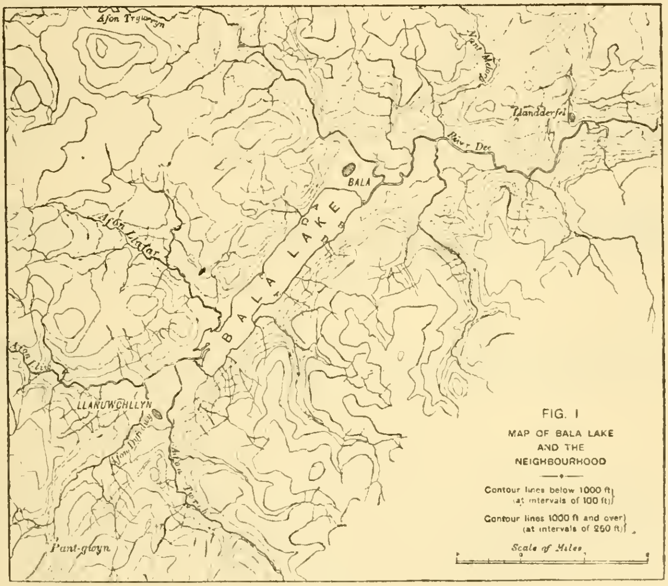


Fig. 1.

Contours below 1,000 feet indicated by dotted lines.
Contours 1,000 feet and over indicated by continuous lines.

Topography of Bala Lake and of the valley in which it lies.

Bala Lake (see Fig. 1), the largest natural sheet of water in Wales, is nearly four miles long and about half a mile wide. It is oblong in shape and unusually regular, the two sides being remarkably straight and parallel, so that the width is nearly uniform throughout. The straightness of the sides is interrupted only by the peninsulas of Llafar, Llangower, and one or two smaller points; and all of these are mere tongues of alluvium. At each end there is a wide alluvial plain, and the lake owes its symmetry partly, but not entirely, to these alluvial deposits.

On February 19, 1885, the surface of the water was determined by the Ordnance Survey to be 529·9 feet above Ordnance Datum;[1]

[1] Merionethshire (6 inches to 1 mile): Quarter-sheets xxii S.W., xxii N.W., and xxii N.E.

and on August 3, 1899, in a dry season, Mr. Hall and I found it to be 15·3 feet below B.M. 543·7 (about a mile south-west of Llangower), or 528·4 feet above O.D. The level of the water, therefore, seems to vary but little, and it may be taken as about 530 feet above the sea.

The depth of the lake is stated by Ramsay to be about 130 feet.[1] On August 1, 1899, Mr. Hall, Mr. Scrivenor, and myself took a series of soundings, and the greatest depth which we measured was 126 feet. This was at a point a little distance north of the Llangower peninsula.

Our soundings were taken along the three lines shown upon the map (Fig. 1). As they were made with 'water-cord,' which is liable to stretch, they are not exact, but (corrected by subsequent experiment) they are probably not more than a few feet out in any case. All the sections[2] (Fig. 2) showed that the sides of the lake

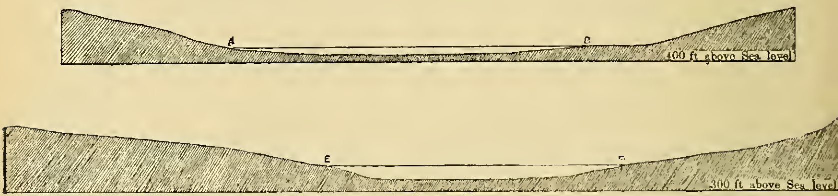


Fig. 2.—Sections of Bala Lake along the lines A–B and E–F in Fig. 1. Scale (horizontal and vertical), 3 inches = 1 mile.

slope inwards at an angle, which, indeed, is not very steep; but the bottom of the slope is well defined, and the central portion of each section is nearly flat. The maximum depth in the line A–B was 66 feet, in the line C–D 77 feet, and in the line E–F 126 feet. The floor of the lake, therefore, appears to slope from north-east to south-west, that is to say, in a direction opposite to the present flow of the water. It would, however, require a more extended series of observations to prove that this slope is continuous.

In the paper already mentioned,[3] Ramsay assumes that there never could have been any other outlet for the water of the lake than the channel of the Dee; and because the Dee flows over rock *in sitû* at a higher level than the bottom of the lake, he concludes that the lake must lie in a rock basin. In the light of Mr. Marr's recent researches on the tarns and lakes of Cumberland and

[1] Quart. Journ. Geol. Soc., vol. xxxii (1876), p. 219.

[2] Our positions were determined by compass bearings from the shore, and have no pretensions to precise accuracy. The section A–B and the south-eastern half of the section E–F are probably correct; but in the north-western half of the section E–F the angles of intersection were somewhat acute, and the positions of the soundings are therefore not so accurately fixed.

[3] "On the Physical History of the Dee, Wales": Quart. Journ. Geol. Soc., vol. xxxii (1876), pp. 219–229. See also Mem. Geol. Surv., vol. iii (1881), 2nd ed., pp. 314–323.

Westmoreland,[1] it is impossible now to maintain this view without a closer examination of other possible outlets.

Now, although Bala Lake empties itself through the Dee, which flows in an easterly direction from its north-eastern end, this is not what the general topography of the district would lead us to expect. The lake does not lie in the continuation of the Vale of Edeyrnion (as the valley of the Dee between Llandderfel and Corwen is called); but it lies in a very distinct and well-defined valley which runs from the sea at Barmouth in a north-easterly direction to the town of Bala; and this valley is entirely shut off from the Vale of Edeyrnion by a ridge of hills, except for the narrow gorge through which the Dee now flows. This great valley is in the line of the Bala fault, and from Dolgelly to Bala its direction is S.W.–N.E., which is precisely that of the lake; while the general direction of the Dee for several miles after leaving the lake is nearly west to east.

It is true that the actual watershed crosses the valley at Pant-gwyn, and that on the one side the waters flow into Bala Lake and thence to the Dee, while on the other side they flow into Afon Wnion and finally into the estuary of the Mawddach. But the watershed forms no feature in the valley, and the slope which determines the direction of flow is so slight that it requires a very careful examination of the streams to discover the position of the water-parting. The floor of the valley in no place rises to a greater height than 774 feet above the sea, i.e. about 374 feet above the bottom of the lake. The depth of the valley near this point is entirely out of proportion to the size of the little rivulets which now flow in it.

Continuing the line of the valley in which Bala Lake lies, it leads us in a north-easterly direction, not along the course of the Dee, but into the valley which is now occupied by Nant Meloch and its tributary from Cors-y-Sarnau. This is a stream which flows from north-east to south-west, and which would enter the lake near Bala, were it not that before it reaches that point it is suddenly deflected almost at right angles, so as to join the Dee at Melin Meloch.

If the gorge near Llandderfel were blocked, this stream would flow into Bala Lake, and Bala Lake would empty itself into the Wnion; and we should have a continuous flow of water down what is now undoubtedly a continuous valley running from north-east to south-west.

From these topographical considerations alone, it appears probable that the drainage of the district originally flowed in this direction, and that the present outlet of the lake is of subsequent formation. In favour of this view it may be noted that at the foot of the lake there is an alluvial plain, which is even more extensive than that which is now being formed at its head; and also that the floor of the lake appears to slope from north-east to south-west.

[1] See, especially, "The Tarns of Lakeland": Quart. Journ. Geol. Soc., vol. li (1895), pp. 35–48. "Additional Notes on the Tarns of Lakeland": ibid., vol. lii (1896), pp. 12–16. "On the Lake Basins of Lakeland": Proc. Geol. Assoc., vol. xiv (1896), pp. 273–286.

Is Bala Lake a rock-basin?

There are only three directions in which we can leave Bala Lake and travel towards the sea without crossing the contour-line of 1,000 feet.

The first of these is north-east, up the valley of Nant Meloch, and along the road to Corwen, where the greatest height to which we are compelled to rise is 891 feet, about 1¼ mile from Bethel Inn.

The second is east, along the course of the Dee; and this is necessarily a continuous descent.

The third is south-west, along the valley of the Bala fault, where we can reach the sea without ever rising higher than 774 feet.

Elsewhere the lake is completely shut in by the 1,000 foot contour-line, and there is no reason to suspect the existence of any former outlet.

I have not examined very closely the valley of Nant Meloch; but I believe that in this direction the rocky floor rises considerably above the level of the bottom of the lake. Even now, where the bottom of the valley is 600 or 700 feet above the sea, the valley is narrow and steep-sided, and it seems improbable that the solid floor lies two or three hundred feet below the present level. The valley, however, deserves a more careful examination than I have been able to give it.

If we follow the present course of the Dee from Bala Lake, we pass first over a wide alluvial plain until we near the ridge which crosses the line of the river at Bodweni, about 2½ miles east of Bala. Here the Dee enters a narrow and rather steep-sided gorge, and is closely hemmed in by hills of solid rock; and a little farther on, the bed itself is formed of rock at a height of about 495 feet above the sea, or 95 feet above the bottom of the lake. So narrow is the valley at this point, and so close lie the exposures of solid rock, that there seems to be no room for any drift-filled gorge; and there can be but little doubt that in this direction at least, as Ramsay pointed out, the lake is rock-bound.

South-westerly, however, along the line of the Bala fault, it is impossible to prove that the solid floor of the valley is at any point higher than the bottom of the lake. Following upwards the course of the Dyfrdwy, we find that at Tal-y-bont the stream flows over rock *in sitû* at a height of more than 600 feet. But the valley here is very wide, and for many hundred yards south-east of the stream there is nothing to be seen but drift. It is quite possible, therefore, that another channel may exist which is now concealed.

No more rock is exposed *in sitû* in the bottom of the valley until we have passed the watershed and proceeded down the other slope to Drws-y-nant-isaf. A few hundred yards below the railway station the river runs in a little rocky gorge, the floor of which is also made of rock; and the height of this floor is about 460 feet above the sea, that is to say, about 60 feet above the bottom of the lake. But at this point, exactly, in fact, where it enters the gorge, the river has left the line of the Bala fault and has been deflected to the right; while in the direct line there is a slight depression, which is certainly filled with drift, however deep or shallow that drift may be.

Here, again, it is impossible to assert that the solid floor of the valley is higher than the bottom of the lake. And as no more rock is seen *in sitû* until we pass below the level of the lowest point of the lake, we are compelled to admit that in this direction there is no certain evidence that the lake is rock-bound.

So far, then, as this evidence goes, Bala Lake may have been formed in the same way as the lakes of Cumberland and Westmoreland. The sections show that, like them, it is a submerged river valley. Its general direction and the slope of its bed indicate that the valley of which it is a portion is the valley of the Bala fault. Originally, no doubt, the waters drained south-westward into the sea at Barmouth (or, perhaps, at Towyn). But the channel was subsequently blocked, and the drainage of the upper portion was forced to seek a fresh outlet.

I shall, however, give reasons for supposing that, although the old channel may have been choked by drift, the reversal of the drainage was due, at least in part, to earth-movements; and that it was these earth-movements which determined the position of the watershed.

Relation of the Faults to the Valley and to the Watershed.

That the valley to which, as we have seen, Bala Lake belongs, is in the line of a great fault, has long been known; and the fault is represented on the Survey maps as passing down the middle of the lake. It lies, I believe, more nearly along the south-eastern shore, and the opposite shore coincides with the line of a second fault, which, like the former, has its downthrow towards the lake. Thus the lake lies in the continuation of a trough, and its two sides coincide or nearly coincide with the two faults enclosing the trough.

South of Pant-gwyn the valley is very narrow. Its north-western side is formed of volcanic rocks, which are usually supposed to be of Arenig age, while the south-eastern side is formed of Middle Lingula beds containing *Lingulella Davisi.* But the floor of the valley is concealed by drift and alluvium, and there is nothing to indicate the exact position of the fault which undoubtedly exists, nor is there any evidence to show whether this fault is simple or compound.

At Pant-gwyn, however, the valley opens out; the faults are much more clearly seen, and here they form a complex system which we shall now proceed to examine. (Fig. 3.)

It is, perhaps, unnecessary to give in detail the evidence on which these faults are drawn. It will almost be sufficient to say that, in general, wherever the volcanic series exists, it is conspicuously visible, and it is an easy matter to trace its boundary.

The slates below the volcanic series are also well enough exposed, but it is different with the post-volcanic slates in the valley; and as many of the exposures of these beds are difficult to find, it may be well to enumerate them.

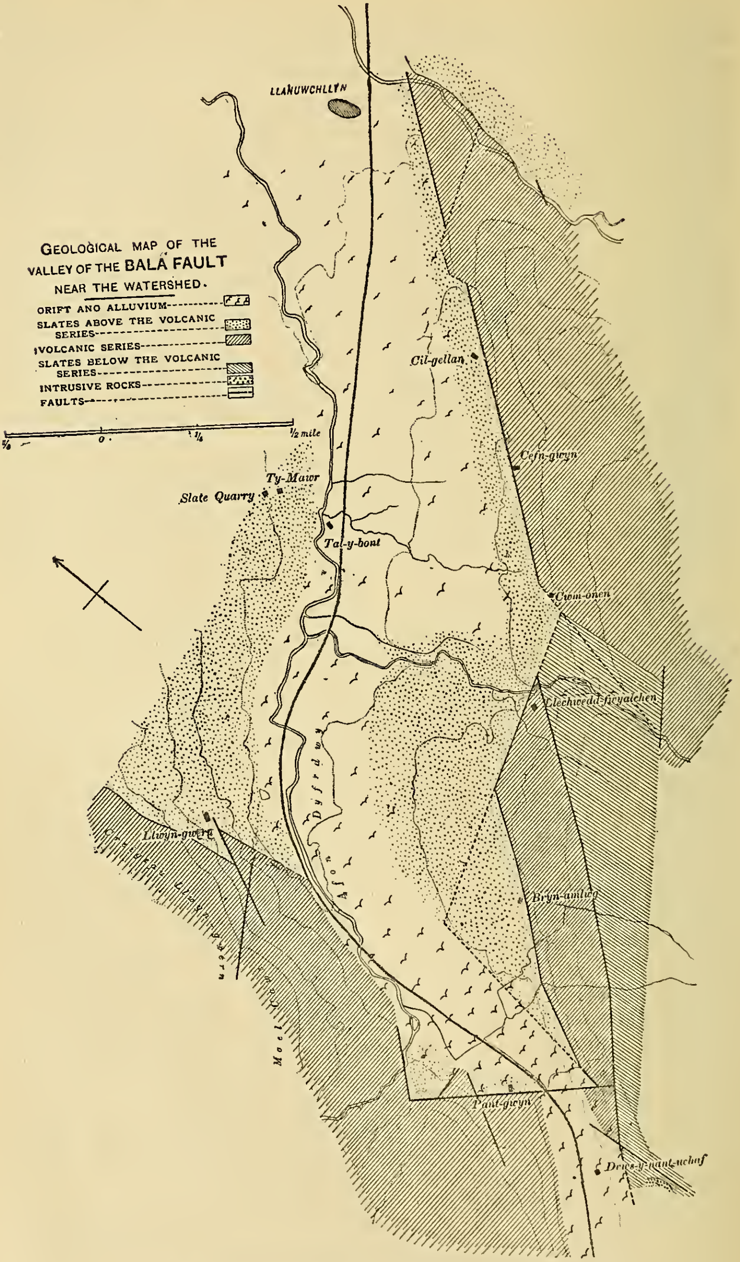


Fig. 3.—Geological Map of the Valley of the Bala Fault.

On the south-east side of the valley, these slates are visible close to the Bala fault at Cilgellan, and again between Cefn-gwyn and Cwm-onen. They, as well as all the other rocks, are well exposed in and near Afon Dwrnudo.[1] They occur also in the banks of a small stream about 300 yards below Bryn Amlwg; and again, close to the Bryn Amlwg patch of volcanics, in the streamlets near the transverse fault.

On the other side of the valley, the slates are found in the farm-yard of Pant-gwyn. They are well exposed in the triangular patch four or five hundred yards north-west of that farm; and in the Dyfrdwy they are seen to overlie the volcanic series, dipping 5° S. of E. (true) at an angle of 38°. They occur also in the quarry near Ty-mawr and in the bed of the river close to Tal-y-bont.

In the neighbourhood of Llwyn-gwern these slates are visible in several places, and the volcanic series dips beneath them. South-east of Llanuwchllyn also, in the valley of Afon Twrch, the slates and ashes are clearly shown, and the ashes dip beneath the slates; but the boundary is here more complex than is represented upon the map, being faulted by a series of little faults of which only one or two are indicated.

The north-to-south fault which lies east of Drws-y-nant-uchaf is plainly visible in the stream 300 yards above the farm, where it brings black slates (presumably Upper Lingula) on its eastern side into contact with Middle Lingula Flags (containing *Lingulella Davisi*) on its western side. The eastern is therefore the downthrow side, and as the hade is towards the west the fault is reversed. The crushing due to this fault is also seen in the little rivulet some 200 yards north-east of the farm.

The fault which is drawn between Moel Caws and Creigiau Llwyn-gwern nowhere, so far as is visible, brings beds of different character into contact with each other, and is inserted upon less evidence than the rest. But I venture to think that few who examine the remarkable little valley in which it lies will be disposed to deny the existence of this fault.

The evidence for the other faults is manifest upon the map, and need not here be recapitulated. In most cases the position and direction can be fixed with considerable accuracy, but seldom so precisely as to determine which of two intersecting faults displaces the other. It may be noted that the fault which crosses the Dwrnudo 600 yards above Llechwedd-fwyalchen is probably continued for a considerable distance in both directions.

One or two patches of intrusive rock exist besides that which is shown upon the map. Granophyre occurs on both sides of the Bala fault at several points north-east of Drws-y-nant-uchaf, but is too imperfectly exposed to be satisfactorily mapped. There are also some masses of intrusive rock on the left bank of the Dyfrdwy, near Rhyd-y-drain; but these have not yet been examined in detail.

[1] Afon Dwrnudo is the stream which flows past Llechwedd-fwyalchen.

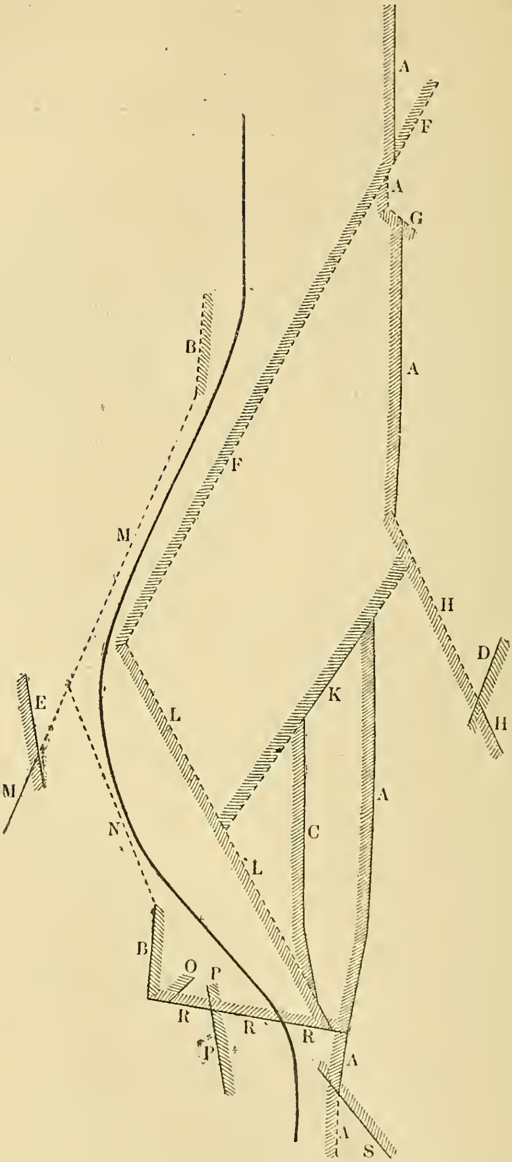


Fig. 4.—Diagram of the Bala Faults.

In the accompanying diagram of the faults (Fig. 4), the downthrow side of each (when it is known) is shaded, and the bottom of the valley is indicated by a heavy line. Some of the faults are continued, in their probable directions, into the area which is now concealed by drift and alluvium; and an additional fault (N) is inserted which is not shown upon the geological map. The existence of this is somewhat doubtful, but the foot of the hills is here so extraordinarily straight that I cannot help suspecting that it coincides with a line of fault.

A comparison of this diagram with the topographical map (Fig. 5) will show that the actual contour of the ground agrees very closely with the contour which would be produced by the faults, if it were determined by them alone. It is true that a few of the faults, such as that near Drws-y-nant-uchaf, have no effect upon the surface.

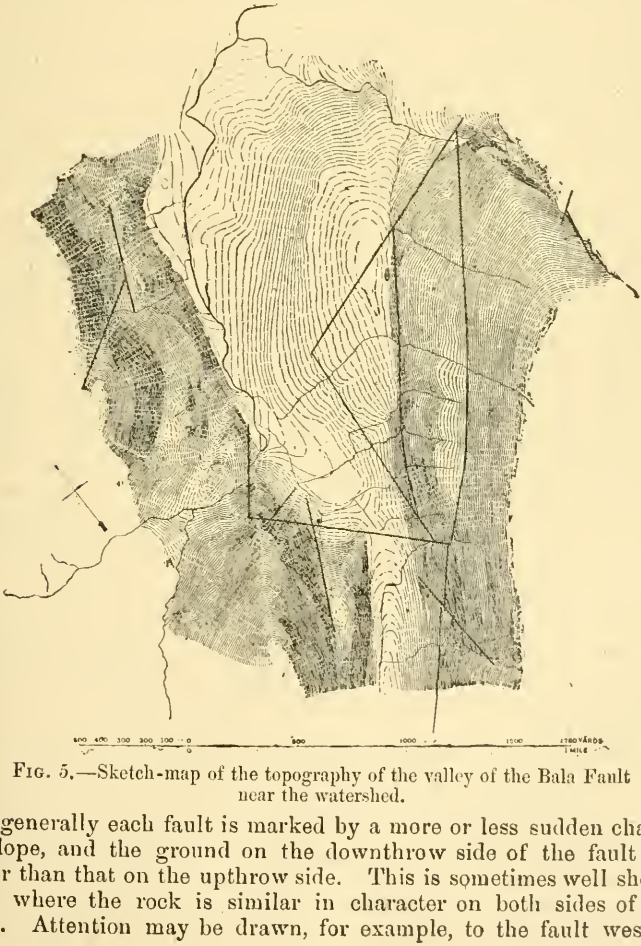


FIG. 5.—Sketch-map of the topography of the valley of the Bala Fault near the watershed.

But generally each fault is marked by a more or less sudden change of slope, and the ground on the downthrow side of the fault lies lower than that on the upthrow side. This is sometimes well shown even where the rock is similar in character on both sides of the fault. Attention may be drawn, for example, to the fault west of Pant-gwyn.

It will be observed that several of the most important faults run parallel to the general direction of the valley, some on one side and some on the other, and that in most cases the downthrow of these faults is towards the valley; the only exceptions are the faults D and E, which indeed are not parallel to the valley, but are nearly so, and are placed symmetrically with regard to it. In these two cases the downthrow is away from the valley.

There is also a series of transverse or oblique faults, and these throw down either towards Bala Lake or towards the bottom of the valley.

Except for a wide curve, convex towards the north-west, the whole of the valley north of Pant-gwyn is enclosed between the outermost of the longitudinal faults—the Bala fault (A) on the one hand and the fault B on the other; and both of these throw down towards the centre of the valley. Moreover, the fault B, if produced, coincides precisely (as is very clearly seen in the field from a position near its southern end) with the north-west shore of Bala Lake. The Bala fault is dislocated at several points, but if the northernmost portion be continued in a straight line it will be found to lie nearly parallel to the south-east shore of the lake, but some distance within the water's edge.

Without any aid from denudation these faults would, of themselves alone, form a valley very similar to that which now exists; and if we take into account the oblique faults F, M,[1] and L and the doubtful fault N, even the convex bend of the valley out of its regular course may be explained as directly due to the faulting.

The general shape of the valley is, in fact, not unlike that which the faults themselves might be expected to produce. But it must be allowed that the form produced by the faults has been considerably modified by subsequent denudation; and it is difficult, if not impossible, to determine how far the present configuration is to be attributed to the direct effect of the faults and how far to their influence in guiding denudation. The relation of the faults to the configuration of the ground is, however, so close that they must, either directly or indirectly, be the cause of that configuration.

Even if we assume that the valley has been actually formed by the faults themselves, it is by no means necessary to suppose that it is so old as, for example, the Bala fault. A comparatively small movement along this fault, perhaps long after its original formation, would be sufficient to account for all the phenomena so far as it is concerned.

The transverse fault at Pant-gwyn is particularly interesting. Its downthrow is towards the north-east, that is, towards Bala Lake; and it appears to form the southern end of the trough produced by the longitudinal faults. On the north-west bank of the valley the ground is much higher on the upthrow side of the fault than on the downthrow side. But this is not the case on the south-east bank. Yet here, near the bottom of the valley, drift on the downthrow

[1] It should be noted that there is no evidence to show which is the downthrow side of either M or N.

side is in contact with solid rock on the upthrow side, and it is possible that the fault produces its full effect upon the solid floor. However this may be, the fault coincides very closely with the watershed in the valley. No water crosses it except a single streamlet, and this rises only a yard or two away.

Whatever the reason may be, therefore, we may safely say that the valley north of Pant-gwyn lies in the trough between two faults, and that this trough is closed at its southern end by a transverse fault, which coincides with the watershed crossing the valley; and further, that many of the other faults apparently produce on the surface of the ground an effect which is similar in kind, if not in degree, to that which they produce on the strata themselves.

That these coincidences are accidental is, to say the least, improbable; and a simple explanation appears to be that the valley was blocked out, so to speak, by the faults themselves, and that the form so produced has been somewhat modified by subsequent denudation.

In advancing this view I am aware that it attributes to the faults a more direct influence upon the topography than many geologists will be disposed to allow. But although most valleys may have been carved out by rivers, it is impossible to deny that some have been formed by faults.

It may be urged that since the formation of the faults there must have been a vast amount of denudation which would obliterate their effect upon the surface. But where erosion exceeds deposition, the tendency of subaerial denudation is to accentuate rather than to obliterate inequalities. Moreover, the evidence of the age of the faults is extremely slight, and there is nothing to show that no movement has taken place along them in comparatively recent times.[1] I shall show subsequently that, however the valley may have been formed, it was probably not in existence when the drainage system of the district was first established.

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

III.—Plant-stems in the Guttannen Gneiss.

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

An important paper[2] on the reputed occurrence of fossil plant-stems in gneiss of Carboniferous age at Guttannen, Switzerland, by Messrs. E. v. Fellenberg & C. Schmidt, for a copy of which I am indebted to the courtesy of the authors, closes, if their view be adopted, a comedy of errors. On this account a brief outline of the story may be of service; for it reduces this supposed relic of Palæozoic forests to a *lusus naturæ*, and, in any case, once more illustrates the truth of the saying, "we are all fallible mortals."

[1] It may be noted that Mr. C. Davison's researches on earthquakes in Great Britain seem to indicate that even at the present time slips occasionally take place along faults which are, in their origin, of very ancient date.

[2] E. v. Fellenberg & C. Schmidt, "Neuere Untersuchungen über den sogen. Stamm im Gneisse von Guttannen": Separat-Abdruck aus den Mitt. der Naturfors. Gesell. in Bern, Jahrgang 1898.

The gneiss-plant's first introduction to English literature was, I think, in 1890, when Professor Heim, in a controversial note appended to my paper on "Crystalline Schists and their relation to Mesozoic Rocks in the Lepontine Alps,"[1] cited it as a proof that gneiss of Palæozoic age existed in the Central Alps; but it was described and figured by Baltzer[2] two years earlier in the official publication of the Swiss Geological Survey. I had, however, examined the specimen when visiting the Museum at Berne in August, 1889, and can best describe its aspect and the impression it produced on me by an extract from my diary. "The rock is a purplish-grey colour, rather fine-grained as a rule, containing numerous small plates of brown mica, many white spots rather angular in outline, apparently felspar, and quartz, in the matrix. One or two quartz veins traverse the block. The rock at first sight is wonderfully like a gneiss. It has evidently been compressed, resulting in a sort of foliation or rude cleavage, with a brown slickensided look on the surfaces of the supposed organisms (cf. the Obermittweida conglomerate, Reusch's Scandinavian fossils in Silurian 'schists,' etc.). The rock does not exactly resemble any gneiss I have seen in the Alps. Though I cannot be quite sure that I detected extraneous fragments, I thought I did. The matrix varies somewhat from coarse to fine, as one traces it through the mass, and its ultimate groundmass or 'paste' has a slightly muddy look. In short, the rock reminded me very much of some of the best 'imitative crystallines' of Vernayaz, and I suspect that it is really an infolding of Palæozoic or Mesozoic 'arkose.' The tree stems are two in number, with obscure traces of what may be a third; the largest about 5 feet long by 8 inches wide; it rises in a low curve, with a sagitta of about 3 inches. There are some indications of cross markings like the stems of calamites; no ribbings or leaf-scars that I noticed. In short, they are obscure markings, but I think it more likely that they indicate vegetable remains than that the rock is a member of the crystalline series." The opinion thus formed was expressed in a note on Professor Heim's comments appended to the above-named paper.[3]

I determined, however, to make a fuller investigation of the question, and in 1891 found an opportunity of visiting Guttannen, in company with my friend Mr. J. Eccles, F.G.S. On my way from England I halted at Berne to make another examination of the specimen in the Museum. The note, written on the spot, is practically an epitome of that already quoted, with the addition that "one stem appears to have a kind of 'bark,' not graphite, but dark carbonaceous matter, as if coaly material were mixed with mud. The outer surface has a sort of brown glaze (irony) over it, and so has the inner one." At Guttannen we examined the outcrops of the supposed Carboniferous gneiss on the eastern side of the valley, with some of those on the western, together with many

[1] Quart. Journ. Geol. Soc., vol. xlvi, p. 237.
[2] Beiträge zur geol. Karte der Schweiz, Lief. xxiv (1888), pt. 4, p. 161.
[3] Quart. Journ. Geol. Soc., vol. xlvi, p. 238.

erratic blocks, including that from which the Berne specimen was said to have been taken.

This field work[1] and subsequent microscopic study of specimens strengthened my conviction that the rock was an 'arkose' of materials from crystalline rocks, and thus only an imitation of a gneiss.[2] I may add that the other possibility—that these objects were not really plants, but imitative markings, produced by earth movements in a truly crystalline rock—had been present to my mind throughout. It would have saved me from wasting my time by a journey to Guttannen, so that, if I could, I would gladly have adopted it. But the markings were accepted as plants by the experts of the Swiss Survey,[3] and, so far as I could form an opinion, on good grounds, while the clastic structure of the rock on the whole appeared to be original rather than superinduced. Moreover, the grounds on which Herr Schmidt claimed the rock for a true gneiss appeared to me, as I pointed out in my paper,[4] defective in more than one respect.

Still, though this visit to Guttannen strengthened my conviction, microscopic study of the specimens did not, as I had hoped, place the matter beyond all question. So in the Summer of 1895 I again visited Guttannen, this time in company with my friend the Rev. Edwin Hill, F.G.S., and now more especially examined the western flank of the valley. Everywhere the so-called Carboniferous gneiss had a grit-like aspect, including a not unfrequent change in coarseness perpendicular to the occasional banded structure. In one place we found a thin band of rock resembling a dark phyllite, but no conglomerate. We traced the 'Carboniferous gneiss' northwards nearly up to its junction with the ordinary gneiss of the district, the difference between them being very marked. Though the field work strengthened me in the view which I had already expressed, complete demonstration was again wanting and was not supplied by a microscopic study of the specimens collected. Among other things, the supposed phyllite band exhibited such indications of crushing as to make it an untrustworthy witness.

I determined, however, to make a third attempt to obtain decisive evidence. According to the Swiss geological map this zone of 'Carboniferous gneiss' crosses the Urbach Thal, just about the foot of the Gauli Glacier. So in the Summer of 1897 I planned a visit to this locality in company with Mr. J. Parkinson, F.G.S. The walk to the foot of the glacier, from Im Hof, the nearest halting-place, and back, takes about eight hours, so our time for studying the gneiss was rather limited. The result of this[5] and of subsequent microscopic examination of specimens was

[1] About a month later I visited Vernayaz to look once more at the well-known Carboniferous infold, parts of which sometimes curiously resemble crystalline rocks; this time examining it as far as the Tête Noire.

[2] This conclusion and the reasons are fully stated in a paper (Quart. Journ. Geol. Soc., vol. xlviii, p. 390).

[3] Beiträge, ut supra, pp. 164–8.

[4] Ut supra, p. 395.

[5] On another day we spent a little time at Guttannen.

disappointing. A truly clastic origin was constantly suggested, but was not placed beyond dispute. Shortly afterwards we visited the Museum at Berne, and again examined the famous stems. Pieces had been cut from the ends, probably for the investigation undertaken by Messrs. Von Fellenberg and Schmidt. One passed through the longer stem, affording a crescentic section, and disclosed a third, circular in outline and much smaller. I wrote thus in my diary: "Both 'stems' seem occupied by a material slightly darker, greener, and compacter than the rest of the block. In places there is about 0·1″ or 0·15″ of a phyllite-like substance, where 'bark' should be on the stem. The outer curve of the stem appears not to enter the stone like a fracture would do, but more as a fossil. The bark-like appearance is very conspicuous in the upper, smaller, and 'indented' stem on the face of the block. This, neither in shape, nor in aught else, looks like a 'roll' in the rock. There are two or three surfaces of mechanical division, but they do not appear to be the same, and the glaze on them, which can also be traced in parts of the stem, seems a mere film." After noting one or two other matters, I conclude thus: "If plants, they are very rough and ill preserved; but if the result of mechanical movements, they are of a most extraordinary and exceptional nature, and the rock certainly has the look of an 'arkose' rather than of a true gneiss."

In the memoir before us Messrs. Von Fellenberg & Schmidt give the results of the investigation which was no doubt in process at the last-named date. It is illustrated by seven plates containing nine figures, giving excellent representations of the supposed remains, both as formerly visible and as disclosed by the new sections. The latter are cut from both the upper and lower ends of the longest stem, which, as we can observe in the photograph, has an extraordinary resemblance to a plant. From a cross cut the outline is seen in one case to be an oval, rudely flattened on one side, in a second very rudely crescent-shaped, and in a third nearly circular. The core of the enclosure, a very tough and compact material, blackish green in colour, proves to be an amphibolite; for it is composed almost entirely of short columnar grains of hornblende, between which lie allotriomorphic water-clear felspars, solitary scales of muscovite, zoisite in thread-like clusters, and numerous grains of magnetite with jagged edges. The compact exterior (the supposed bark) is described as practically composed of biotite. Herr Schmidt has also examined the surrounding rock, and maintains the accuracy of his description already published.[1] In regard to the mineral constituents it agrees with what I have seen in specimens believed to come from another part of the block, especially with reference to the rather remarkable changes in texture, though in my specimen the felspar is rather more converted to sericite, and the 'mörtelstructur' is less noteworthy or characteristic than in the slices which he describes. The block is traversed by

[1] Loc. cit., p. 164.

quartz veins and exhibits (as illustrated by a photograph) irregular folds, the crests of which are roughly parallel with the supposed stem, besides other mechanical disturbance. The result of the investigation, into the more minute details of which it is needless to enter, is summed up in the following words: "Der vermeintliche Stamm erscheint als ein Amphibolit-Einschluss, der beim Faltungsprocess gewalzt worden ist": in other words it is not a fossil plant, but a *lusus naturæ*.

The authors, however, leave without notice some interesting questions. We should welcome some explanation of these isolated and singularly shaped portions of hornblendic rock in a mass which elsewhere is generally without that mineral. Are we to regard them as branches of an intrusive vein of dioritic rock, rolled round and perhaps broken up by mechanical movements; or were they originally concretions, somewhat similarly affected, and if so, how are they to be explained? These questions the authors dismiss with the brief remark that such hornblendic inclusions are common in the Guttannen gneiss. That may be so, but I cannot remember to have observed another instance, and in the rock itself hornblende is seldom, if ever, present. In no one of twenty-four slices in my cabinet, three of them, according to report, from the same block as the specimen at Berne, can I find an indubitable grain of hornblende. Again, what explanation must we give of the biotite 'skin,' which so curiously mimics a 'bark.' Was it a contact product of the gneiss and the amphibolite, or a secondary result of their juxtaposition and of mechanical disturbances? Yet more, how do we account for the curious petrographical character of the so-called Carboniferous gneiss, which is so distinctive as to catch the eye at once in the field, and to have led the official geologists of Switzerland to distinguish it from the other gneisses of the region?[1] I am fairly well acquainted with Alpine gneisses, and this one, so far as I can remember, differs from all others known to me. The 'mörtelstructur' also, exhibited by certain specimens from Guttannen, appears to me abnormal. From the majority, which neither resemble true gneisses nor those called mylonitic, it is absent; in the few, where it occurs, the presence of a fragment seems possible.

But I must admit that, though some aspects of the problem seem to have been overlooked by the authors, their petrographical description of this Guttannen gneiss makes it impossible that these structures can be the remains of plants. Hence, whatever the rock may be, they cease to have any special interest. They do not reveal its geological age, and the inferences founded on them are fallacious. That a mistake had been made, I was confident from the first; but of the two possible explanations of it I have apparently adopted the wrong one. Though I naturally regret this, I cannot but rejoice at the effectual laying of another metamorphic spectre, and for that we are deeply indebted to Messrs. Von Fellenberg and Schmidt.

[1] Near Guttannen they term it Seritische Phyllite, an inappropriate name, as I understand Phyllite.

But I may be allowed to remark that their exorcism comes rather late in the day. Such an investigation ought to have been undertaken at least a dozen years ago, that is to say, before the specimen was displayed in the principal museum at Berne, figured and described by a government department, and trumpeted forth to the world by an official geologist as a discovery of prime importance in the history of metamorphic rocks. For twelve years this error has been infecting textbooks and impeding progress; but at last the plant-remains in the gneiss of Guttannen have gone to join the schists, where garnets and staurolites dwell in unity with belemnites, in that limbo which is appointed for exploded hypotheses. *Requiescant in pace!*

IV.—The Geological Age of the Earth.

By J. Joly, M.A., D.Sc., F.R.S.

The able review of my paper on the Geological Age of the Earth which appears in the March number of this Magazine (p. 124), from the pen of the Rev. O. Fisher, raises again questions of such wide interest that some further remarks, referring principally to the criticism of the distinguished writer of the review, and also to criticisms which I have received from others and which are probably in the minds of many who have considered the matter, may not be out of place.

My position in reference to the mode of estimating the Geological Age of the Earth advocated in my paper has, of course, been that of the Uniformitarian. In answer to general objections on this score, I have only to say that *positive* knowledge on the subject under discussion will probably never be attained by Science. Recognizing this, we may ask of the Physicist on the one hand, and of the Geologist on the other, to what the probable error-limits of their several methods of computation may amount. Will the Geologist admit as probable, denudative activities continued throughout the entire past of geological history which are sufficiently discordant with those of to-day as to bring his error-limit to the magnitude of that confessed to by the Physicist? Will he admit, in short, that the activities of to-day may have been five times excelled or five times diminished, and stand divided between the possibility that they were maintained at the one or the other of these magnitudes throughout geological time? In other words, that our hundred million years may have been five hundred millions or twenty millions so far as denudative processes can tell us? Yet it is just this position the Geologist must assent to before he attains to the uncertainty which divides Physicists on this question at the present day. I need not draw the obvious inference or review the question further.

Among geological methods, that one which I have advocated (and in which I was in part anticipated by Mr. Mellard Reade) claims, as I have contended, the safest and most restricted measure of Uniformitarianism—claims, in fact, uniformity confined more especially to activities depending on molecular processes: processes in which the mutual presence of the reacting substances is the primary factor, their rate of relative motion or circulation entering the result only in a secondary manner. The method, in short, relies principally on uniformity in the prevalence of that most general of geological conditions, the mutual presence of water and rock material over the land areas. I can best explain by an example. Suppose we desire to estimate the rate of solubility of basalt in water. We arrange that a measured quantity of water circulates over the fragments of rock for a certain time. Now in this experiment, whether we circulate the water quickly or slowly over the rock the result will be the same or nearly the same. This is so because the molecular actions are relatively so slow that even very sluggish circulation of the water suffices to renew the solvent before saturation is nearly attained, and so suffices to preserve the action at its maximum rate. The accelerative influence of friction—as in Daubrée's revolving cylinders—plays relatively but a small part in the work of chemical and solvent denudation on the earth's surface.

But advantages depending on the restriction of our Uniformitarianism are not the only ones which the method claims to possess. The quantities involved, those on which our final answer depends, are more clearly defined and more accurately measurable than those required in Uniformitarian methods based on rates of sedimentation. The total volume of the ocean, its composition, the volume and composition of the river water, are quantities *measurable without speculation*; our knowledge of which will grow with the advance of Science.

The value of this restricted Uniformitarianism may be exemplified in the possibilities involved in the abnormal lunar tides suggested by Professor G. Darwin. If such abnormal tides affected the earth's surface within the period of the Geological Time of which we speak, the mechanical effects would remain the chief record; and we could not say if the wider and barer coasts of the period would contribute more or less than the normal dissolved matter to the ocean. We might argue for more on the ground of increased mechanical action; for less, on the grounds that the soils wherein chemical effects would most favourably progress had not been formed. Very probably the ultimate result would be to affect our numbers but little.

This appropriately leads me to the question of the nature of the primitive ocean. I submit that upon those who wish to imagine the waters of the primeval earth charged with alkaline salts rests the onus of showing how these elements escaped the avidity of the silica under early igneous conditions: the combination of the two being the course of events which we *primâ facie* infer. Or, if they admit such formation of alkaline silicates, they have to explain the subsequent release of the alkali.

On this last point I have in my paper gone on the assumption (justifiable, as I submit) that long-continued attack from free acid cannot be assumed as directed to the one element sodium. Free acid in the primitive atmosphere must be supposed to act upon the primitive rock much as it would in the laboratory experiment of to-day, when we put such rock to digest in the aqueous solution of the acid. Taking, then, HCl as probably by far the most abundant of the free active acids of the primeval atmosphere, the outcome of the chemical reaction between the acid and the average rock-crust affords such a mass of sodium as would shorten Geological Time by some six million years. (The corrigenda affixed to my paper should be consulted in reference to this number.)

I may add with regard to vague ideas (not unprevalent) as to long ages of boiling waters acting upon the primitive rocks that calculation relegates these long ages to their proper importance. In fact, the rate of cooling of lava after solidification is so rapid that the long ages shrink to a very few years. "The thickness of the wholly solidified crust grows at first with extreme rapidity—at the end of a year it may be as much as ten metres, with a surface almost or quite cool enough for some kinds of vegetation." (Lord Kelvin, "The Age of the Earth": Address to the Victoria Institute, 1897.) The subsequent rate of cooling may be inferred from a further extract from the same address: "To fix our ideas let us suppose at the end of one year the surface to be 80° (Cent.) warmer than it would be with no underground heat, then at the end of 100 years it would be 8° warmer, and at the end of 10,000 years it would be 0·8 of a degree warmer." So then (and, be it observed, these figures are independent of what we postulate as to the gross thermal actions involved in earth-cooling) the long ages shrink to a period of a century, during which the water fell through its critical point to a liquid resting on our earth, warmed about 8° above what it is to-day; if, indeed, a lesser sun-heat (see Professor Perry's article in *Nature*, vol. lx, p. 247) did not act to make it considerably cooler. Now if we assume that the mean rate of solvent and chemical aqueous denudation during this period was as much as one hundred times as great as to-day, we find 10,000 years' work accomplished in the first 100 years: involving a correction evidently quite negligeable.

But difficulties which may be described as based on highly probable speculation are not the only ones which have to be faced by the advocates of the primitive alkali-charged ocean. Let us suppose they have surmounted the difficulties of accounting for the state of things they desire to establish. They have now to explain how the *known* enormous subsequent formation of sediments was effected from the original rock-crust without putting into the ocean the bulk of the alkalies they have already assumed to be in it. Still more, they have to explain the coincidence that the approximate measure of the sodium missing from these sediments very closely suffices to account (the error being on the side of *excess*) for the amount of sodium in the ocean. This is a point resting on estimates certainly sufficiently reliable for the degree of accuracy required in confirmatory evidence, and can neither be slighted nor ignored till its fallacy is demonstrated.

Before finally dropping the subject of the primitive ocean I must refer to a remark of Mr. Fisher's to the effect—if I understand it aright—that any assumption involving an original ocean free from alkalies also involves chemical proportions between the alumina and the alkalies in the original rocks. "If this proportion did not hold there would have been either alumina uncombined in the crystalline rocks or alkalies over to combine with the acids in the ocean, presumably the latter, seeing that alkali salts abound in it at present. That this due proportion should have existed does not seem probable." I really see no reason why we should look for or except any such equivalence between alumina and alkali. Why not an excess of alumina over alkali? Why not, when a glance at Mr. Clarke's average crust-composition shows that there *is* a very large excess of alumina over what is required to make felspar molecules out of the alkalies or, for that matter, molecules of most of the important alumina-alkali-silicates; and fresh-water lakes of to-day exist among such rocks? Would any special difficulty arise if these lakes were now to be formed by condensation of steam?

Mr. Fisher's criticism on the legitimacy of accepting the river supply of sodium to the ocean is directed to the origin of the chloride of sodium of the rivers; contending that Clarke's crust-percentage of chlorine (0 01) is inadequate to account for the chlorine involved. Hence, he suggests, we must look to Sterry Hunt's "fossil sea-water" contained in sedimentary rocks.

With regard to this point it will conduce to clearness if I first refer to the deductive allowance of sodium chloride required by the presence of this body in rain-water.

In my calculations I had allowed 10 per cent. of the chloride of sodium of rivers as supplied by rain, and on this account not entering the calculations. This, I of course admit, may have been an insufficient allowance. But in the present state of our knowledge on the matter I do not think more or much more is justified. Inland rains show an ever diminishing percentage of salts, and again much of the rainfall richest in salts—that falling immediately on seaboards —finds its way back to the ocean in rills and streams, taking but little from the land. The great rivers of the world, which make up the bulk of the estimate of the river supply to the ocean, gather their constituents from inland areas remote from the coasts. On this point our knowledge will doubtless grow with the years.

It will, however, clear away misapprehension as to the stress to be laid on this matter if I state that, admitting very wide error on my part in making this allowance, the final possible error involved is quite limited in amount. Suppose, in fact, we extend the allowance to a point certainly *not* justifiable, and assume half the total $NaCl$ of rivers to be derived from rain-water. Then it will be found that the estimate of Geological Time increases from 90 to 100 millions of years. If, then, 10 per cent. is too small and 50 per cent. is too large an allowance, we fix our limits as between 90 and 100 millions of years. If we were *sure* of this we might be well satisfied!

Now as to the "fossil sea-water." In the first place we find very conflicting evidence. Mr. Fisher, himself, quotes two observations—one affording 0·042 per cent. of "chlorine calculated to sodium chloride," the other affording a quantity too small for estimation. Sterry Hunt quotes many analyses of deep-seated springs, some in faulted beds, others in apparently undisturbed beds. The results give the most widely varying amounts of sodium and other elements in solution. Even in the case of wells arising in the same rocks and near together (as in the Trenton Limestone) the relative proportions of dissolved salts vary even to 100 per cent. His results did not lead him to the conclusion reached by Mr. Fisher (that but little sodium had entered the sea since Silurian times), but to the conclusion that the original ocean contained large amounts of calcium chloride, and that alkaline carbonates (derived from decomposing felspars) "which from the earliest times have been flowing into the sea have gradually modified the composition of its waters, separating the lime as carbonate and thus replacing the chloride of lime with chloride of sodium." ("Chemistry of Natural Waters," § 24.) A conclusion essentially in accord with the theory of oceanic supply which I have advocated.

Finally, if we refer to No. 148 Bulletin of U.S. Geological Survey, containing Messrs. Clarke & Hillebrand's valuable collection of rock analyses, we find among many very minute analyses of slates, shales, and clay-slates the chlorine, in one case only, given at as much as 0·01 per cent., and generally left blank or entered as "trace."

But the part played by possible "fossil sea-water" is capable of estimation and of having a true value assigned to its importance.

Let us accept Mr. Fisher's first quoted observation, that most favourable to his suggestion, without reserve. Assume the percentage of chloride of sodium derived from "fossil sea-water" to be 0·042 in all slates and similar rocks, and that such rocks cover one-half the land area of the globe. We will also take the figure of one foot in 6,000 years (which Mr. Fisher favours) as the rate of denudation; and remarking that the sodium chloride supply from this source, in order to be continuous, must keep pace with the rate of denudation, we proceed to estimate the amount of sodium set free by denudation, and express this as a percentage of the quantity of the element contained in the river supply to the ocean. The result, as I reckon, comes out as 0·9 per cent. If, then, this amount of sodium chloride *circulated*, our conclusion as to the duration of Geological Time would be falsified by about this percentage, but the assumptions we made in obtaining even this number are evidently entirely unwarranted.

In point of fact, the conclusion which Mr. Fisher draws from his experiments might indicate that the premises were somewhere at fault—that "not much additional sodium can have accumulated in it (the ocean) since Silurian times." Mr. Fisher elsewhere refers to the setting free of the alkalies of the felspars of granites. What, then, became of all the sodium contributed in this manner to the ocean throughout the ages that have since passed away?

Now contrast the foregoing inadequacy of denudation as acting to set free "fossil sea-water" with denudation as dissolving the alkali-silicates, the latter action being very interestingly brought out by Mr. Fisher himself in his estimate of the rate of denudation required to maintain the river supply of alkalies. I venture to claim that Mr. Fisher has strongly supported my view in showing that $\frac{1}{5000}$ of a foot of granite removed per annum over the land area would suffice to supply the sodium of the rivers. In this connection I again urge that detrital rocks passing more readily into soils and exposing finer material to surface actions probably contribute quite as effectively as eruptive rocks to the supply of alkalies.

Finally, in reference to Mr. Clarke's estimate of the crust constituents, it is worth noting that this estimate is not derived in such a manner as to include extravasated substances. As I gather, it is founded on typical rock analyses. Now chlorine, as it happens, entering only with difficulty into the constitution of silicates, occurs chiefly as an extravasated substance. Hence we find it abundant in mineral springs of volcanic regions and in association with ores. Springs arising in connection with lodes are often heavily charged with chlorides. The sources of supply are in these cases probably deep-seated, and would not enter into estimates of crust constituents based on rock analyses. It will be at once apparent, too, that saline waters, where entering occasionally into deep-seated bedded rocks, may well be derived from such sources; or, again, from inland waters of former times which had never communicated with the ocean. The very various composition of such waters from deep wells supports their non-oceanic origin. For the greater part these sources of chlorine are to be included on the side of the crust constituents and (for a large part) so far as they include sodium in combination, go towards explaining the discrepancy, such as it is, in the equation between the sodium missing from the sediments and the sodium of the ocean.

We have no reason to suppose the contributions from these sources to the rivers to have varied in one or the other direction during the past.

V.—Catalogue of the known Foraminifera from the Chalk and Chalkmarl[1] of the South and South-Eastern Counties of England.

By Prof. T. Rupert Jones, F.R.S., F.G.S.

The sources of information are given below.

D. From T. Rupert Jones's Catalogue of the Foraminifera from the Chalk and Chalkmarl in the Second Edition of Dixon's "Geology and Fossils of Sussex," 1878, pp. 284 and 285.

[1] It is not here practicable to divide the Foraminifera belonging severally to the two formations; but some indication of the distribution is shown by the list at pp. 284 and 285 of Dixon's "Sussex," 2nd edition, 1878. Of the range of these Foraminifera in earlier strata of the Cretaceous series, some particulars may be gathered from the list published in Topley's "Geology of the Weald" (Mem. Geol. Surv., 1875, pp. 423 and 424), as far as known at that time.

Cr. Foraminifera of the Chalk and Chalkmarl referred to in the "Monograph on the Foraminifera of the Crag," by T. Rupert Jones and others: Pal. Soc., parts ii, iii, iv, 1895–96–97.

G. Foraminifera belonging to the Chalk and Chalkmarl referred to in F. Chapman's "Description of the Foraminifera from the Gault": Trans. Roy. Microsc. Soc., 1891–98.

T. Chapman, "On Microzoa from the Phosphatic Chalk of Taplow": Quart. Journ. Geol. Soc., vol. xlviii, 1892, pp. 514–518.

L. Chapman, "Foraminifera of the Phosphatic Chalk of Lewes": Quart. Journ. Geol. Soc., vol. lii, 1896, pp. 470–472.

Jones and Chapman, "On the Fistulose *Polymorphinæ* and the Genus *Ramulina*": Journ. Linn. Soc., Zool., vol. xxvi, 1897, pp. 340, etc. Besides several of the *Polymorphinæ*, this memoir treats especially of *Ramulina aculeata*, Wright, for D, G, T; and *R. globulifera*, Brady, for the column G.

Upper Chalk: Purley, Surrey. Mr. Charles Upton's "Chalk under the Microscope": Proc. Cotswold Nat. Field Club, vol. vii, pt. 2, 1898, pp. 209–216. With the nomenclature revised, the species noticed and figured in this memoir are:—

Textularia globulosa, Ehrenberg.
,, *turris*, D'Orb.
Gaudryina pupoides, D'Orb.
Bulimina Murchisoniana, D'Orb.
,, *ovulum*, D'Orb.
Frondicularia coronata, Perner.
Frondicularia inversa, Reuss.
Cristellaria convergens, Bornem.
Ramulina aculeata, Wright.
,, *globulifera*, Brady.
Globigerina marginata, Reuss.
Rotalia Soldanii, D'Orb.

	D.	Cr.	G.	T.	L.
MILIOLIDÆ.					
Nubecularia tibia, Jones & Parker	...	...	...	*	
,, *Jonesiana*, Chapman	...	...	...	*	
,, *novorossica*, Karrer & Sinzow ...	...	...	...	*	
Spiroloculina limbata, D'Orbigny	...	...	...	*	
Miliolina seminulum (Linné)	...	...	...	...	*
,, *trigonula* (Lamarck)	...	...	...	*	
,, *oblonga* (Montagu)	...	...	...	*	
,, *turgida* (Karrer)	...	...	...	*	
Cornuspira (*Trochammina*?) *cretacea* (Reuss)	*	*			
LITUOLIDÆ.					
Haplophragmium irregulare (Römer) ...	...	...	...	...	*
,, *ovatum* (Hagenow)	...	...	...	...	*
Lituola neutiloidea, Lamarck	*				
Placopsilina Cenomana, D'Orb.	*				
Haplostiche Sherborniana, Chapman ...	...	...	?		
Bdelloidina aggregata, Carter. From the Chalk; locality not known.					
Webbina rugosa, D'Orbigny.	*				
TEXTULARIIDÆ.					
Textularia globulosa,[1] Ehrenberg	*	*	...	*	*
,, ,, var. *striata*,[1] Ehrenberg	...	...	...	*	*
,, *decurrens*,[1] Chapman	...	...	...	*	

[1] These are included in a new genus, '*Guembelina*,' by Dr. Egger, 1899.

	D.	Cr.	G.	T.	L.
Textularia quadrilatera, Schwager	...	...	...	*	
,, *anceps*, Reuss	...	...	...	*	
,, *conica*, D'Orb.	...	*	...	*	
,, *trochus*, D'Orb.	*	...	*	*	*
,, *turris*, D'Orb.	*	...	*		
,, *agglutinans*, D'Orb.	*	*			
,, *concava* (Karrer)	...	...	...	*	
,, *serrata*, Chapman	...	...	...	*	
,, *sagittula*, Defrance	...	...	...	*	
,, *gibbosa*, D'Orb.	*	*			
,, *Baudouiana*, D'Orb.	*				
,, *prælonga*, Reuss	*				
Verneuilina triquetra (Münster)	*	...	*	*	
,, *Bronnii*, Reuss	*				
,, *spinulosa*, Reuss	...	...	...	*	
,, *pygmæa* (Egger)	*	...	...	*	
Tritaxia pyramidata, Reuss	...	...	...	...	*
,, *foveolata*, Marsson	...	...	...	...	*
,, *tricarinata*, Reuss	...	...	...	*	*
Spiroplecta rosea, Ehrenberg	*				
,, *annectens*, Parker & Jones	...	...	...	*	*
,, *biformis*, P. & J.	...	...	...	*	
Gaudryina rugosa, D'Orb.	*	...	...	*	*
,, *Jonesiana*, Wright	...	...	...	*	*
,, *pupoides*, D'Orb.	*	...	*	...	*
Bigenerina pennatula (Batsch)	*				
Heterostomella aculeata (Ehrenberg)	*				
Bulimina elegans, D'Orb.	*	*	*	*	
,, *affinis*, D'Orb.	*	...	...	*	*
,, *ovata*, D'Orb.	...	...	...	*	
,, *subsphærica*, Reuss	...	...	...	*	
,, *brevis*, D'Orb.	...	...	*	*	
,, *obtusa*, D'Orb.	*	...	*	*	*
,, *trigona*, Chapman	...	...	...	*	
,, *Murchisoniana*, D'Orb.	*	...	*	*	*
,, *intermedia*, Reuss	*				
,, *obliqua*, D'Orb.	*				
,, *ovulum*, Reuss	*				
,, *Presli*, Reuss	*	...	*		
,, *variabilis*, D'Orb.	*	...	...	*	
,, *polystropha*, Reuss	...	...	...	...	*
Bolivina dilatata, Reuss	...	...	...	*	
,, *strigillata*, Chapman	...	...	...	*	
,, *punctata*, D'Orb.	*	*	...	*	
,, *textularioides*, Reuss	...	...	...	*	
,, *nobilis*, Hantken	...	...	...	*	
,, *obsoleta*, Eley	*				
Virgulina Schreibersiana, Czjzek	*	...	...	*	
,, *subsquamosa*, Egger	...	...	...	*	
,, *Hemprichii* (Ehrenberg)	*				
,, *paradoxa* (Ehrenb.)	*				
Pleurostomella subnodosa, Hantken	...	...	...	*	
LAGENIDÆ.					
Lagena sulcata, Walker & Jacob	...	*	...	*	
,, *globosa* (Montagu)	...	*	*	*	
,, *striatopunctata*, Parker & Jones	...	...	*	*	
,, *lævis* (Montagu)	...	*			
,, *gracilis*, Williamson	...	*			

	D.	Cr.	G.	T.	L.
Nodosaria Zippei, Reuss, = *raphanus* (Linné)	*	*	*		
,, *radicula* (Linné)	*	...	...	*	
,, *ambigua*, Neugeboren	...	*	...	?	
,, *tenuicosta*, Reuss	...	...	...	*	
Subgenus 1. *Glandulina lævigata*, D'Orb. ...	*				
,, *cylindracea*, Reuss ...	...	...	*		
,, *mutabilis*, Reuss ...	...	...	*		
,, *humilis*, Reuss ...	...	...	*		
Subgenus 2. *Dentalina oligostegia*, Reuss ...	*	...	*		
,, *affinis*, Reuss ...	*				
,, *brevis*, Reuss ...	*				
,, *communis*, D'Orb. ...	*	*	...	*	*
,, *gracilis*, D'Orb. ...	*	...	*	...	*
,, *linearis*, Reuss ...	*				
,, *lineolata*, Reuss ...	*				
,, *Lorneiana*, D'Orb. ...	*	...	*		
,, *monile*, Cornuel ...	*				
,, *sulcata*, D'Orb. ...	*				
,, *sulcata* (Nilsson) ...	*				
,, *obscura*, Reuss ...	...	...	...	*	
,, *consobrina*, D'Orb. ...	...	...	...	*	*
,, *hispida*, D'Orb. ...	...	...	...	*	
,, *obliqua*, D'Orb. ...	...	*			
,, *Roemeri*, Neugeboren	...	...	...	*	
,, *aculeata*, D'Orb. ...	*	...	...	*	
,, *pauperata*, D'Orb. ...	*	*			
,, *nodosa*, D'Orb. ...	...	...	...	*	
,, *expansa*, Reuss ...	...	...	*		
Lingulina carinata, D'Orb.	*	...	...	*	
,, *semiornata*, Reuss	...	...	*		
Rhabdogonium tricarinatum, var. *acutangulum*, Reuss	...	...	...	...	*
Frondicularia Archiaciana, D'Orb. ...	*	...	*	*	
,, *Verneuiliana*, D'Orb.	*				
,, *tricarinata*, D'Orb.	*				
,, *angulosa*, D'Orb.	*	...	...	*	
,, *angusta*, Nilsson	...	...	...	*	
,, *Cordai*, Reuss	*	...	*		
,, *striatula*, Reuss	*				
,, *inversa*, Reuss	...	...	*		
Marginulina glabra, D'Orb.	...	*	...	*	
,, *elongata*, D'Orb.	...	...	...	*	
,, *æquivoca*, Reuss	...	...	...	...	*
,, *compressa*, D'Orb.	*				
,, *ensis*, Reuss	*				
,, *raricosta*, D'Orb.	*				
,, *trilobata*, D'Orb.	*				
Vaginulina lævigata (Römer)	...	*			
,, *costulata* (Römer)	*				
,, *strigillata* (Reuss)	...	...	*		
,, *truncata* (Reuss)	...	...	*		
,, *gaultina*, Berthelin	...	...	*		
,, *comitina*, Berth.	...	...	*		
Cristellaria cultrata (Montfort)	*	*	...	*	*
,, *rotulata*, Lamarck	*	...	...	*	*
,, *gibba*, D'Orb.	...	...	...	...	*
,, *navicula*, D'Orb.	...	...	*	...	*
,, *triangularis*, D'Orb.	*	...	*	*	
,, *gemmata*, Brady	...	...	...	*	

	D.	Cr.	G.	T.	L.
Cristellaria convergens, Bornemann ...	...	...	...	*	
,, *Gaudryana*, D'Orb.	...	...	...	*	
,, *gaultina*, Berthelin	...	...	...	...	*
,, *acutauricularis* (Fichter & Moll)	...	...	...	...	*
,, *obsoleta*, Jones	*				
,, *ovalis*, Reuss	*				
,, *recta*, D'Orb.	*				
Flabellina rugosa, D'Orb.	*	...	...	*	
,, *Baudouiana*, D'Orb.	*	...	...	*	
,, *pulchra*, D'Orb.	*				
,, *ornata*, Reuss	*	...	...	*	
,, *cordata*, Reuss	*				
,, *elliptica*, Nilsson	*	*			
,, *ovata*, Geinitz	*				
Polymorphina gibba, D'Orb.	...	...	...	*	
,, *acuminata*, D'Orb.	*	...	...	*	
,, *Thouini*, D'Orb.	*				
,, *sororia*, Reuss	...	*	*	*	
,, *fusiformis* (Römer)	...	...	...	...	*
,, *compressa*, D'Orb.	...	*	*		
,, *communis*, D'Orb.	...	...	*		
Uvigerina Canariensis, D'Orb.	...	...	...	*	
Sagrina rugosa, D'Orb.	*	...	...	*	
Globigerinidæ.					
Globigerina bulloides, D'Orb.	*	*	*	*	*
,, *cretacea*, D'Orb.	*	...	*	*	*
,, *marginata*, Reuss	*	...	...	*	*
,, *æquilateralis*, Brady	...	...	*	*	*
,, *Linnæana*, D'Orb.	...	*			
,, *elevata*, D'Orb.	*				
,, *pelagica*, D'Orb.	*				
Rotaliidæ.					
Planorbulina Clementiana, D'Orb.	*	...	...	*	
,, *Lorneiana*, D'Orb.	*	...	...	*	
,, *Voltziana*, D'Orb.	*				
Truncatulina lobatula (Walker & Jacob) ...	*	...	...	*	
,, *variabilis*, D'Orb.	...	*	...	*	
,, *Ungeriana* (D'Orb.)	*	*			
,, *Haidingeri* (D'Orb.)	*				
Discorbina Berthelotiana (D'Orb.)	...	...	...	...	*
Anomalina ammonoides (Reuss)	*	...	*	*	*
,, *ariminensis* (D'Orb.)	*	...	...	*	
,, *grosserugosa* (Gümbel)	...	...	...	*	
,, *rotula* (D'Orb.)	...	...	...	*	
Pulvinulina elegans (D'Orb.)	...	*	...	*	*
,, *Karsteni* (Reuss)	...	*	...	*	
,, *punctulata* (D'Orb.)	...	...	...	*	
,, *Menardii* (D'Orb.)	*	*	...	*	
,, *Corderiana* (D'Orb.)	*				
,, *crassa* (D'Orb.)	*				
,, *Micheliniana* (D'Orb.)	*				
Rotalia exsculpta, Reuss	...	...	...	*	
,, *Soldanii*, D'Orb.	...	...	...	*	*
,, *Beccarii* (Linné)	...	*	...	*	
Calcarina Spengleri (Gmelin)	*				
Gypsina ovata, Marsson	...	...	...	...	*

REVIEWS.

I.—A Memoir on the Palæozoic Reticulate Sponges constituting the Family Dictyospongidæ. By James Hall, State Geologist and Palæontologist, in collaboration with John M. Clarke, Assistant State Geologist and Palæontologist. Imp. 4to; pp. 350, plates lxx and 45 figures in the text. (University of the State of New York, 1898.)

THIS elaborate monograph treats of a family of siliceous sponges which occur very abundantly in certain portions of the Chemung division of the Upper Devonian in the State of New York; they are also present in lesser numbers in the sub-Carboniferous rocks of Ohio and Indiana. Beyond the bounds of the United States they are represented by a few forms in the Psammites du Condroz (on the same horizon as the Chemung) in the North of France, which have been described by Dr. Charles Barrois; one species is also known from the Middle Devonian of the Eifel, and another, which appears to be the oldest representative of the family, has been found in the micaceous shales of the Upper Ludlow of Westmorland, and described by McCoy under the name of *Tetragonis Danbyi*.

The sponges of this family are very varied in shape, but the majority are vasiform, cylindrical, or prismatic, whilst others are flattened saucer-shaped, and not infrequently they are of large size. They consist of a thin wall which is built up of fascicles, principally of elongate rod-like spicules intermingled with others of cruciform, five and probably six rays, arranged in vertical and horizontal bands so as to form a lattice-like mesh with rectangular interspaces. With the exception of a few specimens from the sub-Carboniferous rocks of Indiana, these sponges are only known in the form of casts or solid moulds of the interior hollow of the sponge, which has been infilled with the arenaceous or calcareous materials of the rock in which they are imbedded. These moulds retain, very perfectly as a rule, the form of the sponge scarcely at all compressed, and their outer surfaces show, in a fairly definite manner, the impressions of the spicular bands bounding the angular mesh-interspaces. But it is very difficult to determine from the impressions the form, size, and disposition of the individual spicules composing these bands, and hence arises the principal obstacle in the classification of these sponges, which rests to a considerable extent on their outer form and proportions, characters of very subordinate value if we may judge from the existing members of the class.

In some specimens from the sub-Carboniferous rocks of Indiana where the matrix is a calcareous shale or mud, the originally siliceous spicules of the bands are now replaced by pyrites, and it has been possible to determine their forms to a certain extent, but of still greater significance is the discovery in these pyritized specimens of very minute flesh-spicules comparable with those in existing Hexactinellids. Amongst these may be mentioned small regular six-rayed forms with the rays minutely spined, peculiar modifications of the pinule, and a comparatively new form, termed an umbel, consisting of a plump rod with an umbrella-shaped summit. There are also rods with anchor-shaped terminations as in recent sponges of the same group.

The Dictyospongidæ in the Chemung rocks of New York are not infrequently met with associated together in large numbers in particular beds of a somewhat coarse sandstone, in which they lived and flourished in large colonies. This habitat is in striking contrast to that of recent hexactinellid sponges, of which the greater number live in mud or ooze and often at considerable depths, whereas the sandy matrix on the surface of which their Devonian progenitors lived indicates a comparatively shallow sea.

The Bibliography of the Dictyospongidæ is not without interest. The earliest known example, *Hydnoceras tuberosum,* was thus named by Conrad, in 1842, under the supposition that it was an unusual form of Cephalopod, and in the same year Vanuxem described *Uphantænia Chemungensis,* another member of the family, as a marine plant. In 1863 James Hall, the senior author of the present monograph, proposed a new genus, *Dictyophyton,* with nine species, including *Hydnoceras tuberosum,* Conrad, the generic name signifying that in Hall's opinion the fossils belonged to marine Algæ. That these supposed fossil plants were in reality siliceous sponges related to the recent Euplectellidæ, was clearly shown by R. P. Whitfield in 1881, who pointed out that in this case the generic term *Dictyophyton,* Hall, was a misnomer, and that therefore it would be necessary to go back to one of the earlier names, *Hydnoceras,* Conrad, or *Uphantænia,* Vanuxem. In 1884 Professor Hall defined several new genera, but though the spongoid character of the family is fully recognized in the name given to it, the term *Dictyophyton* is retained, and the same course is followed in 1890, when other new species were placed in the genus. In the meantime a large collection of these fossils had been gathered together by Professor Hall, who handed them over to Dr. J. M. Clarke for revision, and it may therefore be fairly assumed that this latter author is mainly responsible for the classification and descriptions in the present monograph. We find in it a veritable revolution as regards the nomenclature: the name *Dictyophyton,* Hall, is entirely given up, since it "has proved a misleading term among the sponges"; Conrad's genus *Hydnoceras,* which Hall had merged in *Dictyophyton,* is again revived, and the various species placed under *Dictyophyton* by Hall, and by others who had adopted the generic name without reference to its original signification, are now distributed among *Hydnoceras* and ten new genera!

A summary of the monograph shows that the Dictyospongidæ family is divided into 7 subfamilies, all new; 32 genera, 20 of which are new; and 128 species, of which 77 are new. The descriptions of genera and species are drawn up very carefully, but, as already remarked, the structural characters of the skeleton in these sponges are very imperfectly shown in their casts, and differences of mere outer form and mode of growth, on which many of the generic and specific features are mainly based, are too inconstant to be relied on.

The varied forms of these sponges are very clearly shown in the admirable plates, whilst figures of the remarkable flesh-spicules are given in the text.

This monograph is a worthy addition to the series of volumes on the Palæontology of the State of New York which, under the authorship of the late Professor James Hall, have appeared during the last fifty years, and it also furnishes a happy augury for the further continuance of the series by his successor, Dr. J. M. Clarke.

G. J. H.

II.—Text-Book of Palæontology. By Karl A. von Zittel. Translated and edited by Charles R. Eastman, Ph.D. Revised and enlarged. Vol. I. pp. viii and 706, with 1,476 woodcuts. (London: Macmillan & Co., 1900.)

Of recent years it has become more and more evident that it is impossible for one man, however great, to write unaided an advanced text-book dealing with all the branches of one science. The only way in which an advanced text-book can be compiled so as to be of real value is by the co-operation of a number of specialists under the direction of a competent editor. This has already been done in some sciences, and to this class of work we may refer the book under consideration, which marks an epoch in palæontological literature.

We had long envied our German colleagues the possession of Zittel's *Handbuch der Palaeontologie*, for although it was for the use of all palæontologists, still a work in a foreign language is never quite the same as one in our own; but now we feel that we have the advantage over them, for in the present work we have the foundation laid by Zittel with a superstructure by a number of zoologists who, as specialists in the groups with which they are dealing, possess worldwide reputations. We have only to glance at the list of collaborators to see what an immense advance this work makes on all other palæontological text-books.

The only disadvantage which this type of work appears to us to suffer from, is the fact that specialists are, after all, but human beings, and consequently apt, in dealing with their favourite group of animals, to give undue prominence to their own views, especially in matters of classification and nomenclature; consequently the advanced student will do well to bear in mind that each chapter is either written or revised by an ardent enthusiast, and not by a cool and perhaps unprejudiced general palæontologist.

Looking at this work in more detail, we find that while the chapters on the *Protozoa* and *Cœlenterata* stand essentially as in the original, those on the *Molluscoidea*, *Mollusca*, and *Trilobita* are entirely rewritten, and the remainder enlarged and revised. We cannot help regretting that some of the short descriptions of the sub-kingdoms were not revised along with the other matter, since such statements like those on p. 257 *re* the supposed relationships of the Molluscoidea to the Mollusca, and the supposed total absence of all hard parts in Tunicata, are apt to mislead the student, unless he has had a very thorough zoological training. So also would some of the definitions of the classes and orders of the Mollusca.

Studying a work of this description one cannot help wondering whether specialists in different groups will ever come to any agreement as to the differences which constitute species, genera, and families, and in this connection we think that the student who voluntarily takes up the study of the fossil Cephalopoda will be a bold man indeed.

We must congratulate Dr. Eastman and his collaborators on the excellent results which have attended their efforts, and we think that Professor von Zittel was wise in allowing his work to be expanded and altered to its present form, which Messrs. Macmillan have put before us in such excellent condition. All English-speaking students of Palæontology will rejoice at its appearance.

III.—A Treatise on Zoology. Edited by E. Ray Lankester. Part III: The Echinoderma. By F. A. Bather, M.A., assisted by J. W. Gregory, D.Sc., and E. S. Goodrich, M.A. pp. vi and 344, with 308 figures in the text. (London: Adam & Charles Black, 1900.)

At last we have actually before us the first instalment of Professor Lankester's long promised Treatise on Zoology. It is somewhat unfortunate that the appearance of this part has been so long delayed (for we notice that the MS. of some parts of the work were completed rather more than three years ago), since, as we all know, zoological text-books have a way of getting out of date very rapidly, owing to the enormous amount of work which is being done all over the world.

Professor Lankester promises us nine more parts of this work, which are to be written as far as possible by graduates of Oxford University. We only hope that these parts will make a fairly early appearance, since, judging from the present part, they should be of immense service both to the palæontologist and to the student of living forms.

The present work deals with the Echinoderma, and since the greater part of it is written by two palæontologists it will probably appeal more strongly to the readers of this Magazine than some of the parts which have yet to appear. The ordinary zoologists will be apt to consider that the palæontological side is perhaps a little overdone; but when we remember that the phylum Echinoderma includes the Pelmatozoa, three classes of which are extinct, and the remaining class, the Crinoidea, consists mainly of fossil forms, the preponderance of the palæontological aspect becomes at once accounted for. This group occupies 179 pages and is the main feature of the book; coming as it does from the pen of Mr. F. A. Bather, who has made such a special study of the group, it will form a classical work of reference for all students of the Pelmatozoa, and will form an interesting companion to the shorter account of this group revised by Mr. Wachsmuth in Zittel's Text-book. We think, however, that Mr. Bather might have dealt a little more fully with the actual facts of anatomy in the general part (pp. 1–37), and given us a few more figures of the general morphology of the Echinoderma, and perhaps fewer theoretical diagrams.

The Holothurians are very briefly dealt with in 18 pages, and somewhat meagrely illustrated with a series of almost blackboard diagrams. The remaining 96 pages are devoted to the Stelleroidea and the Echinoidea, and are from the pen of Dr. Gregory. Both these accounts seem unduly compressed, and the forms are perhaps dealt with too much from the standpoint of the skeleton, as if the variations in the soft parts were comparatively of little value.

The whole work is profusely illustrated with a large number of excellent figures, most of which are new. Some, however, of those not acknowledged in the description are old ones, and one or two of the old ones might well have been replaced by fresh figures, notably fig. iv, p. 242, which is a very poor representation of the general anatomy of a starfish.

Professor Lankester, in his conception of this work, has filled a void long felt in zoological literature, and, in obtaining Mr. Bather's assistance to write the greater part of the Echinoderma, he has exercised a wise selection, the result being that the student is furnished with a most admirable systematic text-book, in which he will find the characters of the classes, orders, families, etc., of the Echinoderma dealt with in a manner not hitherto attempted in any of our zoological text-books. We can only hope that the succeeding parts will be of equal merit and not too tardy in their appearance.

IV.—Memoirs of the Geological Survey: The Geology of Belford, Holy Island, and the Farne Islands, Northumberland. By William Gunn, F.G.S. 8vo; pp. iv, 155. (London: Eyre & Spottiswoode, 1900. Price 2*s.* 6*d.*)

THIS Memoir is an Explanation of the New Series Geological Survey Map, Sheet 4 (Old Series 110 S.E.), and it contains accounts of the Carboniferous Limestone Series, Glacial Drifts, and more recent deposits, with descriptions also of the Whin Sill, whose northern limit is seen in the Farne Islands. The chief part of the Memoir is occupied with descriptions of the Carboniferous rocks, the Tuedian or Cement-stone group, the Fell Sandstone, the Scremerston Coal, and the Limestone groups, the two latter containing seams of workable coal. Details of many pit-sections are given, and there are lists of Carboniferous fossils.

REPORTS AND PROCEEDINGS.

Geological Society of London.

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

1. "The Bunter Pebble-Beds of the Midlands and the Source of their Materials." By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

The author states the results of occasional work in the Bunter Conglomerate of Staffordshire. After a sketch of matter already published, he gives additional particulars of the lithology of the pebbles, more especially of the felstones and of some rather compact dark rocks. Of the former he has now obtained about thirty varieties: orthoclase-felsites and porphyrites, some with, others without quartz; several contain tourmaline, which sometimes has replaced biotite, sometimes felspar. One pebble exhibiting reddish spherulites in a dark matrix, once doubtless glassy, but now devitrified, is not like any British rock known to the author. Of the dark pebbles, some are fine-grained quartzites blackened with opacite; others, varieties of 'schorl-rock'; and two (which Dr. G. J. Hinde has kindly examined) are radiolarian cherts, which, however, cannot be more precisely identified.

The mode of transport and source of the pebbles are next considered. The reasons, already published, for a fluviatile, as opposed to a marine, origin are briefly summarized. If the former be accepted, certain conditions must be satisfied, which bear directly on the position of the source. These beds represent the destruction of large masses of rock. If brought by rivers, those must have been important and powerful, of a continental rather than an insular type. Hence the necessary physical conditions exclude limited districts near the Midlands, such as the Wrekin, Lickey, Hartshill, and Charnwood, even if they included (which is not the case) the right types of rock. As regards the Longmynds, their argillites, if they occur, are not common; their conglomerates do not exactly resemble the Bunter pebble-beds; their 'Torridonian' is a quartz-rhyolite rather than a quartz-felspar grit. The rocks required cannot be supplied from either Wales, the Lake District, or the Pennine range, and we have no reason to suppose them concealed under Eastern and South-Eastern England. We have therefore to choose between a southern and a northern source. Cornwall and Devon might perhaps furnish the schorl-rocks; possibly also one or two varieties of felstone (though this is doubtful) and the right quartzites and quartz-felspar grits occur in the Budleigh Salterton pebble-bed. But the characteristic flat ellipsoidal pebbles of grit, dominant here, are not found in the Midlands. Physical conditions also seem opposed to a northward flow of the rivers of Britain in the earlier part of the Trias. In Scotland, however, we find the right varieties of quartzite, the Torridonian grit, and many felstones, some apparently identical with, others closely related to, those in the Midlands. The rarity of tourmaline rocks in that region is the only difficulty in looking to it or its vicinity for the main source of these pebbles.

2. "Further Evidence of the Skeleton of *Eurycarpus Oweni.*" By Professor H. G. Seeley, F.R.S., F.L.S., V.P.G.S.

The original specimen from which this species was named was obtained from the Sneewberg (South Africa) in 1876, and after being doubtfully referred to *Dicynodon* was described and figured in 1889. It was presented to the British Museum by Mr. Thomas Bain through Sir Henry Barkly. The skull was found with the complete specimen, and a short memorandum of its characters, with a sketch of the skeleton, including the skull, was made by Mr. T. Bain and has been preserved in the British Museum. Half of the counterpart of the slab was presented to the author by the Rev. C. Murray, and by means of it complete casts of part of the skeleton have been obtained.

From Mr. Bain's sketch the author is able to give some account of the skull, including its dimensions. From the material mentioned above, he gives new facts with regard to the vertebral column, the ribs, the shoulder-girdle, the fore-limb, the hind-limb, and the armour, which was present upon the limbs and the fore-part of the body.

The locality from which the animal was obtained had already yielded to Mr. A. G. Bain *Lycosaurus pardialis*, *Tigrisuchus simus*, *Cynosuchus suppostus*, *Scalaposaurus constrictus*, and *Dicynodon leoniceps*. It would therefore appear to be one of the chief localities for the Lycosaurian types of Theriodontia and to be on the horizon of the *Dicynodon*-beds. The recovery of the missing half of the Murray slab, with the evidence of the skull and pelvis which it would give, is to be desired in completion of our knowledge of this fossil animal.

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

1. "Notes on the Geology of Gilgit." By Lieut.-Gen. C. A. McMahon, F.R.S., F.G.S.

This paper is based on observations in the field made by Capt. A. H. McMahon, C.S.I., C.I.E., F.G.S., and Capt. J. R. Roberts, I.M.S., and on the petrological examination of the specimens sent home by them. It is divided into three parts. Part I refers to the work of previous observers, and embodies a brief petrological description of the four granites and aplite intrusive in the sedimentary rocks of Gilgit. Part II consists of a topographical account of the Gilgit rocks from Askole and Nanga Parbat on the south to the northern passes leading into the Russian Pamirs. Part III recites the author's conclusions from the facts recorded in the paper. Briefly stated, they are as follows :—

That at one period in the elevation of the Hindu Kush the strata were thrown into a series of folds and compressed into a series of uniclinal beds with a vertical dip.

That the direction of the main drainage of the area was determined before, or at the commencement of, the last series of earth-movements that crumpled up the strata.

The sedimentary rocks were profusely invaded by granite and diorite, and profoundly metamorphosed by contact-action.

As regards the age of the rocks, the author gives his reasons for identifying the Gilgit limestones with the conformable Carbo-Triassic series of the Himalaya. This series was mapped by Mr. R. Lydekker, F.R.S., in the neighbouring district of Kashmir, and it has been traced up to the border of Gilgit. Sir Martin Conway's specimens, reported on by Professor Bonney and Miss Raisin, enable the author to connect it with the limestones of Gilgit. From this correlation the author concludes that the oldest rock in the Gilgit area is of Silurian or Lower Carboniferous age, and that the most recent are of Triassic or even later age. As all the granites are intrusive in the most recent beds, it follows that the granites are younger than the Trias. The author gives his reasons for believing that the oldest granite was erupted while the crumpling of the Gilgit rocks was in progress; but that a portion, at all events, of the younger granites was erupted after the crumpling had taken place.

The author offers an hypothesis to explain certain structures found in the Gilgit granites, including the granophyric structure so common in them.

All the Gilgit granites, the author believes, came from the same igneous reservoir, the differences in them being due to gradual and progressive silification caused by the gradual crystallizing out of the comparatively basic minerals; the process extending over a long period of time measured in years.

2. "The Rocks of the South-Eastern Coast of Jersey." By John Parkinson, Esq., F.G.S.

In this paper the author has continued the study of the deep-seated rocks of Jersey begun in a communication presented to the Society last session entitled "On an Intrusion of Granite into Diabase at Sorel Point (Northern Jersey)." A great resemblance exists between these rocks in the north and south of the island, and it is concluded that they represent parts of the same magma; but in the south-east additional complications arise, owing to the intrusion of another rock before the invasion of the granite. For convenience of study the district under discussion is divided into two parts, an eastern and a western, separated the one from the other by the western termination of the Grève d'Azette. In the eastern district the granite and the intrusive rock which preceded it are found; in the western a rather different rock invades the diabase. The latter is correlated with the aplite intrusion of the northern coast.

Taking first the earlier intrusion found at Le Nez Point, it is shown that it consists of a rock more acid than a diorite, but on the whole more basic than the granite which followed it. Microscopical examination indicates that it was poor in ferro-magnesian minerals, and that quartz and orthoclase, though present, are not found in the proportion which characterizes the granite. This rock, the exact composition of which it is not easy to discover, has invaded the diabase, as well as a dioritic rock associated with it, streaking and veining them. Mixing took place as a result of such intrusion, producing a composite rock characterized by elongated hornblendes which occasionally attain a considerable size. Mica is conspicuously absent.

The intrusion of the granite following this is next described. Here, as on the northern coast, local absorption of the older rock has taken place. The resemblance between the mixed rocks is commented upon, and a parallel drawn between the basic and acid rocks of Jersey and the eastern and northern coasts of Guernsey.

Passing to the western district, the aplite of St. Elizabeth's Castle is described, together with the melting and absorption which have taken place as a consequence of this intrusion. Field evidence indicates that this is later than any intrusion found in the eastern district, though the difference in age is probably but slight; thus it bears out the results of work on the northern coast, where the intrusion of an aplite was found to have followed that of a porphyritic granite. Reasons are given in the body of the paper for believing that successive intrusions cannot be separated the one from the other by hard-and-fast lines. Finally, it is suggested that the various rocks considered are closely related, and indeed form parts of one magma, the successive injections of which became progressively more acid.

3. "The Rocks of La Saline (Northern Jersey)." By John Parkinson, Esq., F.G.S.

The rocks of La Saline closely resemble those of Sorel Point, about a mile to the west. A coarse porphyritic granite is found in the upper part of the cliff which passes rapidly into an equally coarse but redder rock, approaching an aplite in composition. The latter occasionally contains mica in some quantity, and evidence is given for concluding that this mineral has been produced by the combination of the constituents of the augite of a dolerite, through which the acid magma forced its way, and the felspathic parts of the magma itself. This evidence is based (i) on the fact that in one part of the Bay a few outcrops of rock are found identical with others from Sorel Point, which have been clearly formed by the absorption of fragments of diabase (dolerite) by an acid magma; (ii) on the presence of fragment-like patches rich in mica in the aplite itself; (iii) by the irregular distribution of this mineral through the acid rock. A peculiar quartz-less rock is next described containing large orthoclases, plagioclase, and chlorite: it is concluded that the last-named mineral is derived from mica. With some hesitation the structure of this rock is explained by supposing that the intruding magma melted a mass of dolerite, completely dissolved the felspar, and produced mica in the manner indicated above; and that as freedom of movement was not greatly restricted, segregation of the basic elements followed, enclosing among them numerous porphyritic orthoclases. Some movement of the whole then appears to have taken place.

CORRESPONDENCE.

PTEROCONUS MIRUS, HINDE.

SIR,—Last Spring Mr. Upfield Green allowed me to see the fossils to which he afterwards gave the name *Nereitopsis Cornubicus* in the Trans. Roy. Geol. Soc. Cornwall, vol. xii, p. 227, regarding them as Annelids. While studying them, point after point came out which forced me to the conclusion that they belonged either to *Orthoceras* or to a closely allied genus. The surface ornament, the contour, the septa, and other details seemed thus, and only thus, explicable. The chief perplexity was that, while the other parts were crushed and partially obliterated, the siphuncle remained rigid; but the consideration of *Actinoceras*, and still more *Huronia*, seemed almost to clear this away, and I felt able to tell Mr. Green that they were in my opinion certainly Cephalopoda.

With these fossils, or some of them, Dr. Hinde identifies those collected by Mr. Howard Fox at Bedruthan, to which he has given the name *Pteroconus mirus* on p. 149 of the present volume of the GEOLOGICAL MAGAZINE, regarding them as Hyolithidæ. These fossils he has very kindly shown to me, and with the identity of three of the specimens (his figs. 2, 3, 4) I agree, though still venturing, in spite of such weighty authorities as Dr. Hinde and Mr. Crick, to believe that I see in them Cephalopoda. The fossil represented by his fig. 1, I confess that in my hurried examination of it I could not fully decipher; nor did I feel quite certain that it was the same as the rest; but at the same time some Devonian Orthocerata which I have seen did appear as if they might go some way toward explaining it.

Fossils in such an extremely obscure state of preservation may, I think, allow of a different interpretation without disrespect to the authority of my valued friends; and, indeed, I think that my difference of view is mainly due to my regarding them as masked and distorted by the processes of fossilization to a very much greater extent than they appear to consider. G. F. WHIDBORNE.

FOSSILS IN DEVONIAN ROCKS OF NORTH CORNWALL.

SIR,—The fossils figured by Mr. Green in the Transactions of the Geological Society of Cornwall under the name of *Nereitopsis Cornubicus* being very interesting ones, their further illustration and description in the more widely circulating GEOLOGICAL MAGAZINE is a matter of congratulation. But is the renaming of them quite in accordance with accepted rules of nomenclature? Dr. Hinde in his paper[1] mentions the fact that Mr. Green did not fully describe it; but many accepted names rest on figures alone. He also states that as, in his opinion, the fossils could not "in any way resemble any species of *Nereis*," the name is "misleading and should be changed." But has not the author of a genus the right to express in the name what the form reminds him of, even if the resemblance be fanciful?—e.g. *Ophiopsis*, *Pileopsis*, *Galeopsis*. And would not the new name proposed (*Pteroconus*) be open to the same objection,

[1] GEOL. MAG., Dec. IV, Vol. VII, p. 149.

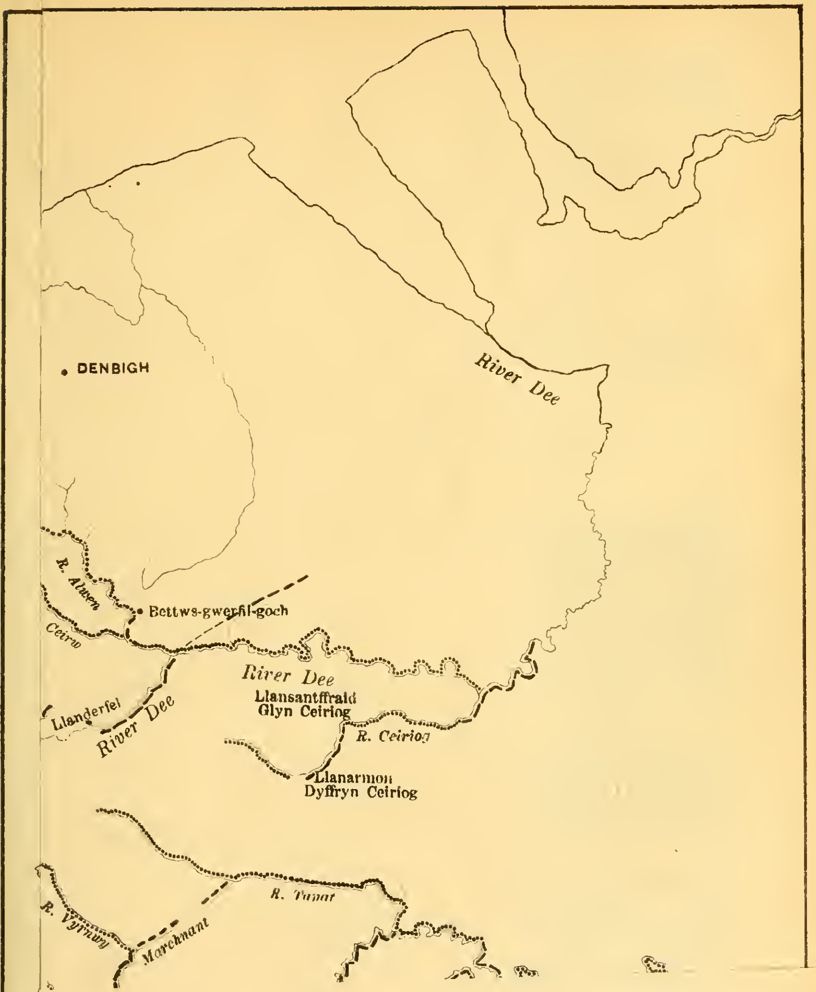
the first half comparing the "flap- or fin-like extensions" to a *wing*, which is not a serial organ, and the second half suggesting a relationship to a genus of shells? As to the specific name, Mr. Green gave the name *Cornubicus* to his specimens as a group, regarding them as specifically one; but if they are to be divided, then his statement that a certain specimen "differs from the others" indicates that the "others" are regarded as the type. As Dr. Hinde says he is "undecided" whether his specimens are different from these others, it follows that the statement *sp. nov.* after the name he gives is quite unproved. I would also point out, what cannot have struck Dr. Hinde, that the name *mirus* implies that the specimens so named are the first discovered. One is not astonished at further examples of a known form, however wonderful, turning up, and Mr. Green showed his specimens to his friends, Cornish and others, and recognized examples in the Penzance Museum before the beginning of last year, when Mr. Fox's specimens were found. In justice, therefore, to Mr. Green the new name ought to be relegated *in toto* to the synonymy.

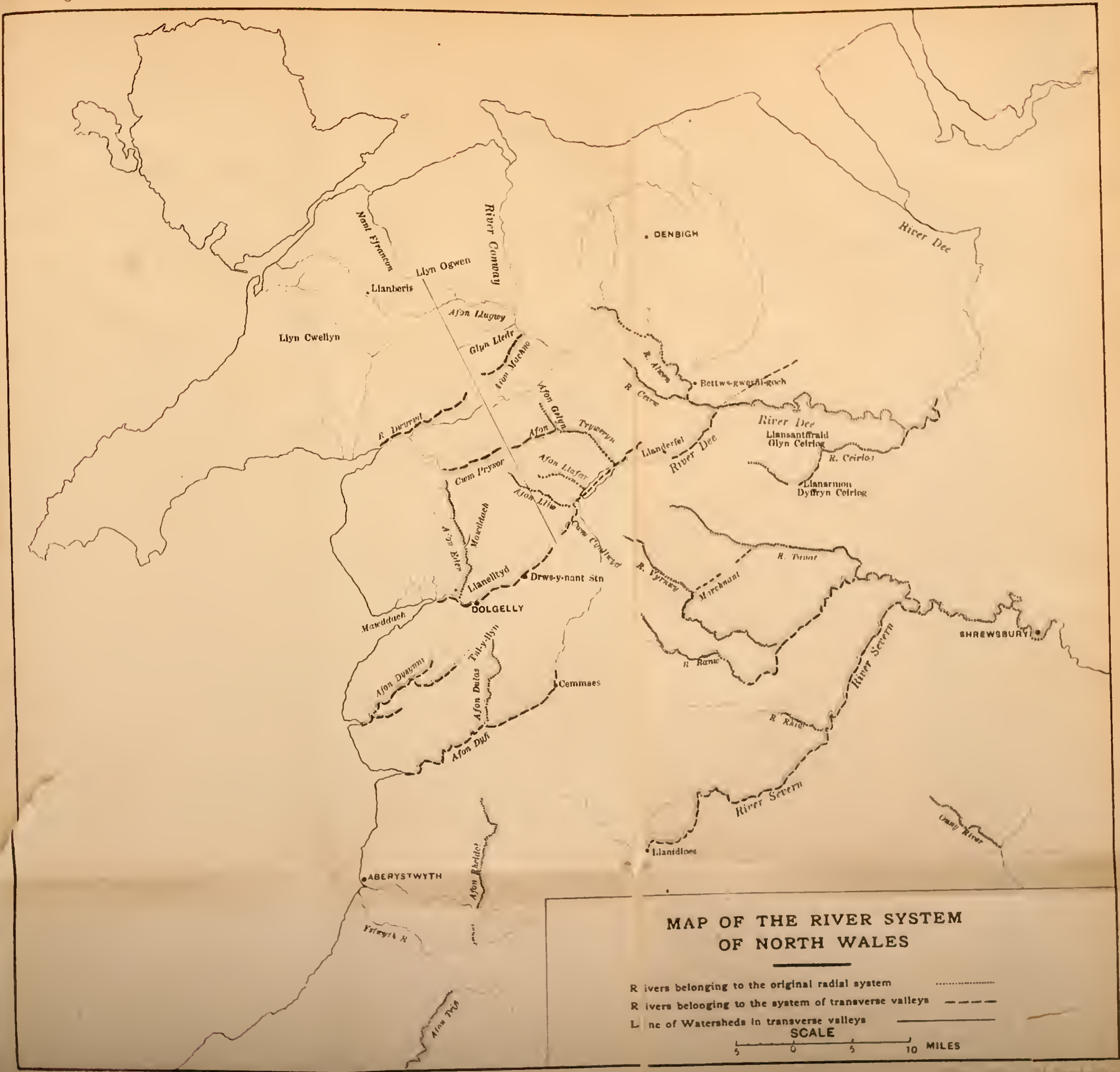
As to the nature of the organisms represented, there will probably continue to be a difference of opinion. The use of the word 'shell' in Dr. Hinde's description is an assumption, as it is admitted that nothing now remains but "some compound of iron," which may be derived, as in the case of the chalk Ventriculites, from other things than shells. The irregularity of the outline indicates rather a soft-bodied animal. The downward bend of the flaps in one specimen, their upward bend in another, and the straight direction of their bases in a third indicate that they were flexible. Dr. Hinde seems to think that downward-bending flaps on both sides might appear as upward-bending if the fossil were turned round on its median axis, but this is impossible. He also states that we cannot tell whether the dorsal and ventral sides are alike or not; but as in one specimen each later flap "dips slightly *under*" the next preceding, we can tell that we are looking at the opposite side in any other specimen if, as appears to be the case in his second figure, the later flap lies slightly *over* the next preceding. The supposed rod may very well be the remains of the intestine filled with matrix, or mere folds in the shrunken integument. In Mr. Green's specimens the bases of the flaps are somewhat swollen, and the distal lines are slightly radial rather than absolutely parallel.

If, then, we figure a soft-bodied animal, lineally elongated, with a series of flexible organs on each side consisting of oblique flaps ending distally in slightly radiating prolongations, the description fits so well with that of a polychætal annelid, as exhibited by many larvæ and by the adult of *Aphrodite*, and so ill with that of any other known group of organisms, that this interpretation of the fossils seems the most reasonable, especially as we have reason to believe that this group was well established before the Devonian period.

J. F. Blake.

Erratum.—On p. 147, line 19, *for* "adunate" *read* "inadunate."


River Dee
DENBIGH
R. Alwen
Bettws-gwerfil-goch
Ceirw
River Dee
Llanderfel
River Dee
Llansantffraid
Glyn Ceiriog
R. Ceiriog
Llanarmon
Dyffryn Ceiriog
R. Tanat
R. Vyrnwy
Marchnant



MAP OF THE RIVER SYSTEM OF NORTH WALES

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

No. VI.—JUNE, 1900.

ORIGINAL ARTICLES.

I.—Bala Lake and the River System of North Wales.

By Philip Lake, M.A., F.G.S.

(With a folding Map, PLATE XI.)

(*Concluded from the May Number, p.* 215.)

Watersheds in other Valleys.

In North Wales there are several valleys which run parallel or nearly parallel to the valley of the Bala fault, and, like it, are crossed by watersheds which are quite inconspicuous. One of these watersheds separates the head of Cwm Prysor from the source of Afon Tryweryn; a second parts the springs of the Conway from those of Afon Dwyryd; and a third divides the waters of Nant Ffrancon from those of Afon Llugwy (a tributary of the Conway). (Pl. XI.)

In the first two cases the valleys are not deep, but they are sufficiently defined to form the lines chosen for the railway from Bala to Ffestiniog, and for the road from Ffestiniog to Denbigh; and in the third case, the valley is at least as striking as that of the Bala fault, and the watershed is even less conspicuous than that at Pant-gwyn.

All these watersheds lie upon one straight line—a line drawn from Pant-gwyn to a point 1,200 yards east of Llyn Ogwen. This may, indeed, be a mere coincidence, but the coincidence is remarkably close, and it seems more probable that the positions of the watersheds have been determined by some general cause.

It can scarcely be supposed that ever since the formation of these valleys (which are certainly pre-Glacial) the whole of Wales has remained absolutely fixed and immovable. And if the region has moved at all, there is little difficulty in supposing that the motion was not uniform throughout. A very slight differential movement, even now, would be sufficient to alter the positions of these watersheds; and it is quite possible, therefore, that their present positions have been fixed by former movements.

It may be remarked that this straight line crosses two other important valleys in which it does not coincide with the watersheds—the valley of Afon Lledr and Nant-y-gwryd. But this is easily explained if we suppose that the heads of these valleys stood too high to be affected by the differential movements. Moreover, in each case there is some evidence that near to the spot where the line crosses, the rocky floor is higher than it is farther up the valley.

In the valley of Afon Lledr the line crosses a little way below Roman Bridge station. Above, the river flows through an alluvial flat: here, rocky spurs run down to the stream, and the stream itself flows over rock *in sitû.*

Nant-y-gwryd is crossed near Dyffryn Mymbyr. The stream flows over a drift-covered flat; but at this point a line of rocky knolls rises through the drift.

These, then, are perhaps attempts at watersheds, frustrated by the fact that the heads of the valleys lay at a higher level. I am not, however, disposed to attach much importance to these unfinished watersheds, until the ground has been more closely examined. The evidence is somewhat doubtful, and near Roman Bridge it is possible that the river has forsaken its ancient channel.

Development of the River System of North Wales.

Among the most striking features in the topography of North Wales are the long deep valleys which run from north-east to south-west, and which, where they enter the sea, form the wide estuaries of the Mawddach, Dyfi, etc. Many of these valleys are dry for a considerable part of their course, or are occupied only by little streamlets out of all proportion to their own size. They are crossed by the principal watersheds of the district, and even at these points the floors of the valleys are comparatively low. They are not perfectly straight, but generally form curves of long radius, the convexity of which faces the south-east. (Pl. XI.)

Sometimes, at least, the valleys coincide with lines of fault; and in one case, as I have shown, two faults form a trough for a certain distance, and the floor of the valley coincides with the bottom of the trough.

My examination of the region not being by any means complete, I do not attempt upon the accompanying map to trace these valleys continuously across the district; but have merely indicated by heavy broken lines the principal streams, or portions of streams, flowing in valleys which I believe to belong to this N.E.–S.W. system. The continuity of the valleys is nevertheless sufficiently evident, although not quite so clear as it is in the field.

Among the most important of these valleys, or—to make less of an assumption—of these lines of valleys, are the following:—

1. The Menai Straits.

2. The estuary Traeth-bach, Afon Dwyryd, Cwm-tegwel, Afon Machno.

3. Mawddach estuary, Afon Wnion, Afon Dyfrdwy below Pant-gwyn, Bala Lake, Afon Meloch, River Alwen from Maerdy to Bettws Gwerfil Goch, and possibly a part of the Clwyd.

The Mawddach estuary is not in a line with the general direction of the Wnion. A valley in more direct continuation of the latter is that in which lies the high road from Dolgelly to Towyn.

4. Valley of Tal-y-llyn and the Towyn Railway. Nearly in line with this, but apparently quite disconnected, is the Valley of the Dee between Llandderfel and Corwen, and the valley of Nant Morwynion.

5. Afon Dyfi up to Cemmaes, and perhaps to the source of the river.

6. River Banw from Llanfair to its junction with the Vyrnwy; then the Vyrnwy to its junction with the Tanat. The rivers Ceiriog and Dee below Chirk perhaps belong to this valley.

7. River Severn from Llanidloes to its junction with the Tanat.

Among the smaller valleys belonging to this system are (*a*) Cwm Prysor and Afon Tryweryn above its junction with Afon Gelyn, and (*b*) a small part of the Vyrnwy below the Liverpool Waterworks, River Marchnant, River Ceiriog from Llanarmon Dyffryn Ceiriog to Llansantffraid Glyn Ceiriog. Other shorter valleys of similar character and direction undoubtedly exist, but these I have made no attempt to indicate.

A closer examination would certainly reveal more clearly the connection and continuations of some of these valleys; but enough is shown upon the map to prove that some at least of these lines of valleys are continued, with little or no interruption, for great distances.

That these valleys have exercised a profound influence upon the drainage of the country is quite clear, and most of the principal rivers lie in them. They cut up the country, more or less completely, into parallel strips; and the drainage of each strip is intercepted by one or other of these parallel valleys. In the most northerly strip, between the Menai Straits and Traeth-bach, most of the streams flow northwards. But in the others the greater part of the drainage of each strip falls into the valley lying south of it; while the streams which run northward are generally small and unimportant.

For instance, entering the valley of the Bala fault from the north, we have Afon Eden, Afon Lliw, Afon Llafar, Afon Tryweryn, the Ceirw, and the Alwen; while from the south, the most important is Afon Twrch in Cwm Cynllwyd.

The question then arises, was the drainage of each strip established independently, after the formation of the long valleys; or was the drainage established first, and the long valleys formed afterwards? In the former case there would, presumably, be no connection between the streams of adjacent strips; in the latter, we should expect the more important streams of one strip to have their representatives in the next.

Beginning with the streams which flow into the valley of the Bala fault from the north, we have first Afon Eden, with its tributary Afon Mawddach.[1] This important river runs southward till it enters the Mawddach estuary at Llanelltyd, where it turns suddenly almost at right angles. But if we continue the line of

[1] After the junction of these two the river is called the Mawddach. But the Eden is clearly the principal branch, inasmuch as it maintains its direction unchanged.

the Eden across the valley and over the opposite hills, it leads us into Afon Dulas. The Dulas maintains the same direction until it enters the valley of the Dyfi, where it also is deflected to the right. If we neglect this deviation and proceed in the same line, we come again upon another stream flowing in the same direction, namely, Afon Rheidol. This river runs southward as far as Devil's Bridge, where it in turn is suddenly deflected at right angles, so as to enter the sea at Aberystwith. But our line is continued still further by the upper part of the Ystwyth and the valley of the Teifi.

So exactly are all these rivers—the Eden, Afon Dulas, the upper parts of Afon Rheidol, and of the Ystwyth and the Teifi—in the same line,[1] that the valleys to which they belong seem all to be portions of one great valley, the head of which probably lay as far north as Blaenau Ffestiniog. This valley, according to my views, was subsequently broken up by the formation of the transverse valleys belonging to the N.E.-S.W. system.

Similarly, on the south-east side of the Bala fault, we find the continuations of Afon Lliw and Afon Llafar in the river which is now called the Vyrnwy; of Afon Tryweryn in the River Tanat; of the Ceirw (probably) in the Ceiriog; and of the Alwen, in the Dee below Corwen.

Another important stream south of the Bala fault is the Banw, and possibly the original head-waters of this are represented by the upper part of the Dyfrdwy.

The Banw, the Vyrnwy, and the Tanat, all enter the sixth of the N.E.-S.W. valleys given in the list on a previous page. The Banw and the Vyrnwy are deflected and flow along this valley; but the Tanat maintains its original course and even crosses the next transverse valley. The original continuation of the Banw is probably to be looked for in the lower part of Afon Rhiw and, across the Severn, in the Onny River.

If we assume that the Eden, Lliw, etc., were the upper portions of the valleys which I have endeavoured to trace, we must conclude that before the transverse valleys were formed—those which now run from north-east to south-west—a radiating system of drainage was established, the centre of which lay in the high ground at and near the present source of the Conway.[2]

This appears also to be the centre from which radiate the principal

[1] It will be noticed that this line is almost exactly parallel to the general trend of the coast of Cardigan Bay, a fact which seems to point to some community of origin.

[2] If the radial valleys existed before the formation of the transverse valleys, we might expect that where the lines joining the remnants of the radial valleys cross the intervening ridges, there should be a col or depression; and this is, indeed, very commonly the case. Moreover, opposite each important stream where it enters a transverse valley, there is generally a little valley running down from the col and entering the transverse valley on the opposite side. For example, opposite the point where Afon Lliw enters the valley of the Bala fault, a valley runs in from the col called Bwlch-y-pawl, which is situated at the head of the River Vyrnwy. Opposite Afon Tryweryn is the valley of the Hirnant, and from this we pass across a col into the head of Afon Tanat. Similarly, in the line of the Ceirw we find Afon Trystion entering the valley of the Dee from the opposite side; and from the head of Afon Trystion a decided depression leads us to the head of the Ceiriog.

tributaries of the Clwyd; the Conway itself; and the rivers of Snowdonia, which occupy Nant Ffrancon, the Vale of Llanberis, and the valley of Llyn Cwellyn. I am not, however, in a position to discuss this question more fully, nor am I prepared to assert that all these streams belong to the same radial system.

There is certainly one important river which seems to be exceptional, namely, the river which flows through the pass of Aberglaslyn.

But the broad outlines of the river history of North Wales seem to be clear. A radial system of drainage was established; and subsequently a series of transverse valleys was formed, which broke up the radial system into sections, and each of the main transverse valleys carries away the drainage of one or other of these sections.

The transverse valleys were, I believe, formed by faults, with an upheaval on one side; but further investigation is needed to elucidate this point. One of the faults appears to have assumed for some distance the character of a trough, with the consequent formation of a lake, which is now Bala Lake; and it seems that the development of this trough was subsequent to the original formation of the valley.

If it were not for these transverse valleys, the drainage system of North Wales would be very similar to that of the Lake District, and the Vale of Clwyd would be the analogue of the Vale of Eden in Cumberland.

Summary.

In the foregoing pages I have endeavoured to throw some light upon the formation of Bala Lake and to sketch the development of the present somewhat complicated river system of North Wales. The explanation suggested is simple and fairly consistent; but it is still, in many respects, hypothetical. This is especially the case, perhaps, with regard to the share attributed to the faults, in the production of the present topography of the country. On this and many other points, further research is certainly necessary. Yet from the evidence adduced, it seems that the following conclusions may, with some probability, be drawn :—

1. Bala Lake belongs to the same valley as the River Wnion; and the drainage of this valley formerly flowed into the sea near Barmouth.

2. Bala Lake and the rest of the valley as far to the south-west as Pant-gwyn lie in a trough between two faults, modified by other faults crossing the trough obliquely.

3. The position of the watershed in this and in several other similar valleys has been determined by earth-movements.

4. The original drainage system of North Wales was a radial system, the centre of which lay in the high ground around the sources of the Conway. Subsequently a series of transverse valleys was formed which divided the radial system into sections, and each of the principal transverse valleys now carries away the drainage of one of these sections. Bala Lake was formed in one of the transverse valleys, probably not at the same time as the valley itself, but at a somewhat later period.

II.—The Parent-rock of the Diamond. Reply to a Criticism.

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

A SHORT time since Mr. G. Trubenbach, Managing Director of the Newlands Diamond Mine, West Griqualand, drew my attention to a notice by Professor Beck[1] of the paper which I read to the Royal Society last June, on the Parent-rock of the Diamond in South Africa, kindly sending me a translation of the original. As Professor Beck's criticisms are founded on such a travesty of my published opinions[2] that I can only suppose his knowledge of our language to be very imperfect, and as the hypothesis which he advances appears to me untenable, I ask permission to reply to the one and point out the improbability of the other.

1. Professor Beck objects to my terming the crystalline garnet-pyroxene rock, which sometimes contains diamonds, an eclogite, remarking,[3] "which, however, must raise doubts, as this name has hitherto been applied only to a similar mineral combination of crystalline schists (*schiefer*), while Bonney particularly emphasizes the eruptive nature in this instance." In my paper I took the precaution of stating that I was well aware doubts had been expressed in the past as to the origin of eclogite, but that after good opportunities of studying it I was convinced it was an intrusive igneous rock. That such doubts should have existed is not surprising. The significance of foliation was for long imperfectly understood, and as eclogite is generally associated with crystalline schists, and is not seldom foliated, it was supposed to have had a similar origin. In such cases it is a metamorphic rock, but not in the sense formerly implied by that word; the foliation (by no means universal) being only a superinduced structure, while the evidence of intrusion is sometimes conclusive. Eclogite formerly was left with sundry other little understood rocks in a kind of 'oddment' drawer.[4] Does this uncertainty in the past as to the genesis of a rock debar us from using its name afterwards when we are able to do it with more precision? Or does Professor Beck mean to say that the whole history of a rock, as well as its mineral composition and structure, must be known before we can give it a name? In both the latter this South African rock is truly an eclogite, and I maintain the name may legitimately be used for it, when ill-grounded uncertainties as to the genesis have been cleared up. What does Professor Beck mean to do with the olivine rocks (or peridotites) and the corresponding serpentines? There also a similar doubt as to origin formerly existed.

2. This, however, is a mere difference of opinion on a question of nomenclature. I pass on to one more important. Professor Beck criticizes, at too great a length for full quotation, my supposed

[1] Zeitschrift für Praktische Geologie, December, 1899.
[2] Proc. Royal Soc., lxv, p. 223.
[3] I quote from the translation sent to me by Mr. Trubenbach, though I have occasionally made a slight alteration in the terms used.
[4] See, for instance, Cotta on Rocks, translated by Lawrence, 1878, p. 310.

views in regard to the original home of the diamond. The more important part, however, runs as follows:—"He assumes that they (the garnet diopside boulders) are fractures from a much older rock, which, having been subjected to the same action as river boulders, were brought to the surface, *together with the kimberlite,* from a *fluviatile deposit,*[1] at a great depth. Quite naturally he now deduces the hypothesis that all the diamonds found in the kimberlite have their origin *in such diamantiferous soapstone formation* (*diamantseifen*) *deposited in the depth of the Karoo formation* and brought to the surface by the same eruptive agencies as produced the kimberlite necks (stocks)." Professor Beck then proceeds to argue against the probability of these "diamantiferous soapstones" underlying the whole of the Karoo formation. But I never even mentioned a soapstone, and do not know what Professor Beck means by it, unless it be the matrix of the so-called kimberlite; neither have I ever asserted anything like the sentences which I have placed in italics. I agree with him that the existence of a bed of "diamantiferous soapstone" at the base of the Karoo (i.e. in the Dwyka conglomerate) is most improbable, but of that he is the sole inventor, and I strongly object to having such nonsense fathered upon me. I have read my paper again, and think, speaking from some experience as a writer, that it ought to be intelligible to anyone who really understands English. I did not, indeed, elaborate every minute detail of the argument.[2] For this I had two reasons—one, that as I was addressing scientific experts, they did not require elementary instruction; the other, that, as I personally object to elaborate demonstrations of the obvious, or to being told with much detail that Queen Anne is dead, I abstain, as far as possible, from inflicting this penance on others. What I said amounted to this,—that the diamond had now been found as a constituent of a coarse-grained eclogite; that this eclogite no doubt formed part of an old crystalline floor, underlying the Permo-Triassic deposits, from which fragments must have been broken off and rolled by water action into boulders; that these probably had been inmates of the Dwyka conglomerate; that after the Karoo Beds were deposited, volcanic explosions had shattered much of the crystalline floor (eclogites, peridotites, etc., some of them diamantiferous), and sent its fragments flying up together with the overlying Dwyka conglomerate[3] and Karoo Beds; and that the pipe was ultimately filled up with this broken material, which was subsequently exposed to solfataric, perhaps also very locally to contact action.

Thus Professor Beck is criticizing an hypothesis which is none of mine, but of his own imagining. From this I turn to the one which he proposes as a substitute. "We take the garnet diopside lumps, notwithstanding their form, not as actual boulders, but of

[1] The italics are mine.

[2] My views will be found on pp. 235, 236.

[3] The boulders, pebbles, and mineral grits in this would be scattered like shot from a gun.

intra-telluric origin, i.e. concretions of the kimberlitic magmas. They hold the same position to kimberlite as the well-known olivine lumps (*olivinknollen*), which sometimes have the same rounded-off form and smooth surface, to the basalt in which they are inclosed." To this I reply that: (1) I have spent some time in the endeavour to prove that kimberlite is only a fragmental rock,[1] and the occurrence in any peridotite of coarsely crystalline 'concretions' of garnet, diopside, enstatite, etc., would be without precedent. (2) It has yet to be proved that these 'olivinknollen' in basalt are 'concretions,' and I do not envy the man who attempts the task. I have examined scores of them; they are seldom, if ever, really well rounded, and are, I believe, fragments of a peridotite, caught up by the basalt, as happens to pieces of granite, gneiss, sedimentary and other kinds of rock. If the lumps of eclogite are concretions it is strange they should be so easily separable from the enclosing 'kimberlite,' and still more so that the minerals at their surface should so often be cut through exactly as they would be by attrition. In other words, speaking from a wide experience in the field, I am certain that these are as truly boulders as any in the bed of an Alpine torrent. But Professor Beck, apparently not quite satisfied with his 'concretion' hypothesis, goes on to suggest that rounding "may be accounted for by a rotatory abrasion during the eruption in the crater." I have examined the materials of a good many volcanic cones, but never saw such perfect rounding as this, and as I foresaw the possibility of that hypothesis being advanced, was careful to insert a sentence to show that I had both considered and rejected it. Thus I find myself unable to admit either the justice of Professor Beck's criticisms or the reasonableness of his hypothesis. The latter, indeed, suggests to me that its inventor has heard the "mouse squeak" more often than "the lark sing."

III.—Derived Limestones.

By Professor W. J. Sollas, D.Sc., F.R.S.

MY attention has been directed to the following paragraph, which appears in Mr. H. B. Woodward's monograph on the Jurassic Rocks of Britain, vol. iii, p. 31 (1893). It is as follows:—

"Prof. Sollas has suggested that rivers sometimes bear to the sea considerable quantities of undissolved calcareous matter, derived from the formation through which they flow. This is a matter that requires confirmation, for it is known that carbonate of lime is more readily soluble in fresh-water than in sea-water."

The statement attributed to me was more than a mere suggestion, and as the subject is of some interest it may be as well if I now present the evidence which I had in mind when asserting that the

[1] I do not deny—nay, I expect—that large masses of peridotite (probably also diamantiferous) exist in the crystalline floor, but not 'kimberlite' as defined by Professor Carvill Lewis. A little lower down, Professor Beck seems to admit the 'kimberlite' to be a breccia. If so, how can it be a 'magma,' unless he means that the unbroken material exists somewhere down below, in which case it is not likely to be 'kimberlite,' but some ordinary variety of peridotite.

denudation of a limestone and the transportation of calcareous sediment may be accomplished not only by solution but by the mechanical action of fresh-water.

On examining under a microscope the suspended matter which floats in the river Cam above Cambridge, and which may readily be separated by filtration through a muslin net, the observer who looks upon them for the first time will be surprised to find associated with a number of minute living organisms certain bodies which resemble in the closest manner the coccoliths of the Chalk. The appearance of these is so fresh that it would not be an altogether inexcusable blunder to regard them as native to the stream, and though it might be objected that fresh-water coccoliths are things hitherto unheard of, yet an answer to this might be found in the fact that on removing the calcareous part of the organism with dilute acid a soft granular film remains behind, which has not only a very organic appearance, but readily stains with magenta and some other aniline dyes.

On pushing the enquiry further, however, it will be found that the residual film is not affected by such stains as are selective in their effects; those which only react upon protoplasm have no effect upon it. Further, the coccoliths give no signs of life; they cannot be made to grow nor to subdivide by fission.

In the old days when the coprolite pits around Cambridge were being worked it was not uncommon to come across streams of chalky water flowing away from the washing tanks. An examination of this revealed all the forms of coccoliths which were to be found floating in the Cam, but in this case there could be no question as to their origin, they were derived from the chalk marl.

Considering, then, that no independent evidence can be cited for the existence of fresh-water coccoliths, that the minute bodies floating in the Cam present no signs of life, and that the river drains a country largely composed of chalk rocks, from which, as we have proof, coccoliths may be derived, the presumption is altogether in favour of regarding the coccoliths of the Cam as mechanical sediments now in process of being carried to the sea.

I have said that these sediments may be "considerable." A good deal depends on what is meant by considerable, but I think the qualification may be justified by the following example. On visiting the gravel-pits at Barnwell occasional white lenticular beds may be observed intercalated amid the finer sands of the deposit. These are composed of carbonate of lime, and a microscopic examination proves them to consist of minute organisms and débris of organisms, which have been derived from the chalk. Foraminifera, whole and broken, of which *Globigerina* is one of the commoner forms, shell prisms, and coccoliths are obvious. Thus we learn that not only may a river transport calcareous sediment, even when constituted of such minute bodies as coccoliths, just as it might an insoluble clay, but further, that under favourable circumstances it may deposit this material and thus form beds of limestone, which are not immediately but only indirectly of organic origin.

It was partly from observations such as these that I was led to suggest a derivative origin for the calcareous substance of the cornstones of the Old Red Sandstone, and for much of the limestone of the Lower Lias; nor has subsequent reflection led me to abandon this explanation, but rather to extend it. A good deal of the magnesian limestone of the North of England is as false-bedded as a modern beach sand, and occurs under circumstances that would lead us to look for its source rather in the mountain limestone than in its poverty-stricken indigenous fauna. Such derivative calcareous matter would by reason of its finely divided state be in a condition to yield readily to the action of magnesian waters and thus pass into dolomite.

It by no means follows that rivers have been the only agents by which mechanical calcareous deposits have been formed from pre-existent limestones; sea waves may have also played their part, as, indeed, is suggested by my friend Mr. Woodward, who also has arrived at the conclusion "that under certain conditions there may be sedimentary deposits of calcareous mud [derivative] as well as chemical precipitates."

IV.—Woodwardian Museum Notes: On the British Species of the Genus *Conocoryphe*.

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

In 1877 Dr. Woodward[1] recorded nineteen British species of the genus *Conocoryphe*, of which seven were doubtful. The following is the list of them:—

Conocoryphe abdita, Salter.
C. applanata, Salter.
C.? bucephala, Belt.
C. bufo, Hicks.
C. coronata, Barrande.
C. (*Solenopleura*) *depressa*, Salter.
C. Homfrayi, Salter.
C. humerosa, Salter.
C. invita, Salter.
C.? longispina, Belt.
C. Lyellii, Hicks.
C.? olenoides, Salter.
C.? simplex, Salter.
C. solvensis, Hicks.
C. sp., Salter.
C.? variolaris, Salter.
C.? verisimilis, Salter.
C. vexata, Salter.
C.? Williamsoni, Belt.

Professor Etheridge[2] in 1888 gave the following four additional species:—

Conocoryphe Malvernius, Phillips.
C. monile, Salter.
C. perdita, Hicks.
C. Plantii, Salter.

Salter[3] in 1872 had doubtfully recorded *C.? ecorne* (Angelin)? from Wales. The latest addition to the list was *C. viola* (H. Woodward) in 1888 from Bethesda.[4]

Since the generic name *Conocoryphe* is now used in a much more restricted manner than formerly, it is desirable that the true position of the above-mentioned species should be determined afresh. The genus *Conocoryphe* is now used[5] as the type of the family

[1] Catal. Brit. Foss. Crust., pp. 31–33.
[2] Brit. Pal. Foss., pp. 48, 49, and 406.
[3] Catal. Camb. Sil. Foss. Woodw. Mus., p. 12.
[4] H. Woodward, Q.J.G.S., vol. xliv (1888), p. 74, pl. iv.
[5] Textbook of Palæontology, by Zittel & Eastman (1900), vol. i, p. 626.

Conocoryphidæ, which also includes the genera *Atops*, *Ctenocephalus*, and *Bathynotus*, besides others of subgeneric rank or of less importance. The characters of the family are given (op. cit.) as follows :—

"Free cheeks very narrow, forming the lateral margins of the cephalon, and bearing the genal spines. Fixed cheeks large, usually traversed by an eye-line extending from near the anterior end of the glabella. Facial sutures running from just within the genal angles, curving forward, and cutting the anterior lateral margins of the cephalon. Eyes rudimentary or absent. Thorax with from fourteen to seventeen segments. Pygidium small and of few segments. Cambrian."

The characters of the genus *Conocoryphe* are given as follows :—
"Cephalon semicircular; genal angles produced into spines; glabella distinctly lobed, wide behind, and contracted in front, not extending to the frontal border. Fixed cheeks very large, with conspicuous furrow parallel to the anterior margin; free cheeks narrow, marginal; thorax of fourteen segments."

The same author, Dr. Charles Beecher, who has written the article on trilobites in the book above quoted, published the same diagnosis of the family Conocoryphidæ in 1897,[1] and included in it the following genera and subgenera :—

Conocoryphe, Corda (= *Conocephalites*, Barrande).
Aneucanthus, Angelin.
Atops, Emmons.
Avalonia, Walcott.
Bailiella, Matthew (= *Salteria*, Walcott, and *Erinnys*, Salter).
Bathynotus, Hall.
Carausia, Hicks.
Ctenocephalus, Corda.
Dictyocephalus, Bergeron.
Eryx, Angelin.
Harttia, Walcott.
Toxotis, Wallerius.

Matthew[2] has contributed much to our knowledge of the genus, and his writings deserve careful study.

The usage of the generic name *Conocoryphe* in Britain has on a previous occasion been briefly criticized by the present author,[3] and some of the British species assigned to other genera. In discussing them here more in detail it will be convenient to take them alphabetically.

Conocoryphe abdita (Salter, Mem. Geol. Surv., vol. iii, 1866, p. 306, pl. v, fig. 13).—This species is at once seen to possess fundamental differences from *Conocoryphe*, sens. str., in the large well-developed eyes and in the course of the facial suture. The presence of pits in the marginal furrow of the head-shield suggests that it should be referred to either *Euloma* or *Apatokephalus*, and the position of the eyes, their relative size, the eye-lines, and the

[1] Amer. Journ. Sc., vol. iii (1897), p. 180.
[2] Trans. Roy. Soc. Canada, vol. ii (1884), sect. iv, pp. 102, 103.
[3] Geol. Mag., Dec. IV, Vol. V (1898), pp. 495, 496.

course of the facial suture indicate that it belongs to the former genus, *Euloma*. Linnarsson and Brögger[1] assigned it many years ago to this genus.

C. applanata (Salter, Brit. Assoc. Rep., 1865, p. 285; Q.J.G.S., vol. xxv, 1868, p. 53, pl. ii, figs. 1–5).—In the first place the presence of eyes and the course of the facial suture remove it from *Conocoryphe*, sens. str. The characters of *Solenopleura*, which Matthew[2] has tabulated, agree in many particulars with those present in this form. The surface is granular or subtuberculate, the glabella is prominent, the dorsal furrows well defined, the genal angles are pointed, the fixed cheeks are strongly swollen, and the pygidium is small with but three segments. The rather remote eyes, with the ocular ridges, the parabolic glabella, the course of the facial sutures, the strong margin to the head-shield, and the marginate pygidium are also points in which *C. applanata* agrees with *Solenopleura*. The tubercle on the neck-segment found in the latter genus is also present in the type-specimen, though not mentioned in Salter's description. The pleuræ, however, of this species are said to be pointed, while in *Solenopleura* Matthew (op. cit.) describes them as bluntly rounded. All the specimens of *C. applanata* which I have examined appear to have had blunt tips to the pleuræ, the pointed appearance being due to oblique crushing or distortion. The weight of evidence is therefore in favour of assigning this form to the genus *Solenopleura*.

C.? bucephala (Belt, Geol. Mag., Vol. V, 1868, p. 10, Pl. II, Figs. 1–6).—This species is certainly not a true *Conocoryphe*, as a brief inspection of the figures shows. The general characters of the species place it amongst the Olenidæ, and it may provisionally be assigned to the genus *Olenus*. The crust of the glabella is said to be unfurrowed as in *Angelina* and *Cyclognathus*, but when this is removed or the glabella crusted two or three pairs of furrows are seen. The triangular margin of the frontal lobe is peculiar, and since the pygidium is also unknown its true generic position must for the present remain a matter of doubt.

C. bufo (Hicks, Brit. Assoc. Rep., 1865, p. 285; Q.J.G.S., vol. xxv, 1868, p. 52, pl. ii, fig. 8).—This is a true *Conocoryphe*, sens. str., as has been previously remarked.[3] It appears to belong to the sub-genus *Bailiella* (Matthew), of which *C. Baileyi* (Hartt) is the type, and which is characterized by the facial suture cutting off a third of the marginal fold instead of running along the outer edge of this fold as in *C. Sulzeri*. Matthew (op. cit.) remarks that *C. bufo* possesses a head-shield very like that of *C.* (*Bailiella*) *elegans* (Hartt), but the pygidium is not known. Linnarsson[4] had previously

[1] Die Silur., Etag. 2 and 3 (1882), p. 98.

[2] Trans. Roy. Soc. Canada, vol. v (1887), p. 134.

[3] Matthew, Trans. Roy. Soc. Canada, vol. ii (1884), sect. iv, pp. 102, 103; Reed, Geol. Mag., Dec. IV, Vol. V (1898), pp. 495, 496.

[4] Sver. Geol. Undersokn., 1877, Om fauna i lagren med *Paradoxides ölandicus*, p. 16, t. 2, f. 2–4; Sver. Geol. Undersokn., ser. c, No. 35, 1879, Om faunan i Kalken med *Conocoryphe exsulans*, p. 19, t. 2, f. 26–28.

noticed the resemblance of the British species to *C. Dalmani* (Sjogren), which may be identical with *C. emarginata* (Linn.).

C. coronata, Barrande (Syst. Sil. Bohême, vol. i, 1852, p. 424, t. 13, f. 20–26). — This species was first described from Britain by Hicks.[1] The type-specimen is in a poor state of preservation, and there may be some doubt if it really belongs to Barrande's species; but Salter's remark [2] that while Hicks' specimen possesses genal spines Barrande's figure shows none, is of no importance, as Barrande's figure was drawn from a specimen without the free-cheeks. Genal spines are characteristic of the genus *Ctenocephalus* (Corda), to which *C. coronatus* belongs, as Matthew (op. cit., p. 103) has pointed out. *Ctenocephalus* is distinguished from *Conocoryphe* (type *C. Sulzeri*) by the possession of a marked protuberance—a frontal lobe—in front of the glabella, and by a smaller pygidium. The number of thoracic segments is also not the same, and the course of development is different. The distinction of these two genera therefore appears to be well founded.

C. (*Solenopleura*) *depressa*, Salter (Siluria, 2nd ed., 1859, p. 47, Foss. 7, fig. 2 [*Ellipsocephalus*]). — Brögger [3] has expressed the opinion that this species belongs to the subgenus *Cyclognathus* of the genus *Olenus*. But the presence of genal spines, the more remote and more backward position of the eyes, the glabellar furrows, the relative shortness of the glabella itself, the possession of a rather wide frontal limb separating it from the margin, and the different shape of the head-shield, are opposed to this view. The form of the pleuræ is certainly somewhat similar, and the number of body-segments is the same, while the pygidium bears a very close resemblance. But a comparison with specimens of the type form *Cyclognathus costatus* from Vestfossen presented by Professor Brögger himself to the Woodwardian Museum confirms my opinion that *C. depressa* cannot be referred to *Cyclognathus*. With *Solenopleura* its affinities are rather closer. The number of body-segments is the same and the pygidium and pleuræ are fairly similar, but the fixed cheeks show no sign of having been swollen, the genal angles are pointed and have no submarginal spine, the eyes are rather forward, and there is no neck tubercle nor granulation of the surface. Matthew, in a manuscript note on the specimens of this species in the Woodwardian Museum, considers it to be allied to *Solenopleura*. Its precise generic position must for the present remain uncertain, though it must be removed from *Conocoryphe*. With the exception of the shape of the pleuræ it has many points of similarity to *Olenus*, sens. str., and it undoubtedly belongs to the family Olenidæ.

C. ? *ecorne*, Ang. ? (Salter, Cat. Camb. Sil. Foss. Woodw. Mus., 1872, p. 12), is a species of *Peltura*, and shows all the characteristic features of that genus.

C. Homfrayi, Hicks (Q.J.G.S., vol. xxviii, 1872, p. 178, pl. vi, fig. 12).—The type-specimen is much compressed and distorted, and

[1] Q.J.G.S., vol. xxviii (1872), p. 178, pl. vi, fig. 11.
[2] Mem. Geol. Surv., 2nd ed. (1881), vol. iii, p. 499.
[3] Die Silur., Etag. 2 and 3 (1882), p. 111.

after a careful examination of it I have much doubt[1] if eyes really existed, though the species has been described as possessing them. The number of thoracic segments and the shape of the pleuræ are the same as in *Conocoryphe*, sens. str., and the genal angles similarly bear spines. The pygidium, according to Hicks, has fewer segments than in *C. Sulzeri*, but the state of preservation of this member is very poor. With much probability this species may therefore rightly be left in the genus *Conocoryphe.*

C. humerosa, Salter (Rep. Brit. Assoc., 1865, p. 285; Q.J.G.S., vol. xxv, 1868; p. 54, pl. ii, fig. 7).—The specimen on which this species was founded has the head-shield very much crushed, and the characters given by Salter (op. cit.) are very imperfectly seen, so that not much weight can be attached to them. The ornamentation of the crust is, however, distinct, and the neck-spine is preserved fairly well. The portion of the thorax is nearly perfect, and all the features mentioned by Salter can be made out, as well as some others not recorded. But all the characters are absolutely different to any found in the thorax of any species of *Conocoryphe*, sens. str., and it can be positively asserted that it does not belong to this genus. The spine on the neck-segment, followed by those on the axial rings of the thorax, the shape, the groove, and free spinose ends of the pleuræ suggest the genus *Olenoides*. The peculiar radiate "venulose lines" and granulation ornamenting the surface of *O. typicalis* (Walcott) described by Walcott[2] are distinctly visible on the head-shield of the type-specimen of *C. humerosa*; and comparison with specimens of *Olenoides* from America shows that the spines on the axis closely resemble those in *O. typicalis*, while the pleuræ are more like those of *O. nevadensis* (Meek). The geological age of the beds in which *Olenoides* occurs is approximately the same as that in which *C. humerosa* was found, and there seems to be no reason for hesitating to ascribe this species to the genus *Olenoides*.

C. invita, Salter (Dec. Geol. Surv., 1865, pl. vii, fig. 6).—This species has been referred by Brögger[3] to his new genus *Apatokephalus*, as I have recently mentioned.[4] The characteristic features of this genus, which shows many points of resemblance to *Euloma* and *Dicellocephalus*, are well exhibited in the head-shields of this form, and Brögger's view needs no further comment.

C.? longispina, Belt (Geol. Mag., Vol. V, 1868, p. 9, Pl. II, Figs. 12–14).—By the characters of the head-shield we can at once decide that this species does not belong to *Conocoryphe*. Judging from Belt's figures and description, it may without hesitation be referred to the genus *Olenus*, and probably to its subgenus *Parabolinella*, as indicated by the course of the facial suture and position of the eyes, but the shortness of the glabella is remarkable.

C. Lyelli, Hicks (Q.J.G.S., vol. xxvii, 1871, p. 339, pl. xvi, figs. 1–7).—On a former occasion[5] I have stated that this species is

[1] Geol. Mag., Dec. IV, Vol. V (1898), p. 495.
[2] Bull. U.S. Geol. Surv., No. 30 (1886), p. 180, pl. xxv, figs. 2, 2*a*, 7.
[3] Nyt Magazin fur Naturvidenskaberne, Bd. xxxv (1896), pp. 179–185, 200.
[4] Geol. Mag., Dec. IV, Vol. VII (1900), p. 46.
[5] Geol. Mag., Dec. IV, Vol. V (1898), p. 495.

probably a true member of the genus *Conocoryphe.* The narrow marginal free-cheeks, the course of the facial suture, the absence of compound eyes, the number and characters of the thoracic segments, are features in which it completely agrees.

C. malvernius, Phillips ("Geology of Oxford," 1871, p. 68, fig. 5).—As far as the imperfect figure allows one to judge, this species appears to belong to the genus *Peltura.* At any rate, it is not a *Conocoryphe,* but is referable to one of the Olenidæ.

C. monile, Salter (Cat. Camb. Sil. Foss. Woodw. Mus., 1872, p. 32; Callaway, Q.J.G.S., vol. xxxiii, 1877, p. 665, pl. xxiv, fig. 4).—This species, which was first described by Callaway (op. cit.), has been assigned to the genus *Euloma* by Brögger,[1] of which it exhibits all the typical features.

C.? olenoides, Salter (Mem. Geol. Surv., vol. iii, 1866, p. 308, pl. viii, fig. 6).—It is quite doubtful to what genus this species should be referred, but we cannot have any hesitation in removing it from *Conocoryphe* and placing it amongst the Olenidæ.

C. perdita, Hicks (Q.J.G.S., vol. xxv, 1869, p. 53, pl. ii, fig. 3).—This species has never been fully described, and the only published figure of it is most unsatisfactory. Hicks (op. cit.) says *C. bufo* is its nearest ally, and if this be the case it must probably be a true *Conocoryphe.*

C. Planti, Salter (Cat. Camb. Sil. Foss. Woodw. Mus., 1872, p. 11).—This species, founded on well-preserved specimens, is an excellent example of the subgenus *Parabolinella* of the genus *Olenus,* and a description of it is now in the press. Salter (op. cit.) assigned it correctly to *Olenus.*

C.? simplex, Salter (Mem. Geol. Surv., vol. iii, 1866, p. 306, pl. v, fig. 17).—The smooth glabella, the very forward position of the eyes close to the front end of the glabella, and the course of the facial suture agree well with *Cyclognathus,* to which it may be referred.

C. solvensis, Hicks (Q.J.G.S., vol. xxvii, 1871, p. 400, pl. xvi, fig. 8).—I have previously[2] referred this species to *Ctenocephalus,* and probably it belongs to its subgenus *Hartella,* as Matthew[3] has remarked, and resembles *C. Matthewi,* Hartt. A Scandinavian species which is very closely allied, or may be only a variety of *C. solvensis,* is *Conocoryphe exsulans,* Linnarsson.[4]

C.? variolaris, Salter (Q.J.G.S., vol. xx, 1864, p. 236, pl. xiii, figs. 6, 7). — The characters of the head-shield, eyes, and facial sutures at once remove it from *Conocoryphe,* sens. str. Salter compares it to *C. Ribeiro,* Barrande, and also mentions that in some respects it resembles the genus *Sao.* But the lobation of the glabella is very different to that in *Sao hirsuta,* and the genal angles are furnished with definite spines, turned slightly outwards,

[1] Die Silur., Etag. 2 and 3 (1882), p. 98.
[2] Geol. Mag., Dec. IV, Vol. V (1898), p. 495.
[3] Trans. Roy. Soc. Canada, vol. ii (1884), p. 103.
[4] Sver. Geol. Undersokn., ser. c, No. 35, Om Faunan i Kalken med *Cono. exsulans* (1879), p. 15, t. ii, f. 21, 22.

and not merely pointed as in that species. The eye is also smaller, and there is no ocular ridge. There are seventeen body-segments in the adult *Sao*, while in *C.* ? *variolaris* there are only thirteen preserved, with traces of a fourteenth. The tuberculation bears, however, a somewhat close resemblance, but this feature is not of much importance in determining affinities.

On the other hand, the lobation of the glabella corresponds with that described by Angelin[1] for *Solenopleura*, and there is also a coarse though not so abundant tuberculation of the head-shield in some of the Scandinavian species. The genal angles in *Solenopleura* appear to have typically borne similar spines. The convexity of the fixed cheeks which Matthew (op. cit.) emphasizes, also existed in *C.* ? *variolaris*, as their cracked surface shows, and in the type-specimen it is crushed in. The tubercle on the neck-segment is also present as in *Solenopleura*. Though in the description of the species it is said the pleuræ have pointed ends, yet in the type-specimen they are certainly rounded so far as they are preserved.

On the whole, it does not seem to be unnatural to assign this species provisionally to the genus *Solenopleura*.

C. ? *verisimilis*, Salter (Mem. Geol. Surv., vol. iii, 1866, p. 308, pl. vi, fig. 13).—Brögger[2] has suggested that this species may belong to *Cyclognathus*; but though the forward position of the eyes seems to favour this view, the shape of the free-cheeks with their pointed genal angles forbids its acceptance. The general appearance of the form is that of an immature individual of *Angelina Sedgwicki*; but it may be a distinct species. There are only twelve body-rings instead of fifteen; the genal spines are much shorter, and the eyes are more forward and nearer the front end of the glabella; but all these characters might be due to immaturity. The pygidium is unknown, but the thoracic segments have similar characters; and it may be with much confidence referred to the genus *Angelina*.

C. vexata, Salter (Mem. Geol. Surv., vol. iii, 1866, p. 307, pl. viii, fig. 7).—Though this species is obviously not a member of *Conocoryphe* as now defined, its true generic position is doubtful. Perhaps it belongs to the Olenidæ, but even this is uncertain.

C. viola, Woodward (Q.J.G.S., vol. xliv, 1888, p. 74, pl. iv).—The figures and description of this form suffice to remove it from *Conocoryphe*, sens. str., but its features, especially its facial sutures, are so peculiar that a new generic title seems requisite.

C. ? *Williamsoni*, Belt (Geol. Mag., Vol. V, 1868, p. 9, Pl. II, Figs. 7–11).—This species belongs to the Olenidæ and probably to the subgenus *Parabolinella* of the genus *Olenus*; the course of the facial sutures, the position of the eyes, and other characters of the head-shield correspond, but only two pairs of furrows on the glabella are described. The thorax rather more resembles that of *Olenus*, sens. str., than that of *Parabolinella*, and the pygidium is

[1] Pal. Scand., 1854, p. 26.
[2] Die Silur., Etag. 2 and 3 (1882), p. 111.

somewhat peculiar, though in the complete margin and number of segments it agrees with *Parabolinella*. To *Olenus* used in a generic sense this species may certainly be referred. Salter's[1] species with the same name is distinct from Belt's, but belongs to the Olenidæ.

From the above revision the so-called species of *Conocoryphe* in Britain should be designated as follows:—

Euloma abditum.
Solenopleura applanata.
Olenus? bucephalus.
Conocoryphe (Bailiella) bufo.
Ctenocephalus coronatus.
Solenopleura? depressa.
Peltura, sp. [= *C.? ecorne?* (Ang.), Salter].
Conocoryphe? Homfrayi.
Olenoides humerosus.
Apatokephalus invitus.
Olenus (Parabolinella?) longispina.
Conocoryphe Lyelli.
Peltura? malvernia.
Euloma monile.
Conocoryphe? perdita.
Olenus (Parabolinella) Planti.
Olenus (Cyclognathus) simplex.
Ctenocephalus (Hartella) solvensis.
Solenopleura? variolaris.
Angelina verisimilis.
Olenus (Parabolinella?) Williamsoni.

The three species of which the genera even are doubtful are *C.? olenoides*, *C. vexata*, and *C. viola*. But none of these three can be attributed to *Conocoryphe*, and their true position must be left to the future to decide.

The distribution of the tabulated forms is as follows:—

Harlech Series.
- *Conocoryphe Lyelli.*
- *Ctenocephalus (Hartella) solvensis.*

Menevian.
- *Solenopleura applanata.*
- *Conocoryphe (Bailiella) bufo.*
- *Ctenocephalus coronatus.*
- *Conocoryphe? Homfrayi.*
- *Olenoides humerosus.*
- *Conocoryphe? perdita.*
- *Solenopleura? variolaris.*

Lingula Flags.
- *Euloma abditum.*
- *Olenus? bucephalus.*
- *Peltura*, sp.
- *Apatokephalus invitus.*
- *Olenus (Parabolinella?) longispina.*
- *Peltura? malvernia.*
- *Olenus (Parabolinella) Planti.*
- *Olenus (Cyclognathus) simplex.*
- *Olenus (Parabolinella?) Williamsoni.*

Tremadoc.
- *Solenopleura? depressa.*
- *Euloma monile.*
- *Angelina verisimilis.*

The genus *Conocoryphe*, sens. str., is thus seen to be confined in Britain to the Lower and Middle Cambrian beds.

V.—On the occurrence of a Blue Amphibole in a Hornblende Kersantite from Co. Down.

By Henry J. Seymour, B.A., F.G.S., of H.M. Geological Survey of Ireland.

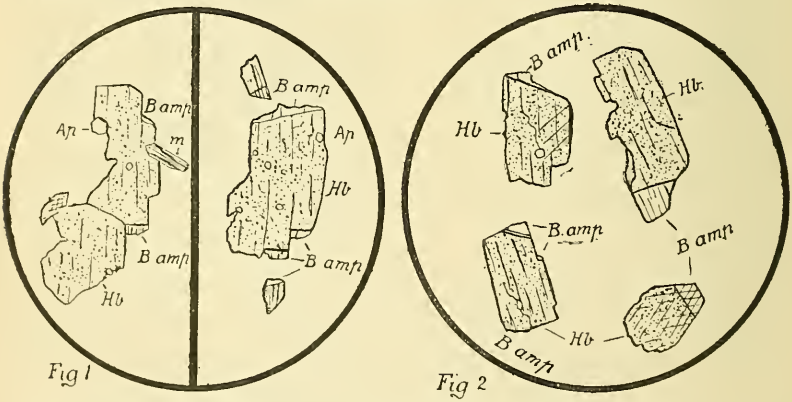
(Communicated by permission of the Director-General.)

In connection with the revision of the Silurian area in Ireland, at present in progress by the staff of the Irish branch of the Geological Survey, a number of rock-specimens of the dykes occurring on the coast of Co. Down were lately petrographically examined by the writer, who detected in one of the slices a *blue* amphibole of secondary origin. As a mineral of this kind was not hitherto known to occur *in sitû* in Ireland, it may be of interest to put its discovery on record here and to give also a few details respecting its characteristics.

[1] Cat. Camb. Sil. Foss. Woodw. Mus., 1872, p. 12.

The rock in which it occurs appears as a dyke (in Upper Silurian sediments)[1] on the shore one-eighth of a mile south of the point where the letter *B* in South Bay is engraved on the map; three miles south-east of Portaferry (1″ sheet 49), and near the spot where the small road south of 'Tara Fort' reaches the coastline. On the original 6 inch working maps of the Survey it is represented[2] as a double dyke, with the ends of each portion in parallel contact, the northern limb forming a semicircular bend in the middle and enclosing a small area of sedimentary rocks. The combined width of the two portions is approximately 20 inches.

In the hand-specimen the rock is of a dull greyish-green colour, and possesses a medium-grained crystalline structure. Bronzy mica is the mineral most readily noticeable, and a few octahedra of magnetite may be seen with the aid of a pocket lens. Its specific gravity was found to be 2·85 in its present slightly decomposed condition. Under the microscope it is seen to consist essentially of a dark mica, with subordinate green hornblende, and an aggregate of felspar crystals. Accessory and secondary minerals also present are apatite, magnetite, a blue amphibole, chlorite, and several calcareous pseudomorphs, apparently after augite or hornblende phenocrysts, more probably the latter.



MINERALS.—*Hb.* green hornblende. *m.* biotite. *Ap.* apatite. *B. amp.* blue amphibole.

FIG. 1 shows two large hornblende phenocrysts, with additions of secondary blue amphibole on some of their terminal faces. × 45 diams.

FIG. 2 shows four crystals which exhibit the typical mode of occurrence of the blue amphibole. That in the S.E. quadrant shows a basal section with the clinopinacoid of the primary green hornblende replaced by the blue amphibole. The crystal in the S.W. quadrant shows a narrow pale-blue zone between the green hornblende and the normal blue amphibole. × 45 diams.

[1] These sediments were originally regarded as Lower Silurian. The recent revision (by Mr. F. W. Egan), however, shows them to be Upper Silurian. Report of Director-General of Geol. Survey, Appendix to 44th Report, Dept. of S. and A., p. 365.

[2] By Mr. W. A. Traill, who mapped the dykes in this district. See Memoir of Geol. Survey to accompany 1″ sheets 49, 50, and 61 (1871), pp. 6 and 43.

The biotite forms small (about 0·40 mm.) hypidiomorphic crystals scattered fairly abundantly and evenly throughout the slide. Sections at right angles to the cleavage planes are strongly dichroic (almost colourless to greenish brown), and are frequently bent into curved forms. Narrow bands of calcite are occasionally noticed between the lamellæ. The mineral is here and there altered to chlorite on its edges, and also to a less extent along cleavage cracks. Sections parallel to the basal plane give a uniaxial interference figure and show an outer rim of a much darker colour than that of the interior of the crystal.

The felspars occur in medium-sized allotriomorphic crystals which are rather altered and mostly micropoikilitic with numerous minute inclusions. In their present condition the exact species is not satisfactorily determinable, but repeated twinning is noticeable in several of the less altered crystals, and they would seem to be essentially plagioclase.

Apatite is an abundant constituent in the rock, and occurs as inclusions in the biotite, plagioclase, and in the green hornblende.

This latter mineral is also hypidiomorphic, and appears to be slightly posterior in date to the biotite, small crystals of which it sometimes includes. Sections parallel to the principal axis attain a length of 0·60 mm. The pleochroism is fairly strong, the tints varying from yellowish to a dull dark green. Basal sections exhibit the characteristic six-sided forms with well-defined cross cleavages intersecting at an angle of about 124°. The blue amphibole occurs mostly as a secondary addition to, but partly also as a replacement of, the primary green hornblende, and has grown in crystallographic continuity with it. The cleavage lines are usually continuous in both varieties, but are finer and sharper in the blue amphibole. In most cases this latter is added to the clinopinacoidal or terminal planes of the green variety, and occurs also, but less often, along cracks in the interior of these crystals. The secondary enlargement is quite limited in extent and seldom exceeds 0·10 mm. in greatest length, the average being rather below this figure. The junction line between the two varieties is generally distinct, and they are also sharply marked off from one another by their notably different pleochroism. Exceptionally a very narrow band or zone of material of a much paler blue colour than the normal blue amphibole occurs between the latter and the green hornblende. The drawings show the characteristic mode of occurrence of the secondary mineral in question. Owing to its small size it does not present facilities for satisfactorily determining its optical properties, but in so far as it is possible to do so, they would appear to be as follows. Sections approximately parallel to the clinopinacoid show that the extinction angle is about 15°, and that this takes place on the opposite side of the vertical axis to that of the green hornblende to which it has been added. Observations with the quartz wedge appear to prove that this direction of extinction corresponds also with the axis of maximum elasticity. The pleochroism is strong and is as follows: $\mathfrak{a}$ = sky-blue, $\mathfrak{b}$ = pale reddish-violet, $\mathfrak{c}$ = pale yellowish. The absorption formula is $\mathfrak{a} > \mathfrak{b} > \mathfrak{c}$.

In some isolated cases the blue amphibole shows wavy extinction under crossed nicols, due apparently to a gradual change in chemical composition during its formation. It was found impracticable to isolate material for chemical analysis, but there can be no reasonable doubt that it belongs to the soda amphibole group of which riebeckite and arfvedsonite are typical examples.

The occurrence of a secondary blue amphibole under conditions exactly similar to those just detailed above has been described by Dr. Whitman Cross[1] in the case of an allied rock from Colorado. A. C. Lane[2] also records a similar occurrence in a syenite from Michigan. More recently J. S. Flett[3] notes the presence of a secondary blue amphibole in cracks in crystals of hornblende in one of the lamprophyre dykes of the Orkney Islands. The mineral from the Co. Down corresponds so closely in every particular with those from the two American localities aboved cited, that the writer has little hesitation in referring it to the same species. The mineral described by Cross has been called crossite by Ch. Pelache,[4] who also has described a species with identical optical properties. Dr. Cross, however, in a later publication[5] states that the mineral in question is considered to be arfvedsonite by Dana,[6] Brögger,[7] and Rosenbusch.[8] It may be noted further that Iddings, in his translation[9] of Rosenbusch's work, describes the secondary amphibole of Cross in the context between glaucophane and riebeckite, which position the at any rate optically similar species of Pelache[10] occupies by virtue of its intermediate chemical composition. Rosenbusch[11] notes the occurrence of a blue amphibole in a minette from Wachenback in the Vosges, the rock belonging to the same group as the Co. Down specimen.

VI.—On *Rhadinichthys monensis*, Egerton, and its Distribution in the Yorkshire Coalfield.

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

This species was first described by Sir P. De M. Grey Egerton[12] as *Palæoniscus monensis*, in 1850, from detached scales from the Coal-measures of Anglesey. Subsequently, Dr. R. H. Traquair[13] proved that the proper position of the fish was in his genus *Rhadinichthys*. Up to this date only detached scales had been known, but in the paper just mentioned Dr. Traquair described specimens showing many points in the structure of the fish which had been

[1] Amer. Journ. Sci., vol. xxxix (1890), p. 359 et seq.
[2] Amer. Journ. Sci., vol. xlii (1891), p. 505.
[3] Trans. Roy. Soc. Edinburgh, vol. xxxix (1900), pt. iv, p. 884.
[4] Bull. Dept. Geol. Univ. California, 1894, p. 181 et seq.
[5] 16th Ann. Rep. U.S. Geol. Survey, 1894–95, pt. ii, p. 30.
[6] System of Mineralogy, 6th edition, 1892, p. 402.
[7] Die Gesteine der Grorudit-Tinguait-Serie, 1894, p. 33.
[8] Die mikro. Phys. der petro. wichtigen Min., 3rd ed., 1892, p. 567.
[9] Translation of the last work by Iddings, 1898, p. 270.
[10] Loc. cit., p. 189.
[11] Mikro. Phys. d. massigen Gesteine, 1896, p. 510.
[12] Quart. Journ. Geol. Soc., vol. vi (1850), p. 5.
[13] Proc. Roy. Phys. Soc. Edinb., vol. iv (1878), p. 241.

hitherto unknown. In my collection there are many fragmentary remains, collected from the Yorkshire Coal-measures, which show, among other interesting points, the form and ornamentation of many of the bones of the head and shoulder-girdle; while one more nearly perfect specimen shows well the form of the fish and some other points in its anatomy which have not been hitherto described, namely, the relative positions of the dorsal, anal, and ventral fins, the former being very well preserved and perfect.

From the material above mentioned, together with that already described by Dr. Traquair, I now think it possible to give a fuller and more detailed description of the fish than has hitherto been possible.

One specimen in my collection, which shows the fish from a line drawn obliquely upwards and backwards from a point immediately behind the pectoral fin to a point slightly beyond the commencement of the caudal fin, would represent a fish about 55 mm. to 60 mm. in length; but other fragmentary remains show that the adult fish reached a larger size, probably about 90 mm., and this size corresponds with that given by Dr. Traquair.

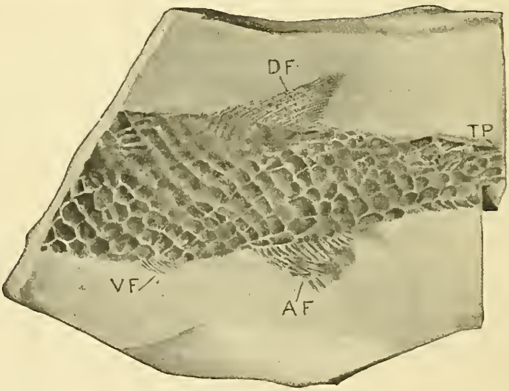
The bones of the head appear to be of the same form and to have the same arrangement as those of other members of the genus *Rhadinichthys*. The cranial buckler, as shown by specimens in my collection and as pointed out by Dr. Traquair, is ornamented with "tolerably coarse ridges, passing here and there into tubercles." The opercular bones are ornamented in a similar manner, but the ridges appear to be somewhat finer, not so frequently interrupted, and rather more irregular in arrangement. On the maxillæ the ridges are moderately coarse, are interrupted at distant intervals, and recur in slightly wavy lines more or less parallel with the inferior border, which does not show any signs of tuberculation. The mandible, as pointed out by Dr. Traquair, is "slender and tapering, sculptured with a few tolerably coarse ridges, which, as usual, pass forwards and also obliquely upwards to meet the dentary margin at a very oblique angle." The teeth are small, conical, and somewhat incurved.

The bones of the shoulder-girdle are of the usual form and arrangement, and are sculptured with ridges which are interrupted at distant and irregular intervals, and which run more or less parallel with the borders of the bones.

The body is elegantly fusiform, but somewhat elongated, the greatest depth being at a point about midway between the occiput and the commencement of the dorsal fin, the depth here in one specimen in my collection being 10 mm. and the total length of the fish (when perfect) probably about 50 mm. From this deepest region the body gradually tapers to a delicate tail pedicle.

The scales on the nape appear equilateral; on the mid-flank they are slightly higher than broad; on the belly they become low and narrow; and posteriorly they get gradually smaller and more nearly equilateral until on the tail pedicle they assume the usual lozenge-shaped form. The scale ornamentation consists of (1) a few sharply cut, faint striæ, which run parallel and close to the anterior and inferior borders, and (2) four or five ridges which commence at the posterior denticulations and run forward for some distance across the scale, the ridges becoming somewhat more oblique from below upwards. This sculpture is most strongly marked on the scales of the nape, but from this point it gradually appears to become fainter, the striæ parallel with the anterior and inferior borders being first lost; the ridges then become fainter and less marked, but the posterior denticles, although they become less in number, appear to be present on the scales far back on the body near the tail pedicle.

The pectoral fin, as pointed out by Dr. Traquair, appears to have been "of moderate size and its principal rays unarticulated until near their termination." The ventral fins are not well shown in any specimen, but one in my collection shows a trace of one of these fins, though not in a condition to permit of a detailed description: it appears to have been small and delicate. The dorsal fin is beautifully shown in the specimen mentioned above: it commences at a point very slightly in advance of the anal fin, the two fins being nearly opposed to each other. This fin is of moderate size, acuminated, concavely cut out behind, and composed of delicate rays which dichotomize distally, the terminal branches of the rays being very fine. The rays are distantly articulated, and show a single, sharply cut, longitudinal furrow. The anal fin in the same specimen is more imperfect, but a fin of similar form and construction is indicated. The caudal fin in the above specimen commences at a point about 17 mm. behind the commencement of the dorsal fin, but unfortunately only the proximal portion of the fin is shown. According to Dr. Traquair, the "rays are delicate and their articulations rather distant."



Rhadinichthys monensis, Egerton. Twice natural size.
DF, dorsal fin; AF, anal fin; VF, ventral fin; TP, tail pedicle.

In the Yorkshire Coal-measures this fish is mostly found in a very fragmentary condition; but it has a wide distribution, and occurs in the shale above the following coal-seams:—

I. Lower Coal-measures.
- *a.* Halifax Soft-bed Coal (Shibden).
- *b.* Halifax Hard-bed Coal (Queensbury).
- *c.* Better-bed Coal (Low Moor and Wyke).
- *d.* Black-bed Coal (Low Moor).
- *e.* Cannel Coal (Whitehall Lane, near Low Moor).
- *f.* Crow Coal (near Leeds).

II. Middle Coal-measures.
- *a.* Cannel Coal (Tingley).
- *b.* Haigh Moor Coal (Castleford).
- *c.* Barnsley Thick Coal (Barnsley).

In different individuals the scale sculpture shows very considerable differences as regards the strength and prominence of the scale-markings, the sculpture being much more pronounced in the case of some individuals than in others where the scales seem almost smooth. Another point of interest is that in the young fish the ventral scales do not appear to be so low and narrow as they are in the more adult fish. The fish, a young one, which has been carefully figured above, shows this well.

VII.—Note on a Tortoise from the Wealden of the Isle of Wight.

By Reginald W. Hooley, Esq.

In May, 1897, a fossil tortoise was found about 10 feet above low water-mark opposite Shepherd's Chine, by Mr. Wm. White, of Atherfield, Isle of Wight. It came into my possession in July of last year (1899). At that time the only portions clear of matrix were the sixth, seventh, and eighth costal bones, the edges of the marginals, and the epi- and hyoplastrals nearly to the notch; the matrix is a fine silt containing much iron. The specimen had been subjected to long attrition by the sea. A very thin but hard seam of whole and broken *Paludina* had offered a stubborn resistance, as likewise it did against a finely pointed and tempered chisel. On the surface of the carapace are several Cyprids (sp.?) and the impression in section of *Paludina*.

The carapace is somewhat distorted and flattened; in its present state it measures $12\frac{1}{2}$ inches long from A to B and $14\frac{3}{4}$ inches wide from C to D; in life its shape was probably ovoid. A semicircular piece of the fifth costal on the left side and the greater portion of the posterior costals, the pygals, and posterior marginals have been destroyed by the sea subsequent to the fall of the specimen from the cliff, but in other respects it is remarkably complete.

The neurals, eight in number, are narrow and elongate, some being twice as long as broad. There are eight costals, of which the second, third, and fourth have been depressed beneath the rest of the carapace to the extent of their thickness, and outer ends of the first and fifth left costals, moreover, have been forced under the marginals. The nuchal is emarginate and seems to be divided; there are eight marginals on the right, with a portion of the seventh and eighth wanting, and seven on the left, with but part of the seventh remaining.

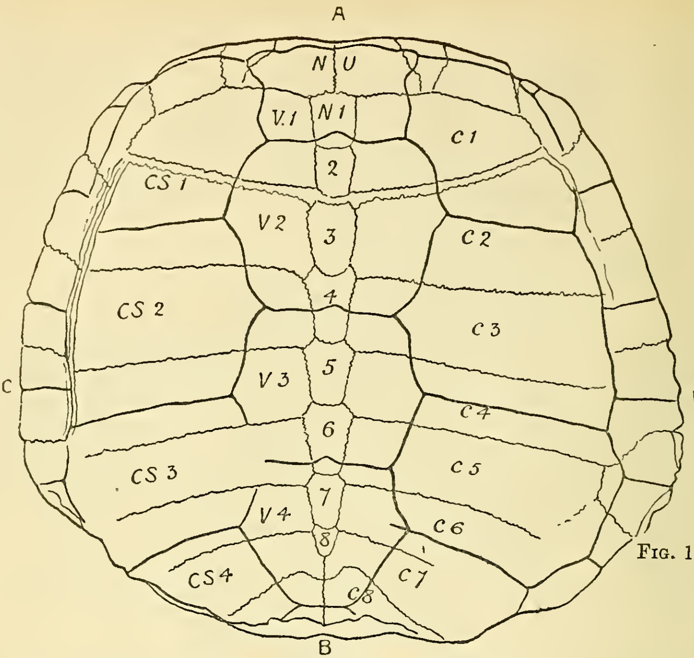


Fig. 1.

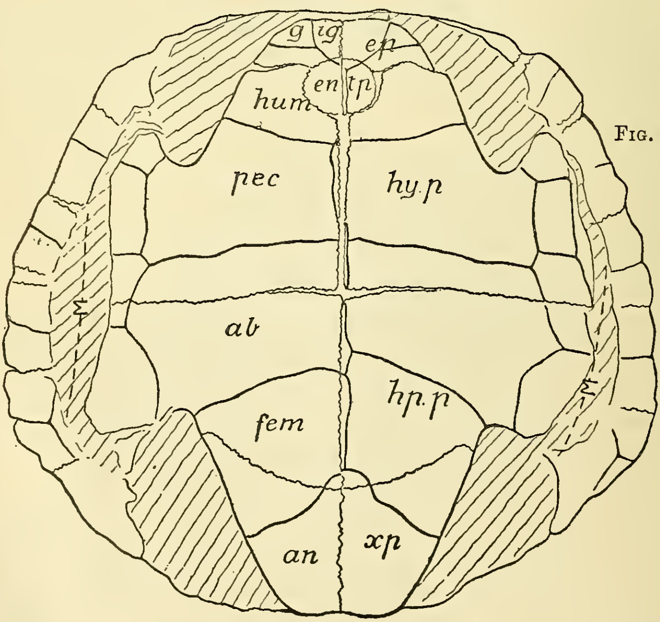


Fig. 2.

Plesiochelys vectensis, sp. nov. Drawn one-fourth nat. size. (For explanation, see p. 265.)

The vertebral shields are wider than long, the first by $1\frac{3}{4}$ inches, the second and third by 1 inch, the fourth by $\frac{1}{2}$ inch. The area underlying the second and third vertebral shields is slightly fluted, that under the others is smooth.

The entoplastral is wide, and rounded anteriorly and posteriorly; mesoplastrals are absent. The suture between the hypo- and the xiphiplastrals commences below the apex of the sulcus dividing the anal and femoral shields, thence it ascends and terminates nearly at the top of the inguinal notch. The sulcus dividing the abdominal and femoral shields is entirely on the hypoplastrals; it ascends towards the hyoplastrals, and terminates in the inguinal notch. The anal shields extend on to the hypoplastrals. The total length of the plastron is $12\frac{1}{4}$ inches.

From the above particulars I conclude that the specimen belongs to the genus *Plesiochelys* (Rütimeyer). It differs from *P. valdensis* by the very slight fluting of the area underlying the vertebral shields; indeed, as mentioned, this is absent except under the second and third. It can be distinguished also by the fact that the vertebral shields extend only one-third across the costal bones; in this respect it agrees with *P. Brodiei.* The shape of the shields differs from that seen either in *P. Brodiei* or *P. valdensis,* and approaches very nearly to the form characteristic of *Pleurosternum concinnum.* The shape of the nuchal bone is different from that of the other species mentioned, and the entoplastral, instead of being V-shaped posteriorly, is rounded. The suture of the xiphiplastral bone in *P. Brodiei* is very nearly horizontal, whilst in the specimen now described it ascends and terminates a little below the inguinal notch.

I endeavoured by the matrix, the *Paludina* seam, and Cyprids on the surface of the carapace to fix the exact horizon whence the specimen came, but after diligent and careful search could not locate closer than it is within the 49 feet of Wealden shales immediately overlying the sandstone of Cowlease Chine and Barnes High, therefore about 120 feet more or less below the Perna Bed; but if the Cyprids on the carapace prove to be *Candona Mantelli* (Jones) this would, I think, be sufficient to fix the horizon at 100 feet below the Perna Bed in the 9 feet of shales with *Candona Mantelli* (Jones) in the section on p. 15, Memoirs of Geological Survey, Isle of Wight, 1889.

My amateur examination seems to point to this being a new species; if it be so I would suggest *Plesiochelys vectensis* as its name.

Explanation of Page-plate Illustration (p. 264 opposite).

Fig. 1, A.—The carapace (dorsal aspect).
Fig. 2, B.—The plastron (ventral aspect).

ab. Abdominal shields.
an. Anal shields.
c 1–8. Costal plates.
cs 1–4. Costal scutes.
cntp. Entoplastral plate.
ep. Epiplastral plate.
fem. Femoral shield.
g. Gular shield.
hum. Humeral shield.
hpp. Hypoplastral plate.
hyp. Hyoplastral plate.
ig. Intergular plate.
n 1–8. Neural plates.
nu. Nuchal plate.
xp. Xiphiplastral plate.
v 1–4. Vertebral shields.

M = matrix.

VIII.—The Stability of the Land around Hudson Bay.

By J. B. Tyrrell, F.G.S.

IN a former number of this Magazine, and also in a Report published by the Geological Survey of Canada, I showed reasons for believing that while the land around Hudson Bay, in the northern part of Canada, had undoubtedly risen several hundred feet in Post-Glacial times, it has now reached a condition of stability similar to that of the land along the Gulf of St. Lawrence and on the eastern seaboard of Canada.

In taking this position I was obliged to combat the views of my friend, Dr. Robert Bell, of the Geological Survey of Canada, who had stated, and who has since repeated the statement before the Geological Society of America, that the land around Hudson Bay is now rising at the rate of from seven to ten feet in a century.

Some valuable historical light has just been thrown on this interesting question by the publication of Jens Munck's account of his expedition to Hudson Bay in 1619 A.D., translated from the Danish and edited by C. C. A. Gosch, and published by the Hakluyt Society in 1897.

Jens Munck entered Hudson Bay eight years after it had been discovered by Henry Hudson, and as far as is known he was the first white man to enter Churchill harbour, on the west side of that great Bay, or inland sea. Here he spent more than ten months, from the 7th September, 1619, to the 16th of July, 1620; but as his account of his expedition was written and published in Danish, and has not previously been translated into English, it has remained almost entirely unknown.

His sailing directions for entering the harbour are as follows:—"Whoever desires to enter the harbour must leave the beacons (on the rocks to the west) to starboard and sail in, steering south-west. A little way inside the entrance there is a sunken rock under the water, but on the eastern side, so that one can pass it without difficulty. One may then cast anchor in 7 or 8 fathoms."

These directions were written nearly three hundred years ago, and they describe the conditions exactly as they exist at present. The sunken rock is still in the eastern side of the channel, so that ships must keep along the western side. As that rock, in 1619, was a menace to navigators, it could not have been more than a few feet under water, and if the land had since then been rising at any such rate as from 7 to 10 feet in a century, it would now be high out of the water. A difference in the relative elevation of land and water of even a few feet would have made a great difference in the character of this channel, but instead it seems to have been the same then as now. There can be no doubt as to the rock meant by Munck, for there is only one conspicuously in the channel, and the banks are otherwise very regular.

After entering the outer channel the depths of 7 or 8 fathoms in the harbour are almost precisely the same as those shown on the chart made by the officers of the Canadian Government in 1886, namely 6 to 8¼ fathoms.

Furthermore, in this book several plates are inserted, one of which, opposite p. 23, shows Churchill harbour, and Munck's ships moored near its western side, one Danish mile ($=4\frac{1}{2}$ English statute miles) from its entrance. The ships lay on the tidal flat, which was "nearly 900 fathoms across," and were "not farther from the shore than about 12 or 14 fathoms." They evidently lay a short distance above a high point extending down to the shore of the harbour from the west, and their position was therefore somewhere in front of where the Hudson's Bay Company's Trading Port is at present situated.

The plate represents a bird's-eye view of the harbour, and shows it very much as it would appear in a similar view at the present time, and not at all as it would appear if the land had been rising since then at any such rate as from 7 to 10 feet in a century, or say in all 19–25 feet, for much of the surrounding land is so low that with such a difference in elevation large areas, which are now dry land, would have then been submerged.

Mosquito Point, a low rocky point at the head of the harbour, is distinctly shown on the plate, and Fort Prince of Wales or Esquimaux Point, which projects beyond the mouth of the harbour on its western side, is clearly seen to be connected with the more southern portion of the mainland, as it is now, and there is no sign of a channel across the connecting neck of land, though the land is there so low that a depression of a few feet below its present level would cause the existence of a wide and distinct channel here. Had this channel existed in Munck's time there can be little doubt that it would have been shown on his map.

As these are the oldest historical records obtainable of the former character of Churchill harbour they are of considerable geological interest, and they are clearly in line with the arguments which I adduced in a former paper in this Magazine, that during the historical period there has been no determinable change in the relative levels of land and water on this portion of the western shore of Hudson Bay.

IX.—Firstfruits of a Geological Examination of Snowdon.

By J. R. Dakyns, Esq.

Ars longa, vita brevis. This is especially true when one reaches the age of 64. I therefore commit to paper some of the results of a geological investigation of Snowdon on which I am engaged. I start of course from the work of Messrs. Ramsay and Selwyn embodied in the Geological Survey Map of Snowdon and Ramsay's memoir on North Wales. To make what I have to say clear I may state that the rocks of Snowdon are by Ramsay and Selwyn divided into three principal groups, viz.: A, an upper felsitic lava; an intermediate band (B) of bedded fossiliferous rocks of Bala age, containing much volcanic material, called the calcareo-felspathic ashy series; and a lower mass (C) of felsitic rocks. This lower mass is in some places divided by sedimentary bands consisting of slates and grits. Below C come blue slates and grits, with occasional volcanic bands, D; and below D the great mass of volcanic rocks (E) which form Glyder Fach and Y Tryfan.

1. The lower Snowdonian felstones (C) are coloured on the map as lavas, and are always spoken of as such in the memoir on North Wales. In many places, however, they are not lavas, but fragmentary rocks. Their fragmentary character may be seen (to mention a few localities) in Cwm Llan, especially west of the copper vein not far from the stone erected in honour of Gladstone, and also near the footpath leading from Rhyd-dhu to Snowdon some five hundred yards or so beyond the half-way house. These rocks, C, in fact, consist of three kinds:—First, massive uncleaved rocks showing fluxion structure and in some places columnar; these are undoubtedly lavas: secondly, compact, often close-jointed, rocks of a smooth fracture, somewhat like lava, but without fluxion structure; these are probably tuffs or masses of consolidated felsitic dust: thirdly, highly cleaved felsitic rocks. These last are in some places obviously of a fragmentary character, but more often not so; and in such cases it is difficult to say whether they are so-called volcanic ash or cleaved lavas. As the obviously fragmentary rocks are part and parcel of them, my own opinion is that they consist mainly of ash; but to settle this question definitely microscopic examination is needed. A slice cut from one of these fine and highly cleaved felsitic rocks shows (as Mr. Greenly tells me) certain small aggregates with igneous structure, which look much more like fragments than surviving augen from such rocks as the Bala felstones. The rock also contains a considerable quantity of calcite, much more than could be expected from the felsitic lavas in question, none of which have yielded so much as ·5 per cent. of lime (Harker, "Bala Volcanic Series," p. 13). It is probable, therefore, that the rock is a felsitic tuff or dust.

2. Ramsay has pointed out on p. 150 of "The Geology of North Wales" how difficult it is to fix on a boundary-line between these lower felsites and the overlying series (B) on the ridge of Llechog, west of the peak of Snowdon, because both are felspathic and both cleaved. In my opinion the difficulty is due to the fact that both are ashes; but I have not yet had any specimen from this locality sliced and examined. In many places, the lower rocks look to me like the 'altered ashes' of the Lake Country.

3. Not only are the lower felsites often intensely cleaved, but a very striking peculiarity about them in many places is their sheared appearance; they are often more than cleaved, they are sheared (or even to a slight extent foliated[1]), so much so as in some places to remind me of the quartz-schist of the Western Highlands. This quasi-foliated appearance is (among other places) remarkable alongside the road from Rhyd-ddu to Beddgelert.

4. The great mass of these rocks (C) is quite devoid of bedding. In fact, their unbedded character is the chief distinction between them and the overlying series. At the same time, it is not always easy to fix upon a good line of demarcation between the two, as

[1] The divisional planes are coated with thin sheets of 'sericitic' mica.

the lower rocks are bedded near the top; or perhaps one should say it is in places convenient to include some well-bedded rocks with the lower group for the sake of carrying on a line. In some places, however, lines of bedding are to be seen in the heart of the group (C). This is the case just above Glaslyn, on the north side of the tarn, where the rocks are of an ashy nature, and are dipping at 60° to the W.S.W. near a fault.

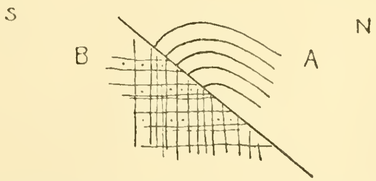
5. Immediately south of the outflow of Llydaw there are some curious greenish rocks of a fragmentary character, in which, however, one can rarely find any distinct bedding. They occur apparently at the base of the calcareous series (B), though very unlike the basement beds of that series seen hard by, and seem to wrap round the upper part of C, partly owing to a roll over, but chiefly from their having, as it seems to me, been deposited against and around a boss of the lower felsitic rocks. They include one or two bosses of an intrusive rock also of a greenish hue, which are probably connected with the great mass of diabase that forms Clogwyn Aderyn and Clogwyn Pen-llechen.

6. I may state, as I have not seen it mentioned anywhere, that the beds B are often beautifully false-bedded, or, as I prefer to say, cross-bedded. This is well seen in Cwm Glas.

7. In the same Cwm the base of the upper felstone (A) is plainly to be seen running down northward from the ridge of Crib-y-ddysgl to the northern end of Clogwyn Person; and it is here manifest that the felstone lies in a hollow in the underlying beds (B), for it is in contact with higher beds of B on the ridge than at the north end of Clogwyn Person, where the junction of the two rocks is clearly seen to be a natural and not a faulted one.

8. On Crib Goch the upper felstone consists entirely of a mass of blue close-grained columnar felstone showing lines of viscous flow. On Crib-y-ddysgl the rock consists of two distinct parts, separated by a thin band of slate or cleaved tuff. The lower part is a massive, but not always columnar, felspathic rock, containing on the ridge calcareous seams interbedded with it near its base. This is succeeded by a thin seam of cleaved tuff, inconstant in occurrence, overlaid by a columnar felstone exactly like the rock of Crib Goch.

The section at the base, seen on the Cwm Glas side of the ridge, is very interesting. The interbedded calcareous seams are bent over thus:—



as if (after consolidation) the rock had been thrust from north to south over the underlying slates and ashes, against which its layers had dragged at the junction. I have not yet traced the outcrop of the thrust plane, but it cannot coincide throughout with the junction of A and B, because, as stated above, that junction is at Clogwyn Person a natural one.

In the figure, which is merely a diagram, the curved lines in A represent calcareous seams in the felstone; and in B the gently sloping lines represent bedding, and the vertical lines cleavage.

9. I had long years ago noticed some peculiar vesicular rocks in the calcareo-ashy series, which puzzled me. It was Sir Archibald Geikie who first pointed out that there were andesites on Snowdon. After reading his account of these, I examined the rocks in the places on Snowdon mentioned by him, and then found that these andesites were one and the same with my peculiar vesicular rocks, so I set about mapping them, and very useful I have found them in showing where faults do and do not occur. In doing this work I have found and partly mapped several rocks that bear a family likeness to one another; some of them are not vesicular, and I fancy may be fine-grained andesitic tuffs; but whether tuffs or lavas, they form a group of similar rocks distinct from the rocks amid which they occur. They are characterized by a splintery fracture, smooth texture, dull grey colour, rusty weathering, and are often highly cleaved. Most of the specimens examined show under the hand lens the characteristic "trachytic meshwork of minute felspar laths." At present I look upon them as contemporaneous interbedded rocks: there are, however, places where they might be supposed to be intrusive, but perhaps this is a deceptive appearance due to faulting. I do not know yet about this.

The regions where I have mapped, or commenced mapping, them are on the flanks of Crib-y-ddysgl and beneath the peak of Snowdon, both above Glaslyn on one side and at the head of Cwm Clogwyn on the other, and on the ridge leading from the summit of the mountain to Bwlch-y-maen. I suspect from what I have lately seen (in unfavourable weather) that similar rocks also occur, as is but natural they should, in the calcareous series south-east of Lliwedd, and I know that a rock of this description forms Clogwyn-y-gysgfa on the east side of the road from Pen-y-gwryd to Beddgelert.

The andesitic rocks lie chiefly in the calcareous series (B), but one, a well-marked lava, which I had mapped as such before I knew anything about andesites, occurs amid the lower felsitic rocks (C) near the head of the rocky spur called the Gribbin or Criman, which runs down to the foot of Glaslyn from the south. I see that the tracing of these beds will necessitate a modification of some of the lines on the Survey map.

10. As far as I know, all the intrusive rocks coloured as Greenstones on the Geological Survey map are Diabases; but there are others of a different character, which are not shown on the Survey map, to wit, a boss of igneous rock of an apparently intermediate but variable character (as I am informed by Mr. E. Greenly) on the south side of Cwm Dyli, a mass of Diorite below Caer-gors (rather more than a mile from Rhyd-dhu station), and several sills and

dykes of an intermediate character on Mynydd Drws-y-coed. I may as well say at once that the mineralogical character of all the above-mentioned rocks, as well as of others not mentioned, were determined[1] for me by my friend Mr. E. Greenly, to whose great kindness in naming my specimens my warmest thanks are due.

There are also some intrusive felstones, bosses, and dykes in the Snowdon area. One of these I have already mentioned in a note to the British Association at Bristol. It is an oblong mass of felstone, showing lines of viscous flow parallel to its north-western face, and rudely columnar perpendicular to that face, exactly like the felstone of Crib Goch, and not like any part of the lower felsitic rocks of the immediate neighbourhood. I take it to be a plug and root of the Crib Goch lava. It occurs between Glaslyn and Bwlch Goch.

On the ridge called Llechog, that bounds Cwm Clogwyn on the south, a band of compact uncleaved felstone, running N.W. and S.E., stands up as a dyke amid the cleaved felsitic rocks (C). In the Cwm also a felstone dyke running W.N.W. and E.S.E. is seen rising up the cliff. This may possibly be the lower part of the dyke mentioned above. I have not decided about this yet.

I may remark that the existence of felstone dykes amid the Snowdonian rocks is a discovery, for none such have been hitherto recognized.

11. The great masses of diabase that occur so plentifully in the neighbourhood of Snowdon are generally massive rocks quite uncleaved, but they are often cleaved or sheared along their margins. Ramsay remarks on this feature, and says, on p. 157 of "The Geology of North Wales": "At its junction with the felspathic porphyry the greenstone is often partially decomposed; its crystalline character is gone (probably from rapid cooling at its sides), and it possesses a flaky structure to so great an extent that it sometimes looks like some of the cleaved dark-green calcareous ashes, or in other cases assumes an appearance of a more slaty description." This is an excellent description of the diabase along its margin, but there is evidently some confusion between the phenomenon of a chilled edge and that of marginal cleavage or schistosity, which must (as it seems to me) be due to movement or pressure. The same sort of thing occurs in the Scottish Highlands, where masses of basic rock among the schists are sheared along their margins, though in the Highlands the rock is generally reconstructed. Besides the above-noted deformation along their margins, the diabases are in some localities deformed and rendered schistose, or something very like it, throughout nearly their whole extent. I first noticed this in Cwm Llan, on the south side of Snowdon, and took Mr. Greenly to see it, so different in appearance was the rock from that of the ordinary run of diabases. A precisely similar rock occurs on the west side of Snowdon near Llyn Nadroedd. On the Geological Survey map a large mass of greenstone is represented there, but it really consists of two separate masses

[1] Only a few, however, have yet been sliced.

of intrusive rock parted by a band of felsite about seventy yards wide. The upper of these is a massive unsheared diabase of the ordinary type. The lower is exactly like the Cwm Llan rock, with which it is doubtless connected underground. Both of these masses (viz., the Cwm Llan rock and the lower of the basic rocks near Llyn Nadroedd) are highly complex, including a considerable variety of material, of the mutual relations of which, as well as of their relation to the surrounding rocks, I hope to be able some day to give a detailed account.[1] The bulk of the rock is a dark-green schist, with a highly developed parallel structure and a fine silky lustre on the foliation planes. Under the microscope the rock is seen to be completely reconstructed and recrystallized, to be a finely felted or schistose aggregate, in fact, a perfect crystalline schist. Chlorite, indeed, forms the bulk of the rock, with granules of epidote, magnetite, and leucoxene; but some specimens are largely composed of minute needles with a much higher double refraction than chlorite, which can hardly be anything but a pale-green hornblende, produced apparently at the expense of the chlorite, and the result therefore of a more advanced stage of metamorphism. A curious feature is the presence in some of these schists of a large number of small concretions (up to the size of large peas). These are composed of a quartz mosaic, with generally a border of radially arranged needles of a green mineral, chiefly chlorite, though hornblende is also present. Some are perfect little radial spherulites. Many of these concretions can be seen to cut sharply across the foliations, and no sign of strain has been observed in their minerals, so that it is clear that they are not amygdules, but that they have grown since the last deforming stresses to which the rock was subjected.

The character of these rocks is so different from that of any other of the Snowdonian rocks that the thought crossed my mind whether they might not be a boss of Archæan rocks sticking up in the valley bottom; but this idea, to say nothing of the structural difficulties, was negatived by finding that the metamorphic rock enveloped masses of grit, and was therefore intrusive.

12. Before closing this summary of my work, I may as well mention that there is a mass of basic intrusive rock, not shown on the Geological Survey Map, amid the rocks of the calcareous series S. by E. from Cwm Dyli waterfall and nearly opposite Gwastad Agnes, which I have not yet mapped; and that I have found and mapped a boss of diabase of the Siabod type, not shown on the Survey Map, from 450 to 700 yards N.N.W. of Pen-y-gwryd.

I find, too, that the upper part of the felstones of Glyder Fach on the southern slope of the hill consist of breccias which pass up gradually into grits.

13. In conclusion I will briefly state the chief things discovered by me in the Snowdon area: these are, first, the fact that much of

[1] The following mineralogical description has been communicated to me by Mr. E. Greenly.

the lower felsitic rock spoken of as lava is really of a fragmentary character; secondly, the existence of dykes and intrusive masses of felstone; and thirdly, the highly metamorphic rocks of Cwm Llan and Llyd Nadroedd. These three things are all new. Fourthly, the occurrence of diorite in the Snowdon area is a discovery.

X.—Diagram of Composition of Igneous Rocks.

By H. Warth, Esq.

RECENT studies about the average chemical composition of larger numbers of igneous rocks in the aggregate have shown that figures obtained from any one hundred or more samples are very similar, in fact practically equal. (See A. Harker, "On the Average Composition of British Igneous Rocks": Geol. Mag., No. V, May, 1899.) This will be found also the case when comparing the following average which I calculated from the analysis of igneous rocks compiled by Roth in his "Petrographie der plutonischen Gesteine."

Now if it is of interest to discuss these average results, notwithstanding the wide discrepancies of many individual compositions, it may also be worth while to find out how on the average the compositions vary with the relative acidity of the rocks. For this purpose I have arranged the bulk of Roth's samples in the order

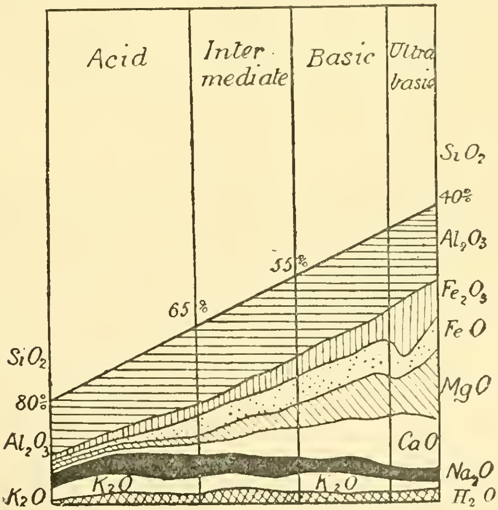


Diagram-Fig. 1.

of acidity, and after calculating average compositions of eighteen groups of closely approaching acidity, I constructed from the figures the subjoined diagrams. The first diagram (Fig. 1) shows the actual results, the second (Fig. 2) shows them rounded off.

The percentage of silica varies from 80 to 40, and the usual limits between acid, intermediate, and basic rocks are indicated by the vertical lines on the diagrams. The diagrams show the percentage of the different bases which corresponds with the percentage of silica indicated on the straight diagonal boundary-lines of the silica which rise from the points marked 80 per cent. on the left of

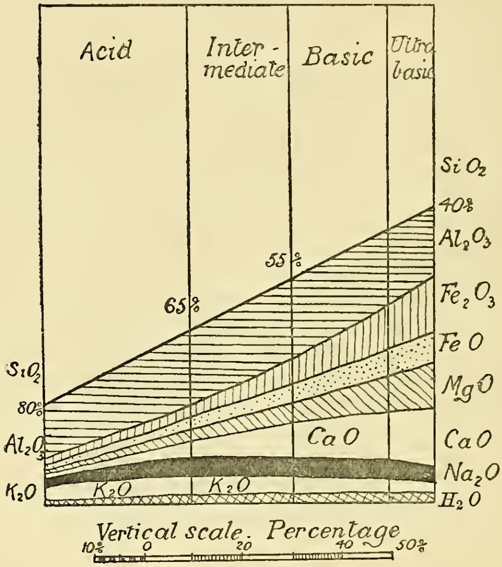


DIAGRAM-FIG. 2.

each diagram to the points marked 40 per cent. on the right of each diagram. As it would not be possible to give so many details on the diagram, small quantities of other acids have been reckoned with the silica and treated as such. These acids are titanic acid, phosphoric, carbonic, and in rare cases also sulphuric acid. In the case of the bases I also included the manganous oxide, and a few other rarer metallic oxides with the ferrous oxide. The total number of specimens which were calculated amounted to 428. About sixty-six of Roth's analyses were omitted, partly because they referred to strongly weathered specimens, and partly to exclude serpentines and some other more purely magnesian silicates. The specimens as given by Roth are from generally distributed localities, and the following are the compositions of extremes and of the total average in numerical figures :—

	Si	Al	Fe	Fe	Mg	Ca	Na_2	K_2	H_2
Most acid... ...	79·7	11·4	1·1	0·3	0·7	0·9	2·6	2·5	0·8
Most basic ...	40·0	12·3	10·2	5·8	14·2	10·5	3·1	1·2	2·3
Average	58·3	15·3	5·0	3·6	4·0	5·9	3·4	3·0	1·5

The diagrams show the alumina to be nearly constant, only slightly diminishing towards both extremes. The soda is also tolerably constant, diminishing slightly at both ends. The potash is decidedly stronger at the acid end, whilst the other oxides increase from left to right so as to show quite a fan-like expansion from the acid end towards the basic end.

The diagrams show also that the arbitrary boundaries between acid, intermediate, and basic rocks are very suitably chosen.

REVIEWS.

Bollettino della Società Sismologica Italiana, Vol. V (1899–1900).

EXCLUDING two bibliographical notices, the present volume contains nineteen papers, of which all are interesting and one is important. In addition, is the catalogue of earthquakes recorded in Italy during the year 1898, compiled by Dr. G. Agamennone and his successor Dr. Cancani. The value of this work is abiding, and increases with every fresh year of its existence.

If we may judge from this volume, the recent energies of Italian seismologists have been directed less to the invention of new instruments and more to the study of their records. Nevertheless, Drs. Vicentini and Pacher have made an important addition in the form of a vertical component microseismograph. The paper in which it is described, and the representations of some of its records, are most interesting. Dr. G. Agamennone has devised a new seismoscopic clock, and Dr. G. Pericle one more seismoscope.

Professor A. Riccò, of Catania, gives a summary of a report on the destructive earthquake of November 16, 1894, in Calabria and Sicily, and on its relations with the earthquakes of 1783. From the same writer we have also an account of the Etnean earthquake of May 14, 1898. Dr. Agamennone describes the Balikesri (Asia Minor) earthquake of September 14, 1896, the Apennines earthquake of March 4, 1898, and the Modena-Bologna earthquake of February 2, 1900; while Dr. Cancani studies the Latian earthquake of July 19, 1899. In connection with barisâl guns Professor Issel's supplementary paper on the Umbria Marches earthquake of December 18, 1897, is deserving of study.

Professor Mercalli contributes observations on Vesuvius (July–December, 1898), and Mr. R. V. Matteucci others on the Italian volcanoes generally. On July 19 and 25, 1899, violent explosions occurred in the central crater of Etna; these are carefully described by Mr. S. Arcidiacono, and their effects on the condition of the crater by Mr. A. Mascari. C. Davison.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—March 21, 1900.—H. W. Monckton, Esq., F.L.S., Vice-President, in the Chair. The following communications were read:—

1. "On a Bird from the Stonesfield Slate." By Professor H. G. Seeley, F.R.S., F.L.S., V.P.G.S.

During his residence at Oxford the late Earl of Enniskillen made a collection of Ornithosaurian bones from Stonesfield, which was acquired by the British Museum in 1866. Among these is one identified by the author in 1899 as the right humerus of a bird about as large as a flamingo. The bone is complete, except for fracture through the proximal articulation, and the specimen is on the whole well preserved. The chief characters available for comparison are the form of the shaft, the character of the proximal end, especially the ulnar tuberosity and the radial crest, and the form of the distal end. The character which first showed the fossil to be a bird was the ulnar tuberosity; probably the flamingo approaches as closely as any living genus to the Stonesfield fossil in this feature. The radial crest shows affinities with those of the flamingo and the eider-duck. The impression left by the humero-cubital muscle on the external surface above the condyles is almost identical with that seen in the flamingo. "The varied affinities of this large Carinate bird appear to lie midway between the ducks and geese on the one side, and the herons and flamingos on the other. It may be placed in a new family; but its characters are in all respects such as might have occurred in an existing bird. There is no indication of affinity to the *Archæopteryx*, or that the bird diverged in any way from modern types."

2. "The Lower Ludlow Formation and its Graptolite-Fauna." By Miss Ethel M. R. Wood. (Communicated by Prof. C. Lapworth, LL.D., F.R.S., F.G.S.)

After dealing with the literature of the stratigraphical and palæontological sides of the subject, the author passes to a full consideration of the sequence and character of the Ludlow Rocks in the following localities: the Ludlow district, the Builth district, the Long Mountain; and gives a briefer account of those of the Dee Valley, the Lake District, Southern Scotland, Dudley, and the Abberley Hills. While the Wenlock Shales are characterized by *Cyrtograptus* and by the *Flemingii*-type of *Monograptus*, in the Lower Ludlow Shales the *colonus*- and spinose forms of *Monograptus* such as *M. chimæra* are abundant. The line between Lower and Upper Ludlow is drawn at the top of the Aymestry Limestone. The Lower Ludlow Rocks are divided into five graptolitic zones, which are not constant in character or thickness in the different areas. The distribution of the zones is given in the annexed table (p. 277). Two of the zone-graptolites are new species, described in the latter part of the paper.

TABLE ILLUSTRATING THE DISTRIBUTION OF THE GRAPTOLITE-ZONES.

Zones.	Ludlow District.	Builth District.		Long Mountain District.	Dee Valley.	Lake District.
		Eastern Area.	South-Western Area.			
Zone of *M. Leintwardinensis*	Aymestry Limestone (275 feet). Calcareous laminated flags, passing down into light-brown flaggy mudstones (210 feet).	Thin calcareous bands and micaceous laminated flags, passing gradually into	Dark micaceous and calcareous flags, well laminated, passing gradually into	Micaceous flags, passing into	'*Leintwardinensis*-Flags.'	Bannisdale Slates. [Upper parts calcareous.] (5,000 feet.)
Zone of *M.* sp. nov.	Light flaggy mudstones (220 feet).	Light flaggy mudstones and darker calcareous flags (400 to 500 feet).	Light flaggy mudstones.	Light flaggy mudstones. (900 feet ?)	Upper Gritty Beds.	Coniston Grits. (Coniston Grits, Upper Coldwell Flags and Middle Coldwell (?) together: 5,000 feet.)
Zone of *M. scanicus.*	Light flaggy mudstones and shales (100 feet).	Greyish-brown shales, with some flaggy mudstones (250 feet).	Unknown.	Greyish-brown thinly-bedded shales (350 feet). (spans this zone and the next)	[No fossils.]	
Zone of *M. Nilssoni.*	More thinly bedded mudstones and shales (120 feet).	Greyish-brown shales, with thin calcareous bands. (with the next: 300 feet.)	Greyish-brown shales, with thin calcareous bands (550 feet).		Nantglyn Flags. (spans this zone and the next)	Upper Coldwell Flags.
Zone of *M.* sp. nov.	Thinly bedded shales. No graptolites. (130 feet.)	Dark-grey calcareous shaly flags.	Dark-grey calcareous flags, with conchoidal fracture (100 feet).	Dark-grey calcareous flaggy shales (600 to 700 feet ?).		Middle Coldwell (?).
	Wenlock Limestone.	Wenlock Shales. (Zone of *Cyrtograptus Lundgreni.*)	Wenlock Shales.	Wenlock Shales.	Moel Ferna Slates.	Lower Coldwell (?).

In the Ludlow area the two lowest zones are rich in graptolites, but shade into each other, and are therefore less clearly defined than the higher zones, which each contain practically only one species and are lithologically distinct. In the Builth area the variation in the zones in different parts may be due to the conditions of depth and current under which the graptolites have been deposited, or to the overlap of higher beds on lower, as has been shown to be the case with the Wenlock and old Red Sandstone rocks. In the Long Mountain syncline *M. scanicus* is practically absent, and the typical *M. Leintwardinensis* of the highest zone has not yet been found, although its place appears to be taken by a varietal form. Two new species of graptolites are almost confined to this district. The succession worked out in these districts is confirmed by that in the Dee valley and the Lake District, but the evidence at present obtained in the three other areas is only scanty.

The Lower Ludlow sediments become thicker, coarser, and more arenaceous when traced from the south and south-east to the north and north-west; but, in spite of this, there is a striking constancy in the lithological sequence of the sediments. Only two of the graptolitic zones, those of *M. Nilssoni* and *M. Leintwardinensis*, are present in all the districts. A table is given to show the distribution of the graptolites in Britain and Europe, and one showing the order of appearance of the graptolites of the formation.

The Lower Ludlow graptolites present, as a whole, the following peculiarities, and stand in marked contrast to those from the Wenlock Rocks in the fact that while the polypary is straight for the greater part of its length, it is distinctly curved inwards at the proximal extremity. The apertures of the thecæ are for the most part either spinose, or wholly devoid of ornamentation. The number of species is eighteen, with thirteen varieties, of which six species and nine varieties of *Monograptus* and one species of *Retiolites* are new, and are described and figured in the paper. All the species and varieties of *Monograptus* are arranged round type-species into six groups. The richest groups in species and varieties are those of *M. dubius* and *M. colonus*. Most of these groups link the Ludlow Series with Wenlock, and even the genus *Retiolites* is common to the two formations. Thus the supposed great palæontological break between the two series to a great extent disappears.

II.—April 4, 1900.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read :—

1. "Additional Notes on some Eruptive Rocks from New Zealand." By Frank Rutley, Esq., F.G.S.

The rocks described in this paper were, with a few exceptions, collected by Mr. James Park. A few of the specimens come from the area of the Hauraki Goldfields, but many of them were procured from other localities in the North Island, including several from Rotorua. The silica-percentages of several of the rocks have been determined by Mr. P. Holland.

The first part of the paper deals with twenty-three rock-specimens and slides from them. These consist of rhyolites and obsidians, with rhyolitic and pumiceous breccias and tuffs, geyserites, and sinters. The rocks exhibit spherulitic and perlitic textures, fluxion, devitrification, and impregnation with silica. In one case the obsidian, after solidification, appears to have undergone the following changes:—(1) devitrification, with formation of spherulites; (2) increase in temperature sufficient to destroy the double refraction of spherulites and the earlier formed felspars; (3) the decomposition of parts of the spherulites, causing them to assume the characters of a cross-grained felsite. The rocks from Rotorua exhibit the effect of solfataric action resulting in the production of a high percentage of silica in the rock, and the development of hyalite and isotropic opal silica or geyserite. In some cases these rocks have had silica substituted for portions of the spherulites which have been dissolved, the fibrous structure being preserved in opal-silica, which, nevertheless, exhibits double refraction.

In conclusion, the author suggests a comparison of certain ancient rhyolites of Great Britain with those of New Zealand affected by solfataric action. As to the causes which may convert a glassy into a lithoidal rhyolite we still seem to lack information; it is possible that the action of steam may be instrumental in effecting such a change, but this is probably only an occasional agent, and the more general cause of such changes must be sought elsewhere.

2. "On the Discovery and Occurrence of Minerals containing Rare Elements." By Baron A. E. Nordenskiöld, F.M.G.S.

The first mineral referred to is scheelite, and the next cerite, which contains no less than four rare metals. The incandescent light produced when the latter mineral is fused with charcoal-powder was first observed by Cronstedt in 1751. The discovery of glucina, lithia, selenium, and yttria is next referred to. Minerals containing yttria and oxides related to it were, at one time, thought to be almost limited to certain pegmatite-veins running in a broad zone on both sides of the 60th parallel of latitude. Latterly, fluocerite, orthite, and gadolinite have been found in Dalecarlia; and among these minerals Benedicks discovered a silicate of yttrium containing 1·5 per cent. of nitrogen and helium. The author discovered kainosite, a silico-carbonate of yttrium and calcium, among minerals from Hitterö; and the same mineral was subsequently discovered in the flucan, fissures, and drusy cavities at the Nordmarken mines. The last-mentioned discovery and others related to it appear to suggest that the mode of formation of fissure-minerals is not so unlike that of the pegmatite-veins of the Primary rocks as is generally supposed.

Thorium, discovered by Berzelius in 1829, was originally obtained from the rich mineral locality of Langesund (called Brevig in mineralogical literature), but it has since been recorded from other localities, including Arendal and Finnish Lapland. It is now obtained from the monazite-sand of rivers in the Brazils and South Carolina. Thorite contains about ·5 per cent. of inactive gas, probably a mixture of nitrogen and helium; but the latter element was first obtained from the mineral cleveite, also containing thorium, discovered by the author in 1877. Other minerals bearing nitrogen, argon, or helium are referred to; and under the head of minerals bearing tantalum, mention is made of Giesecke's discoveries in Greenland. Among these is fergusonite, one of the richest sources hitherto known for obtaining that mysterious gas, or mixture of gases, which on our planet seems to be almost exclusively confined to minerals containing rare earths. "The group of earths, as well as the group of gases, of which we are here speaking, might therefore be compared with certain genera among organic beings, whose species, having not yet fully differentiated, offer to the descriptive zoologist or botanist difficulties analogous to those with which chemists meet in endeavouring to separate the rare earths and rare gases."

III.—April 25, 1900.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair.

The President, having requested all present to rise from their seats, read the following resolution which had been passed unanimously by the Council: "That this Council desire to place on record their deep sense of the loss which both science and literature have sustained in the death of the Duke of Argyll, who was the oldest surviving past-President of the Geological Society;" and stated that on behalf of the Council he proposed to communicate a copy of the resolution to the Duchess of Argyll, coupled with an expression of respectful sympathy.

The following communications were read:—

1. "On a complete Skeleton of an Anomodont Reptile from the Bunter Sandstone of Reichen, near Basel, giving new Evidence of the Relation of the Anomodontia to the Monotremata." By Professor H. G. Seeley, F.R.S., F.L.S., V.P.G.S.

This skeleton was originally described by Wiedersheim under the name of *Labyrinthodon Rütimeyeri* in 1878. The bones are now differently interpreted:

The reputed humerus is the interclavicle.
,, ,, scapula is the humerus.
,, ,, supra-scapula is the left coracoid.
,, ,, ,, ,, right scapula.
,, ,, right and left clavicles are the ribs.
,, ,, right and left coracoids are the pre-coracoid and coracoid of the right side.

Five digits are identified in place of four in 1878. These osteological identifications are inconsistent with reference of the type to the Labyrinthodontia, and it is accordingly described as a new genus, which is placed in association with *Procolophon* as a separate family in the tribe Procolophonia.

The author discusses various views which have been expressed with regard to the position of the Labyrinthodonts. He has already separated these animals from the Amphibia and combined them with the Ichthyosauria in a group of reptiles named Cordylomorpha, and he enumerates a series of characters which constitute so close a link between the two types "that it is not possible, in the absence of evidence, to conceive of their being referred to different classes of animals."

"But if the order Labyrinthodontia is transferred to the Reptilia, it is then manifest that by including such genera as *Branchiosaurus* and *Archegosaurus*, in which gill-arches are found, it introduces into the Reptilia a character hitherto unknown, and commonly regarded as Amphibian. . . . If the osteology of an ordinal type is Reptilian, it cannot be placed in the Amphibia, because two or three genera, or the whole group, preserve gill-arches. . . . The Labyrinthodontia may or may not be a homogeneous sub-class or order, though the circumstance that many writers have separated its groups on different principles, and into a varying number of orders, is some evidence that it includes a wide range in character. . . . In no part of the skeleton is there a close correspondence between living Amphibia, which are probably unknown before the Tertiary period, and the extinct Labyrinthodontia, which are only known with certainty in the Carboniferous, Permian, and Triassic periods of time."

"If the sub-orders of Labyrinthodontia are sub-orders of Reptilia and not of Amphibia, the transition which *Pareiasaurus* exhibits from Labyrinthodonts to Mammals ceases to be an anomaly."

"The close resemblance of form of the bones in the several parts of the skeleton now described with Monotremata and Anomodontia makes the border-line between Reptiles and Mammals more difficult to define."

The fossil is identified as an Anomodont reptile, chiefly on the basis of resemblance to *Procolophon* and *Pareiasaurus*. It is shown not to be a mammal by the large parietal foramen, the composite structure of the lower jaw, and the presence of the pre-frontal bone. It differs from known Anomodonts in making a somewhat closer approximation to Monotreme mammals than has hitherto been evident, and this correspondence extends to successive segments of both the fore- and hind-limbs.

The teeth are in sockets placed obliquely, with conical crowns compressed to sharp lateral margins, and curved inward. The proportions of the vertebral column are those of *Echidna*, though the transverse processes are longer, as in *Pareiasaurus*. The ribs are like those of a Monotreme, though the sacral ribs are longer. The shoulder-girdle resembles that of *Procolophon*, and differs from typical Anomodonts in the constituent bones being unanchylosed, and in the pre-coracoid having a large anterior extension in advance of the scapula. The sternum appears to have been unossified, as in Crocodilia. The humerus is widely expanded at both extremities and twisted, but does not show the peculiar lateral curvature seen in Monotremes. The ulna gives no evidence of an olecranon-process; it is larger than the radius, and appears to articulate with the humerus. The pelvic bones are without acetabular or obturator perforations, are not anchylosed together, and the ilium is not expanded transversely. The hind-limb is no larger than the fore-limb. The femur is more slender than the similar bone in *Echidna*. The fibula is prolonged proximally beyond the stout tibia round which it may rotate. The proximal row of the tarsus is one large bone, formed of the blended astragalus and os calcis.

In conclusion, the author argues that the points of structure are so few in which Monotreme mammals make a closer approximation to the higher mammals than is seen in this fossil and other Anomodontia, that the Monotreme resemblances to fossil reptiles become increased in importance. He believes that a group Theropsida might be made to include Monotremata and Anomodontia, the principal differences (other than those of the skull) being that Monotremes preserve the marsupial bones and the atlas vertebra. *Ornithorhynchus* shows pre-frontal and post-frontal bones, and has the malar arch formed as in Anomodonts and some other reptiles.

2. "On Longmyndian Inliers at Old Radnor and Huntley (Gloucestershire)." By Charles Callaway, M.A., D.Sc., F.G.S.

The grits, with some associated slaty bands, forming a ridge near Old Radnor were considered by Sir Roderick Murchison to be May Hill Sandstone. The author has discovered that one of the beds of Woolhope Limestone, dipping westward, is crowded with rounded and angular fragments of grit bearing a general resemblance to the arenaceous parts of the Old Radnor Group. The bedding of the grits is much obscured by crushing, and the rock is sometimes brecciated. Descriptions of microscopic sections of the rock are given in the paper, and the specimens are grits, the materials of which are mainly derived from gneissic and igneous rocks. The unconformity of the grits to the Woolhope Limestone Series, and the dissimilarity of the grits to the May Hill Sandstones of Presteign are the chief facts relied upon by the author to establish the pre-Cambrian age of the Old Radnor Series; while the occurrence of the rocks on the strike of the Longmynd, their position with regard to the prolongation of the Church Stretton Fault, and their relations to the Ordovician and Silurian rocks of the area are in favour of a comparison with the Longmyndian rocks. The lithological resemblances between the Old Radnor Series and the typical Longmyndian are very well marked. Neither the rocks of the Old Radnor Series nor those of the Woolhope Series are affected by any metamorphic change.

The grits and shaly beds of Huntley are unlike the May Hill Sandstones of that district, and as they occur along the axis of the anticline, and lithologically resemble the rocks of the Longmynd, it is highly probable that they also are of Longmyndian age.

IV.—May 9, 1900.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "The Pliocene Deposits of the East of England. Pt. II: The Crag of Essex (Waltonian), and its Relation to that of Suffolk and Norfolk." By F. W. Harmer, Esq., F.G.S. With a Report on the Inorganic Constituents of the Crag by Joseph Lomas, Esq., F.G.S.

The term 'Red Crag,' including, as it does, beds differing considerably in age, is vague, and, when we attempt to correlate the East Anglian deposits with those of other countries, inconvenient;

the Scaldisian zone of Belgium, for example, with its southern fauna, representing one part of it, and the Amstelian of Holland, in which Arctic shells are common, another. While retaining the name for general use, therefore, the following more definite classification of its various horizons, and of those of the English Pliocene generally, is proposed :—

	NEWER PLIOCENE.	
CROMERIAN.	So-called Forest-bed Series. Fresh-water & Estuarine.) Zone of *Elephas meridionalis.*	
WEYBOURNIAN.	Weybourn and Belaugh Crag. Zone of *Tellina balthica.* (Marine.)	
CHILLESFORDIAN.	Chillesford Clay and Sand. Zone of *Leda oblongoides.* (Estuarine.)	
ICENIAN.	Norwich Crag. (Marine.) Northern part: Zone of *Astarte borealis.* Southern part: Zone of *Mactra subtruncata.*	
BUTLEYAN.	Red Crag of Butley and Bawdsey. Zone of *Cardium grœnlandicum.*	AMSTELIAN. Upper part.
NEWBOURNIAN.	Red Crag of Sutton, Newbourn, Waldringfield, etc. Zone of *Mactra constricta.*	Lower part.
	Red Crag of Bentley & Tattingstone.	
WALTONIAN.	Crag of Essex. Oakley horizon: Zone of *Mactra obtruncata.*	POEDERLIAN.
	Walton horizon: Zone of *Neptunæa contraria.*	SCALDISIAN. Zone à *Trophon antiquum* (*Chrysodomus contraria*).
GEDGRAVIAN.	Coralline Crag. Zone of *Pecten Gerardii.*	CASTERLIAN. Zone à *Isocardia cor.*
	OLDER PLIOCENE.	
LENHAMIAN.	Lenham Beds. Zone of *Arca diluvii.* Boxstone fauna.	DIESTIAN. Ferruginous sandstones of Diest. Waenrode Beds.

The line separating the Older and Newer Pliocene is now drawn by the author between the Lenham Beds, containing *Arca diluvii* and other characteristic Miocene species of the North Sea (or of the Italian Pliocene), and the Coralline Crag, the latter being considered as the oldest member of a more or less continuous and closely connected series of Newer Pliocene age. The palæontological difference between the Coralline and Walton Crags is shown to be less than has hitherto been supposed.

The upper Crag deposits arrange themselves in horizontal and not in vertical sequence, assuming always a more boreal and more recent character as they are traced from south to north. They are the littoral accumulations of a sea retreating, not continuously, but at intervals, in a northerly direction.

A new horizon of the Crag, represented by some beds at Little Oakley, between Walton and Harwich, is described, indicating the period, before the southern mollusca had commenced to disappear, when a few boreal species were beginning to establish themselves in greater or less abundance in the Anglo-Belgian basin. Though hitherto unnoticed, the fauna of this locality has proved to be exceedingly rich, more than 350 species and varieties having been there obtained, from a seam 10 yards long and less than 2 feet in average thickness.

The three divisions of the Red Crag now proposed (the exact position of the Bentley bed not having been ascertained at present), namely, Waltonian, Newbournian, and Butleyan, are distinguished alike by the difference of their faunas and by the position which they occupy. The first, with its southern shells, is confined to the county of Essex; the second, containing a smaller proportion of southern and extinct, and a larger proportion of northern and recent species, occupies the district between the Orwell and Deben, and a narrow belt of land to the east of the latter river; the third, in which Arctic forms such as *Cardium grœnlandicum* are common, is found only farther north and east. All these beds are believed to have originated in shallow and landlocked bays, successively occupied by the Red Crag sea as it retreated northward, which were silted up, one after the other, with shelly sand.

The Norwich Crag (Icenian) occupies an area entirely distinct from that of the Red Crag, no instance being known where the one overlies the other in vertical section; the fauna of the former is, moreover, more boreal and comparatively poor in species. The Arctic species, *Astarte borealis*, is confined to the northern part of the Icenian area; its introduction seems to mark a stage in the continued northerly retreat of the sea. The Icenian deposits thicken rapidly northward and eastward, and are believed by the author to constitute part of the great delta-formation of the Rhine.

The mammalian remains found at the base of the different horizons of the Crag in a *remanié* bed, containing material derived from various sources, are considered to be also derivative from deposits, older than the Coralline Crag, formerly existing to the south.

The Chillesfordian (estuarine) and Weybournian (marine) deposits, the latter characterized by the sudden appearance in the Crag basin, in prodigious abundance, of *Tellina balthica*, represent separate stages in the continued refrigeration of East Anglia during the Pliocene period; but the so-called "Forest-bed" or Cromerian (fresh-water and estuarine) with its southern mammalia, and its flora, similar to that of Norfolk at the present day, clearly indicates a return to more temperate conditions, and should therefore be separated alike from the Weybourn Crag on the one hand, and from the *Leda myalis* Sands and the Arctic fresh-water bed of Mr. Clement Reid on the other. The two latter seem naturally to group themselves together, and with the Glacial deposits.

The conditions under which the Red Crag beds originated seem to exist at the present day in Holland, where sandy material brought down by rivers, with dead shells in great abundance from the adjacent sea, is being thrown against and upon the coast, principally by means of the westerly winds now prevalent. From meteorological considerations, it seems probable that strong gales from the east may have prevailed over the Crag area during the latter part of the Pliocene epoch. No other explanation of the accumulation of such vast quantities of dead shells on the East Anglian margin of the North Sea at that period can be suggested. At the present day, the eastern shores of Norfolk and Suffolk are almost destitute of such débris.

Mr. J. Lomas, in his Report on the Inorganic Constituents of the Crag, states that lithologically the various subdivisions of the Red Crag are the same. Differences of colour may be traced to definite lines of flow along which water containing ferruginous matter has moved.

Among the rarer minerals separated out by high-density fluids, zircon, rutile, cyanite, ilmenite with leucoxene, garnets, andalusite, corundum, tourmaline, muscovite, biotite, glauconite, orthoclase, labradorite, albite, and microcline are found. In the heavy fractions red garnets are very common. Tourmaline occurs abundantly, and includes green, blue, yellow, and brown varieties. Muscovite predominates over biotite, and often includes rounded crystals of zircon, rutile, etc. Ferro-magnesian minerals, with the exception of biotite, are absent. Glauconite is very plentiful, and frequently retains the form of the organisms of which it has formed casts.

In the Norwich Crag the same minerals are present, but muscovite is found in excess. The Chillesford Sands differ from the Crags only in the absence of glauconite. The bulk of the material of the beds described consists of well-rounded grains of quartz, seldom showing traces of secondary crystallization. Flint occurs as large pebbles, and fine angular chips are met with in the sands.

2. "A Description of the Salt-Lake of Larnaca in the Island of Cyprus." By C. V. Bellamy, Esq., F.G.S., Assoc. M. Inst. C.E.

After a brief description of the general geology and geography of the island the author proceeds to deal with the topography of the Lake, which occurs in a basin shut off from the sea, its deepest part being about 10 feet below sea-level. The barrier between the salt-lake and the sea is made of stiff calcareous clay associated with masses of conglomerate resting on plastic clay, that on watery mud, and that again on stiff calcareous clay. The sea-water appears to percolate through the highest deposits, meeting with checks in the conglomerates, and thus reaches the basin somewhat slowly, where it is evaporated to dryness by the summer heat and deposits its salt. Artificial channels have been made, to carry the flood-water from the land direct to the sea, so that it does not dilute the brine of the lake. The rainfall in the catchment-area round the lake is at the most only enough to supply 223 million gallons, and as the lake contains 480 million gallons when full, the balance of 257 million gallons must be derived from the sea. The lake is probably situated on what was an extensive arm of the sea at the close of the Cainozoic era. The salt-harvest begins in August, at the zenith of summer heat, and it is reported that a single heavy shower at that time of year suffices to ruin it. Observations are given on the density of the water, the plants and animals in the water, and the lake-shore deposits.

CORRESPONDENCE.

SHELLS FROM PORTLAND RUBBLE DRIFT.

Sir,—May I ask a few lines space to add to the list of Land and Fresh-water Shells from Portland Bill Rubble Drift recorded in my previous letter (Geol. Mag., Dec. IV, Vol. I, 1894, p. 431).

After about three hours' work there on Feb. 21st last among the numerous shells of species already recorded, I found the following new species: *Helicella itala*, 2 specimens; *Limnæa truncatula* (dwarfed variety), 4 specimens. These identifications have been kindly endorsed by Mr. Edgar A. Smith, F.Z.S., of the Zoological Department, British Museum (Natural History).

On carefully going over the specimens with Mr. B. B. Woodward and Mr. A. Santer Kennard, two other species must be recorded, viz., *Helix*, sp. (protoconch of an indeterminable species), and *Hygromia rufescens* (Pennant). The relative abundance of the species, as found by me, is as under, adding previously recorded finds (Geol. Mag., 1894, pp. 431, 432) to those of February 21 last (new records are in italics):—

Helicella itala (Linn.)	2 spec.
Hygromia hispida (Linn.)	1 ,,
Hygromia rufescens (Pennant)	10 ,,
Vallonia pulchella (Müll.)	5 ,,
Helix, sp.	1 ,,
Pupa muscorum (Linn.)	84 ,,
Succinea oblonga, Drap.	50 ,,
Limnæa pereger (Linn.)	22 ,,
Limnæa truncatula (Müll.)	16 ,,
Pomatias reflexus (Linn.) [=Cyclostoma elegans (Müll.)]	1 ,,
Pisidium, sp.	1 ,,

The numbers of Sir Joseph Prestwich's specimens are not stated, but the above table is probably the order of frequency of occurrence.

Mr. E. R. Sykes, F.L.S. (President Conchological Society), has found *L. truncatula* in a deposit on the east side of the Isle of Portland. He considers this latter deposit as comparatively recent, and derived from a marshy tract which still exists south of Southwell. If this be so the deposits are not synchronous, inasmuch as the geological conditions of the deposit at the Bill are well defined as of late Pleistocene age, not only from the stratigraphical evidence, but from the abundant occurrence of so characteristic a Pleistocene form as *S. oblonga.* Mr. Sykes (Proc. Dorset Field Club, vol. xvi, p. 171) records *L. truncatula* from the 'Bill' deposit. On referring to Prestwich's paper on the raised beaches (Q.J.G.S., vol. xlviii, 1892, p. 278) *L. truncatula* is determined *from the occurrence of opercula only.* Probably *Bythinia tentaculata* is meant, as it occurs also at Chesilton at the north-west of Portland, and is an operculate mollusc, whereas *Limnæa* is non-operculate (Reeve, "British Land and Fresh-water Mollusca," 1863, p. 154). This inadvertence may be a *lapsus calami*, either on the part of our author or of Dr. Gwyn Jeffreys, who generally determined doubtful or critical species for him.

Limnæa truncatula is therefore still a new record from this interesting Pleistocene deposit. R. Ashington Bullen.

Axeland, Surrey.

THE CENOMANIAN OF BAHARIA OASIS, EGYPT.

Sir,—I have to thank Dr. Max Blanckenhorn for his letter in the Geol. Mag., April, 1900, p. 192, disclaiming to have himself "discovered the existence of rocks of Cenomanian age in Baharia Oasis." As Dr. Blanckenhorn maintains that he cannot be held responsible for the abstract report which appeared in the *Zeitschrift für praktische Geologie,* I should like to point out that the copy of this abstract report was sent to the Survey by Dr. Blanckenhorn himself, and although it contained numerous corrections in ink of the type matter, the paragraph to which exception was taken, and which I quoted in my letter of December 7, 1899, was not in any way corrected or explained; I could therefore only come to one conclusion.

As I have already stated my opinion as to the age of the series of beds under discussion, both in my letter of December 7, 1899 (Geol. Mag., January, 1900), and in a paper read before the Cairo Scientific Society in October, 1899, it is not necessary to discuss Dr. Blanckenhorn's assertion that I did not "know the meaning" of the fossils collected, especially as this has nothing to do with the question in dispute. Moreover, as the examination of these fossils has not yet been completed by the palæontologists of the British Museum, the exact horizon or horizons to which they should be referred cannot possibly be indicated with certainty.

Cairo, *April* 14, 1900. Hugh J. L. Beadnell.

OBITUARY.

GEORGE HIGHFIELD MORTON, F.G.S.

BORN JULY 9, 1826. DIED MARCH 30, 1900.

GEORGE H. MORTON, the well-known Lancashire geologist, was born in Liverpool in 1826, and educated at the Mechanics' Institute in that city. From a child he was interested in geology, and at 16 years of age he commenced to form a collection of fossils, some Ammonites, obtained at that time, having first excited his interest. He also purchased, and read with earnestness, an article entitled "The Mineral Kingdom" in Knight's "Store of Knowledge," and "The Romance of Geology" in "Chambers' Miscellany." Other works of more importance were obtained and diligently studied. In those days textbooks on scientific subjects were few in number, and there were no science classes in Liverpool which young Morton could attend. He continued to collect minerals, rocks, fossils, and shells, which he named at the Royal Institution, Liverpool.

In 1845 Morton examined the Boulder-clay at Egremont, and the New Red Sandstone quarries at Storeton with their wonderful footprints of *Cheirotherium* and other reptiles on the slabs of ripple-marked sandstone. In 1847 he visited Holywell, where he obtained a few Carboniferous fossils. In later years he worked at and described this formation in great detail. He contributed his first paper of importance to the Literary and Philosophical Society of Liverpool in 1856, "On the Subdivisions of the New Red Sandstone between the River Dee and the rise of the Coal-measures east of Liverpool." He also contributed papers to the British Association, the Geological Society of London, etc. In 1864 he was appointed Lecturer on Geology at Queen's College, Liverpool, where he taught successfully for several years.

Most of Mr. Morton's published papers relate to home geology or to the Carboniferous Limestone of North Wales. His "Geology of the Country around Liverpool" was published in 1863, and a second edition appeared in 1891. This work contains all his previous writings on local geology. An appendix was added in 1897, giving the results of constant and careful observations in the field extending over fifty years.

Mr. G. H. Morton was a member of numerous scientific societies, and founded the Liverpool Geological Society in 1859. He was elected a Fellow of the Geological Society of London in 1858, and in 1892 was awarded the Lyell Medal by the Council in recognition of his long and meritorious services to geology in the work which he had done around Liverpool, especially for the knowledge of the Triassic and other strata of that district.

"The Geology of the Country around Shelve," "The Carboniferous Limestone of North Wales," and "The Country around Llandudno," the last-named read before the Geological Society of London, well illustrate the earnest and careful labours of Mr. Morton's long and well-spent life. He passed away very peacefully on the 30th March in his 74th year.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VII.

No. VII.—JULY, 1900.

ORIGINAL ARTICLES.

I.—Colonel Feilden's Contributions to Glacial Geology.

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

In 1877 and the following year Colonel H. W. Feilden published the results of his scientific investigations on the coasts of Smith Sound and the channel to the north.[1] In 1896 he made contributions to the geology of Kolguev, Waigats, and Novaya Zemlya in two other papers.[2] These are reprinted, together with one previously unpublished, in the appendix to Mr. H. J. Pearson's book, "Beyond Petsora Eastward" (1899). As the earlier work appears to have been forgotten by some writers upon glacial subjects, and the last-named might very easily escape their notice, I urged Colonel Feilden to give a summary of his chief resnlts in some generally accessible periodical. Shortly afterwards, on being unexpectedly called away for service in South Africa, he requested me to undertake the task. For the sake of brevity, I restrict myself mainly to the investigations which throw light on the formation of Boulder-clay and its associated sands and gravels, because these establish two points: (1) that such deposits are sometimes formed beneath the sea; (2) that the land in these Arctic regions has been elevated, in places not less than a thousand feet, since either some time in or the close of the Glacial epoch. I draw especial attention to these points, because I have noticed in certain writings a tendency to take it for granted that Boulder-clays can only be the leavings of an ice-sheet upon the land, and to treat the idea of any such important change of level as an hypothesis so improbable as to be practically impossible. Hence I shall pass over sundry important observations which show that projecting rocks can be scratched, polished, and even rounded by the action of floating ice, and shall not enter upon "the literature of the subject," for it is of Colonel Feilden's work alone that I am concerned to give a summary. So, after remarking that he more than once calls attention to the amount of débris seen on floating ice,[3] I proceed to the observations bearing on these two points, not, however, arranging them under the separate heads, but giving them in geographical order.

[1] Ann. & Mag. Nat. Hist., ser. iv, vol. xx (1877), p. 489; Quart. Journ. Geol. Soc., vol. xxxiv (1878), p. 556. See also Nares' "Voyage to Polar Sea."
[2] Quart. Journ. Geol. Soc., vol. lii (1896), pp. 52, 721.
[3] "Beyond Petsora," pp. 250, 269, 270.

A. *Grinnell Land, etc.*[1]—Here we find abundant evidence that this "part of the land round the North Pole has been affected by a movement of upheaval since there was any subsidence." That statement is justified by the following observations:—(*a*) Fragments of mollusca and erratics are scattered over mountain tops and elevated plateaus. (*b*) Terminal moraines of ancient glaciers, containing numerous marine mollusca, are found above the present sea-level. (*c*) Raised beaches, with remains of such mollusca and with erratics stranded on their tops and slopes, occur tier above tier with great regularity. They appear to be frequent up to about 400 feet above sea-level, and the most elevated mentioned is at about 1,000 feet.[1] It consists of a clay containing ice-scratched erratics, with *Mya truncata, Saxicava rugosa, Astarte borealis,* and *Pecten Grœnlandicus.* A similar deposit with the same fossils also occurs here[2] just above sea-level; the latter resting on sandstone of Miocene age, the former on Azoic slates. Colonel Feilden also mentions a plateau at 800 feet, in which some remains of *Mya truncata* were found. Coniferous wood, still retaining its buoyancy and just like that stranded on the existing coastline, was found "at elevations of several hundred feet," and "there was no evidence in the mud beds of Grinnell Land to encourage the idea that any of these trees had grown *in situ.*"[3]

B. *Arctic Norway.*—With this region Colonel Feilden has dealt briefly, because, as he says, numerous observers have already called attention to the raised beaches containing marine shells and the wave-marks on ice-worn crags high above sea-level, so that the fact of a general glaciation, followed by some submergence, and that by considerable elevation, can hardly be disputed.[4] But he mentions more particularly a conspicuous terrace on the mainland opposite to Tromsö, at the mouth of a valley about a quarter of a mile wide, which is continued north and south along the present coastline, its base being a few feet above present high-water mark. In 1894 a good section of this terrace, some 20 feet in height, was exposed. "From base to summit it is a homogeneous mass of blue clay, with boulders and stones interspersed throughout." These are ice-scratched, and "mollusca are abundant throughout the bed. *Cyprina Islandica* and *Pecten Islandicus,* partially retaining their colour, are common, likewise stones to which the 'bases' of a *Balanus* are attached." He also cites Professor A. Newton and Mr. Hudleston as having found in the Varanger Fjord, not far from Vadsö, the bones of a whale, about 50 feet above high-water mark and 200 yards from the shore, which they deemed to have been stranded in old times." Colonel Feilden himself found on Vardö a marine sand deposit, some 40 to 50 feet above sea-level, in which he collected bones of *Halichœrus gryphus* (grey seal), *Phoca hispida*

[1] Ann. & Mag. Nat. Hist., ut suprà, p. 483.
[2] In Watercourse Bay, Grinnell Land, lat. 81° 44′ N.
[3] Quart. Journ. Geol. Soc., vol. xxxiv (1878), p. 556; Nares, ut suprà, p. 327.
[4] A number of instances from different parts of Scandinavia are cited by J. F. Campbell: "Frost and Fire," vol. i, p. 351.

(the ringed seal), and *Gadus morrhua*, with *Buccinum undatum*, *Modiola modiolus*, and *Pecten Islandicus*.

C. *The Kola Peninsula.*—The coast scenery is bold, but the hills inland seem planed down to a general level, the highest summits apparently rising to 500 or 600 feet. In bays and indentations immense raised beaches are noticeable, especially to the westward of Cape Cherni. A "remarkable and prevailing feature of the country is the vast number of erratic blocks spread over it in every direction."[1] These are of local origin, so that they cannot be the leavings of a circumpolar ice-sheet. Mr. F. G. Jackson is quoted as having observed raised beaches and coniferous wood, proving an elevation of something like 250 feet eastward of the estuary of the Petsora river.

D. *Kolguev Island.*—This lies about 50 miles away from the mainland of Europe, and 130 miles south-west of the nearest part of Novaya Zemlya; the depth of the sea in the one case not being greater than 30 fathoms, in the other probably 70 fathoms. It is oval in shape, and about the area of Norfolk, being apparently "a vast accumulation of glacio-marine beds."[2] The highest ground in the island is about 250 feet above sea-level, but the shore-line is often formed by low cliffs of a bluish-grey clay, not exceeding 60 to 70 feet in height; the island becomes flatter towards the south-west, and there a considerable district is overlain by sea-sand. The ground is furrowed by ravines, often rather short, which have been cut by rivulets and afford sections of the clay, their beds being strewn with stones and boulders derived from it. These vary in form from angular to rounded and polished, a large proportion being ice-scratched. "The medley of rocks represented is remarkable—granites and gneisses, limestones Silurian and Carboniferous, grits, quartzites, porphyries, etc.; they vary in size from walnuts to large dimensions.[3] They do not exhibit the slightest tendency to form lines of horizontal deposit in the clay," the matrix of which shows no signs of stratification or of disturbance. "My opinion is, that all have been dropped from floating ice intermittently and tranquilly . . . . Not unfrequently the clays pass into horizons of a more sandy composition, although so insensibly that the alteration is evidenced more by the change in colour than by any definite lines of demarcation." Deposit has been continuous; there are no beds of gravel traversing the clays as in Grinnell Land and at Smith Sound, where the horizons of clay, sand, and gravel are often distinctly defined. No drift-wood occurs; the remains of mollusca are not common, and for the most part fragmentary. The following were obtained: *Natica affinis*, fragments of gasteropod (*Sipho* ? sp.), *Saxicava arctica*, *Astarte compressa* and *borealis*, *Mya arenaria*, and fragments of *Mya*, sp. The clay, Colonel Feilden remarks, is not

[1] Some peculiarities in their distribution are mentioned, but on these it is needless to dwell.

[2] No rock of greater solidity was anywhere seen *in situ*.

[3] One, of a hard yellow sandstone, polished, scored, and striated, measured 15 × 9 × 6 feet.

similar to the "firm, tough, tenacious, strong" material called 'till' in Scotland, but rather resembles the Boulder-clays of the Yorkshire coast and the Chalky Boulder-clay of Norfolk.[1] He regards it as a glacio-marine deposit, not that of an ice-sheet, and "formed under conditions similar to those which at present exist in Barents Sea."

E. *Waigats Island.*—This is about sixty miles in length and twenty in breadth. Its ridges probably in no case exceed 300 feet, and, as a rule, are much lower. Specimens collected *in situ* represent: limestones, sometimes dolomitic; argillite and green schistose rocks, perhaps compact basic igneous rocks modified by crushing. The first-named bear a general resemblance to some of the Carboniferous limestones of Britain, and contain foraminifera which make their identification highly probable.[2] The valleys and troughs are filled by clay and sand, mostly the former, which is of the same character as that now forming under water in the bays and around its shores. These deposits at Cape Matinsela exceed 100 feet in thickness. They were followed for several miles on both sides of the Cape, forming low hills 50 to 100 feet in height along the coast (the result of denudation). Where examined, they showed no definite signs of stratification, and contained large ice-polished boulders;[3] in fact, they resemble the Kolguev clay. No shells of marine mollusca were found in them, but samples submitted to Mr. Joseph Wright contained foraminifera and sponge spicules, the latter in abundance. "These Matinsela beds pass by almost imperceptible gradations into the grey marine clay, with shells of recent mollusca, that now forms the surface of the present tundra land." This is rich in foraminifera, and is the most widely dispersed deposit, for it is spread over the tundra land of Arctic Russia, over Waigats, and over Novaya Zemlya up to an altitude of at least 500 feet, always forming the surface layer. "Precisely the same clay comes up in the dredge or on the flukes of the anchor in the Straits of Yugov, in Dolga Bay, and other anchorages on the coasts of Waigats." Colonel Feilden also calls attention to the effects of floating ice in smoothing, polishing, and scoring projecting rocks, and in thrusting up mounds of gravel "many feet beyond tide line, both here[4] and in Novaya Zemlya."[5]

F. *Novaya Zemlya.*—Colonel Feilden landed at places on the west coast of the southern island, on the east coast of the northern one as far as Pachtussoff Island, and in Matyushin Shar, the dividing strait. On Gooseland and the islands in Kostin Shar, deposits of Boulder-clay lie in their undulations and hollows, a depth of 20 feet being shown. The clay was of the same colour as the rock on

[1] See "Beyond Petsora," pp. 238, 239, for a note on the composition of the Kolguev deposits.

[2] Ut suprà, pp. 279, 280. Silurian and possibly Lower Devonian rocks occur at Cape Greben, at the south end of the island; see E. T. Newton, pp. 287–294.

[3] The following specimens were taken from erratics: granite (three varieties), felspathic grit (three varieties), limestone (two varieties, one shown by fossils to be Carboniferous or possibly Devonian in age); fragment of a guard of a belemnite, probably Jurassic; lignite, probably not earlier than Tertiary age.

[4] Ut suprà, pp. 270, 271.

[5] Ut suprà, pp. 249–254.

which it rests; the included stones were angular fragments of that rock; none were rounded or ice-scratched. In many places it is "full of shells of marine mollusca, *Saxicava arctica* predominating, though I found other species common enough. In some localities one might gather these shells by the bushel, few of them broken, never triturated, and in some cases the two valves are in contact." Raised beaches were observed in all the above-named parts of Novaya Zemlya, but more particular descriptions are given of those around Beluga Bay in the Matyushin Shar, and on the eastern outlet of that strait. The beaches, four or five in number, rise one above the other in a series of terraces with broad level surfaces, separated by slopes of about 100 feet in height, the most elevated being about 500 feet above present sea-level. Sections have been cut in them by streams, which disclosed accumulations of shells, chiefly *Saxicava arctica* and *Astarte borealis*. "The 100-foot terrace has a common origin with a series of outliers in the shape of rounded hills and eminences, now detached to some distance from the line of terrace and bordering the present sea-shore. A section in one showed it to be composed of the same materials, viz., rounded stones, sand, and gravel." At elevations up to 1,000 feet on the hillsides bounding the Matyushin Shar, Colonel Feilden came across "patches of rounded waterworn pebbles, that seemed to be remnants of still loftier sea beaches," but they were so overwhelmed by the screes falling from the upper parts of the mountains, that they could not be traced very far in a horizontal direction.

Mr. Joseph Wright, F.G.S., has written a most valuable report on the foraminifera from these deposits in Novaya Zemlya and Waigats Island. The samples of clay, twenty-six in number, twelve from various parts of the Cape Matinsela terraces, averaged about $2\frac{1}{2}$ oz. from each locality. It may suffice to give a brief abstract of the general results, referring the reader to the report[1] for particulars. In Waigats Island, clay or mud with shells at 50 feet elevation from four localities yielded foraminifera: one, two genera; another, three; a third, three genera; individuals in all cases being rare; but the fourth locality afforded 8 genera and 14 species, four of these being common, besides frequent sponge spicules.[2] Clay with shells, 100 feet elevation, gave 6 genera and 9 species, only one of them common. Eleven small samples from the terraces and deposits of Cape Matinsela, which rise to the height of 150 feet, furnished only two foraminifera, of the same number of genera, but sponge spicules were very common. On the Russian mainland, near Habarova, clay with shells, forming the surface soil of the tundra, at 25 feet elevation, contained 9 genera and 13 species, six of them common, besides frequent sponge spicules and very numerous ostracods. From the same neighbourhood, clay with shells at 50 feet elevation afforded 3 genera and 4 species. The specimens from Matyushin Shar, Novaya Zemlya, gave the following results:—East side of Beluga Bay, 100-foot terrace, 3 genera and

[1] Ut suprà, pp. 297–310.

[2] In the remainder of this summary, the omission of any statement means "rare."

species; two openings in a terrace, composed of a stiff yellow clay, at about the same elevation, afforded in one case one genus, in the other two genera. Clay and sand from a terrace 130 feet high contained 7 genera, 13 species, with one specimen of an ostracod and a few sponge spicules. Shell bed, belonging to the 300 feet mud beds of Beluga Bay, but three miles inland, contained a great profusion of foraminifera, many of them being large in size and in fine preservation. They represented 15 genera and 34 species. A very few echinus spines also occurred. Clay with shells from the 500-foot terrace contained 10 genera and 24 species, twelve being common, and half of these estimated as making up between them 840 specimens, all the rest together amounting to 75. Ostracods were rare, echinus spines more abundant, the specimens being large. The last sample comes from Nameless Bay, west coast of Novaya Zemlya proper, 250 feet elevation. In it foraminifera were abundant, numbering 8 genera, 13 species. To sum up in Mr. Wright's words:—"Foraminifera occurred in all . . . . ; in nine of them they were very rare or rare, in one of them they were plentiful, in the other five they were in great profusion. Sponge spicules in a somewhat fragmentary state were found in nearly all of them, and ostracods and spines of echinoderms in several.[1] . . . . Nearly all the stones which occurred in the clays were more or less rounded, and presented the appearance of having been worn by marine action; in a few cases they were smoothed and striated, as if by the action of ice. The conditions under which these clays were deposited must have been very varied, as in some of them foraminifera are abundant, whilst in others they are extremely rare. When they are abundant it may be inferred that the clays were laid down in quiet water or in sheltered bays, and not subjected to the rapid running of currents or tides; and when they are few it may be presumed that the reverse was the case."

In this summary I have restricted myself to Colonel Feilden's observations of facts, excluding inferences, except in one or two cases where they express the impression produced by the general aspect of a deposit, which, from an experienced observer, has almost an equal value. I may, however, add that he saw no reason for attributing any of the deposits on the low islands or the mainland tundra to the action of a great polar ice-sheet. As Novaya Zemlya, at least in the centre and north, is mountainous, the summits rising to not less than 4,000 feet above sea-level, it must have always been a nucleus of outflowing ice,[2] so that the materials of its terraces cannot have made a subglacial journey uphill from the bed of the sea. Such an hypothesis would be more than ever improbable in the narrow strait of Matyushin Shar.

[1] A few samples of the mud of the sea-bed were collected and examined. They were found to correspond generally with the above-named.

[2] The interior of Lütke Land at the present day is covered with ice which probably forms a single sheet, "similar to that enveloping Greenland, but on a smaller scale."—Pearson in "Beyond Petsora," p. 150.

II.—The Order of Consolidation of the Mineral Constituents of Igneous Rocks.

By Professor W. J. Sollas, LL.D., D.Sc, F.R.S., V.P.G.S.

THE order in which the various mineral constituents of an igneous rock may crystallize out from an igneous magma offers to the petrologist a problem of great difficulty and complexity. It is generally admitted that the order of consolidation is not wholly determined by the order of the fusion-points of the constituents, and with this admission the fusion-points have come to be consistently disregarded, as though they might safely be left out of account. That this is not the case has of late become strongly impressed upon me, especially after a consideration of the important data obtained by Mr. Ralph Cusack, B.A.,[1] who, by means of Professor Joly's meldometer, has determined the precise temperature of fusion of most of the rock-forming minerals.

In the following table I have arranged the more important of the minerals in question in the order of their fusion-points, as determined by Mr. Cusack.

Fusion Point.

Zircon	infusible.	Augite, Hornblende	1188° to 1200°.
Quartz	1425°.		
Olivine	1363° to 1378°, softens at 1342° C.	Albite	1172°.
		Microcline	1169°.
Leucite	1298°.	Adularia	1164° to 1168°.
Enstatite	1295°.	Sphene	1127° to 1142°.
Labradorite	1223° to 1235°.	Sodalite	1127° to 1133°.
Apatite	1221° to 1227°.	Nepheline	1069° to 1078°.

If for the moment we disregard quartz, there is seen to be on the whole a general correspondence between the order of fusion-points and the order of consolidation; but this is by no means constant, and is subject to several important exceptions. Zircon is well known as a very early product of most magmas, and this accords with the very high temperature of its fusion-point. Apatite and sphene, however, often appear earlier than their fusion-point would indicate. Olivine, with the highest fusion-point among the silicates, also usually crystallizes out at an early stage, though not always before leucite, of which the fusion-point is lower by 100° C. It is true that petrographers are not wholly agreed as to the relation in which leucite stands to olivine in this respect, but the balance of evidence appears to show that both may crystallize out together, or that leucite may actually precede olivine. It is of importance to notice in connection with this that the leucite and olivine on which Mr. Cusack experimented were both derived from Vesuvian rocks; had this not been the case the argument might have been maintained that the particular species of these minerals which enter into the composition of the lavas of Vesuvius may differ in chemical composition from those of which the fusion-points have been determined, and therefore may differ also in fusion-point. Enstatite

[1] Proc. Roy. Irish Acad., ser. III, vol. iv, p. 411 (1897).

occupies a position in the order of consolidation corresponding with that of the order of fusion. Similarly labradorite, with a fusion-point between enstatite and augite, usually follows enstatite and precedes augite in order of consolidation. That it is as a rule extricated from the magma before augite, is illustrated by the frequent occurrence of ophitic structure in dolerite. Albite fuses at a lower temperature than augito, and usually crystallizes after it.

It would be natural to suppose that the species of felspar intermediate with labradorite and albite in composition would be also intermediate as regards their fusion-points, and if so, the irregularities which distinguish the succession of plagioclase and pyroxene might find an explanation in the fact that the fusion-point of augite stands almost midway between that of albite and labradorite.

The potash felspars have a lower fusion-point than albite, and, as is well known, generally succeed it in order of consolidation.

The order of fusion of orthoclase, sodalite, and nepheline is repeated in the order of consolidation of these minerals in nepheline basanite; but an anomaly is presented in the case of some examples of æleolite syenite, in which nepheline and leucite precede orthoclase in order of consolidation. To this allusion will be made later. The most important exception to the rule that the order of fusion corresponds to the order of consolidation is afforded by quartz, which with a fusion-point of 1425° crystallizes later than orthoclase with a fusion-point of only 1164°–1168°. An explanation, however, may be found for this, and if admitted may throw light on some other inversions of the rule. The statement of Zirkel will, I think, be generally conceded. "A mineral may crystallise out from the molten silicate-magma at the most various temperatures—naturally, however, never *above* its own fusion point."[1]

The fact to be explained therefore in the case before us is the consolidation of quartz at a temperature below the fusion-point of orthoclase, i.e. at least 260° below its own fusion-point. In the report of the meeting of the British Association for 1882 will be found an account of some experiments made by Mr. Hunter for a committee of the Association (p. 239). Some chemically pure silica, "prepared by precipitation from sodium silicate with hydrochloric acid, evaporation to dryness, thorough washing, and subsequent ignition, was placed in a sealed iron-tube and heated with water to 300° C. for two days. At the conclusion of the experiment the impalpable powder of silica was found to have caked together into a white opaque granular mass." It consisted of anhydrous silica, as was proved by chemical investigation. The results of an examination which I made under the microscope were as follows:—"It was found to have passed into a state of glass. The glass is transparent and colourless and hard enough to scratch ordinary window glass; it is, however, filled with innumerable oval and tubular cavities, so as to resemble pumice, and it is to them that it owes its whiteness and opacity when seen by the unassisted eye."

[1] Zirkel: "Lehrbuch der Petrographie," 1893, vol. i, p. 728.

These facts prove that in the presence of water anhydrous silica is rendered fluid at a temperature so low as 300° C. Whether or not under these circumstances water enters into its constitution is not known, but after consolidation it consists of truly anhydrous silica ($Si O_2$), though in a state of glass.

That water is associated with the quartz of granite and other plutonic rocks is well known, for this mineral is the chief home of fluid cavities, which recall those described in the glassy silica of Mr. Hunter's experiment, though in the quartz of igneous rocks they are relatively far less abundant. The old explanation of the late consolidation of quartz, which rested on the suggestion that solution played as important a part as fusion in contributing to the fluidity of igneous magmas, is to a certain extent thus supported by experimental evidence. The mistake of the older school of petrologists lay in attributing too subordinate a rôle to fusion, which we now know plays the chief part; but in making this nearer approach to the truth there seems to me a possibility that we may have fallen into the other extreme of neglecting to take into consideration the influence of water, which may have played an important though minor part. If this can be shown to be the case we shall be provided with an explanation of anomalies, which hitherto have resisted all analysis. To return to the case of æleolite syenite, examples are known of this rock in which the several minerals have crystallized out in the order of their fusion-points; on the other hand, examples can as certainly be cited in which this order has been reversed, so that sodalite has followed æleolite; æleolite, orthoclase; and orthoclase, plagioclase felspar.

No satisfactory explanation has yet been offered of this and numerous similar cases, but if the order which follows that of the fusion-points be looked upon as the normal, our task will be simplified, since it will be reduced to finding special explanations of particular cases. It is possible that these explanations will not always be of the same nature, and I do not propose now to enter into a detailed study of this question, but I may perhaps be allowed to point out that several hypotheses would appear to be excluded. The influence of the chemical constitution of the magma is sometimes alluded to in general terms, though rarely analyzed in detail. That it must be very limited in its application is suggested by the experiment of Fouqué and Levy, in which they showed that in the case of two fused mixtures, one consisting of equal parts of anorthite and augite and the other with twice as much anorthite as augite, the order of consolidation was the same for both, the anorthite, as might have been expected from its higher fusion-point, crystallizing out in both cases before the augite. Change of pressure is sometimes invoked, and considering the very large reduction in volume which accompanies the consolidation of fused silicates this might naturally be supposed to have some effect. If, however, such were the case some law should be found distinguishing the order of consolidation of minerals in a plutonic magma from that in a volcanic flow; but hitherto no constant difference has been discovered. The effects of 'mixture' have also been appealed to, and it is possible that in some cases the minerals which consolidate out of turn may be 'xenocrysts,' derived from some ingested foreign rock. But as a general explanation this admittedly cannot be maintained.

No doubt difficulties will also be found to attend any attempt to explain anomalies by the presence of water, but it appears to me that the attempt is worth suggesting. The problem as it now presents itself is to show why certain minerals retain the fluid state at a temperature below, often far below, that of the fusion-point: thus, in the case of some examples of æleolite syenite the question is why plagioclase felspar crystallized out at a lower temperature than orthoclase, orthoclase at a lower temperature than sodalite, and sodalite than æleolite. Can this be due to the effects of included water? To answer this question definitely might not be difficult by means of experiment. The determination of the fusion-points having been accomplished, the next step that awaits us is the determination of the temperatures at which the minerals in question crystallize from solution. An investigation in this direction could not fail to give interesting results.

In conclusion, it may be pointed out that the results definitely obtained in the case of quartz indicate that the temperature of consolidation of granite might naturally be expected to be below that of dolerite. The quartz of granite has consolidated at a temperature below that of orthoclase and *à fortiori* below that of plagioclase and pyroxene. The temperatures of fusion of these two rocks, as observed in the laboratory, stand in inverse order to the temperatures at which they consolidate in nature, owing to the fact that in the case of fusion by artificial means water plays no part.

III.—A Word on Geological Hypothesis.

By Professor H. Macaulay Posnett, LL.D., etc.

"SCIENTIFIC men," said Professor Thomas H. Huxley,[1] "get an awkward habit—no, I won't call it that, for it is a valuable habit—of believing nothing unless there is evidence for it; and they have a way of looking upon belief which is not based upon evidence, not only as illogical, but as immoral."

Quite so. There is no higher conception of truth—the most exact knowledge attainable at the given time and place—no nobler practice of truthfulness—the unflinching utterance of the most exact knowledge we possess—than our best men of science constantly display. And it is just because they are the world's highest guardians of truth, the world's noblest exponents of truthfulness, that our men of science are bound by the laws of their order to set the study of facts before the acceptance or retention of any theory, to expose in the clearest light any weak points in reasoning that on the whole receives their approval, to boldly dwell upon the

[1] "Science and Hebrew Tradition," p. 65.

hypothetical character of every hypothesis they make, and never to leave hypothesis or assumption to the tardy discovery of those who study their works.

There may indeed have been a time when theological dogmatism was strong enough to provoke a sort of scientific dogmatism by way of counterpoise. But neither theology nor any other power in the sphere of popular thought can now restrict the freedom of scientific discovery or teaching in the British Empire. Science nowadays can well afford to point out her own shortcomings, and can do so better than any of her foes. To some of these shortcomings it is my present purpose to refer.

1. Our geological textbooks sometimes show too much eagerness to impart the results of discovery or hypothesis without any adequate statement of the facts or the reasoning upon which these discoveries and hypotheses rest. Evidences are always the primary, never the secondary, material of science as a body of more or less probable truths. Evidences, therefore, are very improperly handled when they are relegated to a secondary place. If, for example, a geological writer accepts the theory of the origin of hot springs as due to the escape of subterraneous gases, it is his duty not merely to state the theory but to add the evidences for and against its truth. We may be told that makers of textbooks have not sufficient space for the statement of evidences, but the answer is plain: either do not put forward the theory at all, or give as fully as possible what must always be of higher value—the facts upon which the theory rests.

2. Many of our scientific manuals suggest, without positively claiming, a degree of foreknowledge that is not really as yet within our reach. An experience in New Zealand will illustrate the sort of claim I have in mind. Shortly after the Tarawera eruption of June, 1886, some professors of science proceeded to the Rotorua district and there held a Maori meeting. The Maoris were told that, the lines of volcanic energy having such and such directions, they need entertain no fears of a recurrence of the late disaster—"they might plant their kumeras (sweet potatoes) in peace." Hereupon an old Maori chief, with the usual sagacity of his race, rose and remarked, "If the volcano-doctors know so much about what is to be, what a pity it was they did not come and forewarn us of the eruption." Needless to say, the 'volcano-doctors' had no reply; and in our civilized views of volcanic forces it would be far better to own ignorance than to even hint a claim to foresight where it does not as yet exist. It is worth adding that, not very far from the Rotorua district, in the now famous goldfields of the Thames, an eminent but dogmatic and hasty geologist many years ago prophesied that no gold could there ever be found.

3. The points at which geological study touches other sciences and needs their aid are too frequently obscured, understated, or even completely omitted in some geological textbooks. I have now before me a textbook written by a very able geologist. I open it at the chapter entitled "The Earliest Conditions of the Globe." Here I find a lucid statement of the Nebular Hypothesis — but

unaccompanied by any detail of the grounds upon which that hypothesis rests — and of the accepted periods of the geological record; but not a word about the astronomer's theory of the diminishing velocity of the earth's rotation produced by tidal friction, not a word on the important bearing of this theory on the primary geological problem, the age of the earth.

I choose this example—the time problem—because there are other sciences dependent for the settlement of this problem on the joint labours of geologist, astronomer, and physicist, and my example therefore illustrates the paramount importance of such joint study. "The biologist," said Professor Huxley,[1] "knows nothing whatever of the amount of time which may be required for the process of evolution. . . . . A biologist has no means of arriving at any conclusion as to the amount of time which may be needed for a certain quantity of organic change. He takes his time from the geologist."

This interdependence of scientific studies must be fully recognized by the geologist, both for his own sake and for the sake of others. He cannot afford to ignore any knowledge possessed by any other science if that knowledge has an important bearing on his own pursuits. Always he must be ready to learn from astronomer, physicist, chemist; and though to the last of these three he has been generally willing to acknowledge his many obligations — obligations likely to be increased in the near future—he has but too often displayed a desire to avoid the physical and astronomical aspects of geological science. If I am told that I am asking too much from the geologist—making him a kind of universal genius like the ideal poet described in Johnson's "Rasselas"— I reply, "Nothing of the sort; I am merely insisting upon the absolute necessity that any first-rate geological discoverer or teacher shall keep steadily in view the points at which other sciences may increase his light, and never rest satisfied with either his discoveries or his teaching until he has assured himself that he has borrowed whatever light they can at present afford him."

4. Sir Archibald Geikie[2] reminds us that the various processes of geological changes occurring at the present day "gain enormously in interest for the student of nature when he reflects that in watching the geological operations of the present day he is brought face to face with the same instruments whereby the very framework of the continents has been piled up and sculptured into the present outlines of mountain, valley, and plain."

Quite so. The hypothesis of the unchanging laws of nature may not only be regarded as the geological postulate, but as the postulate of all science as at present conceived. We are fully justified, too, in assuming, e.g., that the facts summarized by what we call the law of gravitation have been as we know them for a vast period of time. But we can lose nothing by candidly admitting the hypothetical character of even this great postulate of all science, and

[1] "Science and Hebrew Tradition," pp. 134, 135.
[2] Class-Book of Geology, p. 299.

the possibility that new knowledge may ultimately modify the principle as at present held. To keep an open door for all increase of knowledge cannot but aid the cause of scientific progress. Only the survival of dogmatism beyond the conditions that gave it birth and the need of dogmatic teaching in our schools and colleges can account for the continued readiness of some men of science to repeat the old watchword, "It cannot be conceived."

Let me illustrate my meaning by an anecdote. At Takapuna, near Auckland, is a fresh-water lake, nearly at sea-level, regarded by popular theory as the crater of an extinct volcano. Here, one day, discussing the origin of the lake with some Auckland University students, I was asked, "Has the earth's water-envelope been greater or less in past ages? Are we justified in assuming the relative conditions of land and water to have been in the past as they are now? May not both the igneous and the aqueous forces observed by our geologists differ both in degree and kind from the similar forces of a primitive age?" And led on by these questions we soon ventured upon all sorts of heterodoxy, drew imaginary pictures of an evolution of water, of air, of combustion, until we at last came to a conclusion that nature had intended us for the founders of a new science which was to be named "The biology of the elements ancient and modern."

Twelve years have elapsed since our ideal conversation, and physicists need not be reminded of certain signs now visible on the horizon of knowledge which seem to dimly foreshadow the partial realization of our Takapuna dreams. But it is not my present purpose to discuss new physical hypotheses; it is merely to say what I then said to our Auckland students: "There is no finality in any hypothesis or law of science, and for this reason, if for no other, it is the duty of every man of science to plainly state every assumption on which his science rests, and to put these statements not in out-of-the-way corners, but in the very front of his scientific teaching or writing." How much the advance of discovery could be aided by the student's early acquaintance with the hypothetical and provisional character of his principles—by the constant reminder of an open door for new observations and new inferences—none but those who hold exaggerated views of the need of dogmatic teaching for the young will fail to perceive.

The dogmatism of some geological textbooks deserves the more severe censure because there are no textbooks of science more eagerly read by that omnivorous person, 'the general reader'—none, consequently, more likely, if they contain loose thinking, to diffuse unscientific thought under the name of science. For your 'general reader,' be it noted, is almost as intolerant of hypothesis, plainly stated as such, as an ancient Hebrew would have been if his rulers had boldly told him, "These useful changes in your barbarous customs we assume to be the will of a divine Lawgiver, because we know that you will not accept the improvement unless it comes to you through the door of this fiction." But rational faith in hypothesis—i.e. faith ready at any moment to accept new knowledge and to modify the hypothesis accordingly—is just the essential quality of a truly scientific mind, just the quality that the 'general reader,' with his eternal haste for generalization and his eternal zeal for dogma, can never understand.

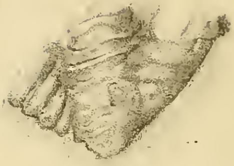
> "For such the story of the race—
> Chance oft has found what System lost;
> For System claims too high a place,
> And oft too high a price has cost."

5. There are other directions in which the candid statement of hypotheses can only minister to the real strength and interest of geological science. The various classifications of rocks, for example, lose none of their value by being openly reduced to their true level of tentative work, instead of aping a 'natural' origin. Botanical and zoological systems of classification can lose nothing by the same straightforwardness. But there is another aspect in which the deficiencies of our geological textbooks disclose themselves.

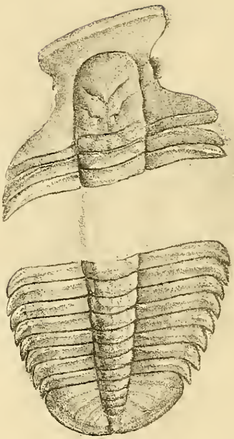
The historical study of geology may not at first sight appear a fruitful field for research. A science comparatively young seems to possess as yet but little history, though this fact should by no means excuse the total absence of any sketch of such history in almost all textbooks of geology. But though geology, under its own name and working by scientific methods, is of such recent origin, geological thinking of some sort is found all over the world and in all the literatures of the world from the earliest times. When, for example, Hebrews described their God as "moulding mountains" or "cleaving the earth with rivers," as "putting forth his hand upon the flint" or "breaking down the rocks," it is clear that the geologists' earth-sculpture was being observed, though very differently explained, by these primitive thinkers.

If it be said that such primitive thinking is not nowadays worth our study, I answer that even our wisest men of science are liable to gross blunders if they neglect such historical work. Professor Huxley, for example, in his "Physiography," not long ago confused the modern theory of atmospheric circulation with the ancient thought of that Hebrew writer who speaks of the rivers "returning to the place from whence they come." The author of "Ecclesiastes," as I have elsewhere proved, was referring to an entirely different kind of water-circulation by which ancient Hebrew thought accounted for the origin of springs as an outlet of their "waters beneath the earth," waters upon which they conceived their earth to rest. If it were for no other purpose than to guard ourselves against a wild confusion of modern with ancient thinking, we must study primitive geology as expressed or implied in the writings of ancient times. A fascinating study, this primitive geology, but needing not only patient research but also large linguistic knowledge. Yet I see no reason why our handbooks of the future should not contain both a brief history of geology as a science and an outline of the beginnings of thought on geological subjects, alike in ancient literatures and in uncivilized peoples now living.

2

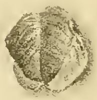


5



1 × 1½

3 × 2



4 × 2

7

6 × 1½

G. M. Woodward del. et lith.

West, Newman imp.

Salter's Undescribed Trilobites (*Part 1.*)

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

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

(PLATE XII.)

IN the "Catalogue of the Cambrian and Silurian Fossils in the Woodwardian Museum," compiled by J. W. Salter, F.G.S., and published in 1873, many new specific names occur, in some cases accompanied by a few words of description, but frequently by none at all. Although several of these species have been described by subsequent writers, there yet remains a large number which are only known by their names, some of which have found their way into geological literature. It therefore seemed desirable to rescue these forms from their present unstable position, and to issue a detailed account of their characters to avoid future confusion. The original specimens are in the Woodwardian Museum, and though in many instances they are in a poor state of preservation, rendering the precise and minute diagnosis of the species difficult, yet the subsequent acquisition of further specimens of the same forms has enabled me to make the descriptions more complete.

TRILOBITA.

Olenus (s.g. Parabolinella) Planti, Salter. (Pl. XII, Fig. 1.)

1873. *Olenus Plantii*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 11 (*a* 272).
1877. *Olenus Plantii*, H. Woodward: Cat. Brit. Foss. Crust., p. 47.
1891. *Olenus Planti*, Woods: Cat. Type Foss. Woodw. Mus., p. 149.

Salter described this species (loc. cit. supra) as follows:—"An oval species, much flattened and expanded. Mr. J. Plant, who discovered it, has distributed casts and photographs of this fine and well-marked fossil." In addition to the almost complete specimen labelled *a*, 272, from the Upper Lingula Flags of Moel Gron, Upper Mawddach, there are two casts and a photograph of the same, and two casts and a photograph also of an imperfect head-shield, showing the free cheek attached, from the same beds at Craig y Dinas. These were presented to the Woodwardian Museum by Mr. Plant. On the specimen *a*, 272 the name "*Conocoryphe Plantii*" is written in white paint, but by whom or at what date is uncertain. From this material the following diagnosis of the species is possible:—

Diagnosis.—General shape oval. Head-shield almost semicircular in outline, the curve being slightly flattened in front; about twice as broad as long. Genal angles spined. Glabella subquadrate, nearly as broad as long, slightly narrowing anteriorly; about three-fourths the total length of the head-shield; gently convex and raised above cheeks, from which it is sharply marked off by straight regular axal furrows which converge a little towards the front end round which they curve and meet, defining it from the flattened pre-glabellar common portion of the fixed cheeks. Surface of glabella marked with two distinct pairs of lateral furrows. The furrows of the posterior pair run obliquely backwards with rather an irregular wavy course at angles of about 45° to the axal furrows, and unite in the middle at a distance from the neck-furrow equal to the width of the occipital ring, thus forming a broad U-shaped groove across the glabella. The furrows of the anterior pair have a similar wavy backward course parallel to the posterior pair, but they meet in the middle at an acute angle in a broad V instead of U at a point situated at just half the total length of the glabella. The outer ends of both pairs of furrows, particularly of the posterior pair, curve backwards just before reaching the axal furrows, and diminish considerably in strength.

Frontal lobe of glabella subtriangular in shape and large, being just half the length of the glabella. Neck-furrow nearly straight, marking off a rather broad occipital ring of regular width ornamented with a small median tubercle, and divided obscurely into three portions by two faint oblique arched furrows arising from the posterior angles and meeting in the middle on the neck-furrow. Eye rather small, equal in length to the width of the middle glabellar lobe; situated just opposite or a little in front of this lobe, a short distance from the axal furrow and near the front end of the glabella, with which it is connected by a weak 'eye-line.'

Facial sutures cut the front margin of the head-shield at angles of rather more than 60°, and at a distance apart of about one and a half times the width of the glabella. From the point of section each suture takes a backward and inward course in nearly a straight line to the eye, round the projecting lobe of which it sweeps; thence it bends obliquely backwards in a weak outward curve to cut the posterior margin of the head-shield at an angle of about 45° and at a distance from the axal furrow nearly equal to the basal width of the glabella and at about two-thirds the distance to the genal angle.

Border present round the anterior edge of the head-shield, of moderate width and rounded, marked off by a distinct marginal furrow. Neck-ring behind the fixed cheeks about equal in width to this anterior border, but only half the width of the occipital ring.

Free cheeks (shown in the specimen from Craig y Dinas attached to a portion of the middle-shield) roughly triangular in shape, and furnished with a short straight genal spine less than half the length of the head-shield and directed slightly outwards.

Thorax, incompletely known. Only ten segments are preserved in our specimen from Moel Gron, two of these being attached to the head-shield and separated from the rest of the body by a space of 7 mm. in length, which is equal to about five segments. It is clear from an examination of the specimen that this space was originally occupied by segments of the body which are now missing, for the axis of the second segment attached to the head is nearly one and a half times as wide as the axis of the first segment of the detached posterior portion, and the two portions did not therefore fit together. There does not seem to have been any movement or separation of the two portions of the specimen, for if the axial furrows of the anterior part be continued in their course backwards across the gap they are found to exactly meet those of the posterior part and to preserve the regular tapering of the axis. We may therefore conclude that the thorax was composed of the ten segments which we now see *plus* five segments to fill up the existing gap.

Axis of thorax gently convex, unornamented, and gradually decreasing in width posteriorly. Pleural portions on each side about one and a half times as wide as the axis, but showing posteriorly a slight increase in relative width. Pleuræ straight with parallel margins as far as the distant fulcrum, at which they bend backwards to end in a short broad falcate free point. Each pleura is marked by a strong straight continuous diagonal furrow, curving round at the fulcrum to end at the point.

Pygidium transverse in shape, broadly semicircular, with a regular rounded margin, and with a distinct marginal furrow marking off a narrow border. Axis convex, bluntly pointed, very slightly tapering, composed of four rings; length about two-thirds that of the pygidium, connected with the posterior edge of pygidium by a short, sharply pointed, unsegmented, and less elevated appendix, which interrupts the continuity of the border. On the lateral portions of the pygidium four pairs of pleuræ with their diagonal furrows are present, and of these the anterior pair has the furrows the most strongly marked.

Measurements.

	mm.
Length of trilobite	37·0
Length of head-shield	12·0
Width (estimated) of head-shield	25·0
Width of middle-shield at base	19·0
Width of fixed cheek at base	6·0
Length of glabella	8·5
Width of ditto at base	7·0
Length of pygidium	5·0
Width of ditto	12·5

Remarks.—The subgenus of *Olenus* to which this species appears to belong is that named *Parabolinella* by Brögger.[1] The subquadrate glabella not reaching the front margin, the wide preglabellar portion of the head-shield, the rounded margin, the course of the facial suture, the position and relative size of the eyes, the characters of the occipital ring, the genal spines of the free cheeks, the pygidium with regular bordered edge, not furnished with spines, with a 3–4 jointed axis, and lateral lobes marked with distinct furrows, are the most important features in common between *O. Planti* and the subgenus *Parabolinella* as defined by Brögger. The presence of only two instead of three lateral furrows on the glabella is a point of difference, but perhaps not of much importance in this case, as we see on examining Brögger's figure of *P. rugosa* (loc. cit., tab. iii, f. 3) that an indefinite number of furrows seem to be present in that species, and their irregular character and tendency to unite in the middle also reminds us of *O. Planti*. In the case of the pleuræ their shape and straight diagonal furrow resemble more closely those of *Parabolina spinulosa*, but the short

[1] Die Silur. Etag., 2 and 3 (1882), p. 102, tab. iii, f. 2*a*, *b*, 3, and 4*a*.

falcate instead of long spinose ends distinguish them. Moreover, the characters of the pygidium and head-shield completely separate *O. Planti* from the subgenus *Parabolina.*

The only other British forms calling for any comparison are the so-called '*Conocoryphe*' *Williamsoni* (Belt),[1] the species of *Parabolinella* described by Miss Crosfield and Miss Skeat,[2] and *Olenus triarthrus* (Callaway) from the Shineton Shales. Belt's species probably belongs to *Parabolinella*, the only important point of difference being the presence of two instead of three pairs of glabellar furrows. The pygidium of '*Conocoryphe*' *Williamsoni* seems to be almost identical with that of *O. Planti,* and the pleuræ are very similar, but the characters of the glabella and head-shield are sufficient to warrant their specific separation.

The species of *Parabolinella* from the Tremadoc of Nant y Glasdwr, described by Miss Crosfield and Miss Skeat (loc. cit.), is only known by an imperfect head-shield. It differs from *O. Planti* by the greater number of glabellar furrows, by the larger eyes, by the course of the facial sutures, and by the narrower fixed cheeks.

The only other British species of *Parabolinella* is *P.* [*Olenus*] *triarthrus* (Callaway),[3] from the Shineton Shales, and it differs from *P. Planti* by its broader glabella, by the union of the posterior and anterior pairs of glabellar furrows, by the tubercles on the axial rings of the thorax, and by the characters of the pygidium. But it is evidently a closely allied species.

Olenus (Ctenopyge?) expansus, Salter. (Pl. XII, Figs. 2 and 3.)

1873. *Olenus* (*Sphærophthalmus*) *expansus*, n.sp., Salter: Cat. Camb. Silur. Foss. Woodw. Mus., p. 12 (*a* 275).
1877. *Olenus* (*Sphærophthalmus*) *expansus*, Woodward: Cat. Brit. Foss. Crust., p. 47.
1891. *Olenus* (*Sphærophthalmus*) *expansus*, Woods: Cat. Type Foss. Woodw. Mus., p. 149.

The two specimens on which Salter founded this species are exceedingly imperfect and fragmentary, and consist only of a few broken thoracic rings attached in one case to a portion of a pygidium showing the margin. This specimen, though crushed and flattened out, is the less incomplete of the two, but is extremely unsatisfactory for a specific description. Salter (loc. cit. supra) describes the species thus: "A very narrow axis and enormously wide flanks distinguish this." The long narrow pleuræ, of which 7–8 are visible in the better and larger specimen and 7 in the smaller one, are straight, with parallel sides, extend at right angles to the axis, and bend sharply close to the ends to terminate in short points, not projecting outwards nor produced into spines. Each pleura is apparently furnished with a narrow raised rounded ridge running along its anterior margin, with a distinct groove behind it. The general

[1] Geol. Mag., Dec. I, Vol. V (1868), p. 5, Pl. II, Figs. 7–11. Salter's *Conocoryphe Williamsoni* (Cat. Camb. Sil. Foss. Woodw. Mus., p. 12) is distinct from Belt's form.

[2] Q.J.G.S., vol. lii (1896), p. 537, pl. xxvi, figs. 11 and 12.

[3] Callaway: Q.J.G.S., vol. xxxiii (1877), p. 666, pl. xxiv, fig. 6. Brögger: Nyt Magazin für Naturvidenskaberne, vol. xxxvi (1897), pp. 179–185, 200.

surface of the pleura bears no furrow or ridge, but close to the posterior margin are two equal raised thread-like lines parallel to the margin and to each other and separated by a narrow groove.

The axis of the thorax is very narrow relatively to the pleuræ; it is cylindrical as in *Ctenopyge pecten* (Salter), not tapering at all posteriorly, so far as is seen in the smaller specimen. In the larger specimen the axis is too imperfectly preserved to make out any feature clearly. The pygidium, according to the latter specimen, appears to be broadly parabolic and slightly pointed or apiculate posteriorly, but this appearance may be due to distortion and crushing. Its lateral lobes are flat and marked by straight pleuræ similar to those of the thorax, and like them distinctly furnished with the ridge and thread-like lines. They terminate on the margin in free ends, bluntly pointed and backwardly directed, of which six or seven are distinguishable. The axis of the pygidium is not preserved.

It is extremely doubtful to what subgenus or even genus this imperfect fossil should be ascribed. It however seems more allied to *Eurycare* or *Ctenopyge* than to *Sphærophthalmus*. The long, straight spinose pleuræ of the thorax, the narrow axis, the numerous segments of the pygidium, with the free pointed terminations of the pleuræ on its margin, resemble *Ctenopyge*, but the shorter length of these spines and their falcate shape distinguish them. It is not, however, possible to fix with certainty the true generic position of this imperfectly known species.

The specimens (*a*, 275 of Salter's Catalogue) were found in the Upper Lingula Flags of Moel Gron.

	mm.
Length of pygidium of larger specimen ...	12·0
Width of ditto	23·0
Width of thorax	25·0
Width of axis of thorax	4·0

N.B. These measurements are only approximate, owing to the bad state of preservation of the specimen, and its distortion.

Neseuretus recurvatus (Hicks)? (Pl. XII, Fig. 4.)

1873. *Calymene vexata*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 22 (*a* 469).
1888. *Calymene vexata*, Etheridge: Pal. Foss. Brit. Isl., p. 46.
1891. *Neseuretus*, sp., Woods: Cat. Type Foss. Woodw. Mus., p. 148.

The small pygidium named by Salter *Calymene vexata* occurs on a slab with *Niobe* [*Asaphellus*, Brögger] *menapiensis*, *Neseuretus quadratus*, *Ctenodonta menapiensis*, and *Ctenodonta cambriensis* from the Tremadoc Beds (=Arenig, according to Salter) of Ramsey Island. The species is somewhat doubtful, but the pygidium appears to resemble that of *Neseuretus recurvatus* (Hicks).[1]

Neseuretus quadratus (Hicks)? (Pl. XII, Fig. 5.)

1873. *Calymene ultima*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 22 (*a* 469).
1888. *Calymene ultima*, Etheridge: Pal. Foss. Brit. Isl., p. 46.
1891. *Calymene ultima*, Woods: Cat. Type Foss. Woodw. Mus., p. 141. (Specimen supposed to be lost.)

The slab of rock on which Salter's *Calymene vexata* occurs also contains his original specimen of *Calymene ultima*. It consists of

[1] Hicks: Q.J.G.S., vol. xxix (1872), p. 45, pl. iii, figs. 5, 6.

a good head-shield only slightly distorted, and corresponds in character to *Neseuretus quadratus* (Hicks),[1] but apparently belongs to a young individual, as it is of comparatively small size (13 mm. long). The glabella is too narrow to ascribe it to *N. ramseyensis*, Hicks. The basal lobes are well shown, and there is a faint indication of the two anterior pairs of lateral furrows. The punctation of the surface also corresponds to that of *N. quadratus*.

NESEURETUS, sp. (Pl. XII, Fig. 6.)

1873. *Homalonotus monstrator*, Salter: Cat. Camb. Sil. Foss. Woodw. Mus., p. 22 (*a* 482).
1888. *Homalonotus monstrator*, Etheridge: Pal. Foss. Brit. Isl., p. 54.
1891. *Neseuretus*, sp., Woods: Cat. Type Foss. Woodw. Mus., p. 148.

Salter gave the name *Homalonotus monstrator* to a trilobite from what he considered the base of the Arenig Beds (= Tremadoc. according to Hicks) in Ramsey Island. The single original specimen (*a* 482) on which this species was founded consists of an imperfect and badly-preserved pygidium, which obviously belongs to the genus *Neseuretus*,[2] though the species is indeterminable.

EXPLANATION OF PLATE XII.

[All the figures are of Salter's original specimens in the Woodwardian Museum.]

FIG. 1.—*Olenus* (*Parabolinella*) *Planti*, Salter. Upper Lingula Flags, Moel Gron. *a*, 272.
FIGS. 2 and 3.—*Olenus* (s.g. ?) *expansus*, Salter. Upper Lingula Flags, Moel Gron. *a*, 275.
FIG. 4.—*Neseuretus recurvatus*, Hicks? Tremadoc, Ramsey Island. *a*, 469.
FIG. 5.—*Neseuretus quadratus*, Hicks? Tremadoc, Ramsey Island. *a*, 469.
FIG. 6.—*Neseuretus*, sp. Tremadoc, Ramsey Island. *a*, 482.

V.—TERTIARY FORAMINIFERAL LIMESTONES FROM SINAI.

By FREDERICK CHAPMAN, A.L.S., F.R.M.S.

(PLATES XIII AND XIV.)[3]

THE following descriptions are based upon a collection of foraminiferal limestones, chiefly nummulitic, from Sinai, which were sent to the British Museum for description and determination by Captain H. G. Lyons, R.E., F.G.S., Director of the Geological Survey of Egypt.

Our previous knowledge of Sinaitic foraminifera has been somewhat scanty. It was pointed out, however, chiefly by Bauerman, that the Nummulitic Series is very well developed in this particular area, the country on the east side of the Gulf of Suez.

The occurrence of *Nummulites* and *Operculina* is recorded in Mr. Bauerman's paper[4] mainly from a locality south of Wadi Gharandel. Professor Rupert Jones supplied a note to that paper, and from the latter locality recorded *Nummulites Gizehensis* (large

[1] Hicks: Q.J.G.S., vol. xxix (1872), p. 45, pl. iii, figs. 11–13.
[2] Hicks: Q.J.G.S., vol. xxix (1872), p. 44.
[3] The Plates will appear with Part II, in the August Number.
[4] "Note on a Geological Reconnaissance made in Arabia Petræa in the Spring of 1868": Quart. Journ. Geol. Soc., vol. xxv (1868), p. 38.

and small), *N. Ramondi*, *N. curvispira*, and *N. intermedia*; whilst from "the lowest rock seen just beyond Pharaoh's Fall" he records remains of *Nummulites Ramondi* and *Operculina canalifera* (?).

Foraminifera have been recorded from Sinai also by Ehrenberg.[1] These were principally obtained from washings of the rocks, and consequently are exceptionally minute forms.

Other occurrences of foraminifera from the adjacent country, chiefly Palestine, are noted by Fraas,[2] who described a form under the name of *Nummulites cretacea* from the Hippurite Limestone near Jerusalem, and which from the figure given is certainly not a nummulite, but bears some resemblance to a turgid *Orbitoides*, and is most probably of Tertiary age.[3] The same author mentions two other species, *Nummulites variolaria* and *N. Arabiensis.*

Lartet has figured and noted three species of *Nummulites* from Wadi Gharandel,[4] namely, *N. Lyelli*, *N. Guettardi*, and *N. Lucasana.*

Lastly, a series of specimens collected by the Palestine Exploring Expedition in 1865 from Gerizhem have been identified by Professor T. Rupert Jones,[5] who enumerates ten species, and some of these are comparable with our Sinaitic specimens.

The specimens dealt with in this paper were collected by Mr. Barron, of the Egyptian Geological Survey, between January and June, 1899.

The following is an epitomized account of the rock-specimens, with their contents :—

No. 4,111, 1*l.*—"Foraminiferal limestone; top of Jebel Abyad, south of Wadi Gharandel, Sinai." Mokattam Series (Middle Eocene).

A dense cream-coloured limestone, largely composed of *Nummulites subdiscorbina* and *N. curvispira*, associated with a fair number of *N. Gizehensis*, var. *Pachoi*. The nummulites in these rock-specimens lie massed together, forming a kind of bank, which is in turn covered with fine detrital mud containing smaller foraminifera, such as *Bolivina*, *Globigerina*, *Discorbina*, and *Rotalia*. One of the nummulites in this rock has been partially transformed into beekite.

The genera and species found in these rock-specimens are :— *Bolivina punctata* ?, d'Orbigny ; *Globigerina bulloides*, d'Orb. ; *G. conglobata*, Brady ; *G. cretacea* ?, d'Orb. ; *Discorbina rugosa* (d'Orb.) ; *D. globularis* (d'Orb.) ; *Rotalia calcariformis* (Schwager) ; *Nummulites subdiscorbina*, De la Harpe ; *N. curvispira*, Meneghini ; *N. Gizehensis*, Ehr., var. *Pachoi*, De la Harpe ; *Orbitoides dispansa* (Sow.) ; *O. ephippium* (Schlotheim) ; and *O. papyracea* (Boubée).

No. 4,112, 2*l.*—"Foraminiferal limestone, beach deposit (later) ;[6]

[1] Mikrogeologie, vol. ii (1854), pl. xxv c. Also Parker & Jones: Ann. Mag. Nat. Hist., vol. ix (1872), p. 289.

[2] Aus dem Orient, 1867, pp. 82–4, pl. i, figs. 8*a–c*.

[3] See also Lartet: "Explor. géol. Mer Morte," 1877, pp. 157–9.

[4] Lartet, "Essai sur la Géol. Palestine," pt. ii, Paléontologie: Ann. Sci. géol., vol. iii (1872), p. 89, pl. ix, figs. 23, 25, 26.

[5] Catal. Foss. Foram. Brit. Mus., 1882, p. 49.

[6] Mr. Barron writes (March, 1900) with regard to this deposit: "It has the characters of a beach deposit in that it is gritty and contains well-marked conglomerate beds. There is no doubt, however, that it is part of the Eocene series."

Jebel Abyad, Sinai." ? Bartonian (Upper Eocene) or ? top of Mokattam Series (Middle Eocene).

A soft-textured, pale cream-coloured rock. Thin sections of this specimen when viewed under the microscope show the rock to be finely granular to crystalline, and to contain a fair number of foraminifera, some of which are broken and worn (? derived).

The foraminifera in this rock are :—*Globigerina bulloides*, d'Orb.; *Operculina complanata* (Defr.), var. *discoidea*, Schwager; *Nummulites planulata* (Lamarck); *N. variolaria* (Lam.); and *Orbitoides dispansa* (Sowerby).

Nos. 4,135, 3*l*, and **4,113,** 4*l*.—"Foraminiferal limestone; junction of Wadi Baba and Wadi Shellál." Libyan Series (Lower Eocene).

This rock has a whitish chalky appearance, and is seen under the microscope to be almost completely recrystallized as dolomite, the rhomb-sections of that mineral being very perfect. The foraminifera have retained generally their shape and structure, but in many instances their tests are bitten up by dolomite rhombs. The chambers of the foraminifera are also often filled up by the crystals. Besides foraminifera numerous fragments of polyzoa (unaltered) are scattered throughout the rock.

The foraminifera seen in these specimens are :—*Textularia agglutinans*, d'Orb.; *Operculina complanata* (Defr.), var. *canalifera*, d'Archiac; and *Nummulites Ramondi*, Defr.

No. 4,163, 5*l*.—"Nummulites near top of Jebel Safariat, Sinai." Mokattam Series (Middle Eocene).

A collection of nummulites of the type *N. complanata*, comprising *N. Gizehensis* (Forskål), var. *Ehrenbergi*, De la Harpe; *N. Gizehensis*, var. *Lyelli*, d'Archiac & Haime; and *N. Gizehensis*, var. *Pachoi*, De la Harpe.

No. 3,598, 13*l*.—"Nummulitic bed, Wadi Khadáhid, Sinai." Mokattam Series (Middle Eocene).

An ochreous-coloured, incoherent limestone, consisting almost entirely of nummulites (chiefly *N. curvispira*).

The following foraminifera were found :—*Truncatulina umbonifera* (Schwager); *Nummulites Gizehensis*, var. *Pachoi*, De la Harpe; *N. curvispira*, Meneghini; *N. Barroni*, sp. nov.; and *N. Ramondi* ?, Defrance.

No. 3,902, 15*l*.—"Foraminiferal limestone, Jebel Krer (same range as Jebel Abyad), Sinai." Libyan Series (Lower Eocene).

An impure chalky limestone, with many included fragments of an older rock, possibly Cretaceous in age, which includes *Globigerina cretacea* ?, d'Orb. When viewed microscopically, this limestone appears to have originally been a fine-grained calcareous mud, with numerous specimens of foraminifera. We find here *Miliolina circularis* (Born.); *Alveolina Boscii* (Defr.); *A. decipiens*, Schwager; *Bigenerina*? *nodosaria*, d'Orb.; *Globigerina cretacea* ?, d'Orb.; *Operculina complanata* (Defr.), var. *canaliculata*, d'Archiac; *Nummulites Guettardi*, d'Arch. & Haime, var. *antiqua*, De la Harpe; *Orbitoides dispansa* (Sow.); and *O. papyracea* (Boubée).

In the following descriptions, especially with regard to the nummulites, I have had the advantage of consulting Professor T. Rupert Jones, F.R.S., to whom I am much indebted.

FORAMINIFERA.

Family MILIOLIDÆ.

Subfamily MILIOLININÆ.

MILIOLINA, Williamson [1858].

Mioliolina circularis (Bornemann). (Pl. XIV, Fig. 1.)

Triloculina circularis, Bornemann, 1855: Zeitsch. deutsch. Geol. Gesell., vol. vii, p. 349, pl. xix, fig. 4.
Miliolina circularis (Born.), Sherborn & Chapman, 1886: Journ. Roy. Micro. Soc., ser. II, vol. vi, p. 742, pl. xiv, figs. 2*a*, *b*.

A *Miliolina* occurs in a section of one of the Sinai limestones. It perfectly agrees in outline and the disposition of the inner chambers with the above species, especially those found in Tertiary clays elsewhere, as the London Clay and the Septarian Clay of Hermsdorf.

Coll. Geol. Surv. Egypt, No. 3,902, Box No. 15*l*. Libyan Series (Lower Eocene): Jebel Krer, Sinai.

Subfamily ALVEOLININÆ.

ALVEOLINA, d'Orbigny [1826].

Alveolina Boscii (Defrance). (Pl. XIII, Fig. 6*a*.)

Oryzaria Boscii, Defrance, 1820: Dict. Sci. Nat., vol. xvi, p. 106; Atlas Zooph., pl. xlviii, fig. 4.
Alveolina Boscii (Defr.), d'Orb., 1826: Ann. Sci. Nat., vol. vii, p. 306, No. 5; Modèles, No. 50. Brady, 1884: Rep. Chall., vol. ix, p. 222, pl. xvii, figs. 7–12.

The elongate and more or less fusiform specimens of *Alveolina* in the oldest Tertiary limestones of Sinai may be referred to the above species. Schwager figures an allied form, *A. frumentiformis*,[1] which is more slender than *A. Boscii*, from the Egyptian limestone of the Libyan Series.

Coll. Geol. Surv. Egypt, No. 3,902, Box No. 15*l*. Libyan Series (Lower Eocene): Jebel Krer, Sinai. Rare.

Alveolina (*Flosculina*) *decipiens*, Schwager. (Pl. XIV, Fig. 2.)

Alveolina (*Flosculina*) *decipiens*, Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 103, pl. xxvi (iii), figs. 1*a*–*k*.

This interesting species appears to be similar to some *Alveolinæ* from India, associated in like manner with *Nummulites* and *Orbitoides*. It was found by Schwager in the Libyan Series of Nekeb-el-Farudj and El-Guss-Abu-Said.

Coll. Geol. Surv. Egypt, No. 3,902, Box No. 15*l*. Libyan Series (Lower Eocene): Jebel Krer, Sinai. Frequent.

[1] Palæontographica, vol. xxx (1883), Pal. Theil, p. 100, pl. xxv (ii), figs. 4*a*–*i*.

Family TEXTULARIIDÆ.

Subfamily TEXTULARIINÆ.

TEXTULARIA, Defrance [1824].

Textularia agglutinans, d'Orbigny. (Pl. XIV, Fig. 3.)

Textularia agglutinans, d'Orb., 1839: Foram. Cuba, p. 144, pl. i, figs. 17, 18, 32–34.

A specimen of the above was met with in one of the sections, which has the aboral end somewhat more attenuate than is usual in the typical form. The texture of the shell-wall is coarsely arenaceous, and the limestone in which it occurs was probably deposited in quite shallow water.

Coll. Geol. Surv. Egypt, No. 4,113, Box No. 4*l*. Libyan Series (Lower Eocene): junction of Wadi Baba and Wadi Shellál.

BIGENERINA, d'Orbigny [1826].

Bigenerina nodosaria ?, d'Orbigny. (Pl. XIII, Fig. 7*b*.)

Bigenerina nodosaria, d'Orb., 1826: Ann. Sci. Nat., vol. vii, p. 261, No. 1, pl. xi, figs. 9–11; Modèles, No. 57.

Dimorphina nodosaria, d'Orb., 1846: Foram. Foss. Vienne, p. 221, pl. xii, figs. 21, 22.

Bigenerina nodosaria, d'Orb., Brady, 1884: Rep. Chall., vol. ix, p. 369, pl. xliv, figs. 14–18.

A vertical section of a stout bigenerine form occurs in one of the sections, and is most probably referable to the above species. *B. nodosaria* has been recorded from various deposits dating from Middle Tertiary times.

Coll. Geol. Surv. Egypt, No. 3,902, Box No. 15*l*. Libyan Series (Lower Eocene): Jebel Krer, Sinai.

Subfamily BULIMININÆ.

BOLIVINA, d'Orbigny [1839].

Bolivina punctata ?, d'Orbigny. (Pl. XIV, Fig. 4.)

Bolivina punctata, d'Orb., 1839: Voyage Amér. Mérid., vol. v, Foraminifères, p. 63, pl. viii, figs. 10–12.

B. phyllodes (Ehrenberg), Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 113, pl. xxix (vi), fig. 10.

The specimen under notice is a vertical section of a narrow form cut at such an angle as to give a chevroned aspect to the chambers. It is possibly referable to the well-known Tertiary species *Bolivina punctata*, and similar specimens have occurred in both the Libyan and Mokattam Series of Egypt.

Coll. Geol. Surv. Egypt, No. 4,111, Box No. 1*l*. Mokattam Series (Middle Eocene): top of Jebel Abyad, south of Wadi Gharandel, Sinai.

Family GLOBIGERINIDÆ.

GLOBIGERINA, d'Orbigny [1826].

Globigerina bulloides, d'Orbigny. (Pl. XIV, Fig. 5.)

Globigerina bulloides, d'Orb., 1826: Ann. Sci. Nat., vol. vii, p. 277, No. 1; Modèles, No. 76. Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 118, pl. xxvii (iv), figs. 5*a–c*.

Several undoubted specimens of this form were detected in the fine material of the sections made from rock-specimen No. 4,112.

Schwager found *G. bulloides* in both the Libyan and the Mokattam Series in Egypt.

Coll. Geol. Surv. Egypt, No. 4,112, Box No. 2*l*. Bartonian Series (Upper Eocene) or top of Mokattam Series (Middle Eocene) : Jebel Abyad, Sinai.

Globigerina conglobata, Brady. (Pl. XIV, Fig. 6.)

Globigerina conglobata, Brady, 1879 : Quart. Journ. Micro. Sci., vol. xix, p. 72. Id., 1884 : Rep. Chall., vol. ix, p. 603, pl. lxxx, figs. 1–5 ; pl. lxxxii, fig. 5.

This species is occasionally seen in the sections of No. 4,111, but the specimens are somewhat fragmentary. It has previously occurred in beds as old as the Oligocene or Miocene, notably in the limestones of Christmas Island. It is distinguished by the fewness of the chambers and the comparative thickness of the shell-walls.

Coll. Geol. Surv. Egypt, No. 4,111, Box No. 1*l*. Mokattam Series (Middle Eocene) : top of Jebel Abyad, south of Wadi Gharandel, Sinai.

Globigerina cretacea ?, d'Orbigny. (Pl. XIV, Fig. 7.)

Globigerina cretacea, d'Orb., 1840 : Mém. Soc. géol. France, ser. I, vol. iv, p. 34, pl. iii, figs. 12–14.
G. cf. *cretacea*, d'Orb., Schwager, 1883 : Palæontographica, vol. xxx, Pal. Theil, p. 119, pl. xxix, figs. 13*a–d*.

Numerous small specimens of a small-chambered, neatly coiled *Globigerina*, very closely resembling *G. cretacea*, occur in the presumably oldest nummulitic beds of Sinai. This species has also been doubtfully referred to as occurring in the argillaceous beds (Libyan Series) of El-Guss-Abu-Said by Schwager.

It is of great interest to note this occurrence here, since if the species be proved by specimens isolated from the rock, they will either have been derived from neighbouring Cretaceous beds or otherwise show an upward range for the species, typical examples of which are not known out of the Cretaceous formations.

Coll. Geol. Surv. Egypt, No. 4,111, Box No. 1*l*. Mokattam Series (Middle Eocene) : top of Jebel Abyad, south of Wadi Gharandel, Sinai. Also No. 3,902, Box No. 15*l*. Libyan Series (Lower Eocene : Jebel Krer (same range as Jebel Abyad), Sinai.

Family ROTALIIDÆ.

Subfamily ROTALIINÆ.

Discorbina, Parker & Jones [1862].

Discorbina rugosa (d'Orbigny). (Pl. XIV, Fig. 9.)

Rosalina rugosa, d'Orb., 1839 : Voyage Amér. Mérid., vol. v, pt. 5, Foraminifères, p. 42, pl. ii, figs. 12–14.
Discorbina rugosa (d'Orb.), Brady, 1884 : Rep. Chall., vol. ix, p. 652, pl. lxxxvii, figs. 1, 4. Sherborn & Chapman, 1889 : Journ. Roy. Micro. Sci., p. 487, pl. xi, fig. 33.

This neat little shallow-water organism is fairly well known in Eocene strata, and is a characteristic form in the London Clay.

Coll. Geol. Surv. Egypt, No. 4,111, Box No. 1*l*. Mokattam Series (Middle Eocene): top of Jebel Abyad, south of Wadi Gharandel, Sinai.

Discorbina globularis (d'Orbigny). (Pl. XIV, Fig. 8.)

Rosalina globularis, d'Orb., 1826: Ann. Sci. Nat., vol. vii, p. 271, No. 1, pl. xiii, figs. 1–4; Modèles, 1826, No. 69.

Discorbina globularis (d'Orb.), 1897, Jones & Chapman, in Professor Judd's Second Report on specimens of the deposits of the Nile Delta: Proc. Roy. Soc., vol. lxi, p. 38.

The specimen seen in section is that of a simple, strongly inflated *Discorbina*, similar to the above-named species. It has already been recorded from slices of Eocene pebbles from the Nile Delta, and it is also known from the Eocene of Grignon. It occurs in nearly all fossiliferous strata dating from Tertiary times to the present. In recent deposits *D. globularis* is most abundant in shallow water, averaging about 50 fathoms.

Coll. Geol. Surv. Egypt, No. 4,111, Box No. 1*l*. Mokattam Series (Middle Eocene): top of Jebel Abyad, south of Wadi Gharandel, Sinai.

TRUNCATULINA, d'Orbigny [1826].

Truncatulina umbonifera (Schwager). (Pl. XIV, Figs. 10*a*, *b*.)

Discorbina umbonifera, Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 126, pl. xxvii (iv), figs. 14*a–d*.

The specimen obtained from the limestone of Sinai is apparently a depauperated or irregularly grown individual of the above species. The affinities of the original specimens and also of the present appear to be nearer *Truncatulina* than *Discorbina*. Schwager's specimens came from the Libyan Series of El-Guss-Abu-Said, Egypt.

Coll. Geol. Surv. Egypt, No. 3,598, Box No. 13*l*. Mokattam Series (Middle Eocene): Wadi Khadáhid, Sinai.

ROTALIA, Lamarck [1804].

Rotalia calcariformis (Schwager). (Pl. XIV, Fig. 11.)

Discorbina calcariformis, Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 120, pl. xxvii, figs. 9*a–d*.

The specimens seen in these sections show a true rotaliform structure in the shell-wall, with an interseptal canal system. Schwager's figures also show secondary shell-thickening, and we therefore refer them to the genus *Rotalia*. *R. calcariformis* is not far removed in outline from *R. calcar* of the present day, but since the latter species shows a marked tendency to vary in the direction of the elongation of the cuspid processes on the outer segments, and *R. calcariformis* has a somewhat blunt cusp, the two series of specimens may reasonably be kept distinct.

R. calcariformis was found in the argillaceous beds of El-Guss-Abu-Said (Libyan Series), Egypt.

Coll. Geol. Surv. Egypt, No. 4,111, Box No. 1*l*. Mokattam Series (Middle Eocene): top of Jebel Abyad, south of Wadi Gharandel, Sinai. Frequent.

Family NUMMULINIDÆ.

Subfamily NUMMULITINÆ.

Operculina, d'Orbigny [1826].

Operculina complanata (Defrance), var. *canalifera*, d'Archiac.
(Pl. XIII, Figs. 3*a*, 4*a*; Pl. XIV, Fig. 12.)

Operculina ammonea, Leymerie (pars), 1844: Mém. Soc. géol. France, ser. II, vol. i, p. 359, pl. xiii, fig. 11.

O. canalifera, d'Archiac, 1850: Hist. Prog. Géol., vol. iii, p. 245. D'Archiac & Haime, 1853: Descr. Anim. groupe nummulitique Inde, p. 182, pl. xii, figs. 1*a–c*; and vol. ii (1854), p. 346, pl. xxxv, fig. 5*a*; pl. xxxvi, figs. 15*a*, 16*a*.

O. libyca, Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 142, pl. xxix (vi), figs. 2*a–g*.

After a careful comparison of the various specimens of the large and compressed forms of *Operculina* which are often so abundant in the nummulitic series and subsequent formations of Asia, Africa, Europe, and the West Indies, we have arrived at the conclusion that the so-called species, so numerously described and figured, can only be regarded as varieties of the type form *O. complanata* (Defrance). These varieties, nevertheless, when confined within certain limits of characters, determined probably by the influence of local conditions, will prove of value in determining facies and minor series of strata in given areas.

O. complanata, var. *canalifera* is characterized by the rapid increase in the width of the whorls in the last turn or so. The surface of the central area of each chamber is slightly excavate, and the sutural lines of the segments are often marked out by a thick secondary shell growth. Greatest length of test in the specimens from Sinai, $\frac{2}{5}$ inch (10 mm.); diameter at oral extremity, $\frac{7}{25}$ inch (7 mm.); thickness, $\frac{1}{50}$ inch (·5 mm.).

The original specimens, described by d'Archiac, were from the yellow limestone, Hala range, province of Cutch, India, where it was associated with *Nummulites Ramondi*. *O. complanata*, var. *canalifera*, has also been recorded from the nummulitic beds of Beni Hassan and Cairo, Egypt, and from Palestine and Bulgaria. Described under the name of *O. libyca* by Schwager, and recorded by him from the Libyan Series of El-Guss-Abu-Said.

Coll. Geol. Surv. Egypt, Nos. 4,113 and 4,135, Box Nos. 4*l* and 3*l* respectively. Libyan Series (Lower Eocene): junction of Wadi Baba and Wadi Shellál, Sinai. Abundant and typical. Also No. 3,902, Box No. 15*l*. Libyan Series (Lower Eocene): Jebel Krer, Sinai. Frequent, but somewhat dwarfed specimens.

Operculina complanata (Defrance), var. *discoidea*, Schwager.
(Pl. XIV, Fig. 13.)

Operculina discoidea, Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 145, pl. xxix (vi), figs. 5*a–d*.

O. cf. *canalifera*, d'Arch., id., 1883: ibid., p. 144, pl. xxix (vi), figs. 3*a*, *b*.

This variety is distinguished from the foregoing by the even width of the whorls of the shell, which increase but slightly in each turn of the series.

Gümbel has figured a somewhat similar variety from the nummulitic series of Kressenberg, Bavaria, which he has referred to d'Archiac's *Operculina canalifera*.[1]

The specimens from Sinai measure $\frac{7}{25}$ inch (7 mm.) in the diameter of the shell, and its thickness is $\frac{1}{50}$ inch (·5 mm.).

Schwager's specimens were obtained from the white clay of Aradj (Mokattam Series), Egypt.

Coll. Geol. Surv. Egypt, No. 4,112, Box No. 2*l*. ? Bartonian Series (Upper Eocene) or ? top of Mokattam Series (Middle Eocene): beach deposit, Jebel Abyad, Sinai. Common.

Heterostegina, d'Orbigny [1826].

Heterostegina depressa, d'Orbigny. (Pl. XIII, Fig. 7*a*.)

Heterostegina depressa, d'Orb., 1826: Ann. Sci. Nat., vol. vii, p. 305, No. 2, pl. xvii, figs. 5–7; Modèles, No. 99.

The specimens now under description are very distinctly coiled at the commencement, and in general aspect resemble those specimens which belong to the microspheric form; and which are rare in our modern marine dredgings. This species is more commonly found in the later Tertiaries, but it is not entirely absent from the base of the Eocene.

Coll. Geol. Surv. Egypt, No. 3,902, Box No. 15*l*. Libyan Series (Lower Eocene): Jebel Krer, Sinai. Rare.

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

VI.—The Development of Brown Mica from Augite by Reaction with Felspathic Material.

By James Parsons, B.Sc. (Lond.).

THE conversion of augite or hornblende into brown mica appears to take place from three causes:—

1. By crushing of pyroxenic minerals and felspar, as has been observed by Professor Bonney in sundry schists of the Alps.[2]

2. By the intrusion of felspathic material into a rock containing augite or hornblende, as in the Harz, where granite invades diabase, converting the augite into biotite.[3] A similar change has been observed in the gabbro of the Barnavave Mountain, in the Carlingford district, the diallage being wholly or in part replaced by biotite owing to the invasion of granophyric magma.[4] In Sark the intrusion of an aplitic magma into almost pure hornblende has resulted in the formation of biotite.[5]

3. By the corrosive action of a residual felspathic magma on previously consolidated augitic constituents. This method of formation has been noted by Mr. T. H. Holland in the augite-diorites

[1] Abhandl. bayer. Akad. Wiss., vol. x (1868), 1870, p. 664, pl. ii, figs. 112*a*, *b*.

[2] Q.J.G.S., vol. xlix, p. 104.

[3] K. A. Lossen: Congrès Internat. Géol. Comptes Rendues de la 4me session, 1888, p. 184.

[4] Sollas: Trans. Roy. Irish Acad., vol. xxx (1894), p. 477.

[5] Bonney: Q.J.G.S., vol. xlviii, p. 122 et seq.

of Southern India. In this instance, after augite and plagioclase had consolidated a hydrous magma was left, which ultimately solidified as micropegmatite; this magma acted readily on the augite, converting it into biotite.[1] Under this head the following observations on some Norwegian rocks should probably be classed.[2]

(1) A granite from Almäs shows a similar process of change to that observed in the above-mentioned augite-diorites. The principal constituents of the rock are, oligoclase, orthoclase, augite of the pale-green non-aluminous type (sahlite), which commonly occurs in granite, biotite, and sphene. The biotite is developed round the augite, which is much corroded, passing into it along its cleavage cracks, in such a way that, in many cases, the line of division is fixed with difficulty. The two minerals are curiously intergrown, but not in such a way as to suggest simultaneous crystallization, for while the biotite invades the augite from the outside it does not form isolated inclusions in the latter. The quartz and orthoclase occur as a mosaic of varying coarseness and of later date than the oligoclase, and locally form patches of micropegmatite. The mosaic extends in narrow seams between the oligoclase crystals, broadening out at their angles to fill the intercrystalline spaces. It is largely developed round the augite-biotite aggregate, the grains separating the flakes of biotite at the margins of the main masses. Appearances suggest that the magma, from which the quartz and orthoclase formed, effected the corrosion of the augite and subsequent development of the biotite in the manner suggested by Mr. Holland. The sphenes occur as idiomorphic crystals, and are the earliest constituents of the rock, for they are included in the augite, which is itself earlier than the oligoclase. Where present in the biotite or in its immediate neighbourhood they are much corroded and cracked. The iron of the augite appears to be completely used up in forming the biotite, for though a few grains of magnetite occur, these are due to the subsequent hydration of the mica accompanied by the formation of a chloritic mineral. A little hornblende is present, apparently secondary, after augite.

(2) An augite-syenite from Svenöre well shows the conversion of augite into dark mica. This rock is closely allied to the well-known Lauvigite. The felspars are orthoclase, apparently of two varieties, with a little plagioclase. They exhibit microperthitic intergrowth, and this in many places at their margins passes into micropegmatite. The augite is of two types: (i) Pale brown, slightly pleochroic, showing, in the central portions of the crystals, good cleavage marked by the deposition of iron oxide in the cracks, which occasionally assumes the form of negative crystals. Incipient diallagic cleavage may be observed, traversing the earlier prismatic one. This augite is much corroded by the felspars, its margin being in some places curiously broken up and intergrown with the

[1] Q.J.G.S., vol. liii, p. 405.

[2] I am indebted to Professor Bonney for the opportunity of studying these slices, which belong to his collection.

surrounding felspar in a manner approaching micropegmatite. (ii) A pale-green augite, irregularly cracked, probably sahlite. It occurs in rounded fragments, which in places have been broken up and separated. Biotite is chiefly developed round the first-named augite, and it occurs only when that mineral is in contact with the felspar, and has been manifestly corroded by it. With ordinary light it is often impossible to say where the passage of augite into mica commences, for its first manifestation is a very faint brown tinting. With crossed nicols the first indication of its development is a marked increase of intensity in the polarization tints, along a narrow zone at the junction; this presently shows the characteristic mica cleavage, and varies in colour from a very light brown to a dark bright brown. Beyond the latter magnetite is developed. On the other side of the mass of magnetite the augite shows irregular cracks in which the magnetite is deposited, and beyond this the regular cleavage sets by marked iron oxide, as mentioned above. It should be understood that though this *order of sequence* is apparently constant, yet any stage owing to the irregularities of the decomposition may be locally very poorly shown or even absent. In some cases the augite is completely decomposed, and there remains only a core of magnetite with a corona of mica, darker in colour near it and lighter in contact with the felspar. The pale-green augite does not so readily develop mica as the other variety, though its smaller fragments show in places an abundant marginal growth.

Much serpentinization occurs along its cracks, accompanied by the formation of a little mica. Both these facts confirm the idea that this is a non-aluminous augite. It is, however, rich in iron oxide, which is largely excreted in the formation of mica and the serpentinization. Apatite is an abundant constituent of the rock, the larger crystals acting as the nuclei round which the augite consolidated.

(3) A similar formation of dark mica from augite may be observed in Lauvigite, which closely resembles the Svenöre syenite described above. The rock is too well known to require detailed description, but in the present connection the following points may be noted. The augite is of two types: (i) pale-brown, slightly pleochroic, with incipient diallagic cleavage; (ii) pale-green sahlite, irregularly cracked, some serpentine and a little biotite forming along the cracks. This is earlier than the first-named augite and in many places is enclosed by it. The felspathic mixture (anorthite, microperthite) has much corroded the augite, with which at its margins it is in places intimately intergrown. Round the augite mica is developed, the one passing almost insensibly into the other as already described, and the same darkening of the mica and final formation of magnetite occurs as the distance from the felspar increases. The felspathic magma has in places invaded the augite, producing in its centre patches of dark mica which appear at first sight to be isolated inclusions. Here also the mica is only formed with difficulty in the sahlite.

(4) A gabbro from Humlebäk affords an interesting example of the corrosion of a felspar by augitic magma, resulting in the formation of brown mica. In this case the felspar is labradorite, occurring in idiomorphic crystals, round which the augite, a colourless variety, extends in ophitic fashion. The felspars are much corroded and in part melted down, thus enclosing small portions of the augite. Round the edges of the felspar, mica is developed, appearing at the outset as a faint brown tinting of the augite. At first the cleavage of this mineral is alone apparent as a rule, though occasionally traces of the mica cleavage may be discovered parallel to one of the cleavage planes of the augite. There are indications that at this earliest stage a mixture of augite and mica is present, or rather, a *solution* of mica in the augite is suggested. In one instance where a felspar lath is surrounded by biotite, obviously derived from augite, it has lost almost half its bulk by corrosion, and the remainder appears to be permeated by augitic material, converting it into a colourless mica whose cleavage planes are continuous with those of the biotite on each side. The mica when traced inwards from the margin of the augite loses its scaly appearance, due to the cleavage of that mineral, becomes more compact, and develops its own cleavage. At first it is a straw colour, then it becomes a dark bright brown, and finally magnetite is formed; and in the larger augite grains this is followed by an irregularly cracked zone which passes into a central portion showing fine cleavage striation. With this, as a rule, the outer portion is in optical continuity. When the augite is more remote from and unaltered by the felspar, it is twinned sometimes more than once parallel to the orthopinacoid; this, combined with basal cleavage striation, giving the well-known herring-bone structure. In the smaller augite grains the conversion into mica and magnetite is sometimes complete, a corona of light mica surrounding the bright brown mica, and in most cases a core of magnetite occupying the centre of the grain. The following explanation may be offered of the transition shown in this rock and the syenites :—where the felspar is in contact with the augite a mica is formed, poor in iron and rich in alumina, probably phlogopite, while, as the distance from the felspar increases, ferric oxide takes the place of alumina, resulting in lepidomelane, biotite being formed as an intermediate stage, and finally, beyond the limit to which the felspathic magma permeated, magnetite is excreted.

Thus the normal order of change seems to be as follows (commencing from the side of the felspar): (1) fusion of felspar and augite with faint brown tinting of the augite, due to incipient development of mica; (2) pale-brown mica (phlogopite); (3) biotite; (4) dark red-brown mica (lepidomelane); (5) intimate mixture of dark mica and magnetite; (6) mass of magnetite; (7) augite with irregular cracks in which magnetite is excreted, which is followed by augite with fine cleavage striation.

VII.—The Rate of Erosion of some River Valleys.

By C. C. Brittlebank, Esq.

(Read before the Geological Section of the Australasian Association for the Advancement of Science, Melbourne Meeting, January, 1900.)

THE district in which these observations have been made is a very suitable one for such experiments, and is situated from 2 to 12 miles from Bacchus Marsh and from 32 to 54 miles west of Melbourne.

The chief streams which pass through the above area are the Werribee and Lerderderg Rivers with their tributary creeks. The country is somewhat rough, being intersected by numerous deep gorges and wide flat-bottomed valleys.

Early in 1892, when working on the glacial deposits of Bacchus Marsh, I was greatly astonished at the immense amount of work done by those puny streams, which have in places cut fairly narrow gorges and valleys through solid rock, to a depth in one place of at least over 1,000 feet.

It occurred to me that, if by any means I was able to ascertain the amount of rock worn off the river bed within a given time, I should be able to arrive at an approximate estimate of the time the rivers have been cutting their channels. Even without detailed observation we should expect that a vast period had elapsed since the streams first ran on the surface of the basaltic tableland. I was, however, hardly prepared for the enormous time which my observations show, more especially as the erosion is subsequent to the flow of newer basalt.

After thinking the matter over, and striving to devise some method other than the level, I hit on a somewhat rough and ready plan, and it is from these measurements, taken over a period of five years, that my provisional estimate has been obtained. My method is as follows:—A number of holes are drilled in lines across the river bottom—if in soft rock, one inch in diameter by three inches deep, and one inch by two inches in hard dense rocks. Into these holes are placed a number of wires which have been carefully measured, cut, and fastened by solder into small bundles containing from 20 to 100 according to the hardness of the rock. The wires being placed in the holes with the longest wire exactly flush with the rock surface, cement is poured in and allowed to harden. As various kinds of wire have been used in the softer rocks, a strip of slate pencil of equal length to the longest wire is placed in each hole; this acts as a check on the wire in case of corrosive action.

Now as the surface of the river bed is worn away the end of a fresh wire is exposed for every hundredth part of an inch removed from the harder rocks, and one for every fifth or twentieth of an inch in the softer rocks.

There is reason to suspect from geological evidence that the gorge of the Lerderderg River above the alluvial flats is of much greater age than that of the Werribee. Prior to the flow of newer basalt the Lerderderg had cut a fairly deep channel, as had also the ancient Werribee, but the latter was blotted out of existence by the flows of basalt. The Lerderderg, being guarded by high Silurian ranges on the south over which the lava did not rise, continued in the same channel as it now occupies. I will therefore confine my remarks to the Werribee and tributary creeks.

The formations through which the Werribee has cut are: Lower Silurian (Ordovician), granite, Glacial Series, fresh-water 'Miocene' gravels, and basalts, both older and newer. The newer basalt has at one time formed an extensive plateau from Mt. Blackwood, the Lerderderg Ranges, and Ballan on the W. and N.W. to the Brisbane Range and the plains on the S. and S.E. The surface slope is to the S.E., and is broken here and there by ridges and hills of the various older formations which stand at a higher level. In making my observations I have used the present surface of the basaltic plateau as a bench mark. Careful measurements have been taken from the surface to the river bed at all places where erosive action is being checked.

The different rocks through which the rivers have cut their valleys greatly influence the amount and direction of erosion and denudation. I find that the resistance offered by the various geological formations to the erosive power of river action is in the following order: Basalt, Silurian Granite, Glacial Series, Miocene ferruginous gravels. Jointing, dip, strike, dykes, and bands of hard rock have considerable influence in aiding or retarding the river action. Fallen rock masses, especially huge blocks, check erosion to a considerable extent. A band of hard rock crossing the river valley acts in two ways, first by contracting the channel and second by checking vertical erosion below its own level on the up side. Numbers of these bands cross the stream, and many of my observations have been taken from them. Probably the best position for observing the wearing of any river channel is at the outer angle of a sharp bend. At such places the bed is almost always free from boulders, gravel and sand. Moreover, by the constant undermining action of the river an almost vertical cliff is formed on the outer bend. The greatest advantage, however, lies in the fact that the upper part of the river rarely moves from side to side, but cuts a fairly straight course through the country.

I had expected that the erosion of the river valleys would be carried on at a comparatively rapid rate, but after many observations along their courses I find the amount removed in a period of five years is very small, so small in fact that had the amount not been checked at numerous points I should hesitate to place on record the results, but having undertaken the observations with this object in view I give the average obtained at many separate stations on the Werribee and tributary creeks.

Basalt	0·02	inches in	5 years	=	1 inch in	250	years.
Silurian	0·03	,,	,,	=	,,	166⅔	,,
Granite	0·04	,,	,,	=	,,	125	,,
Glacial	0·05	,,	,,	=	,,	100	,,

Having ascertained the amount of erosion over a given period, it is necessary to calculate the time taken to cut the cliff sections. To be as brief as possible I have selected three sections on the Werribee between Bacchus Marsh and Ballan.

	Thickness.	Time required for cutting.
(1) Glacial	195 feet	234,000 years.
Silurian	415 ,, ...	830,000 ,,
Total	610 ,, ...	1,064,000 ,,
(2) Basalt	235 ,, ...	705,000 ,,
Glacial	60 ,, ...	72,000 ,,
Granite	176 ,, ...	264,000 ,,
Total	471 ,, ...	1,041,000 ,,
(3) Basalt	240 ,, ...	720,000 ,,
Glacial	98 ,, ...	117,600 ,,
Silurian	122 ,, ...	244,000 ,,
Total	460 ,, ...	1,081,600 ,,

In compiling these notes I have assumed that the rainfall has not been greater in past ages, say since the flow of newer basalt, than it is on the average at the present time.

VIII.—On the Naparima Rocks, Trinidad.

By R. J. Lechmere Guppy, Esq.

I HAVE received a copy of the paper by Messrs. Harrison and Jukes-Browne on the Oceanic Deposits of Trinidad, and wish to place on record a few remarks on it.

In the first place I must compliment these gentlemen upon the manner, at the same time courteous and impartial, in which they have dealt with my work.

Our authors state that my writings leave both the nomenclature and the succession of the Trinidad Tertiaries in a very uncertain state. I am afraid that there is much of truth in this statement; and I should feel satisfaction could I clear up the uncertainty either by producing evidence of a nature distinctly confirming or distinctly refuting Professor Harrison's opinion that the Nariva Series is older than the other Naparima beds, and that the Sanfernando beds are closely connected with and are probably an upward continuation of the Nariva Series. I have not been able to satisfy myself with positive certainty either one way or the other. Our authors admit themselves that no sections were seen showing the junction of the two formations, but they consider that there is abundant evidence that the two series occupy the relative positions assigned to them by the geological surveyors. I am not so wedded to my own opinion that I would not welcome theirs if I could be satisfied about this evidence. But so far as I know, no evidence of a conclusive nature is forthcoming, as in no place is the junction of the two series seen. A similar doubt formerly prevailed respecting the junction of radiolarian and foraminiferal beds; but this has been dispelled, and we are now aware that these two series pass gradually and conformably one into the other. A similar result may hereafter happen in regard to the Naparima marls and the Nariva Series. In the meantime my opinion is based mainly upon conjecture, though one point weighs a good deal with me, that is, the strong resemblance of the Nariva beds to the strata now being deposited in the gulf derived from the degradation of the Naparima beds; and if this inference is correct the Nariva Series must be later in date than the foraminiferal marls. The resemblance I refer to is one not only of mineral composition and mechanical aggregation, but of organic contents, inasmuch as some of the deposits now being laid down and (notably those off the mouth of the Sipero river) contain foraminifera of the same character and in similar condition and of similar frequency of occurrence as the Nariva beds. To take an example, *Globigerina* is a very abundant organism, both in the mud deposits off Sanfernando and in the Nariva beds, but in both these deposits it is relatively much less abundant than in the foraminiferal marls; and the relative infrequency of occurrence is due to the destruction of the fossils in the course of the denudation and redeposition of the marls. No such foraminifera now exist or can exist in a living state in the gulf, though in my very first dredgings off Sanfernando I recorded *Globigerina* at every haul in shallow water near the shore. That was before I had recognized *Globigerina* in the rocks of Naparima, and, as I have already stated, the foraminifera so dredged by me were fossils derived from the Naparima marls. Also, I consider that the abundance of gypsum in tho Nariva Series is due to the breaking down and redeposition of the foraminiferal marls, in course of which the carbonate of lime existing in the latter was partly changed into sulphate.

Respecting the nature and origin of the Argiline of Naparima Hill, I somewhat timidly expressed my opinion in former papers. As I find that Messrs. Harrison and Jukes-Browne are substantially of the same opinion as myself on the subject, I may take the opportunity of restating it. The nature and origin of the Argiline are similar to those of the Naparima foraminiferal and radiolarian marls, and it contained similar Radiolaria and Foraminifera. But the Argiline has undergone a change consequent upon an alteration in the form of its silica; a change analogous to that which has taken place in part of the so-called 'cement' of the White Hills of Bendigo, Australia, described by me in the Proceedings of the Geologists' Association of London, 1864, p. 409, and which consists in an induration by probably a partial solution and redeposition of the siliceous constituents. The whole mass of Naparima Hill is thus affected; but a similar change has partially and locally affected other portions of the Naparima rocks.

To my description of the Argiline of Naparima Hill published in the Geological Society's Journal, November, 1892, p. 526, should be added the remarks contained in my paper in the Trinidad Field Naturalists' Journal, 1893, p. 7, as follows: "Beds of different texture occur in the Argiline, some being more sandy in composition.

In these I have found very evident organic remains, though I cannot yet say exactly what they are. In another stratum of the same rock, I found two or three identifiable Foraminifera, namely, *Pullenia* and *Sphæroidina*, both deep-water forms." J. W. Gregory found indeterminable fragments of Radiolaria in this rock, and I can confirm this observation, such remains being abundant.

It is singular that no attempt was ever made to ascertain whether water could be obtained from beneath the Naparima Rocks. Previous to my arrival in the island (1859), the Government offered a reward of £2,000 for the discovery of water by means of an artesian well in Naparima. One would have thought that that would have been sufficient encouragement for such an attempt. A close examination of the physical features and geology of the country might afford to an observant eye and a sanguine mind further encouragement for a prosecution of the search for subterranean water. In my paper on the water-bearing capacities of Trinidad Rocks (published in the Trinidad Agricultural Record, 1891), also in my paper in the Journal of the Geological Society already quoted, I gave a description of the marls of Naparima, showing that these rocks do not yield springs, nor do they contain water except in union with the rock. It is true the rock (marl) is capable of union with any quantity of water, but it will not give up this water except by the process of evaporation. I had not mentioned the fact, however, that in one or two places in Naparima there are at the bottom of ravines or gullies springs of water which, though too small to give rise to any stream, being rapidly absorbed by the soil or dissipated by evaporation, serve to a very limited extent for drinking and washing purposes. Their existence is usually obvious to the wayfarer, for they assail his senses by the view of linen spread on bush and grass, the smell of foul water, and the noise of banging and beating of clothes characteristic of the Creole way of washing. Now it has occurred to me that these springs arise from the rock vertically underlying the marls, and that they only occur where the depth of the marl above the underlying rock is not great. This underlying or hypogene rock I suppose to be an extension of the hypogene or granitoid rocks of South America.

I am satisfied now that the Naparima deposits are not a continuous series of formations of several thousands of feet in thickness, but that the rocks as shown in section are several repetitions of the same beds or series of beds. As these beds are now almost vertical, it is evident that the movements which have brought about the alteration in position have been very extensive, and the intermediate and connecting portions of the strata have been removed by denudation.

In my paper on the Gulf of Paria, printed in the Proceedings of the Victoria Institute of Trinidad, 1894, p. 106, I touched cursorily on the remarkable depression between Trinidad and Venezuela passing through the Bocas. I reproduce here what I there wrote :—

"The Bocas are narrow channels connecting the Gulf of Paria with the Caribean Sea. These channels have had their origin as subaerial valleys, now submerged. (See papers in Proceedings Scientific Association, 1877, p. 103, and Agricultural Record, 1891, p. 79.) The first Boca (Boca de Monos) is barely half a mile wide, the second (Boca Huevos) a little wider. The third (Boca Navios, so called, I suppose, because ships do not use it), about the same. The Grand Boca is about six miles wide. These widths may be taken to be the clear widths in the narrowest parts. The rapid currents through these channels have kept them scoured out, and the depth reaches 120 fathoms. No mud or sand of any kind is deposited in these Bocas. The bottom is one of rocky inequalities whose existence is evidenced in the violent eddies and ripples of the so-called 'remu,' a phenomenon which occurs when the water outside the Bocas is at its lowest and consequently the water surface gradient from the middle parts of the Gulf the greatest. Outside the Gulf the Caribean Sea varies in depth from 20 to 60 fathoms except in the line of the great downthrow passing along the axis of the Grand Boca. Here the depth attains 120 fathoms, and is probably not less than 90 in any part. This line of depression seems to be a terrestrial feature of some magnitude. Its extension north-eastward from the Boca Grande, between the islands of Grenada and Tobago, is indicated by deep water marking the boundary between the volcanic region of the Antilles and the non-volcanic region to the south and east thereof."

It is strange now to myself that in writing my paper on the Microzoic Deposits of Trinidad I should have given so little weight to the bearing the existence of this depression must have on any theory of the movements of the earth's crust in this region. I am unable now to go further into this subject, but I cannot forbear pointing out that this great depression of a portion of the earth's surface, which evidence clearly shows to have been formerly a continuous land surface, had most probably an intimate connection with, or rather was part of, those movements, which among other events broke up and elevated the Naparima Rocks and tilted them on edge.

IX.—Two New Species of Ostracoda of Tithonian Age from Nesselsdorf, Austria.

By Frederick Chapman, A.L.S., F.R.M.S.

THE following descriptions of Ostracoda from the Tithonian of Austria relate to specimens kindly forwarded to me by Dr. M. Remeš. They were obtained, together with numerous other fossils, including Foraminifera, from the Red Limestone of Nesselsdorf.

The Ostracoda seem to be very rare in these beds, for the two specimens now described were the only forms obtained by Dr. Remeš, whilst other microzoa were fairly numerous.

Bythocypris, G. S. Brady [1880].

Bythocypris (?) *Jurassica*, sp. nov. (Figs. 1*a*–*c*.)

Carapace somewhat compressed; from the side subreniform, the greatest height a little in front of the middle, anterior extremity broad and rounded, posterior rounded but narrower. Edge view, anteriorly rather sharp, posteriorly slightly swollen. End view, dorsal edge acute, ventral well-rounded. Surface of shell finely punctate; this latter feature renders the generic determination as *Bythocypris* a little doubtful. Length, ·56 mm.; height, ·26 mm.; thickness of carapace, 18 mm.

From the Red Limestone of Nesselsdorf, Austria (Tithonian).

This species approaches *B. reniformis*, Brady,[1] in general form, but in the side view of the latter, the posterior extremity is more broadly rounded.

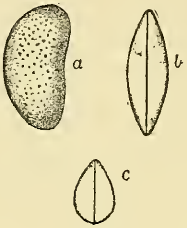


FIG. 1.—*Bythocypris Jurassica*, sp. nov. × 30.

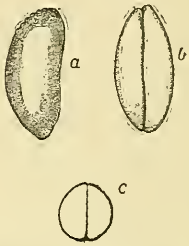


FIG. 2.—*Bairdia Nusseldorfensis*, sp. nov. × 30.

BAIRDIA, McCoy [1844].

Bairdia Nesselsdorfensis, sp. nov. (Figs. 2*a*–*c*.)

Lateral view of carapace subtriangular, dorsal margin boldly arched, ventral nearly straight, but slightly incurved near the lowest third. The postero-dorsal margin incurved, postero-ventral angle rounded. The antero-dorsal margin with numerous small and pointed tubercles. Edge view elliptical, with rounded ends; edges of right valve embraced by the left. End view subcircular.

Length, ·6 mm.; height, ·25 mm.; thickness of carapace, ·26 mm.

From the Red Limestone of Nesselsdorf, Austria (Tithonian).

REVIEWS.

I.—ON A COLLECTION OF STONE IMPLEMENTS IN THE MAYER MUSEUM, MADE BY MR. H. W. SETON-KARR IN THE MINES OF THE ANCIENT EGYPTIANS, DISCOVERED BY HIM ON THE PLATEAUX OF THE NILE VALLEY. By HENRY O. FORBES, LL.D., Director of Museums to the Corporation of Liverpool. Reprinted from Bulletin Liverpool Museum, II, Nos. 3 and 4 (20th January, 1900). With Illustrations.

WE have here the results of Mr. H. W. Seton-Karr's examination and survey of the district where he collected stone implements in two of his Egyptian journeys (1896 and 1897), together with his account of the conditions under which they occur on the surface of a part of the Eastern Egyptian Desert, traversed by the Wady el Sheikh, about 50 miles long, from S.E. to N.W., and entering the

[1] Rep. Chall., 1880, Zool., pt. iii, p. 46, pl. v, figs. 1*a*–*l*.

right bank of the Nile opposite El Fent, which is on the Cairo-Assiout railroad, half-way between the stations of Feshn and Maghagha. Rising up from the Wady el Sheikh are the escarpments of three successive plateaux (the lowest about 400 feet high, the highest about 700 feet). They consist of Cretaceous (latest) limestone below and Eocene (Nummulitic) limestone above, all bearing flint nodules.

The worked flints occur in either isolated or continuous heaps of débris thrown out from the many quarries or mines, either on the edges or the surface of the plateaux, mostly on the right side of the Wady. Flint-workings had been cursorily noticed in this region by Greg and Johnson. Mr. Seton-Karr, however, designedly visited them, and made a careful survey. The mines or pits are about two feet in diameter, and not deep, nor showing lateral galleries. They are more or less choked with blown sand. The excavated material has been piled up around the mouth of the pit and the implement-maker's workshop. Similar pits were examined by Mr. H. Seton-Karr in 1896 in the Wady Sojoor, about ten miles to the south. A serviceable map and six excellent photographic views of the plateaux and their special features (pp. 81, 101–104) enable the reader to master the topographical details.

Dr. H. O. Forbes gives careful descriptions of a selection of 47 from the 2,000 specimens (pp. 78–80 and 97–105), together with good clear figures, after photographs (pp. 82–96). The heaps of refuse at the different sinkings for the most part contained different kinds of implements. The author's conclusions as to the relative age and origin of the mines and specimens are careful, liberal, and sound.

Judging from the plates and the descriptive notes, we can enumerate the several kinds of flint-work treated of. The author's grouping is preserved:—

a. Thin-edged discs; in many cases neatly dressed on the surface and perforated in the middle, the central opening being widened until a narrow delicate ring has been worked out, for bangles, etc. (Pages 78–80.)

b. Axes, chisels, hoes, etc.; of triangular shape (6 in. to 9 in. long), broad at one end and tapering at the other (butt end). Broad end sometimes subacute or somewhat narrowed by rounding; thus figs. 14 and 16 are variants; the former has the broad end subacute, the latter is narrower throughout. (Pages 80 and 97.)

c. Leaf-shaped; figs. 18 and 19 more symmetrically chipped; almost equally convex on the two faces; more rounded at one end than at the other. (Page 97.)

d. Knife-like; figs. 20 to 35 (pages 97, 98). Many carefully dressed flakes (about 6 in. to 9 in. long) good for cutting, flaying, scraping, etc., with sharp edges, and having one edge more convex than the other, but in some cases almost symmetrical and even quite equal (fig. 24). Some, neat in shape, are like the Danish knives and daggers; others have a sharp-edged portion irregular in shape (figs. 30–33), and the other part reduced by chipping to a narrow handle or tang. Fig. 34 is a roughly chipped three-sided piece of flint, "partly blocked out" for a knife possibly. Fig. 35 is a flat, curved, sharp-edged blade, probably broken in the making.

e. Agricultural implements, etc. Fig. 36 is a nearly symmetrical truncheon or beater, of a thick spatula-shape, with a knob at the narrow end; it is very common. Fig. 37 has a coarse, thick blade, triangular in section and sharpened along one edge, and the butt end is deeply chipped for a tang. This large chopper-like implement ($8\frac{1}{2}$ in. by $2\frac{1}{4}$ in.) is of common occurrence, and must have been an efficient tool in the hands of the old labourers. Fig. 38 (from Wady Sojoor), p. 99, another large anomalous tool ($8\frac{13}{16}$ in. by $7\frac{9}{16}$ in.) flat and quadrangular or diamond-shaped, with the angles distinct, one of them very prominent, is carefully chipped along its edges.

f. Figs. 39 and 40 are two small subglobose hammer-stones (3 in. by $2\frac{1}{2}$ in.), bearing marks of wear.

g. Scrapers (p. 99). Fig. 45, large, comma-shaped; broad and rounded at one end, tapering and curved at the other, where one edge has been hollowed as a concave and hooked scraper. Fig. 46 (from the Plateau of Thebes) is a rough and irregular flake, broad at one end, narrow at the other; dressed along the edges, one of which bears a small semicircular hollow. Fig. 47 is a roughly dressed, somewhat semicircular flake, with a definite concave hollow at the middle of the edge, suitable for scraping and shaping round staves and sticks.

h. Cores, and the narrow flakes struck off from them, are common; one long hoof-shaped core is shown by fig. 42.

i. Nondescripts. Fig. 41 is a long, narrow, and very coarsely dressed, three-sided flake (17 in. by $3\frac{1}{2}$ in.), sharp at the ends. Fig. 43 is a rough flake, possibly an early state of some such an implement as that of figs. 26 or 27.

Dr. Forbes now takes into consideration "What is the age of these implements from Wady el Sheikh and Wady Sojoor, and how long probably were the mines worked?" "No find of implements so extensive as the one which is the subject of this paper has ever been made in Egypt; nor had any previously been found in relation to the mines which supplied the material, or to the workshops in which they were fabricated." Therefore archæologists may expect much from the careful study of this undisturbed locality.

Introducing these very ancient Egyptian relics to the people of to-day, who may be looking at them in the Liverpool or other Museums, the author explains first of all, briefly, that implements of stone have been in use down to the present from very early, even geological, times; more especially (1) as rough and merely chipped and flaked pieces of siliceous rock (flint, quartzite, and other varieties), so abundant in certain old gravel beds that they characterize a long-past period of time called the Palæolithic Age. (2) Instead of stones merely chipped into useful shapes, in many places gravels and loams deposited in much later times contain well-dressed and polished implements of stone; and these, being characteristic of newer periods, are termed 'Neolithic.' (3) As stone tools, in process of making, pass through rough-chipped to more finished, smoother, and polished shapes, it happens that sometimes all sorts occur together; and, indeed, prejudice and fashion, as well as convenience, kept old forms in use until, as at the present day, the more finished and best adapted stone implements only are used, after having been made from such natural material as is most fit and ready to hand.

The relative age or chronology of old worked stones can be decided only when the natural deposit, or artificial heap of débris, in which they are found can be definitely referred to some unit in a geological or historical standard. The shape by itself is a guide of limited value, except for neoliths; the colour and the patination are other guides that cannot be taken alone. The varieties of patination and tint, due to exposure on the desert, are carefully dealt with at pages 106, 107, 110, and 111, and are not found serviceable in fixing the age of this crowd of Egyptian specimens.

Forms similar to many of them have been found (as the author insists) in the ruins of Kahum (explored by Professor Petrie), which was built in the Twelfth Dynasty, at least 2660 B.C. (pages 108–110); and, just as neoliths are found there with palæolithic forms, so in the Wady el Sheikh and Wady Sojoor the fine workmanship of bangle-rings (pl. i) and very neat dagger-knives (figs. 24, 26, and 28) is associated with the many rude and very rude examples among the other figures. The latter may be more or less exactly matched with specimens of neolithic and early historic periods from localities at home and abroad. The few that approximate to the so-called 'spear-head' and 'leaf-shape' forms (figs. 11, 13, 14, 16, 18, and 19) found in real Palæolithic gravels are not proofs that Palæolithic Man worked these stone-pits; they are variants in the old Egyptian workshops, and may be matched with neolithic and historic finds in museums and archæological books.

It may be noticed that the Egyptian paintings of the flint-knife manufacture, in the tombs of Beni Hasan (reproduced at pages 108, 109), present outlines comparable with some of Dr. Forbes's figures, and are said to be of the same age as the Kahum ruins.

Other occurrences of stone tools, flakes, and flint nodules, have been noted by Petrie, Quibell, and Seton-Karr, on the Egyptian plateaux bordering the Nile. They lie in groups scattered around working places; and the author doubts if the great pluvial denudation since the time of the European Palæolithic age would not have carried away the loose débris, whilst cutting the Wadys down from the plateaux into the great Nile Valley.

Dr. Forbes has done good service in giving us this example of the value of the indestructible direct evidence of the past, better than the best papyrus and parchment of versatile history. He shows that these veritable evidences of Early Man in Egypt, though not much less than 5,000 years old, are not, like those from the old gravel found by the late Pitt-Rivers, of real Palæolithic age.

T. R. J.

II.—A Monograph of Christmas Island (Indian Ocean): Physical Features and Geology. By C. W. Andrews. With descriptions of the Fauna and Flora by numerous contributors. 8vo; pp. xiii, 337, 22 plates, 1 map, text illustrated. (London: printed by order of the Trustees of the British Museum, 1900.)

THE present work is the first monograph issued by the Trustees of the Natural History Branch of the British Museum dealing with the fauna and flora, the geology and palæontology, of a single geographical unit of the globe, and owes its inception to the advocacy of the Assistant-Secretary, Mr. Charles E. Fagan, F.R.G.S., who has, we learn, greatly interested himself in its publication.

The little island that forms the subject of this monograph lies to the south of Java, 190 miles from its shores, and must not be confused with its namesake in the Pacific Ocean.

This almost undisturbed little spot of land, 12 miles by 9, is now being opened up for commercial purposes, and it seemed desirable that before its primitive fauna and flora were ousted by man, a careful record of them should be made, whilst at the same time it appeared likely that its geological investigation would throw light on the origin of coral islands, of which it was manifestly one. Accordingly, Sir John Murray having agreed to provide the requisite funds, the Trustees of the British Museum granted the necessary leave of absence to Dr. C. W. Andrews, whose selection for the purpose of carrying out the investigation is seen by the present volume to have been most amply justified.[1]

With the zoological and botanical results of the expedition, interesting and important though they be, we have nothing to do in these pages. The facts ascertained concerning the geological structure of the island show that it presents some important peculiarities, differentiating it from other oceanic islands, and difficult to explain. It is, in fact, the flat summit of a submarine mountain, whose steep slopes sink rapidly to a depth of over 14,000 feet below the sea. The summit of this mountain peak is formed of a succession of tertiary limestones ranging in age from the Eocene (or Oligocene) up to recent reef-deposits, with intercalations in the older beds of volcanic rocks.

The tertiary beds, especially the Miocene orbitoidal limestones, end abruptly on the coast in vertical cliffs, sometimes 250 feet high: they must therefore at one time have covered a far wider area, and have been reduced by peripheral faulting.

The principal volcanic rocks are the basalts and basic tuffs at the base of the Miocene limestone, separating it from the Eocene (or Oligocene) beds below, and the basalts and trachytes underlying the latter. These older eruptive rocks form the basis of the island, which basis Dr. Andrews considers "is almost certainly a volcanic

[1] We published some Notes of an expedition to Christmas Island by C.W. Andrews (reprinted from the author's paper read before the Royal Geographical Society, November 28, 1898) in the Geological Magazine, Dec. IV, Vol. VI (1899), pp. 19–27.

peak." We venture to think, however, that this assertion, qualified though it be, is still rather stronger than the evidence.

Owing to the dolomitization and phosphatization of the limestones the palæontological collections were not rich. The few Molluscan remains obtained are described by Mr. R. B. Newton. The corals, which were more abundant, but still not in so satisfactory a condition as could be desired, were carefully worked out by Dr. Gregory, and include representatives of nineteen determinable species, of which eight are new. Their general character is typically Indo-Pacific.

The Foraminifera, of which the limestones, especially the Miocene (orbitoidal), are largely composed, had mainly to be studied from sections, and are reported on by those past masters of the subject, Professor T. Rupert Jones and Mr. F. Chapman, who have made their work as comprehensive as possible in the time, and hope at some future date to furnish further details. Unfortunately, beyond a "list of species of Orbitoides" there is no summary of the results set forth in the thirty-nine pages to which their report extends.

A "note on the composition of some dolomitic and other limestones" from the island, by Mr. E. W. Skeats, completes the geological matter in the monograph.

As regards the get-up of the work, we are glad to note that the print is better than in many Government publications with which we are acquainted, whilst the plates, although somewhat closely cut, are of the quality which we have become accustomed to expect in the publications of the British Museum. Concerning the views reproduced in the text, however, we prefer to be silent: our remarks might be considered libellous. B. B. W.

III.—Report on the Great Earthquake of June 12th, 1897. By R. D. Oldham, A.R.S.M., F.G.S., Superintendent, Geological Survey of India. Mem. Geol. Survey of India, vol. xxix. (Calcutta, 1899.)

PHYSICAL geologists will with one accord be grateful to Mr. Oldham for his admirable report on the Indian earthquake of 1897. Chief among modern shocks, if not among all recorded shocks, the wonderful phenomena which it presented, and the wide area over which they were observed, combined to render the earthquake in every way remarkable and deserving of the most careful study. Fortunately, it was possible to give to it the attention which its exceptional character demanded. Four officers of the Indian Geological Survey were despatched to different parts of the area chiefly affected, and, about six months later, Mr. Oldham made as thorough an examination of the epicentral tract as his limited time and the impracticable nature of the country would allow. The results of all this labour are as important as they are novel and interesting; and those who have been engaged in similar work will be the first to recognize that we are here presented with a record report as well as a record earthquake.

The study of such an earthquake must have been an almost unalloyed pleasure to its investigator. There was no need to spend three or four months in flooding the disturbed area with circulars, though work of this kind had of course to be done. The materials to be collected were not the fleeting impressions of a transitory phenomenon; they were for the most part permanent effects that could be examined without haste, suffering little from the lapse of time and nothing at all from defects of the human mind. They had to be observed, disentangled, and classified,—no light work, rather one requiring, and, what is more, obtaining, the best energies of a capable field-geologist.

It would not be easy within moderate limits to refer to all the points of interest that are to be found in this report. Though filling a complete volume of the Memoirs, and extending to more than 400 pages, it should be read from cover to cover, not by seismologists alone, but by every geologist who wishes to study the mechanics of mountain-building or to realize the scale on which the operations of nature are sometimes carried out. In doing this, he will no doubt be struck by some passages more than by others. Among them he will probably include the descriptions of the fissures that were formed in alluvial ground far away from river-banks, etc. (pp. 88–94), of sand-vents and the forcing up of river-beds and the bottoms of wells (pp. 99–107), and of the numerous landslips (pp. 111–123); the chapter on the earthquake-sound and on Barisâl guns (pp. 191–207); the investigation of the velocity of the earth-wave within the disturbed area (pp. 53–77), and the tracking of the unfelt vibrations through the body of the earth and of the surface-undulations almost completely round the globe (pp. 227–256). To the physicist the last-named chapter will prove the most interesting; but the geologist will probably regard with the highest favour that which deals with the permanent changes in the epicentral tract. Here we have described the Chedrang fault-scarp (pp. 138–147), which crosses many times the river of that name, forming a series of waterfalls and lakelets along its course; the Bordwar fracture (pp. 148–151); numerous pools, due to a reversal of drainage, but without any visible connection with faulting (pp. 152–157); changes of level evidenced by the visibility of rivers and roads formerly hidden by intervening hills (pp. 157–163); and, in an appendix which properly belongs to this chapter, an account of the re-survey of certain trigonometrical stations within the epicentral area (pp. 361–371), the chief result of which is to show the urgent need of its repetition on a much larger scale.

Exceptional as the Indian earthquake was, one cannot read without astonishment of the vast district over which these permanent changes took place. Mr. Oldham estimates that it was about 200 miles in length, not less than 50 miles in breadth, and more than 6,000 square miles in area. The fault-scarps and fractures discovered within it are merely evidences of displacements continued up to the surface. They manifest the extreme complexity of the earthquake's origin, which Mr. Oldham traces to a slide along a huge, but hidden, thrust-plane, inevitably accompanied by nearly simultaneous and more or less visible movements along the minor faults connected with it.

The volume is illustrated by 44 plates and 3 maps, in addition to a large number of woodcuts. There are pictures of damaged and utterly ruined houses, monuments overthrown and twisted on their bases, railway lines crumpled as if they were made of wire, and fissures, sand-vents, and fault-scarps, as well as the diagrams of distant magnetographs and horizontal pendulums. Many of these are worthy of a wider circulation, and will doubtless live again in books made better by their presence. C. Davison.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 23. 1900.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "The Igneous Rocks of the Coast of County Waterford." By F. R. Cowper Reed, Esq., M.A., F.G.S.

The first part of this paper is devoted to a discussion of the field-evidence, as shown by the coast-sections from Newtown Head to Stradbally. The igneous rocks there exposed are divided into the following six categories:—(*a*) The felsitic rocks; (*b*) necks of non-volcanic materials; (*c*) the basic sills and vents; (*d*) intrusions of dolerite; (*e*) intrusions of trachyte, andesite, etc.; (*f*) intrusions of other types. In regard to the age of the rocks, there appear to have been two main periods of volcanic activity: the first, in Ordovician times, was marked solely by outpourings of a felsitic nature; the second, post-Ordovician but pre-Upper Old Red Sandstone, was characterized by a succession of several distinct types of igneous rocks. The lavas and tuffs, interbedded with fossiliferous rocks, have been already described. These are overlain by other felsites and ashes, developed near Great Newtown Head, which show the same dip and strike and partake in the same movements. Next occurred an outburst of green and pink felsites, tuffs, and coarse agglomerates, developed from Great Newtown Head to Garrarus; and possibly the xenolithic felsites and greenish tuffs belong to the same series. It is doubtful whether these were poured out before the first folding of the Ordovician beds, but their strike, when traced inland, agrees with that of the series last mentioned. The intrusion of some irregular masses of felsite-porphyry took place subsequently to the folding; it was followed by small veins of trachyte and andesite; these by basic sills, diabases, etc., and by a few dolerite-dykes and veins. Subsequently the igneous intrusions assumed an acid character, and the felsitic masses of Newtown Head, Knockmahon, etc., were extruded; probably at this time, too, were formed the isolated necks filled with brecciated fragments of the earlier rocks. The felspar-porphyry dykes and isolated felsitic sheets and veins which pierce the folded rocks, particularly west of Kilfarrasy, probably belong to this late period.

The relative age of some of the peculiar types of intrusive rocks is indicated in the paper in those cases in which it can be determined. That those rocks which are later in date than the folding of the Ordovician are older than the Upper Old Red Sandstone is shown (1) by the unconformity of the Upper Old Red Sandstone; (2) by the fact that the latter rock does not contain any interbedded igneous rocks; and (3) by the absence of felsitic or other intrusive rocks from the Old Red Sandstone of the district.

The second part of the paper is devoted to petrological notes on the different rock-types. The felsites are classified by means of their groundmass into microcrystalline, cryptocrystalline, and micro-poikilitic and other types; potash-felsites, potash-soda-felsites, and keratophyres, all appear to be present; some of these rocks are linked to the trachytes and bostonites. The diabases and dolerites are sometimes ophitic, but more usually allotriomorphic in texture. The trachytes and andesites are of various types, and some are probably keratophyres. Quartz- and felspar-porphyries, augite-porphyrites, and several miscellaneous types are also described.

2. "On a new Type of Rock from Kentallen and elsewhere, and its Relations to other Igneous Rocks in Argyllshire." By J. B. Hill, Esq., R.N., and H. Kynaston, Esq., B.A., F.G.S. (Communicated by permission of the Director-General of H.M. Geological Survey.)

A rock originally described by Mr. Teall from Kentallen is used by the authors as a type round which they group a peculiar series of basic rocks discovered in several localities. The rocks consist essentially of olivine and augite, with smaller amounts of orthoclase, plagioclase, and biotite, while apatite and magnetite are accessory. The peculiar feature of the rocks is the association of alkali-felspar with olivine and augite, and the group is related to the shonkinite of Montana and the olivine-monzonite of Scandinavia. The occurrence of the rocks is connected with four neighbouring but distinct areas of intrusion, each characterized by granites and diorites, and by dykes and sills of lamprophyres, porphyrites, etc. In these areas the new rock is the most basic type, and it occurs in the marginal portions of the areas. Close relationships exist between the different intrusive rocks in each area, so that it may be concluded that these constitute a 'rock-series' ranging from granite through augite-diorite towards the olivine-bearing rocks, in the plutonic phase, and from orthoclase-porphyry and porphyrite to augite-lamprophyre, in the dyke-and-sill phase. The whole assemblage appears to have been derived by a process of differentiation from one parent magma; and the order of intrusion has been, in the main, one of increasing acidity. There is further a 'facies-suit' in each intrusion, showing progressive increase in basicity from centre to magma, due to concentration of the more basic oxides in the cooler portions of the magma, which was originally of intermediate composition; from this 'complementary rocks' were produced. It is extremely probable that the underlying magmas of the four intrusive areas resembled one another more or less closely in composition.

II.—June 6, 1900.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "Mechanically-formed Limestones from Junagadh and other Localities." By Dr. J. W. Evans, LL.B., F.G.S.

After reviewing the conditions under which granular limestones may be accumulated by current- or wind-action, the author proceeds to describe the limestone of Junagadh, a deposit some 200 feet thick, resembling in hand-specimens the Oolites of this country, though less firmly cemented together. It is mainly formed of grains consisting of a nucleus of a fragment of a marine organism or foraminiferal test, surrounded by a layer of deposited carbonate of lime. Particles derived from the igneous rocks of the neighbourhood and rounded quartz-grains also occur, but amount to only a small percentage of the rock. The whole is bound together by colourless calcite-cement. The deposit is situate at a distance of 30 miles from the sea, and contains no large fossils of any kind.

Calcareous rocks of similar character are described from other parts of Kathiawad, Kach, the south-eastern coast of Arabia, and the Persian Gulf; some of these contain unbroken marine shells and other fossils. These beds are included by Dr. H. J. Carter under the name of miliolite, on account of the frequent presence in them of the genus *Miliola*.

The author discusses the origin of these deposits, and comes to the conclusion that the grains were formed in sea-water saturated with carbonate of lime: some being deposited by currents in shallow water, and others thrown up as a calcareous beach, from which a portion were sifted out by the wind and blown inland to form æolian deposits, as contended by Professor Blake in the case of certain superficial limestones in Kach. The Junagadh limestone falls into the last group, but must have been formed when the land was at a low level and the sea-shore was at no great distance.

A rapid survey is then taken of similar rocks in other parts of the world, which may be grouped into the same three classes. The remarkable wind-blown foraminiferal deposit of Dog's Bay (Galway) is referred to in some detail; and the author concludes by suggesting that in the Oolites of the Jurassic period we have representatives of all three groups.

2. "Note on the consolidated Æolian Sands of Kathiawad." By Frederick Chapman, Esq., A.L.S., F.R.M.S. (Communicated by Dr. J. W. Evans, LL.B., F.G.S.)

The name miliolite-formation was originally given by Dr. H. J. Carter to certain granular calcareous deposits occurring on the coast-line between the peninsula of India and the mouth of the Indus. The foraminifera and other organic remains in the rocks must have inhabited moderately shallow to littoral marine areas. The minute granules are worn and polished; the prevailing genera of foraminifera are roundish, and would be easily moved by wind; remains of larger organisms are absent; and the deposits are false-bedded. All these phenomena are explicable if the deposits represent the accumulation of material derived from littoral calcareous sand of marine origin, mixed with mineral detritus from adjacent hills. The rocks can hardly be older than Pliocene; and there is nothing in the general character of their organic remains which is inconsistent with a still more recent date. The tests of some of the foraminifera have been filled with limonitic substances or with the yellow, brown, or green varieties of glauconite. Six specimens are described in detail, and lists of the contained foraminifera given. In one instance the granules are all invested with a thin, dark layer, which seems to be the first stage towards an oolitic structure. A note is appended on the foraminiferal wind-borne sands of Dog's Bay (Galway), discovered by Welch.

3. "On Ceylon Rocks and Graphite." By A. K. Coomara Swamy, F.G.S.

Ceylon is surrounded by raised beaches, and has been elevated in recent geological times; fluviatile deposits also occur: the gems for which Ceylon is famous are obtained from gravels in the Ratnapura district. With the exception of these recent deposits, the island probably consists entirely of ancient crystalline rocks. Pyroxene-granulites are recorded from several localities; they are dark in colour and greasy in lustre. Foliation is not evident, but it may appear in thin slices. The minerals most frequently present are augite or hypersthene, or both, plagioclase (usually labradorite), orthoclase-microperthite, garnet, quartz, amphibole, magnetite, apatite, zircon, and biotite—the pyroxene and felspar alone being essential constituents. Varieties approach gabbro and eclogite. The texture is granulitic or granular. Centric structures are very characteristic, probably resulting from the corrosion of garnets. Normal granulites are white or grey, and usually contain red garnets. The minerals are quartz, orthoclase- and microcline-microperthite, plagioclase, and garnet; biotite, magnetite, ilmenite, apatite, and zircon are often present; and the texture is granulitic. Microcline-gneiss, sometimes with hornblende, occurs in conical hills, originating the term domoid gneiss employed by Professor Walther. The minerals include orthoclase- and microcline-microperthite, quartz, plagioclase, biotite, pyroxene, amphibole, pyrite, magnetite, apatite, and zircon. Anorthosite-gneiss, gneissic granite, and pegmatite are also described. Dark diorites (containing amphibole, plagioclase, quartz, pyroxene, biotite, magnetite, apatite, and zircon), dolerite, hornblende-gabbro, and ophitic quartz-norite are also present. The white, crystalline limestones usually contain pale mica and blue apatite; sometimes also colourless pyroxene. Banded scapolite- and wollastonite-bearing rocks are found at Galle. Certain rocks, apparently vein-products, are also described, which contain quartz and calcite micrographically intergrown.

Graphite occurs chiefly in branching veins in igneous rocks, which at Ragedara are granulites and pyroxene-granulites. The relations to the matrix are described, and are held to favour the idea of the deposition of the mineral as a sublimation-product (Walther), or from the decomposition of liquid hydrocarbons (Diersche). Analyses of several of the minerals, including manganhedenbergite, are given; and a bibliography of the geology of the island is appended.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VII.

No. VIII.—AUGUST, 1900.

ORIGINAL ARTICLES.

I.—On the Fauna of the Upper Cassian Zone in Falzarego Valley, South Tyrol.

By M. M. Ogilvie Gordon, D.Sc.

HAVING the opportunity of revisiting Munich, I have drawn up a list of the fossils which formed the basis of the "Upper Cassian Zone," erected by me in 1893. These fossils,[1] when I discovered them in Falzarego Valley in 1891, were then for the most part unknown. The tuffs and breccias in which they occur had been referred by Loretz to the fossiliferous Raibl horizon of the Schlern Plateau, and by Mojsisovics to the much lower horizon of Wengen strata. I found, by careful collection from strata in position, that the fauna, in addition to a fair proportion of St. Cassian types and a few Raibl types, comprised a number of types common both to Cassian and Raibl horizons and a still greater number of species which had not been found elsewhere (Q.J.G.S., 1893, pp. 31, 44, 46, 47).

Judging both from the transitional Cassian-Raibl character of the fauna and from the stratigraphical position of the fossiliferous series in the field, above a zone containing typical St. Cassian fauna, I concluded that this Falzarego Valley fauna represented a palæontological zone younger than the typical St. Cassian fauna as known at Stuores and Prelongei, and older than the lower Raibl fauna as known at Schlern Plateau and described by von Wöhrmann and Koken.[2] I therefore placed it as an independent palæontological zone, naming it Upper Cassian.[3] This determination of an Upper Cassian zone in South Tyrol practically demonstrated the same gradual faunistic transition from Cassian to Raibl zones in South Tyrol which had been demonstrated by von Wöhrmann[4] in the Cardita and Raibl strata of North Tyrol.

[1] My zonal collections from the Enneberg and Ampezzo Upper Trias are in the Palæontological Museum in Munich.

[2] von Wöhrmann und Koken: "Die Faunen der Raibler Schichten von Schlernplateau": Zeitschr. d. D. geol. Ges., 1892.

[3] Ogilvie: "On the Wengen and Cassian Strata in Southern Tyrol," Quart. Journ. Geol. Soc., 1893; "Coral in the Dolomites," Geol. Mag., 1894.

[4] von Wöhrmann: "Die Fauna der sogenannten Cardita u. Raibler Schichten in den Nordtiroler u. bayerischen Alpen": Jahrb. der k.k. geol. Reichs., 1889.

After the publication of my paper in 1893, at Dr. Bittner's request I sent to him in Vienna my private collection of the Falzarego Valley fauna. I hoped that in Vienna, among the South Tyrol collections of the Austrian Geological Survey, a nearer identification of the material might be attained. Thus the fauna has had the advantage of Dr. Bittner's close examination and judgment, and I am now in a position to publish a list of the types named in accordance with the most recent advances in the literature of Alpine Trias.[1] The Lamellibranchs have for the most part been described and illustrated in Dr. Bittner's "Monograph." The Roman numerals and figures entered in the list refer to that work, and the bivalves are enumerated in the order adopted there.

LIST OF FOSSILS.

Abbreviations.—C* = occurrence in Stuores-Cassian zone; R* = occurrence in Raibl zones. S.Pl. after R = occurrence also in the Raibl beds of Schlern Plateau.

	C	R
LAMELLIBRANCHIATA.		
Cuspidaria siliqua, Bittn. (i, 19, 20)	*	...
Gonodon (*Corbis*) *plana*, Mnst., sp.	*	...
Laubeia (*Megalodus*) *strigilata*, Klipst., sp. (ii, 13–18) ...	*	...
Astartopis Richthofeni, Stur	...	* S.Pl.
Myophoriopis lineata, Mnst., sp. (xiii, 1–6)	*	* (?)
Myophoria decussata, Mnst., sp. (xii, 1–8)	*	* S.Pl.
,, *fissidentata*, von Wöhrm.	...	* S.Pl.
Myophoria (?) *solitaria*, Bittn. (xxiv, 27)	...	...
Trigonodus Rablensis, Gredl., sp.	...	* S.Pl.
Cucullæa (*Macrodon*) *impressa*, Mnst., sp. (xv, 1, 2)	*	* S.Pl.
Pinna, sp. inn. (v, 15, 16)	...	...
Avicula Sturi (= pars *A. Gea*, D'Orb.), Bittn. (viii, 3, 4) ...	*	* S.Pl.
,, *Cassiana* (= pars *A. Gea*, D'Orb.), Bittn. (viii, 6) ...	*	...
,, *Cortinensis* (aff. *A. Gea*, D'Orb.), Bittn. (viii, 5) ...	...	...
,, *Tofanæ*, Bittn. (viii, 9–11)	...	...
Cassianella euglypha, Lbe. (vii, 1)	*	*
,, *decussata*, Mnst., sp. (vii, 6–15, 20)	*	* S.Pl.
,, *angusta*, Bittn. (v, 23–26)	...	*
,, *Ampezzana*, Bittn. (vi, 10, 11)	...	...
Hoernesia Johannis Austriæ, Klipst. (x, 10–15)	...	* S.Pl.
Gervillia angusta, Gdf. (ix, 13)	*	*
,, *angulata*, Mnst. (ix, 11–17)	*	* (?)
,, *Ogilviæ*, Bittn.	...	...
Pecten tubulifer, Mnst. (xix, 13–15)	*	...
,, cf. *auristriatus*, Mnst. (xix, 23–26)	*	...
,, aff. *Saccoi*, Par. (xix, 22)	...	*
,, aff. *subdemissus*, Bittn. (xix, 29)	*	...
,, *Landranus*, Bittn. (xix, 21)	...	...

[1] Bittner: "Die Brachiopoden der Alpinen Trias," Abhandl. der k.k. geol. Reichsanstalt, Wien, 1890; "Die Lamellibranchiaten der Alpinen Trias," Theil i, "Revision der Lamellibranchiaten von St. Cassian," Wien, 1895. Kittl: "Die Gastropoden der Schichten von St. Cassian der Süd-Alpinen Trias," Annalen des k.k. naturhist. Hofmuseums, Wien, 1891; "Die triadischen Gastropoden der Marmolata u. verwandt. Fundstetten in den weissen Riffkalken Südtirols," Jahrb. k.k. geol. Reichs., 1894; "Die Gastropoden der Esinokalke nebst einer Revision der Gastropoden der Marmolatakalk," Annalen des k.k. naturhist. Hofmuseums, Wien, 1899. Salomon u. Böhm: "Fauna der Marmolatakalk," Palæontographica, 1895.

	C	R
Lima angulata, Mnst. (var. *opulenta*, Bittn.)	*	...
,, (*Plagiostoma*) *subpunctata*, D'Orb. (xxi, 19, 20) ...	*	...
,, (*Mysidioptera ?*) *spinigera*, Bittn. (xx, 32)	...	...
Mysidioptera aff. *vixcostata*, Stopp. (xx, 30)	...	...
,, cf. *tenella*, Bittn. (xxi, 1)	...	...
Plicatula solea, Lbe.	*	...
,, *Ogilviæ*, Bittn. (xxiii, 20, 21)	...	...
Placunopsis, sp. indet. (xxiii, 16)	...	...
Solen, *Mytilus*, *Anaplophora*, and *Myacites* (in poor specimens).		
GASTEROPODA.		
Dentalium simile, Mnst.	*	...
Acmæa (*Patella*) *campanæformis*, Klipst., sp.	*	...
Patella capulina, Braun (? *granulata*, Lbe.)	*	...
Neritopsis decussata, Mnst., sp.	*	* S.Pl.
,, *armata*, Mnst., sp.	*	* S.Pl.
Neritina imitans, Kittl	*	...
Eucycloscala (*Scalaria*) *ornata*, Mnst., sp.	*	...
Collonia cincta, Mnst., sp.	*	...
Delphinulopsis, sp indet.	...	...
Naticopsis neritacea, Mnst., sp.	*	...
,, *expansa*, Lbe., sp.	*	...
,, aff. *Cassiana*, Wissm., sp.	*	...
Ptychostoma pleurotomoides, Wissm., sp.	*	*
Ptychostoma, n.sp., aff. *Trochei*, Kittl	...	...
Hologyra Ogilviæ, Böhm	...	...
Loxonema, sp.	...	...
Goniogyra, n.sp.	...	...
Natica plicatilis, Klipst.	*	...
Spirostylus subcolumnaris, Mnst., sp.	*	...
,, *columnaris*, Mnst., sp.	*	...
Euthystylus hastile, J. Böhm (*Orthostylus* cf. *Fuchsi*, Kittl)	...	...
Hypsipleura subnodosa, Klipst., sp.	*	...
Cœlostylina crassa, Mnst., sp.	*	...
,, sp., cf. *infrastriata*, Kittl	...	...
Promathildia (*Turritella*) *subornata*, Mnst., sp.	*	...
,, sp. ?	...	...
Pseudomelania (*Turritella*) cf. *similis*, Mnst., sp.	*	*
CEPHALOPODA.		
Aulacoceras inducens, Mojs.	*	* S.Pl.
Orthoceras elegans, Mnst.	*	...
Nautilus, sp. indet.	...	...
Lobites (*Clydonites*) *nautilinus*, Mnst., sp.	*	...
Trachyceras Aon, Mnst., sp.	*	...
Pinacoceras Philopater, Lbe.	*	...
BRACHIOPODA.		
Cyrtina Buchii, Klipst., sp.	*	...
Amphiclina scitula, Bittn.	...	*
Thecospira tenuistriata, Bittn. (aff. *T. Gümbeli*)	*	* (?)
Rhynchonella cf. *tricostata*, Mnst., sp.	*	...
Terebratula, n.sp., aff. *Cassiana*, Bittn.	...	...
Waldheimia, n.sp.	...	...
ECHINODERMATA.		
Cidaris parastadifera, Schafh.	*	*
,, *dorsata*, Braun	*	* S.Pl.
,, *alata*, Ag.	*	* S.Pl.

	C	R
Cidaris Hausmanni, Wissm.	*	*
,, *decorata*, Mnst.	*	...
,, *Braunii*, Desor	*	*
,, *flexuosa*, Mnst.	*	...
,, *Liagora*, Mnst.	*	...
Entrochus (*Encrinus*) *Cassianus*, Lbe., sp.	*	* S.Pl.
,, ,, *granulosus*, Mnst., sp.	*	*
,, ,, *varians*, Mnst., sp.	*	...
,, (*Pentacrinus*) *Tirolensis*, Lbe., sp.	*	*
,, ,, *propinquus*, Mnst., sp.	*	*
Cœlenterata.		
Cladophyllia sublævis, Mnst., sp.	*	...
Isastræa Gümbeli, Lbe.	*	...
Thamnastræa Zitteli, von Wöhrm.	*	...
Toechastræa Oppeli, Volz.	*	...
Stylina, n.sp., and several *Thecosmilia*, sp. ind.		

Reckoning the percentages from the Lamellibranchs as a sure standard, the result yields 34 per cent. new species not yet known in any of the Cassian or Raibl zones of Alpine Trias; 25 per cent. species present in the Stuores-Cassian fauna but not in Raibl horizons; 25 per cent. species common both to Stuores-Cassian and to Raibl faunas; and 16 per cent. species present in Raibl horizons but not in the Stuores-Cassian fauna. The thick-shelled larger habitus of the bivalves at once marks a difference from the Stuores-Cassian fauna, and presents a striking resemblance to the character of recognized Raibl faunas in this district, e.g. the Travernanzes Raibl fauna at the higher horizons in Falzarego Valley and the Schlern Plateau Raibl fauna farther west. This faunistic transition in the bivalves is undoubtedly attributable to renewed local accumulations of tuff and volcanic dust, to strong current action, and the frequent reconstitution of littoral molluscan colonies at one place or another as the eruptive invasions permitted. The same transition seems to have taken place simultaneously in the neighbouring localities of Rimbianco, Misurina, and Seeland Alpe (Q.J.G.S., 1893, pp. 24, 33, 36).

While the list shows clearly the close affinities of this fossiliferous zone with the older Stuores-Cassian fauna, a few observations may be made regarding the affinities with the younger Raibl fauna.

The most commonly occurring genera among the bivalves are *Avicula* and *Cassianella*. According to Dr. Bittner's terminology, two species, *A. Sturi* and *A. Cassiana*, represent the older name of *A. Gea*, while *A. Cortinensis* has close affinity with these species. On the actual ground it was *A. Sturi* which distinguished itself by the number of its representatives. On the other hand, *Avicula Tofanæ* is a more distinctive local type. *A. Sturi* occurs in North Tyrol at a high horizon of the Cardita strata, and continues in the upper (Torer) Raibl fossiliferous series. *Hoernesia Johannis Austriæ* and *Gervillia angusta* likewise continue, both in North and South

Tyrol, in the Upper Raibl zone (von Wöhrmann, loc. cit., N. Tyrol, 1889, p. 250).

Cassianella decussata and *Cucullæa impressa* are present in the Schlern Plateau strata, which von Wöhrmann regards as contemporaneous with the 'Upper Cardita' or 'Lower Raibl' series in North Tyrol.[1] Opinions differ regarding the absolute identity of the two species *Myophoria decussata* and *Myophoriopis lineata*, in the Falzarego fauna, with the types described by von Wöhrmann at Schlern Plateau, but the affinity is certainly close. *Myophoria* (?) *solitaria* has, according to Dr. Bittner, nearest resemblance to a Raibl form, *M.*, sp. *Tommasi*. The *Gervillias* and *Pectens* are genera which are relatively exceedingly rare in the Stuores-Cassian zone, but here, as in Raibl strata, they are of common occurrence and comprise a few species identical with, or closely related to, Raibl species.

Thus, the close examination which the Cortina Lamellibranchs have now undergone has served to prove that the evidence which I gave in 1893 of an Upper Cassian or Cassian-Raibl transition zone was well-founded. Previously to 1893 the only intermediate Lamellibranch fauna known in South Tyrol between the Stuores-Cassian zone and the typical Torer Raibl zone was the Schlern Plateau fauna, but a palæontological gap existed between it and the Stuores-Cassian zone.

With regard to the Gastropods in the foregoing list of the Upper Cassian fossils in Falzarego Valley, the majority of the species are identical with Cassian species. This is natural, since the Stuores-Cassian fauna is characterized by the extraordinary number of small Gastropod species and individuals, whereas the Raibl fauna is characterized by a greater number of Lamellibranchs in proportion to the number of Gastropod species. As a local feature it may be noted that certain species, e.g. *Neritina imitans* and *Scalaria ornata*, are present in relatively far greater number of individuals in the Falzarego area than in the Stuores Meadowland. More important as a sign of transition is the occurrence in large number of individuals of two species, *Neritopsis decussata* and *armata*, which are common both to the Stuores-Cassian zone (in small number) and to the Schlern Plateau and other Raibl faunas. *Ptychostoma pleurotomoides*[2] is a species numerously represented in the Upper Cassian zone in Falzarego Valley and at Heilig-Kreuz, and is one which continues in Raibl horizons.

Another interesting feature in connection with the Gastropods is, that several species are identical with species found in the Marmolata-Kalk or calcareo-dolomitic facies south of this area, and that the beds of dolomitic limestone which immediately overlie the Falzarego tuffs are locally full of Gastropod fossils. The transitional Cassian-Raibl relations of the other groups call for less remark. Amongst the Brachiopods, *Amphiclina scitula*, amongst

[1] von Wöhrmann, "Die Raibler Schichten," m. Uebersichtstabelle: Jahrb. k.k. Reichs., 1893, p. 768.

[2] See Kittl, "Die Gastropoden der Schichten von St. Cassian der Süd-Alpinen Trias": loc. cit., pp. 157–8.

the Echinoderms, *Pentacrinus Tirolensis* and *Cidaris parastadifera*, continue in the highest Raibl horizons. In all groups the revised list is found to fulfil the requirements of a palæontological bridge between the Stuores-Cassian and the Schlern Plateau (or Upper Cardita) strata, and therefore to merit the place I assigned to the fauna in the percentage table and accompanying remarks of my earlier paper (Q.J.G.S., 1893, p. 44; also Geol. Mag., 1894, p. 10 seq.).

I now submit the complete series of Upper Triassic zones in Falzarego Valley.

PALÆONTOLOGICAL AND STRATIGRAPHICAL SERIES.

	Locality: Schlern. Comparative extract from von Wöhrmann's "Die Raibler Schichten": Uebersichtstabelle, 1893.		Locality: Falzarego Valley and Travenanzes. (Cf. Ogilvie, 1893–4.)
Upper Raibl Series.	Horizon *d* (von Wöhr.). Dolomite banks with species of *Megalodus*. Dolomite with coral growths, etc.	Upper Raibl Series.	Dolomite bands and variegated marls. Numerous *Megalodus* fossils: *Megalodus triqueter*; *Megalodus* cf. *compressus*. Thin band of dolomite weathered as terrace. '*Ostræa* marls' and limestones: leading type, *Ostræa montis caprilis*. Thick-bedded limestones, full of imperfect Pecten fossils: *Pecten Hallensis*, etc. 'Cipit Limestone' bed with coral and echinoderm remains. Soft, flaky limestone, with ammonite and nautiloid sp. Gypsum, red marls, dolomitic flagstones, rauchwackes. Hard arenaceous limestones, poor in fossils.
	Horizon *e* (von Wöhr.). Red Schlern Plateau fossiliferous strata with *Myophoria fissidentata* and *Kefersteinii*, *Pachycardia Haueri*, *Trigonodus Rablensis*, *Hoernesia Johannis Austriæ*, *Patella J. Boehmi*, *Tretospira multistriata*, *Joannites cymbiformis*, etc. (Sphærocodien, coral growths, plants, etc.)	Lower Raibl Series.	Brown sandstones, the chief horizon of *Myophoria Kefersteinii* & *M. Whateleyæ*; *Myophoria fissidentata*, *Myophoricardium lineatum*, *Physocardia Ogilviæ*, *Trigonodus Rablensis*, *Hoernesia Johannis Austriæ*; *Pecten*, sp.; *Turbo*, n.sp.; plant stems; numerous coaly fragments, and specks of various mineral ores; 'Cipit Limestones' interbedded with sandstones. Thin band of dolomite weathered as terrace. Red nodular marls of tufaceous character. Quartziferous sandstones with *Trigonodus Rablensis*, *Myophoria fissidentata*, etc., passing into upper horizons of
	Horizon *b* (von Wöhr.). Stratified dolomite.		Cliff of stratified dolomite, and finely interlayered volcanic sand; locally developed as dolomitic limestone, with many Gastropods; in lower horizons interbedded with

Lower Raibl Series (= Cardita Strata, North Tyrol).	Horizon *a* (von Wöhr.). Augite porphyry and tuffs.	Upper Cassian Series.	'Cipit Limestones' and volcanic tuffs; tufaceous marls, impure limestones, lignite, and aragonite. *Spirostylus subcolumnaris*, *Ptychostoma pleurotomoides*, *Neritopsis decussata*, *armata*, *Astartopis Richthofeni*, and crowded fragments of species of *Solen*, *Plicatula*, *Placunopsis*, *Avicula*, etc.
			Pale-greenish tufaceous shales, reddish-brown tufaceous breccias with quartz grains, glassy and metalliferous ore inclusions, limestones with uneven bedding surfaces. These are the chief horizons of Upper Cassian bivalves: *Avicula Cortinensis*, *Tofanæ*, *Sturi*, *Cassiana*; *Cassianella decussata*; *Gervillia Ogilviæ*, *angulata*; *Myophoria decussata*; *Hoernesia Johannis Austriæ*; *Lima angulata*; *Pecten Landranus*, *tubulifer*; *Trigonodus Rablensis*; etc.
		Lower or Stuores-Cassian Series.	Irregular crags and blocks of 'Cipit Limestones' in tuffs.
			Dark tufaceous earth and marls; thin-bedded shales and limestones containing rich fauna of small forms, in typical 'Stuores' character: *Cardita crenata*, *Koninckina Leonhardti*, *Trachyceras Aon*, *Nucula lineata*, *strigilata*, *Schizogonium subcostatum*, etc.
			Gypsiferous marls, aragonite, tufaceous grits and shales with 'Cipit Limestones'; sponges, corals, echinoderms, *Posidonomya Wengensis*, etc.
		Wengen Series.	Ashy and felsitic series, black tufaceous earth, occasional dark bituminous limestones: *Halobia Lommeli*, *Posidonomya Wengensis*, plants, etc. (for Stuores-Cassian and Wengen Series, cf. aut., 1893, p. 16).

The Lower and Middle Cassian horizons, distinguished by me in 1893, are here combined as one palæontological zone, the Lower or Stuores-Cassian zone; since, although the subdivision is useful in field survey, the horizons are not palæontologically independent.

The stratigraphy of the Upper Cassian zone in Enneberg and Ampezzo is more difficult than the palæontology, since the lower Raibl fossiliferous sandstones are replaced by various local facies, wholly dolomitic (as at Lagazuoi), or developed as a series of dolomitic limestones and irregular banks of dolomite, interbedded with marls and sandstones (as at Roces Alpe).

In Falzarego Valley the Upper Cassian tufaceous series rests conformably upon Cassian strata containing the typical Stuores fauna, and is succeeded by a bed of dolomite of varying thickness, in some places fossiliferous, with Gastropod colonies, coral banks, algæ, etc., in others unfossiliferous and interlayered with volcanic sand

and nodular iron ore. Sometimes the sandy material occurs in patches, sometimes in layers a few inches thick, sometimes in layers as fine as the finest dust. The chemical decomposition of the calcareous and the volcanic material and the weathering-out of the finely and coarsely interlayered sands and tuffs from the rock largely account for the frequent occurrence of toothed and fantastic erosion forms at this horizon of the Schlern Dolomite.

The relations of these dolomitic and sandy layers are such as are presented to us in recent descriptions of volcanic and organic muds in the vicinity of oceanic islands, or more generally of 'Red Clay' and pelagic 'Oozes.' I have always held that the deposits of Raibl age represented the actual sediments in South Tyrol in which a dolomitic character may be regarded as original ("Coral in the Dolomites," 1894, pp. 11–13, 20–22), and that it was there associated with chemical decomposition going on contemporaneously with sedimentation. My specimens from this horizon are under examination in Prof. Armstrong's laboratory at South Kensington.

The chemist is confronted in the dolomites with the same possibilities of chemical decomposition and interchange, both in the past submarine and in the present subaerial conditions, which were clearly set forth by Sir John Murray in his Presidential Address to the Geographical Section, British Association, 1899, from which I quote the following passages: "The inorganic constituents of the Pelagic Deposits are for the most part derived from the attrition of floating pumice, from the disintegration of water-logged pumice, from showers of volcanic ashes, and from the débris ejected from submarine volcanoes, together with the products of their decomposition. . . . . . If the whole of the carbonate of lime shells be removed by dilute acid from a typical sample of Globigerina Ooze, the inorganic residue left behind is quite similar in composition to a typical Red Clay. . . . . The volcanic materials in a Red Clay having, because of the slow accumulation, been for a long time exposed to the action of sea-water, have been profoundly altered. The massive manganese-iron nodules and zeolitic crystals present in the deposit are secondary products arising from the decomposition of these volcanic materials."

The development of organic and inorganic muds, with all possible variations in the alternative bedding, is the normal character of the Schlern Dolomite within Enneberg and Ampezzo. And, as I previously pointed out, the contemporaneity of this dolomitic series, in whole or in part, "*with fossiliferous Raibl strata elsewhere* (e.g. *the Schlern Plateau strata*) *would in nowise afford evidence of the Coral Reef Theory, but only of the familiar fact of Raibl heteropism.*" ("Coral in the Dolomites," 1894, p. 13.)

The dolomite cliff and marls in Falzarego Valley, Roces Alpe, and Travenanzes are succeeded by a well-defined group of sandstones, shales, and shaly limestones, in which a typical Raibl fauna occurs. The fossils enumerated at this horizon, in the above table of Upper Trias, were all personally collected from a number of places along this high mountain terrace above the valley. Strange to say, I never found *Pachycardia Haueri*, which is such a numerously represented type in the Schlern Plateau strata. The limited colonial aspect of local faunas seems to have been the leading palæontological feature of the Cassian-Raibl period.

Whilst the age of the intervening calcareo-dolomitic and sandy series is quite securely fixed by the presence of the *Myophoria* and *Ostræa* fossil zones above, and the *Avicula Tofanæ* and *Cortinensis* fossil zones below, I have always referred to it in previous papers as "Schlern Dolomite," following the original intention of von Richthofen, who applied this term to any dolomitic facies of Upper Triassic tufaceous series in the district. The fossiliferous Upper Cassian tuffs are present at Pec di Palu, south of the Falzarego road, and may be followed over Valparola, Pordsi, and Sella Pass to the south of Langkofl and Mahlknecht. Remnants of the series occur at Cra di Mont, Crap di Sella, Freina Meadow, and elsewhere farther north.

I already showed, in 1893–4, that throughout Enneberg and Ampezzo the *horizons of Raibl time were those which displayed the most extreme and complex facies relations.* All Raibl zones pass now at one place, now at another, into local massive developments of Schlern Dolomite (e.g. Lagazuoi, Dürrenstein, etc.). The Upper Cassian zone also presents varying local facies relations *within* Enneberg and Ampezzo, but the Wengen and Stuores-Cassian zones underlie the dolomitic deposits in Enneberg and in all parts of Ampezzo which I have examined. Thus, the identification of successive palæontological zones proves that the tufaceous invasions overspread the floor of the Enneberg and Ampezzo areas more generally in the earlier periods of the Upper Trias epoch in South Tyrol. And the passage-limit between the tufaceous material and the ordinary sediments was at that time locally situated within that wide 'Buchenstein-Mahlknecht' series of lavas and tuffs which represents one of the chief local areas of contemporaneous eruptive fracture-planes. These are the heteropic conditions which I have depicted in a series of diagrams, showing the successive stages in the accumulation of deposits, and the intermixture from time to time of volcanic material during the Wengen, Cassian, and Raibl periods ("Coral in the Dolomites," 1894, Geol. Mag., Pl. II).

In the second part of the same paper (in the Geol. Mag.), Sasso Pitschi (a small mountain that occurs in the Buchenstein-Mahlknecht passage-area of facies) was selected as an example of the tendency displayed by later differential movements to coincide with the original passage-areas between different lithological groups of strata, whether these areas occurred in the horizontal extension of different rock facies, as at Sasso Pitschi, or in the ordinary geological succession. My publication[1] in 1899 rests on the same standpoint.

[1] "Torsion-Structure of the Dolomites": Quart. Journ. Geol. Soc., 1899. Attention may be directed here to a printer's slip that unfortunately evaded me in the proofs, and which causes some confusion: see p. 580, under '5,' near the bottom of the page: "A and C to be moved counterclockwise, B and D clockwise," should read "A and C to be moved clockwise, B and D counterclockwise."

Subordinate movements have readily taken place at the planes where the more rigid and the more plastic rock-groups have been next one another. Thus local conditions have produced local modification of the more general movements due to compression and cross-compression of this district in subsequent epochs of Alpine upheaval.

In addition to its use in the solution of the stratigraphy, the value of an Upper Cassian fauna is in the link it adds to the Upper Trias chain of faunas in South Tyrol. Its discovery and its identification by me in 1893 as a transitional Cassian-Raibl zone established, for the first time in South Tyrol, a closely connected series of palæontological zones traceable through Wengen-Cassian-Raibl periods. The Upper Cassian zone has therefore given important evidence of the impracticability of placing a palæontological limit between Middle and Upper Alpine Trias anywhere within that series. The transition from Raibl horizons to Dachstein Dolomite in Enneberg and Ampezzo also takes place quite gradually, as evidenced by species of the genus *Megalodus*. Hence the only subdivision between Middle and Upper Trias which seems natural in the 'Dolomites' is between the Upper Muschelkalk (Buchenstein strata of some authors) and the Wengen series, that is, at the horizon of Triassic time, when eruptive material began to be incorporated with the local sediments of that area. (Cf. von Wöhrmann, "Die Raibler Schichten," 1893; Rothpletz, "Querschnitt," 1894; Salomon, "Palæontographica," 1895; von Zittel, "Zeitschrift," 1899.)

A farther confirmation of the presence of a transitional Cassian-Raibl fauna in the 'Dolomites' has been given by the fauna in the '*Pachycardia* Tuffs' of the Seiser-Alpe. Geheimrath von Zittel, who made the discovery, during a geological excursion with his students, that these tuffs contained a large number of Raibl forms in addition to Cassian forms, has since published a short account of the faunal characteristics of these tufaceous horizons at the Seiser-Alpe (von Zittel, "Zeitschrift," 1899; also Rothpletz, "Zeitschrift," 1899). The preliminary notes on the stratigraphy given by Prof. Rothpletz show that these tuffs at the Seiser Alpe rest conformably upon strata containing a Stuores-Cassian fauna, so that in this important feature their position at the Seiser-Alpe agrees with that which I determined at Falzarego Valley and other localities. The 'Cipit Limestones' also occur, as blocks or irregular banks, at various horizons, in the way that I described for other localities along the Buchenstein-Mahlknecht area of eruptive invasions. "Along the hem of this volcanic girdle communities of Corals and Echinoderms settled and formed a series of small barrier reefs (Cipit Limestones), frequently interrupted in their growth by fresh lavas" (aut., l.c., 1894).

But, compared with the Falzarego Valley fauna, the '*Pachycardia*-tuff' fauna bears a distinct local impress. For example, just as I never found *Pachycardia Haueri* in the higher Raibl horizons of Falzarego Valley, so I never found *Pachycardia rugosa*, the leading fossil of the *Pachycardia* tuffs, in the Upper Cassian zone of Falzarego Valley. Both may be there, as my personal collection can only represent a small part of the fauna, but they at least cannot be common.

A similar impression of narrow spacial limitation is given by each of the local developments of a fossiliferous Upper Cassian zone, at Heilig Kreuz, Seeland Alpe, Misurina, and Rimbianco. This horizon of Upper Triassic time is characterized, therefore, not only by marked differences in the local lithological facies, but also by marked local specializations in the aspect of contemporaneous faunas inhabiting neighbouring seas and lagoons. Many of the fossils have affinity with Cassian or Raibl species, yet can neither be identified with, nor clearly distinguished from these. Hence, we may regard it as probable that those specialized Upper Cassian faunas included, amongst the species peculiar to themselves, certain types due to strong adaptation or to retrogression. And we may learn from the faunas of the Upper Cassian zone, no less than from those of the higher Raibl zones, that there are biological questions in South Tyrol which concern the occurrence of pelagic and of littoral faunas as local colonies in a neighbourhood of very unequal depth and subject to volcanic interruptions in the form of lavas, tuffs, and fine volcanic sand. These questions are one with the consideration of lithological facies in the same district.

The following table of Upper Trias strata in South Tyrol represents the zonal succession and local occurrence of facies as described in former papers (cf. Geol. Mag., 1894, Pl. II, and Q.J.G.S., 1893, p. 16).

<table>
<tr><th></th><th>Fassa-Schlern, south of the Buchenstein-Mahlknecht eruptive fractures.</th><th colspan="2">Within Enneberg and Ampezzo, north of the Buchenstein-Mahlknecht eruptive fractures.</th></tr>
<tr><td rowspan="6">Upper Trias (South Tyrol).</td><td colspan="3">Dachstein Dolomite.</td></tr>
<tr><td>Raibl series.</td><td rowspan="3">Schlern Dolomite</td><td>or Upper Raibl series (von Wöhrmann), with Ostræa and Megalodus beds.</td></tr>
<tr><td rowspan="4">Schlern Dolomite.</td><td>or Lower Raibl series (von Wöhrmann), equivalent to Upper Cardita series in North Tyrol, represented by "red Schlern Plateau fossiliferous series" or by a varying thickness of stratified dolomite in South Tyrol.</td></tr>
<tr><td>or Upper Cassian tufaceous series (Ogilvie), with Avicula beds.</td></tr>
<tr><td colspan="2">Cassian series in 'Stuores' development.</td></tr>
<tr><td colspan="2">Wengen series, with Halobia Lommeli.</td></tr>
</table>

Upper Zone of Muschelkalk or Middle Trias.

As, however, Baron von Wöhrmann, in his comparative work on "The Raibl Strata," found the palæontological transition quite gradual throughout the Cardita and Raibl zones in South Tyrol, he included the whole series from the *Halobia Lommeli* to the *Ostræa* beds as Raibl strata in wider sense (cf. "Uebersichtstabelle d.

Raibler Schichten": Jahrb., 1893). Hence, to continue to call the 'Red Schlern Plateau' series 'Lower Raibl' would undoubtedly cause confusion. The distinction of Upper, Middle, and Lower Zones in a series of 'Raibl strata' (using the term in the now wider sense given by von Wöhrmann), might be locally possible, but at the present time it is more important to arrive at a clear presentation of the complete series of palæontological zones in each Alpine locality. Thus in South Tyrol we have :

LEADING FOSSIL-TYPES

in the Wengen-Cassian-Raibl series ('Raibler-Sch.' in wider sense, von Wöhrmann).

	'TORER'-RAIBL ZONE: *Ostræa montis caprilis*, *Megalodus triqueter*, etc. (diverse local developments of volcanic marls and sand, limestone, gypsum, dolomite).
	'RED SCHLERN PLATEAU' RAIBL ZONE: *Pachycardia Haueri*, *Myophoria Kefersteinii*, *Myophoricardium lineatum*, etc. (diverse local developments of volcanic sand and calcareo-dolomitic facies; molluscan faunas contain almost exclusively Raibl species).
All pass into the Calcareo-dolomitic facies in South Tyrol; von Richthofen's 'SCHLERN DOLOMITE.'	UPPER CASSIAN OR TRANSITIONAL TUFF ZONE: *Avicula Sturi*, *Tofanæ*, and *Cortinensis*, *Pecten Landranus*, etc. (diverse local facies of Upper Cassian series, containing a mixed fauna of Cassian and Raibl species).
	STUORES-CASSIAN ZONE: *Koninckina Leonhardti*, *Cardita crenata*, *Nucula strigilata* (tufaceous, marly, and calcareous series, containing almost exclusively Cassian species).
	WENGEN ZONE: *Halobia Lommeli*, *Monophyllites Wengensis*, *Trachyceras Archelaus*, *Posidonomya Wengensis*, etc.; series of shales and limestones, grits, tuffs, and lavas.

SUMMARY.

(1) Conformably above strata containing the typical or Stuores-Cassian fauna as known before my paper of 1893, and below any palæontologically well-defined Raibl horizon, so regarded before von Wöhrmann's paper of 1893, I found in Falzarego Valley in 1891 a series of tufaceous breccias, shales, and quartziferous sandstones, containing a transitional Cassian-Raibl fauna, and passing upward into interstratified dolomite, dolomitic limestone, and volcanic sand and marl, or into a wholly dolomitic group of strata. The latter I termed 'Schlern Dolomite,' stating it to be the time-equivalent in part, or wholly, of the 'red Schlern Plateau fossiliferous strata' which von Wöhrmann had in 1892 called a Lower Raibl zone in South Tyrol. Revised identifications of my Falzarego Valley material, carried out in accordance with the recent special monographs on Alpine Molluscan faunas by Dr. Bittner, Dr. Kittl, Dr. J. Böhm, and others, have fully corroborated the palæontological position which I gave to the fauna in 1893–4 as a local 'tuff' facies

of part of the Schlern Dolomite, comprising a gradual transition from a typical Stuores-Cassian fauna to the 'Travenanzes' Raibl fauna of the Falzarego district.

(2) The Wengen and Stuores-Cassian fossiliferous tufaceous series are present throughout the district of Enneberg and Ampezzo in complete zonal development. These palæontological zones are therefore *not*, as has been said, the tufaceous facies of the dolomitic rock composing the massives in these areas. On the other hand, the Upper Cassian zone and the higher Raibl zones are developed in varying degree *within* Enneberg and Ampezzo as local facies of local dolomitic sediments. 'Cipit Limestones' (the true coral-reefs of the district) occur both in the tufaceous and in the dolomitic facies at all horizons as occasional local beds of comparatively small thickness (loc. cit., Geol. Mag., 1894).

(3) The Wengen and Stuores-Cassian tufaceous and calcareous series of Enneberg and Ampezzo represent time-equivalents of part of the calcareo-dolomitic series south of the Buchenstein-Mahlknecht passage-area of facies, that area having been one of the chief localities of contemporaneous eruptive fracture-planes.

(4) In many cases the passage-areas between facies of different lithological character, as well as the passage-bands between subjacent rock-groups of different lithological character, have been the seat of subsequent differential movement or distortion. So that the complex local developments of passage-areas and passage-bands in the Upper Trias of South Tyrol have induced many local effects of cross-movement which now complicate the stratigraphy of that district.

(5) The more general movements associated with Cretaceous-Tertiary upheaval in the Eastern Alps have called forth an east-west strike, which must be regarded as fundamental in the district, and also a cross-compression from east and west or slightly oblique directions. The complex resultant system of folds, faults, and overthrusts has been cut by subsequent faults associated with local subsidences.

II.—The Geology of Bad Nauheim and its Thermal Salt-Springs.

By A. Vaughan Jennings, F.L.S., F.G.S.

I. Introduction.

The eastern extremity of the wooded range of the Taunus, where its last spurs slope down to the Wetterau Plain and the streams from its valleys give up hurrying and wander lazily across the fertile flats towards the Main, has been a spot rich in interest since at least pre-Germanic times. The ancient Kelts, when overwhelmed by their Germanic foes, left behind them, now deep in the detritus at the foot of the Johannisberg, their hearths, chisels, and millstones, mixed up with shells and bones. In addition to these typical relics of the race, there have also been found special forms of earthen vessels, used evidently for evaporating the waters of the saline springs. The tribes described by Tacitus as being in possession at the end of the first century do not seem to have been similarly enterprising, but it is known the victorious Romans of the third century resorted thither for medicinal baths.

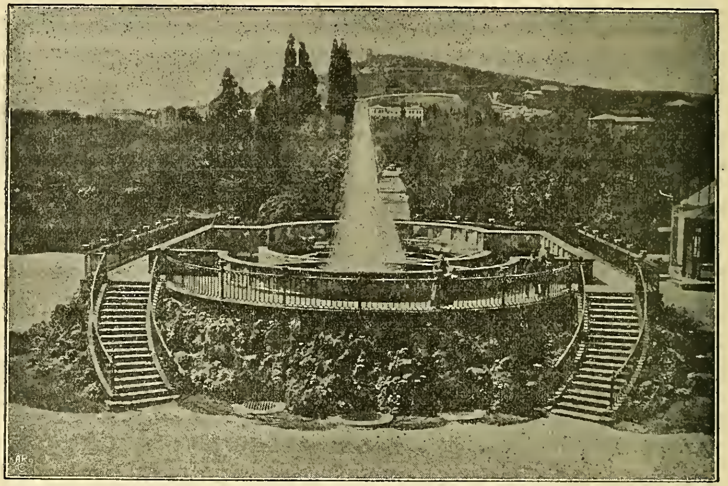


Fig. 1.—Bad Nauheim. View looking west. In the foreground the Grosser Sprudel and Friedrich-Wilhelm's Quelle [Borings 7 and 12]. The Johannisberg in the distance.

The place was, in fact, a Roman sanatorium sixteen centuries before the modern Teuton evolved the 'Kur' to music, or the somewhat over-subtle phonendoscope whispered in the doctor's ear of fell diseases that are at work below, and perhaps, occasionally, of some that are not. In mediæval times and throughout the later centuries its ancient reputation was sustained and increased. The nineteenth has seen the opening of a system of baths in 1835, which has so advanced in public estimation that the number of visitors has risen in 60 years from 189 to 17,760, and of baths from some 112,000 in 1890 to over 227,000 in 1897.

It is not, however, the object of this paper to give statistics or to advertise a health resort. The above figures are quoted only to indicate the growth of the place as a justification for giving some account of its geological features in English. Several thousands of the visitors annually are British, and I have found that there really is a small percentage, even of these, who would be glad to know something of the structure of the country which produces the waters they seek to benefit by.

It is a matter of great difficulty to obtain information on the spot, as the geological map and its description are old and out of print; while the excellent guide, written in 1888 by Herr Bergrath Otto Weiss[1] and Dr. Groedel, contains in its geological chapter some views as to the order of succession of strata which later research has corrected, and is insufficiently illustrated to give a clear idea of structural features. This is my excuse for attempting to give some sort of account of the district, though an imperfect one. For many of the details I am of course indebted to the older works mentioned at the end, but on the other hand a considerable part of the following notes are from personal observation, though made only on short excursions under conditions of a necessarily limited activity.

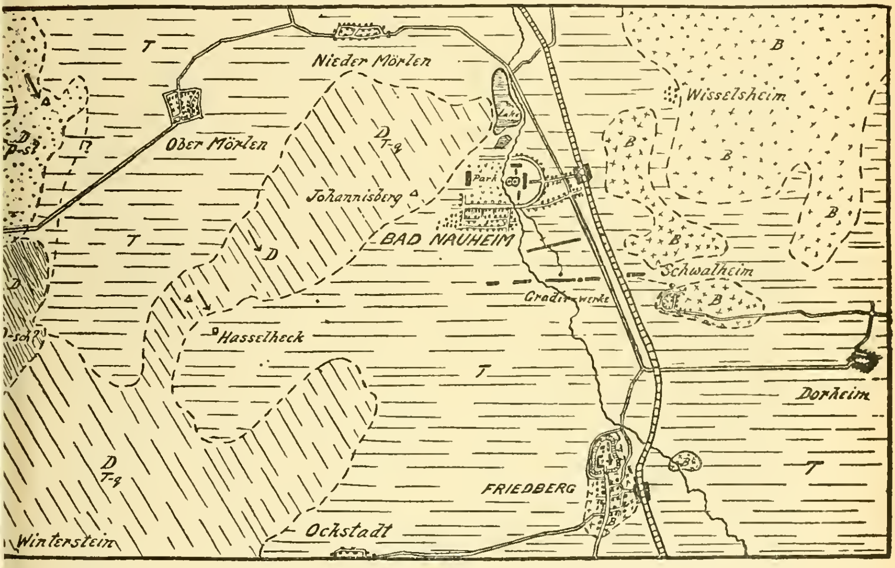


FIG. 2.—Geological Sketch-map of country around Bad Nauheim.

B. Blättersandstein. O. Orthoceras-schiefer.
D. Devonian series. Sp. Spiriferen-sandstein.
T. Taunus-quarzit.

II. General Physiography.

The old village of Bad Nauheim, and the new town which has grown up beside it round the springs, lie at the foot of the Johannisberg. The hill, rising 858 feet above the sea and about 390 feet above the plain, is wooded at the top and on the northern slopes;

[1] Herr Weiss has been identified with the history of the locality from the earliest days of organized baths, and knows more than anyone else as to the various borings. He was most courteously willing to give all information, but unfortunately his illness prevented my profiting by his store of knowledge, except in a few minutes interview when I was on the point of leaving.

vine-clad on its steeper southern aspect, but scarred here and there by reddish rock patches where the iron-stained quartzites of which it consists have been quarried for building material or for road-metal. From the summit there is a drop on the south and west to the saddle at Hasselheck, and then a steady rise to the Winterstein and the general mass of the Taunus. Towards other points of the compass one looks over a wide valley-country with rich fields and scattered villages and trees, so that our hill of observation constitutes as it were a promontory running out from the high ground into the plain.

On the south the plain stretches away twenty miles to Frankfurt, merging into the broad valley of the Main. The plain is not, however, a monotonous level, as in the foreground rises the low hill on which stands the old town of Friedberg, with its picturesque turreted tower rising above the ancient fortress. Northward the low country extends past Weisel and Butzbach to the blue distance round the Vogelsberg. To the east the landscape is similarly varied by the low rises behind the railway and the more distant Münzenberg with its double-towered castle.

Taking thus a comprehensive view of the whole district, the geologist will note that there are three distinct scenic elements to be considered. First, the Taunus range which stretches south and west from his point of observation; secondly, the relatively low land on the south, east, and north-east; and lastly, the detached and separated elevations which rise from the plain. To understand the meaning of these three features it becomes necessary to examine the rocks of which they are composed.

A superficial examination of specimens in the immediate neighbourhood shows that the rock is a white or reddish 'quartzite,' using the term in its widest sense; more accurately, a series of compact sandstones and grits which have suffered greater or less alteration.

There is in many places a well-defined flaggy structure, indicating the sedimentary character of the formation. It has a distinctly Palæozoic aspect, and in many places recalls some of the British Devonian strata to the mind. Such is, in fact, the age ascribed to it, as it belongs to the 'Taunus-quarzit,' which, though here devoid of fossils, is now known, by observations elsewhere, to belong to the Lower Devonian series.[1]

The dip of the beds is here a very steep one to the south and east, but many variations will be found in the districts lying to the west. In fact, the whole range is much contorted and the strata doubled up in sharp folds, as has been shown by Koch, Kayser, and others.

Leaving for future consideration the question of the presence of other strata than the 'quartzite' in this Palæozoic ridge, and descending to the lower ground, one meets with a marked change in the character of the rocks, though the wooded condition of the ground and the accumulation of detritus and Post-Tertiary deposits have to a great extent obliterated the abruptness of the transition.

[1] The suggestion of Gosselet (Ann. Soc. Geol. Nord, xvii, p. 300) that the base of the series is Archæan does not seem to be accepted by English or Continental geologists.

In the quarries south of Bad Nauheim or round the village of Ockstadt there is a series of sands, sandstones, pebble-beds, and loosely cemented conglomerates, which are horizontally stratified and evidently of far later date than the rocks of the hill. They are, in fact, Tertiary beds representing the infilling of a great lake which once occupied the whole of the western district.

If one crosses the broad zone of fertile fields covering these later strata, the hill at Friedberg shows another abrupt change. Here, though the outer slopes of the hill are green and gradual, there are rough black crags under the castle of distinctly basaltic appearance. Round Schwalheim and Wisselsheim there are less prominent exposures, but it is easy to ascertain that these eastern elevations are of the same lithological nature.

III. The Rock-Formations present.

It is therefore evident that the three scenic features above referred to have a definite geological meaning, and that the component parts of the whole area may be classed under three corresponding headings—

A. The Palæozoic Ridge.
B. The Tertiary Strata.
C. The Igneous (basaltic) Series.[1]

Before proceeding to a study of the position of the salt springs and borings it will be well to notice in somewhat greater detail the characteristics of these different formations.

A. *The Palæozic Ridge.*

As has been already observed, the Palæozoic rocks are of Devonian age; a series of flaggy, more or less ferruginous, altered sandstones, grits, and 'quartzite.' They are evidently of sedimentary origin and belong to the 'Taunus-quarzit' group; overlying the 'Sericit-schiefer,' but stratigraphically below the other members of the Devonian system. Fossils are apparently absent, though some obscure plant remains are said to have been found near the Winterstein. The strike is N.E.–S.W., and the dip varies from 28° S.E. to 72° or more in the same direction. It is not probable that the student will meet with any other form of Palæozoic rock in the neighbourhood, but if he has an opportunity of consulting the geological map he will find certain other formations recorded. Thus the 'Stringocephalen-kalk' is mapped as occurring near Hasselheck. I have been unable to find it there, and in suggesting a doubt as to its presence I am glad to find I have the support of Professor Wittich. The 'Orthoceras-schiefer' are similarly marked as cropping out by the Teich and north of Nieder Mörlen, but I have not been able to identify them in either locality. The

[1] Throughout this paper the Post-Miocene deposits are left out of consideration. There is doubtless much interesting matter awaiting study in this direction, and Herr Professor E. Wittich (see list of references at end) has studied what he regards as Pliocene and Glacial beds in the neighbourhood.

'Spiriferen-sandstein' is recorded from the borings, but has not been mapped as appearing at the surface in the immediate neighbourhood.[1] In the concluding section of this paper the relationship of these formations will be again referred to, and a possible explanation of their position in the borings suggested. Even if, however, there have been errors of observation in the field, it is probable that the evidence of the borings may be trusted in showing the existence of these formations below the surface. Comparison with other districts would lead one to expect them here, as the usual succession for North Germany is as follows:—

(A) Upper Devonian	Cypridinen-schiefer Goniatiten-kalk	Absent.
[1] (B) Middle Devonian	Stringocephalen-kalk. Calc-schiefer = 'Orthoceras-schiefer.'	
[2] (C) Lower Devonian	Koblenzer Grauwacken Hunrückschiefer	= 'Spiriferen-sandstein.'
	Taunus-quarzit.	
	Taunus-phyllite = 'Sericit-schiefer.'	

B. *The Tertiary Strata.*

The softer, almost horizontally stratified, beds which form the fertile fields of the Wetterau belong, as already stated, to Oligocene times. In the south-west the whole series of strata is well seen, but at Bad Nauheim itself it is only the upper part that is represented at the surface. In the quarries south of the town and round Ockstadt this portion, however, is typically developed and easily observed. In places there are loosely compacted sands, beautifully colour-banded, and reminding one of those at Alum Bay. Other beds consist of coarse quartz-sand with some ferruginous cement, but infiltrated with calcite, the shining cleavage faces of which often extend over considerable areas. Selenite and chalybite are also commonly present. In the coarser beds the pebbles of older rocks are frequently coated with concentric pellicles of yellow, brown, or brilliantly red iron oxides, and a remarkable ferruginous conglomerate results.

In spite of their varied character these strata appear to belong all to the 'Blättersandstein.' Though unfossiliferous here, they contain at Münzenberg such mollusca as *Litorinella*, *Cyrena*, *Unio*, *Cyclas*, and *Helix*, as well as leaves of plants such as *Cassia*, *Rosa*, *Acer*, *Ficus*, *Cinnamomum*, *Sapindus*, *Amygdalus*, and *Cratægus*.

Below the Blättersandstein comes the 'Litorinellen-kalk,' a yellowish limestone with fossils; again partly of fresh and partly of brackish water habit. *Succinea*, *Pupa*, *Helix*, and *Neritina* occur

[1] The nearest is a little west of Ober Mörlen, where it is said to occur with a dip of 40°–50° S.E. in the same strike line as the Oppershofen-Krausberg outcrop, where characteristic fossils occur. A patch of schiefer, believed to be equivalent to those of Pfaffenwiesbach containing *Orthoceras*, is mapped as occurring immediately south of the sandstone.

[2] All these strata are unfossiliferous at Bad Nauheim, but in the Koblenz district contain characteristic types, such as *Rensseleria*, *Meganteris*, *Pentamerus*, and *Ctenocrinus*. In other parts there occur *Stromatopora*, *Calamopora*, *Fenestella*, and *Chonetes sarcinulata*.

together with *Cyrena* and *Mytilus*. A specially interesting feature is the occurrence at Bönstadt of porous limestones, evidently formed by incrustation of Algæ such as *Vaucheria* and *Chara*, with shells bearing a fibrous overgrowth, apparently due to incrustation of *Chætophora*.

Under this lies the 'Cerithienkalk,' with *Nerita*, *Mytilus*, and *Litorina* in association with familiar friends of the Hampshire Basin, such as *Cerithium plicatum*, Lam., and *Cytherea incrassata*, Sow.; passing gradually below into the 'Cerithiensand and Sandstein.' In this case also there are beds with typical land or fresh-water shells—*Helix*, *Bulimus*, *Pupa*, and *Planorbis*—but these occur in narrow and unimportant bands, while the associated strata contain not only the brackish-water genera but also such marine forms as *Perna*, *Fusus*, and *Bulla*.

At the base of the series lies the 'Cyrenenmergel,' a blue or yellow, clayey or sandy deposit, in which the proportion of marine shells is still greater, and includes, in addition to those above mentioned, *Nucula*, *Buccinum*, and *Murex*.

C. *The Igneous Series.*

The hills formed by the third group of rocks in the Nauheim neighbourhood have been spoken of as interrupting the continuity of the Tertiary plain, but they do not rise with the striking abruptness of, for instance, the phonolitic Hohentwiel and neighbouring basaltic hills in Southern Baden. They are low, rounded elevations, except at the north end of the Friedberg outcrop, evidently parts of lava flows rather than denuded volcanic necks.

The rock itself appears to be a typical dark basalt; often compact and without crystals distinguishable by the eye, but at times with distinct clear green olivines. It is rarely slightly vesicular,[1] but shows a slight tendency to columnar jointing in places. Weathering results in the usual pale-brown crust, and often a rough spheroidal structure is revealed in the process.

Surface accumulations seem everywhere to mask its actual contact with the Tertiary beds, but I have been unable to observe any phenomena of metamorphism in the latter. This at first sight gives one the impression that the basalts are older than the Oligocene strata, but there is evidence elsewhere to show that such is not the case. At Wickstadt, for example, the Litorinellen-kalk is overlaid by basalt.

IV. The Springs, Borings, and 'Salines.'

Having thus obtained some insight into the nature of the strata of the district, one is led to consider what is the relationship between the character of these rocks and the presence of the thermal and saline springs to which the locality owes its fame. With this in view it will be necessary to note in some detail the position and

[1] There is a brownish-grey scoriaceous rock, which is used in Nauheim for kerb-stones, etc., but which I could not find *in situ*. Closer observation showed the presence in it of clear blue Hauyn crystals, and it probably comes from the well-known quarries of Niedermendig.

depths of the various borings and some of their characteristic phenomena. As, however, a good deal of statistical information is obtainable from the guidebooks published on the spot, an attempt is here made to direct attention only to such facts as bear on the geological questions involved.

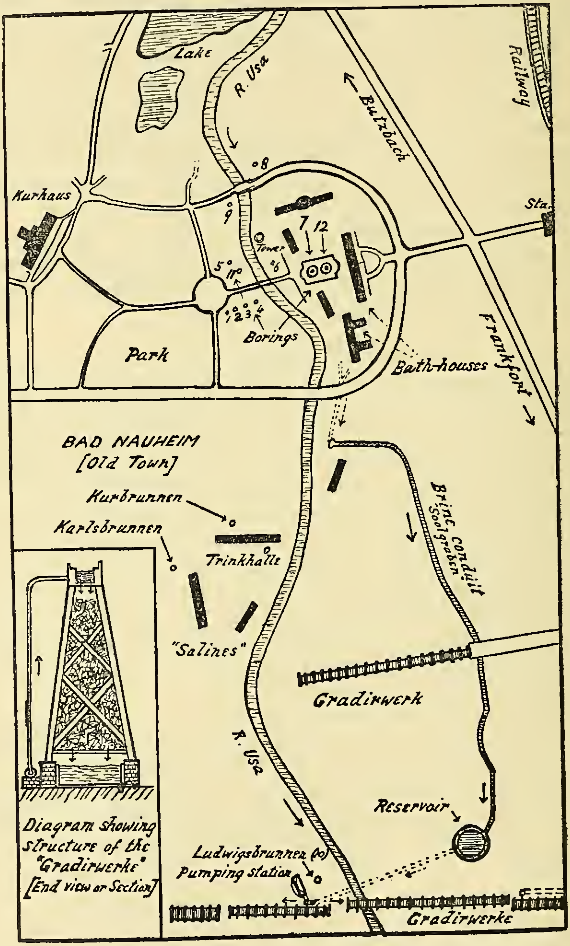


Fig. 3.—Ground-plan of Bad Nauheim showing site of Old Town and New Baths and Park, with Springs and Borings.

The various borings which have been made during the present century in order to obtain a larger supply than that yielded by the small natural springs, have been numbered from 1 to 12.

That known as No. 1 (ignoring an attempt made in 1816) was made in 1823; it was carried down 18 metres, and gave a spring yielding 284,500 litres a day, with 2½ per cent. of salt and a temperature of 25° R. The second, made in 1824, was 153 metres in depth; it gave water of similar composition at 21° R. Nos. 3 and 4 were stopped at 31 and 22 metres respectively.

These four[1] were bored near together in a N.E.–S.W. line on the south-east side of the circular 'platz' which now occupies the centre of the park. No. 5 seems to have been a little north-west of these, and was undertaken in 1838. At 32 metres it gave a supply of 397 cubic metres per day, with 3·55 per cent. of solid matter and with a temperature of 26° R. The 'Alte Kurbrunnen,' known as No. 6, was situated about 100 yards further east, and at 19 metres produced a similar spring with temperature 18° R.

The great boring made in 1839, No. 7, going down to a depth of 159 metres, shares with the last of all (12) the responsibility of supplying the great system of baths. It had been carried down to a depth of 159 metres when, as there was no result, the works were abandoned. In December, 1846, after violent thunderstorms and heavy rains lasting for some days, there was a sudden rush of water up the deserted shaft, and the supply has never stopped since. The water contains a large quantity of carbon dioxide, and solids to the extent of 3·5 per cent., with a temperature of 26–29 R.

Numbers 8 and 9 were experimental borings made a short distance to the northward (between the 'Waitz' tower and the Teich); but the temperature of the water was much lower and the general result unsatisfactory.

The tenth attempt, made a mile south by the third 'gradirwerk,' could only be carried to 65 metres, when it gave an effervescent water with much bicarbonate of soda. It is much used as a medicinal drinking water, and is known as the Ludwig's Quelle (Ludwigsbrunnen).

The eleventh was a small boring 29 metres deep, which subsequently ceased to give any supply.

Lastly, the twelfth, now the Friedrich-Wilhelm's Quelle, was bored in 1855 to a depth of 180 metres, with an 18 cm. diameter. The water did not rise spontaneously at first, and two hand-pumps were employed. In about half an hour a column of water charged with carbon dioxide rose suddenly in the boring, blowing up the pumping apparatus and rising 16 metres above the ground. It was found to give 1,214 cubic metres in the 24 hours, with a temperature of 30° R. and 4·3 per cent. of dissolved solids. The boring is situated only 4 metres east of No. 7, and the two together supply practically the whole bath system. The ordinary thermal brine baths are derived mainly from 12, but there are underground pipes from both sources to supply the effervescent baths, or 'sprudel-bäder,' in the bath-houses 1 and 5.

[1] In the plan (Fig. 3) I have unfortunately numbered these four from west to east, instead of in the reverse order, as correctly shown in the sections (Figs. 4 and 5), but their close proximity and the fact that 2 is the only deep one renders the error of no importance.

Such is a brief summary of the history and nature of the Nauheim borings. From the geologist's point of view the features of interest fall into two series: first, the strata traversed by the borings; and second, the temperature and contents of the waters themselves.

The former question may be more conveniently dealt with in the concluding section of this paper, but it may be noted, in passing, that those borings which are likely to give most help in explaining the subterranean structure are Nos. 1–7, 11, and 12. An almost straight line can be drawn through these, approximately at right angles to the general strike of the rocks.

The results of chemical analysis of the contents of the different springs are given in many of the books of local and medical information published on the spot, and there is no necessity to investigate the numerous variations here. With a view to geological considerations, however, it may be well to reproduce the details of one typical analysis, that of the Friedrich-Wilhelm's Quelle (No. 12).

Amount per 1,000 Grammes of Water.[1]

Sodium chloride	29·29
Lithium chloride	·05
Potassium chloride	1·11
Ammonium chloride	·07
Calcium chloride	2·32
Magnesium chloride	·52
Calcium sulphate	·03
Strontium sulphate	·04
Calcium carbonate	2·60
Iron carbonate	·04
Silica	·02

At the risk of seeming to break the promise given above to keep entirely to such matters of detailed description as bear on the geology of the district, I am tempted to insert here a note on the process by which the concentrated brine, and subsequently the dry salts, are obtained. It is distinctly difficult at first for the enquiring visitor to understand the meaning of the curious structures round the town; and the process is not only interesting from the commercial, chemical, and mechanical points of view, but in some of its features is very suggestive to the biologist and geologist as well.

About the middle of the century the old method of simple evaporation in troughs was discarded and a more elaborate system adopted. A short distance south of the town a number of long tanks across the plain of the Usa were constructed, and above each an immense erection of heavy timber frameworks. The interspaces of these massive structures are entirely filled in with what may in general be termed 'brushwood,' but which consists almost entirely of close-packed bushes of blackthorn. Along the top of each of these 'gradirwerke,' as they are termed, runs a trough containing the water from the springs with nearly all its lime, iron, and salts; and this is allowed to percolate down through the brushwood

[1] These are the chief constituents of the dissolved solids. There are traces of various other substances, but those given here are such as can be recorded in the second decimal place.

masses below. As the water trickles over the twigs the lime and remaining iron oxides are deposited as a stalagmitic crust upon the wood; but the more soluble salts remain, and the water which drips into the underlying tank is a more or less concentrated brine.

Such is the principle of the process, but it takes one a little time on the spot to discover how the mechanical difficulties are overcome. The method seems to be this. The saline waters from the two great 'sprudels' are directed into an open trench, which empties them into a large round tank situated in the fields south of the town. To raise this water to the top of the 'gradirwerke' would appear a difficult task; and yet, in spite of the flat country, the very small quantity of water in the Usa, and the almost imperceptible current, it is performed by means of two water-wheels. The three western 'works' are supplied by a large double pump by the Ludwig's Quelle. There is not sufficient force of water to turn the wheel directly, but having been once started it is able to pump up sufficient water to resupply itself as well as to pass on the remainder up two great pipes to the top of the framework. The eastern 'works' are similarly supplied, but in this case the wheel is as far away as the village of Schwalheim beyond the railway on the east. The 'connecting-rod,' if such it can be called, between the wheel and the nearest of the Gradirwerke is a long series of hollowed tree trunks placed end to end. These are supported at intervals on the axles of pairs of iron wheels, which run on rails laid on the top of low stone walls. The whole row moves backward and forward some eighteen inches with the turning of the wheel. A mechanical system distinctly cumbrous, but as there is no haste necessary in the process it is probably as effective as any other and more economical.

The first of the solid contents of the spring water to separate are the iron oxides, with which the basin of the Great Sprudel is coated. In the trench leading off the waters to the Gradirwerke there is a similar deposit of a powdery red oxide on twigs, leaves, etc., that have fallen in. With the exception of a few diatoms and filaments of cyanophyceous algæ there seems little life here. I had expected to find *Leptothrix ochracea*, but was unsuccessful. Further on, when the lime begins to precipitate, a red porous 'travertine' is produced. Almost all the remaining iron seems removed after passing the tank, as the stalagmite on the brushwood is very rarely tinged with red.

At the present time there is little evident incrustation of the brushwood, owing to its having been comparatively recently renewed,[1] but the lately removed material often shows a crust nearly two inches in thickness, and blocks of it are used all over the neighbourhood as ornamental rockwork for gardens.

In the western salines the brine, freed from lime and iron, undergoes some evaporation, and at times very delicate, hollow, salt stalactites are formed, as well as imperfect or hollow salt crystals like the 'hopper-shaped' crystals, seen by evaporation

[1] I understand that the period of renewal is about every ten years.

of salt solution under the microscope. The brine in the tank at this point is clear, and contains but little life. A few floating patches of a green alga (*Rhizoclonium*?) are, however, generally present.

In the last or most westerly tank the appearance is very different. The water has a stagnant and turbid aspect, and is often covered with bacterial scum. Dense masses of *Vaucheria* form rounded cushion-like growths at the bottom, and the filaments become completely incrusted except at the growing tips. If these had been formed under natural conditions, and subsequent infiltration by lime had occurred, a formation would be produced which can be paralleled by the oblique limestones already referred to as found at Bönstadt in the Northern Wetterau.

The algal masses are crowded in the spring by larval cases of a dipterous insect, some half an inch long, and later in the year the surface of the water swarms with small black flies. As the cases become similarly incrusted they would contribute to rock formation and produce a rich 'indusial' limestone deposit. As the water here contains a high percentage of salts the luxuriant growth of these two organisms is remarkable; and doubtless microscopic study, which I was unable to undertake, will reveal other forms of interest.

V. Geological Problems involved.

Leaving here this brief description of the distribution of the various formations and of the general character of the springs

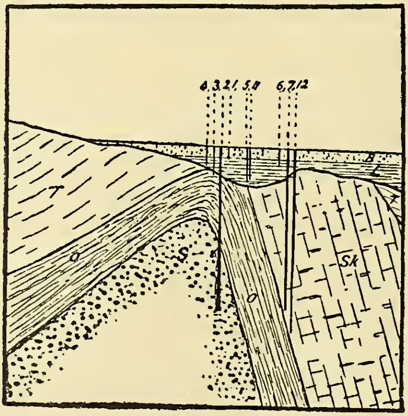


Fig. 4.—Geological explanation of the data furnished by the borings as given by Dieffenbach (Desc. of Geol. Map of Hesse, Darmstadt, 1856).

B. Blättersandstein.	L. Litorinellen-kalk.
T. Taunus-quarzit.	S. Spiriferen-sandstein.
O. Orthoceras-schiefer.	S.k. Stringocephalen-kalk.

and borings, we may turn, in conclusion, to some consideration of the geological problems involved. The chief of these may be enumerated as follows:—(*a*) the underground structure as indicated by the data given by the borings; (*b*) the extent and character of the ancient lake; (*c*) the reasons for the chemical and physical characteristics of the springs; and (*d*) the connection between the eruptive rocks and the general phenomena of the district.

In discussing these points it is scarcely possible in any case to make dogmatic statements, and the following remarks must be regarded only as a statement of the case for investigation.

(*a*) When one examines the published details of the different borings one cannot fail to be struck by the wide differences which exist, in so small an area, between the depths at which the Palæozoic rocks were encountered.

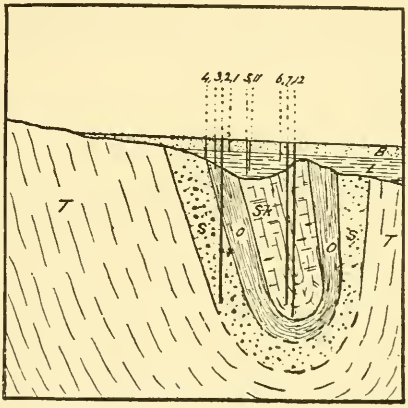


Fig. 5.—Geological explanation of the data furnished by the borings here suggested.

B. Blättersandstein. L. Litorinellen-kalk.
T. Taunus-quarzit. S. Spiriferen-sandstein.
O. Orthoceras-schiefer. S.k. Stringocephalen-kalk.

Although the Devonian rocks of the Johannisberg are dipping south-east at a high angle where they disappear below the Tertiary beds, and are met with at 120 m. in boring 4, yet they are not touched at all in borings 5 and 11. The deep boring 2, on the other hand, while it meets Palæozoic rock at 130 m., does not touch the Taunus-quarzit, but traverses some 165 m. of 'Orthoceras-schiefer' and terminates in 'Spiriferen-sandstein.' Borings 7 and 12, on the other hand, strike the 'Stringocephalen-kalk' immediately below the Tertiaries, and terminate in that formation.

These facts appear to show that in the first place the old land-surface on which the Tertiary beds were deposited has a distinctly irregular contour, and secondly, that by some agency, either folding or faulting, the members of the Middle Devonian series are present under Nauheim at no great depth, but with very limited horizontal extension.

The explanatory section published in connection with the old geological map, a copy of part of which is given on p. 351, looks fairly satisfactory at first sight, but on study is found to contain serious difficulties. The 'Stringocephalen-kalk' on the right can hardly be accounted for without any corresponding mass on the left; and the theory requires that the dip of the 'Taunus-quarzit' on the east slope of the Johannisberg should be represented in exactly the reverse direction to what is actually the case. More serious still is the difficulty that it places the 'Taunus-quarzit' above the other members of the Devonian, whereas it really underlies all but the 'Sericit-schiefer.'

Under these circumstances I thought one might try to make a hypothetical section which would better fit in with the known data; and it seems to me that some such structure as is shown in Fig. 5 would meet the requirements of the case. It is not necessarily true, as there may be considerable faulting, but until there is evidence of the presence of faults it is as well to try to explain matters without their help.

An infolding such as this is just what might be expected from the structure of the Taunus range as a whole. The peculiarities of the boring records are easily accounted for on this supposition, and several other isolated facts fall readily into place. Thus, if it is true that boring 10 in the plain on the east passed through 'Sericit-schiefer' and then touched the 'Taunus-quarzit,' such is what might have been expected, as is shown in Fig. 5. Similarly, the reported outcrop of 'Orthoceras-schiefer' near the Teich-haus is by no means impossible; while the patches of the same rock and of 'Spiriferen-sandstein' mapped to the west of Ober Mörlen can also be accounted for as an infold similar to that below Nauheim.

(*b*) Passing on from the question of these contorted Devonians to the simply and conformably stratified Tertiary beds of the Wetterau plains, one expects a simplification of the task of explanation. Such there is to a certain extent; but, on the other hand, there are new questions of a totally different character which crop up in the endeavour to follow out the history of the country.

While there can be no doubt that the area over which these deposits extend was in Middle Tertiary times an enclosed lake, yet the stages which preceded the isolation of this extent of water are not so easily recognizable.

The fact that mollusca characteristic of brackish water—such as *Cyrena*, *Cerithium*, and *Litorinella*—are found in beds as high as the Blättersandstein, is somewhat remarkable in itself. When we find, moreover, that in the deeper layers there is a much larger percentage of such types, and finally in the lowest strata we have to deal with typically marine genera, it is evident that the succession of beds records a series of great physiographic changes. It seems almost certain that in Oligocene times these districts were covered by sea-waters from the south; and the contours of Central and Northern Europe suggest a similar communication with the ocean on the north.

It seems probable that the district was a dry land area, while the Cretaceous rocks of other parts of Germany were being deposited; that an Eocene or post-Eocene subsidence let in the sea-water from a long northward extension of the Mediterranean reaching from the Marseilles neighbourhood up the Rhône and Rhine valleys, perhaps establishing communication with the North Sea; and that the earth-movements which subsequently completed the upheaval of the Alpine chain separated the northern gulf from the sea to which it had formerly belonged.

The process of severance was doubtless gradual, and allowed of a transition period in which the marine *Murex* and *Perna* were slowly displaced by the brackish-water *Cerithium* and *Cyrena*. In the upper strata there are narrow bands in which the fossils indicate the prevalence of purely fresh-water conditions, but the brackish-water types continued to exist apparently through Miocene times.

(*c*) As to the chemical and physical questions connected with the Nauheim springs, anything like a complete discussion is beyond the scope of this paper. Those who wish to know how far the consideration of the amount of soluble salts in springs, rivers, and seas may lead them in the discussion of the geological age of our planet, should read Professor Joly's interesting paper in the Transactions of the Royal Dublin Society for 1899.

So far as the local questions are concerned we can only make a note or two on, firstly, the chemical contents, and secondly, the physical conditions.

In the first case it is evident that we are not dealing with 'special' types of springs—saline, chalybeate, or calcareous—but with a combination of all. It would be interesting to know the sources of the different contents, but it is difficult to make anything but the vaguest suggestions.

As to the iron, it is evident that a certain amount may come from denudation of the Devonian rocks on the west, and more from the breaking up of the basalts. The extraordinary amount of iron oxides in some beds of the 'Blättersandstein' suggests that they may have contributed large quantities to the underground supply from which the springs now rise, but they, in turn, must have derived it from neighbouring Palæozoic or igneous rocks in Tertiary times.

With respect, again, to the calcareous contents, there seems a much larger proportion than the geological features of the surrounding country would lead one to expect. The limestone strata are of small extent, and anything contributed by the decomposition of the felspars in the basalt would be insignificant. There is, on the other hand, a great quantity of calcareous matter in the Tertiary beds, derived at that date, most likely, from a greater distance and from a larger extent of since denuded limestone in the district. Much of this has been and is still being gradually carried down through fissures to the subterranean reservoirs which the borings have 'tapped.' The lime was doubtless largely separated through the agency of organisms, but in beds of this character the shells would almost certainly be to a large extent redissolved.

It is possible, however, that we have not here sufficient to account for the surface phenomena, especially when we also take into consideration the enormous amount of carbon dioxide in the waters of the Sprudel. Probably there are deep-seated calcareous strata, beyond the reach of the borings, where a high temperature prevails and intense chemical reaction is still in progress.

The soluble saline constituents again offer us much the same problem. The physiographic changes of Tertiary times must have been slow, gradual, and constantly varying, and the alternations of marine, brackish, and fresh-water conditions probably resulted in a large residue of salt in the strata then being deposited. The minerals present in such formations as the Blättersandstein certainly suggest this; but whether or not such a residue is still present, a vast amount has probably been washed down into the subjacent rocks.

If this be considered insufficient as a source of the present regular supply, one is obliged to fall back again on the supposition that there exist below the deepest borings either great salt beds or a stratum of immense chemical activity.

Turning from the question of chemical contents to that of physical conditions, one meets again with questions more easily asked than answered. The most obvious are the cause of the high temperature of the waters, and the reason for their expulsion. As to the former one might suggest a very great depth of origin, but we have no evidence that these springs rise from a stratum deep-seated enough to account alone for their heat. Mechanical pressure, added to such strong chemical activity as may exist at a relatively high level in the earth's crust, even locally, might also account for it in part. In addition to such conditions, however, we have to remember the proximity of great basaltic masses which were themselves in a state of fusion at a period not, geologically speaking, so very remote. As the presence of thermal springs is so commonly correlated all the world over with the existence of comparatively recent volcanic action, it is probable that we are safe in here regarding the present temperature of the brine-springs as residual from volcanic times.

With respect to the cause of the expulsive force with which the waters of the two great 'sprudels' are thrown up, it seems that the German geologists, as a rule, are inclined to follow their great leader Bunsen, who studied the district early in the century and ascribed the effects entirely to the freeing of the carbon dioxide.

That the sudden liberation of gas, with the diminishing pressure as the water rises in the tube, must have a very great effect in producing the violence of the final escape, cannot be denied; but this does not necessarily justify a neglect of hydraulic pressure altogether. The great drainage area of the Taunus, its large rainfall, and the fissures and cavities it contains all seem to suggest the probability of a very efficient hydraulic system at work; and the history of the Great Sprudel, where the first outburst only occurred some years after the construction of the boring, as a consequence of heavy rains, would appear to support this view.

Also, as Professor Cole has pointed out to me, why neglect 'residual pressure'? Just as we may attribute high temperature to the survival, *in extremis*, of volcanic conditions, so the tectonic 'Alpine' movements are not to be regarded as entirely dead, but the remaining strains and pressures in the earth's crust may still be factors in the ejection of these heated waters.

(*d*) With regard, lastly, to the agency of the basaltic eruptions, the considerations involved have been already referred to, and my own observations have been too limited to permit of a definite opinion. A superficial study of the country would lead one to the

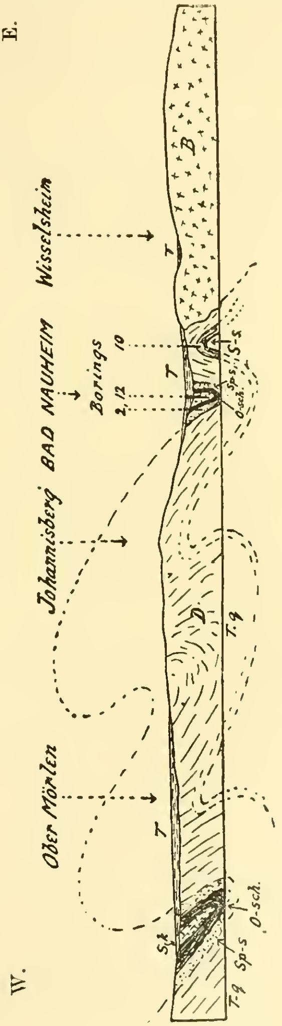


Fig. 6.—Diagrammatic Section through the Bad Nauheim District (East and West).

D. Devonian. (*T.q.* Taunus-quarzit; Sp s. Spiriferen-sandstein; *O.sch.* Orthoceras-schiefer; *S.k.* Stringocephalen-kalk; *S.s.* Sericit-schiefer.)

T. Tertiary (Blättersandstein and Litorinellen-kalk below). *B.* Basalt.

conclusion that the basaltic masses had been consolidated before the Oligocene seas or lakes deposited sediments round their bases, and that they formed islands in the waters of Middle Tertiary times.

There is, however, I understand, evidence elsewhere for the Miocene age [1] of the eruptions, and of a still later date for part of

[1] See note on p. 355.

those of the Vogelsgebirge. One can only conclude that the patches in the immediate neighbourhood of Bad Nauheim represent lava-flows at a considerable distance from the active centres, and that they forced their way through the sedimentary rock, with comparatively little disturbance or metamorphism.

The fact that there are reappearances of basalt between Homburg and Ober Erlenburg and on towards Wiesbaden, suggests the existence of a very wide zone which may have a far greater subterranean extent than the minor surface exposures lead one to expect.

In conclusion, I have to express my thanks for assistance to Professor Kinkelin, of Frankfurt; Professor Brauns, of Giessen; Professor Wittich, of Darmstadt; and Professor Denckmann, of Berlin; to Herr Bergrath Otto Weiss, of Nauheim; and lastly, and very gratefully, to Herr Sanitätsrath Dr. Ferdinand Credner, who, in the interests of geology, treated with a generous leniency a somewhat disobedient patient.

The works mentioned below cannot, of course, be regarded as a complete bibliography. I have only recorded such as were brought to my notice during a brief visit as a starting-point for the next student who has the good or bad luck to find himself at Nauheim.

"Geologische Specialkarte des Grossherzogthume Hessen." Descriptions of (*a*) Giessen section by *Dieffenbach*, 1856; (*b*) Friedberg (including Nauheim) section by *Ludwig*, 1855.

Bad Nauheim: Guide by *Herr Bergrath Otto Weiss & Dr. Groedel*, 1888. (This edition is mentioned here as it contains a chapter on the geology of the district more complete than that of the ordinary guides.)

Kinkelin.—(*a*) "Erlaüterungen zu den geologischen Übersichtskarten der Gegend zwischen Taunus und Spessart": Senckenbergischer Bericht, Frankfurt, 1889. (*b*) "Die Tertiär u. Diluvialablag. d. unteren Mainthales": Abh. z. geol. Specialkarte von Preussen, Bd. ix, Heft 4, 1892. (*c*) "Geol. Tektonik d. Umgebung v. Frankfurt": Senckenbergische Naturforsch. Gesellschaft, 1885.

Wittich.—"Bericht über die geologische Aufnahme der Umgegend von Bad Nauheim": Vereins für Erdkunde und der Grossh. geol. Landesanstalt zu Darmstadt, Folge iv, Heft 19, 1898.

Denckmann.—"Silur und Unterdevon im Kellerwalde": Jahrb. der königl. preuss. geol. Landesanstalt, 1896.

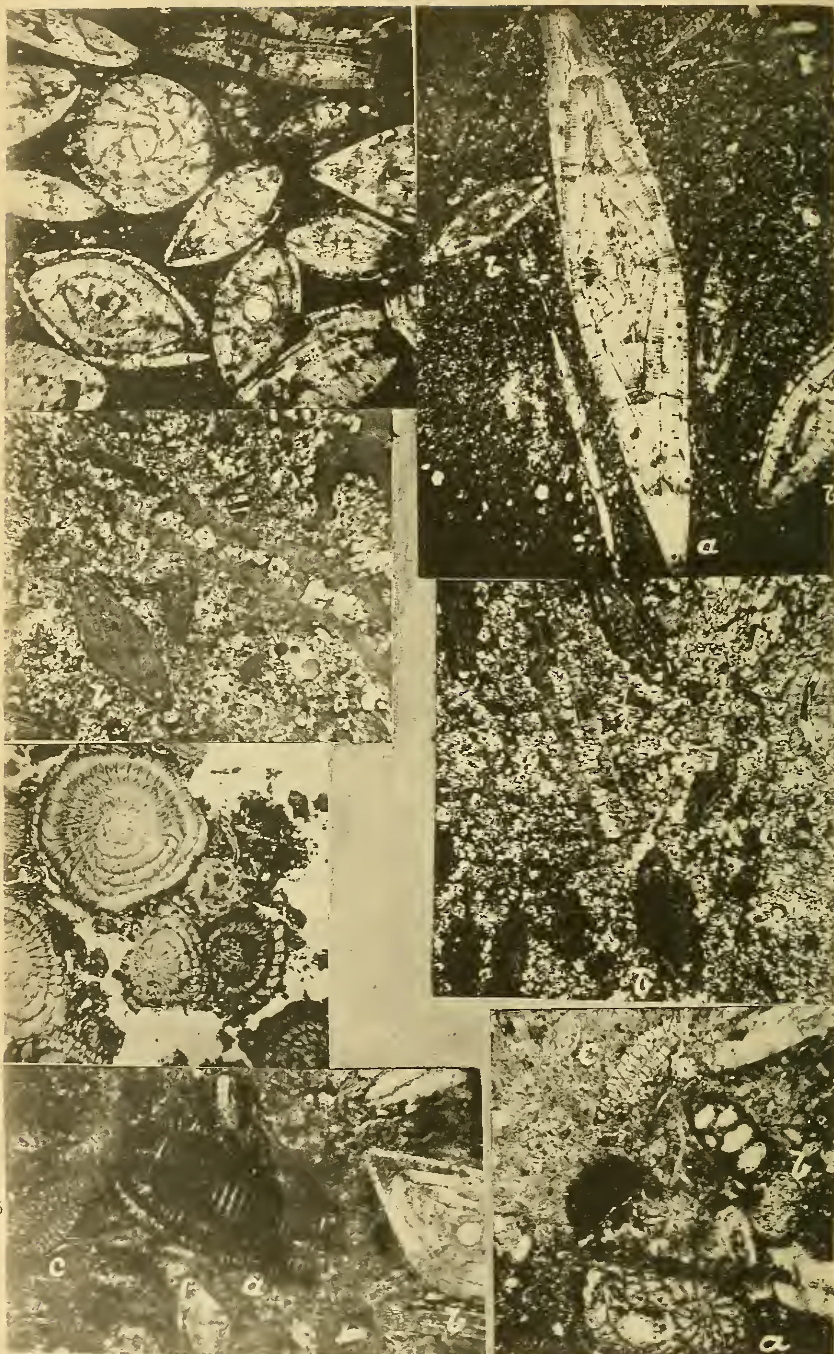
Wagner.—"Chronik von Bad Nauheim," Nauheim, 1897.

Lepsius.—"Geologie von Deutschland," Bd. i (1892).

Koch.—Jahrb. Preuss. Geol. Landesanstalt, Bd. i (1881), Taf. vi, Fig. 1.

Bunsen. — Stud. der Göttingischen Vereins Bergmännischen Freunde, Bd. iv, Heft 3 ("Über de Nauheimer Thermalquellen").

Bromeis. — Jahresbericht. d. Wetterauischen Gesellschaft f. d. Naturkund. ("Grosse Soolsprudel v. Nauheim").



1 ×16

2 ×12

3 ×16

4 ×16

5 ×4½

6 ×16

7 ×16

F. C. Photo.

TERTIARY FORAMINIFERAL LIMESTONES FROM SINAI.

III.—Tertiary Foraminiferal Limestones from Sinai.

By Frederick Chapman, A.L.S., F.R.M.S.

(PLATES XIII and XIV.)

(*Concluded from the July Number, p.* 316.)

Nummulites, Lamarck [1801].

Preliminary remarks on the genus.—The interesting observations on the dimorphism of the genus *Nummulites*, which have been made from time to time by special investigators, such as Von Hantken, Munier-Chalmas & Schlumberger, De la Harpe, Rupert Jones, and Van den Broeck, have resulted in the establishment of couples of so-called species, constituting a species in the zoological sense, in which the smaller form, with a large central chamber, is referred to as form A, whilst form B usually has a larger test and invariably possesses a diminutive central chamber. The two forms are otherwise spoken of as the megalospheric and microspheric forms. In some cases there may be little doubt as to the accuracy of the assignment of the two forms to one species, especially since they may be the only examples present in the rock. In the case of a stratum containing more than two species, however, there may be no small difficulty in coupling the actual forms which constitute the species, for there is often little in either the internal or external characters to guide one in linking the forms. In our present state of knowledge, therefore, it appears to be most convenient to describe the forms under their specific denominations as already known, at the same time pointing out their relationship to one another. Some good suggestions as to the naming of Nummulites and other Foraminifera which exhibit the two modes of growth and shell form have lately been made by Dr. A. Silvestri.[1]

With regard to the older method of grouping the Nummulites according to their superficial appearance and texture, this can be at the best only an artificial method of arrangement, for it sometimes happens that two different forms constituting a zoological species may be found to belong to two of the separated so-called groups; as, for instance, *N. curvispira*, which has been placed in the granulate group, and *N. complanata* or *N. complanata*, var. *Pachoi*, in the group of smooth forms. Moreover, it will be seen by referring to Rupert Jones' Catalogue of Fossil Foraminifera in the British Museum,[2] that *N. curvispira* is an example of the granulate group which does not invariably exhibit the characters ascribed to it.

Nummulites planulata (Lamarck). (Pl. XIII, Fig. 2*a*.)

Lenticulites planulata, Lamarck, 1804: Annales du Muséum, vol. v, p. 187.
Nummulites planulata (d'Orb.), d'Archiac & Haime, 1853: Descr. Anim. groupe nummulitique Inde, vol. i, p. 142, pl. ix, figs. 5*a*, 6*a–c*, 7*a–h*, 8*a–d*, 9*a*, *b*, 10*a–c*.

One recognizes this form by the minute or almost invisible central chamber, and the flatness of the test. In section it exhibits from

[1] Atti dell' Accad. Pont. Nuovi Lincei, Anno liii (1900), pp. 1–10. See also Van den Broeck: Bull. Soc. Belge Géol. Pal. Hydr., vol. x (1896), 1899.
[2] Op. cit., pp. 46, 47, specimens P 1014 and P 890.

four to six whorls, which increase rapidly in breadth (in median section), especially towards the last.

The specimens here dealt with are very typical when compared with d'Archiac's figures. Those forms of the same group or type recorded by De la Harpe from Egypt[1] differ chiefly in their umbonate centre and comparatively sharp peripheral edge.

N. planulata appears to be distributed chiefly through the Lower and Middle Eocene beds of Europe, but it is occasionally found with a higher range. This species has been recorded by Dr. Fraas from Egypt.

Coll. Geol. Surv. Egypt, No. 4,112, Box No. 2*l*. ? Bartonian (Upper Eocene) or ? top of Mokattam Series (Middle Eocene) : Jebel Abyad, beach deposit (later). Common.

Nummulites Guettardi, d'Archiac & Haime, var. *antiqua*, De la Harpe. (Pl. XIII, Fig. 6*b*.)

Nummulites Guettardi, d'Archiac, var. *antiqua*, De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 172, pl. xxx (i), figs. 37–42.

The central chamber in our specimens from Sinai is fairly large, agreeing in this particular with the typical examples of the species figured by d'Archiac.[2] De la Harpe, however, states that his specimens have a small central chamber, so that it is possible that we have here the two forms A and B confused by the above-named authors.

The variety *antiqua* differs from the typical *N. Guettardi* in having a lenticular and more compressed shell. The type form was found by De la Harpe only in the Upper Eocene beds of Egypt.

The above variety was found by De la Harpe in rocks of the Libyan Series (Lower Eocene) of Nekeb, east of Farâfrah, and of El-Guss-Abu-Said.

Coll. Geol. Surv. Egypt, No. 3,902, Box No. 15*l*. Libyan Series (Lower Eocene) : Jebel Krer, Sinai (same range as Jebel Abyad). Common.

Nummulites Ramondi, Defrance. (Pl. XIII, Figs. 3*b*, 4*b*.)

N. Ramondi, Defrance, 1825: Dict. Sci. Nat., vol. xxxv, p. 224. D'Archiac & Haime, 1853: Descr. Anim. groupe nummulitique Inde, vol. i, p. 128, pl. vii, figs. 13*a–d*, 14*a*, 15*a*, 16*a*, 17*a*, *b*.

This is a small species, but has no large central chamber. The peripheral edge is sharper than that of *N. Guettardi*, and the test is much thinner.

N. Ramondi is one of the most widely distributed of the nummulites; amongst many localities it has been found in France, the Alps, the Pyrenees, Egypt, the Crimea, and India. From Egypt De la Harpe obtained it in the Lower Libyan Series of Jebel Têr.

Coll. Geol. Surv. Egypt, Nos. 4,113 and 4,135, Box Nos. 4*l* and 3*l* respectively. Libyan Series (Lower Eocene) : junction of Wadi

[1] Palæontographica, vol. xxx (1883), Pal. Theil, pp. 161–4, pl. xxx, figs. 1–18 : *N. Fraasi*, *N. Rütimeyeri*, and *N. Chavannesi*.

[2] Descr. Anim. groupe nummulitique Inde, vol. i (1853), p. 130, pl. vii, figs. 18*a–c*, 19*a*, *b*.

Baba and Wadi Shellál, Sinai. Common. ? No. 3,598, Box No. 13*l*. Mokattam Series (Middle Eocene): Wadi Khadáhid. Rare.

Nummulites Heberti, d'Archiac & Haime.

Nummulites Heberti, d'Archiac & Haime, 1853: Descr. groupe nummulitique Inde, vol. i, p. 147, pl. ix, figs. 14*a–g*, 15*a*. De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 178, pl. xxxi (ii), figs. 26, 27.

This is a very minute nummulite, having an umbonate centre and a sharp peripheral edge. The central chamber is almost invisible. The specimens from Sinai measure about 2 mm. in diameter and ·85 mm. in thickness. *N. Heberti* was found by Schwager in both the Libyan and Bartonian Series of Egypt.

Coll. Geol. Surv. Egypt, No. 4,112, Box No. 2*l*. ? Bartonian (Upper Eocene) or ? top of Mokattam Series (Middle Eocene): Jebel Abyad, Sinai, beach deposit (later). Frequent. Also No. 3,902, Box No. 15*l*. Libyan Series (Lower Eocene): Jebel Krer (same range as Jebel Abyad), Sinai. Rare.

Nummulites variolaria (Lamarck). (Pl. XIII, Fig. 2*b*.)

Lenticulites variolaria, Lamarck, 1804: Ann. du Muséum, vol. v, p. 187, No. 2.
Nummularia variolaria (Lam.), Sowerby, 1829: Mineral Conchology, vol. vi, p. 76, pl. DXXXVIII, fig. 3.
Nummulites variolaria (Sow.), d'Archiac & Haime, 1853: Descr. Anim. groupe nummulitique Inde, vol. i, p. 146, pl. ix, figs. 13*a–g*.
N. variolaria (Lam.), De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 179, pl. xxxi (ii), figs. 28–36.

This is one of the most widely distributed nummulites. It occurs in Hampshire, near Brussels, Biarritz, in Hungary, Asia Minor, Kurdistan, etc. It is usually characteristic of the Middle and Upper Eocene. In Egypt it has been found in the Lower and Upper Eocene (De la Harpe).

It is fairly common in the specimen from Sinai, No. 4,112, and is associated with *N. planulata*. The characters by which one recognizes it in section are the lenticular outline and sharp peripheral edges. In the tangential aspect the sections exhibit the regularly striated shell surface. The central chamber is moderately large.

Coll. Geol. Surv. Egypt, No. 4,112, Box No. 2*l*. ? Bartonian Series (Upper Eocene) or ? top of Mokattam Series (Middle Eocene): beach deposit, Jebel Abyad, Sinai. Frequent.

Nummulites subdiscorbina, De la Harpe. (Pl. XIII, Fig. 1.)

Nummulites subdiscorbina, De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 185, pl. xxxii (iii), figs. 8–15.

This species is not unlike *N. Guettardi*, var. *antiqua*, but differs in the greater proportionate breadth of the test; it also exhibits strongly developed double cones of tubuli at the umbilical axis. This species is relatively larger than *N. Guettardi*, var. *antiqua*.

De la Harpe states that *N. subdiscorbina* usually accompanies the larger species *N. discorbina*, but this is not the case with those of the Sinaitic limestones. The Egyptian specimens were found near Cairo, at Beni Hassan and Minieh.

Coll. Geol. Surv. Egypt, No. 4,111, Box No. 1*l*. Mokattam Series (Middle Eocene): top of Jebel Abyad, south of Wadi Gharandel, Sinai. Abundant.

The group of *Nummulites Gizehensis* (Forskål), Ehrenberg.

From a zoological standpoint the various forms of nummulites so closely associated in certain beds of the Mokattam Series in Egypt and neighbouring areas, referred to under the name of *N. Gizehensis* and its varieties, are clearly local modifications of the more widely distributed *Nummulites complanata*, Lamarck. In consideration of the practical use of distinctive terms for local varieties in relation to their stratigraphical distribution, it is here proposed to retain the grouping of this series so minutely and carefully worked out by Dr. De la Harpe.

Nummulites Gizehensis (Forskål), Ehrenberg, var. *Ehrenbergi*, De la Harpe. (Pl. XIV, Fig. 15.)

Nautilus Gyzehensis, Forskål, 1775: Descriptiones Animalium, p. 140. 1776: Icones rerum naturalium, etc.
Nummulites Gyzehensis, Ehrenberg, 1838: Abhandl. Akad. Wiss. Berlin, p. 93.
N. Gyzehensis, Ehr., d'Archiac & Haime, 1853: Descr. Anim. groupe nummulitique Inde, vol. i, p. 94, pl. ii, figs. 6*a–f*, 7*a*, 8.
N. Gizehensis Ehrenbergi, De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 190, pl. xxxii, figs. 16–25; pl. xxxiii, figs. 1, 2.

This is the well-known form with the thick disc and rounded edge. The septa between each chamber are unusually thick and inclined.

This variety has been chiefly obtained from Egypt, but it has also been recorded from Sinai, Syria, Anatolia, and Vicentin. In Sinai it occurred at Wady Gharandel (Rupert Jones and Bauerman). It has also been doubtfully recorded from Biarritz.

Coll. Geol. Surv. Egypt, No. 4,163, Box No. 5*l*. Mokattam Series (Middle Eocene): near top of Jebel Safariat, Sinai. Several specimens.

Nummulites Gizehensis (Forskål), Ehrenberg, var. *Lyelli*, d'Archiac & Haime. (Pl. XIV, Fig. 14.)

Nummulites Lyelli (pars), d'Archiac & Haime, 1853: Descr. Anim. groupe nummulitique Inde, vol. i, p. 95, pl. iii, figs. 1*a*, *b*, 2. Fraas, 1867: Aus dem Orient, p. 129.
N. Gizehensis Lyelli, d'Archiac, De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 192, pl. xxxiii (iv), figs. 3–10.

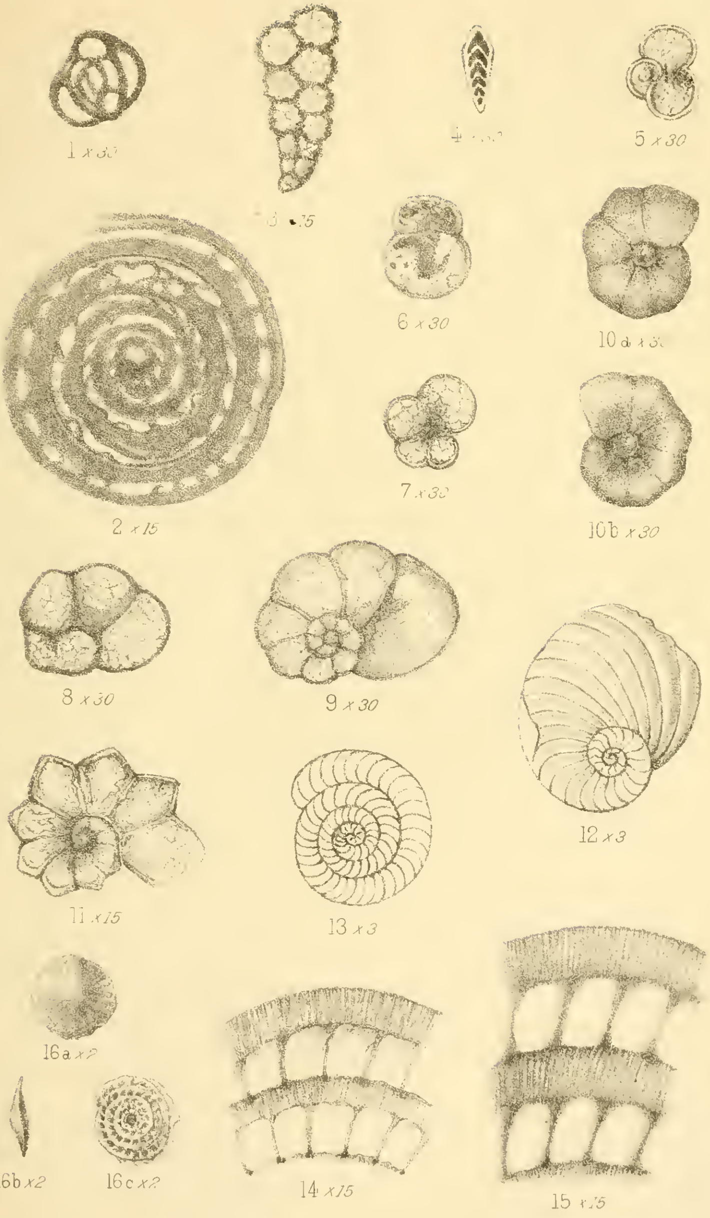
This is a large variety, and perhaps approaches the type *N. complanata* most closely. It is rather regular in outward form, and has the peripheral edge fairly sharp and thin. The septa, seen in section, run nearly straight across from whorl to whorl, especially in the later turns of the shell, instead of being arcuate and inclined, as in the variety previously mentioned. The chambers are irregularly spaced. The specimens from Sinai measure as much as 38 mm. in diameter and about 6 mm. in thickness.

N. Gizehensis, var. *Lyelli*, has been recorded from Egypt, near Cairo; and from Syria, in the white limestone of Gerizhem.

Coll. Geol. Surv. Egypt, No. 4,163, Box No. 5*l*. Mokattam Series (Middle Eocene): near top of Jebel Safariat, Sinai. Very common.

Nummulites Gizehensis (Forskål), Ehrenberg, var. *Pachoi*, De la Harpe.

Nummulites Gizehensis Pachoi, De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 193, pl. xxxiii (iv), figs. 14–18; pl. xxxiv (v), figs. 1–5.



F. Chapman del. ad nat.
G. M. Woodward lith.

West, Newman imp.

Eocene Foraminifera from Sinai

This variety is large, or moderately large compared with others of the same type; discoid, compressed, and with rounded, blunt, or sharp edges. The cross section shows the sides to be parallel.

De la Harpe has recorded this variety from the Pyramids of Gizeh, in the Wadi Emsìd-el-Flûs, between Mêr and Farâfrah, on the Gâret-el-Dalleh, and near Rajân, between the Fajûm and Beharieh.

Coll. Geol. Surv. Egypt, No. 4,111, Box No. 1*l*. Mokattam Series (Middle Eocene): top of Jebel Abyad, south of Wadi Gharandel, Sinai. Frequent. No. 4,163, Box No. 5*l*. Mokattam Series (Middle Eocene): near top of Jebel Safariat, Sinai. Frequent. Also No. 3,598, Box No. 13*l*. Mokattam Series (Middle Eocene): Wadi Khadáhid, Sinai. Frequent.

Nummulites curvispira, Savi & Meneghini. (Pl. XIII, Fig. 5.)

Nummulina curvispira, Savi & Meneghini, 1851: Consid. Geol. Toscana, p. 137.
Nummulites curvispira (Menegh.), d'Archiac & Haime, 1853: Descr. Anim. groupe nummulitique Inde, p. 127, pl. vi, figs. 15*a–d*. Fraas, 1867: Aus dem Orient, p. 130. De la Harpe, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 200, pl. xxxiv (v), figs. 42–67.

This nummulite, although very variable, is generally of a flattened lenticular shape, with rounded peripheral edge, sometimes more or less sharp. In the latter feature it approaches *N. Rouaulti*, d'Arch. and Haime. Clean fresh specimens often show the flexuose striation which is characteristic of *N. Gizehensis*. The surface of specimens slightly weathered is radially or sinuously striate, with granulations sparsely scattered between them. The central chamber is usually very large, and is followed by a semilunar segment. The whorls are somewhat irregular, and there are usually six turns on a radius of 3 mm. The chambers are elongate and greatly curved.

N. curvispira has already been recorded from Sinai (Wadi Gharandel) by Rupert Jones. It is commonly found at most of the localities in Egypt in the Mokattam Series, at Mokattam, Gizeh, Minieh, Beni Hassan, and the Libyan Desert.

Coll. Geol. Surv. Egypt, No. 4,111, Box No. 1*l*. Mokattam Series (Middle Eocene): top of Jebel Abyad, south of Wadi Gharandel, Sinai. Frequent. No. 3,598, Box No. 13*l*. Mokattam Series (Middle Eocene): Wadi Khadáhid, Sinai. Very common.

Nummulites Barroni, sp. nov. (Pl. XIV, Figs. 16*a*, *b*, *c*.)

Test lenticular, swollen in the centre, hollowed near the periphery, edge quite sharp. Surface striate and sometimes feebly granulate. Average diameter, 5 mm.; thickness at the centre, 2 mm.; shell with from 4 to 5 whorls; 4 turns in a radius of 2 mm. Septa strongly arched. Central chamber subspherical and very large, one measuring ·75 mm.

This species recalls *N. Rouaulti* by its general shape, but the edge is much sharper, and the thickness at the centre is greater in relative proportion to size.

The three species *N. curvispira*, *N. Rouaulti*, and *N. Barroni* are probably related, and represent a group of the megalospheric type which has a dimorphic relationship with *N. Gizehensis* and its varieties.

This species is named after Mr. T. Barron, F.G.S., who collected the specimens during his work in Sinai, January to June, 1899.

Coll. Geol. Surv. Egypt, No. 3,598, Box No. 13*l*. Mokattam Series (Middle Eocene): Wadi Khadáhid, Sinai. Common.

ORBITOIDES, d'Orbigny [1847].

Orbitoides (*Discocyclina*) *dispansa* (Sowerby). (Pl. XIII, Figs. 6*c*, 7*c*.)

Lycophris dispansus, Sowerby, 1837 [1840]: Trans. Geol. Soc. Lond., ser. II, vol. v, pp. 327, 718, pl. xxiv, figs. 16, 16*a*, *b*.
Orbitoides dilabida, Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 140, pl. xxix, figs. 7*a–e*.

Schwager records this species under the name of *O. dilabida* from both the Libyan and the Mokattam Series of Egypt; Dr. Carter found it in Scinde, Kutch, and Arabia.

Nearly all our Sinaitic examples are slightly abraded, as if rolled by current agency, and in one of the specimens, No. 4,112, of later age, they are quite fragmentary.

Coll. Geol. Surv. Egypt, No. 4,111, Box No. 1*l*. Mokattam Series (Middle Eocene): top of Jebel Abyad, south of Wadi Gharandel, Sinai. Frequent. No. 4,112, Box No. 2*l*. (Derived) ? Bartonian Series (Upper Eocene) or ? top of Mokattam Series (Middle Eocene): beach deposit, Jebel Abyad, Sinai. Rare, broken. No. 3,902, Box No. 15*l*. Libyan Series (Lower Eocene): Jebel Krer, Sinai. Common.

Orbitoides (*Discocyclina*) *papyracea* (Boubée).

Nummulites papyracea, Boubée, 1832: Bull. Soc. géol. France, ser. II, p. 445.
Orbitoides (*Discocyclina*) *papyracea* (Boubée), Gümbel, 1868 [1870]: Abhandl. M. ph. Cl. k. bayer. Ak. Wiss., vol. x, p. 690, pl. iii, figs. 3–12, 19–29.
O. papyracea (Boubée), Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 139.
O. nudimargo, Schwager, 1883: op. cit., p. 139, pl. xxix, figs. 8*a–e*.

The specimens in the Sinaitic limestones show every deviation between the forms figured by Schwager as *O. nudimargo* and ordinary specimens of *O. papyracea*, which sometimes have a slightly thicker test. Our examples are seen in section and are generally more or less fragmentary.

O. papyracea has been found in both the Libyan and Mokattam Series in Egypt.

Coll. Geol. Surv. Egypt, No. 4,111, Box No. 1*l*. Mokattam Series (Middle Eocene): top of Jebel Abyad, south of Wadi Gharandel, Sinai. Frequent. No. 3,902, Box No. 15*l*. Libyan Series (Lower Eocene): Jebel Krer, Sinai. Rare.

Orbitoides (*Discocyclina*) *ephippium* (Schlotheim).

Lenticulites ephippium, Schlotheim, 1820: Die Petrefactenkunde, p. 89.
Orbitoides (*Discocyclina*) *ephippium* (Schlotheim), Gümbel, 1868 [1870]: Abhandl. m. ph. Cl. k. bayer. Ak. Wiss., vol. x, p. 696, pl. iii, figs. 15, 16, 38, 39.
Orbitoides ephippium (Schlotheim), Schwager, 1883: Palæontographica, vol. xxx, Pal. Theil, p. 139.

A few characteristic examples of the above species occur in our sections. It was recorded by Schwager from the Mokattam Series of Egypt.

Coll. Geol. Surv. Egypt, No. 4,111, Box No. 1*l*. Mokattam Series (Middle Eocene): top of Jebel Abyad, south of Wadi Gharandel, Sinai. Rare, somewhat fragmentary.

SPECIES DESCRIBED IN THIS PAPER.

1. *Miliolina circularis* (Bornemann). Libyan Series: Jebel Krer.
2. *Alveolina Boscii* (Defrance). Libyan Series: Jebel Krer.
3. *A. decipiens*, Schwager. Libyan Series: Jebel Krer.
4. *Textularia agglutinans*, d'Orbigny. Libyan Series: junction of Wadi Baba and Wadi Shellál.
5. *Bigenerina nodosaria*?, d'Orb. Libyan Series: Jebel Krer.
6. *Bolivina punctata*?, d'Orb. Mokattam Series: Jebel Abyad.
7. *Globigerina bulloides*, d'Orb. Bartonian or top of Mokattam Series: Jebel Abyad.
8. *G. conglobata*, Brady. Mokattam Series: Jebel Abyad.
9. *G. cretacea*?, d'Orb. Mokattam Series: Jebel Abyad. Also Libyan Series: Jebel Krer.
10. *Discorbina rugosa* (d'Orb.). Mokattam Series: Jebel Abyad.
11. *D. globularis* (d'Orb.). Mokattam Series: Jebel Abyad.
12. *Truncatulina umbonifera* (Schwager). Mokattam Series: Wadi Khadáhid.
13. *Rotalia calcariformis* (Schwager). Mokattam Series: Jebel Abyad.
14. *Operculina complanata* (Defrance), var. *canalifera*, d'Archiac. Libyan Series: junction of Wadi Baba and Wadi Shellál; Jebel Krer.
15. *O. complanata*, var. *discoidea*, Schwager. ? Bartonian or top of Mokattam Series: Jebel Abyad.
16. *Heterostegina depressa*, d'Orb. Libyan Series: Jebel Krer.
17. *Nummulites planulata* (Lamarck). ? Bartonian or top of Mokattam Series: Jebel Abyad.
18. *N. Guettardi*, d'Arch. & Haime, var. *antiqua*, De la Harpe. Libyan Series: Jebel Krer.
19. *N. Ramondi*, Defrance. Libyan Series: junction of Wadi Baba and Wadi Shellál.
20. *N. Heberti*, d'Arch. & Haime. ? Bartonian or top of Mokattam Series: Jebel Abyad. Also Libyan Series: Jebel Krer.
21. *N. variolaria* (Lamarck). ? Bartonian or top of Mokattam Series: Jebel Abyad.
22. *N. subdiscorbina*, De la Harpe. Mokattam Series: Jebel Abyad.
23. *N. Gizehensis* (Forskål), var. *Ehrenbergi*, De la Harpe. Mokattam Series: Jebel Safariat.
24. *N. Gizehensis*, var. *Lyelli*, d'Arch. & Haime. Mokattam Series: Jebel Safariat.
25. *N. Gizehensis*, var. *Pachoi*, De la Harpe. Mokattam Series: Jebel Abyad; Jebel Safariat; Wadi Khadáhid.
26. *N. curvispira*, Savi & Meneghini. Mokattam Series: Jebel Abyad; Wadi Khadáhid.
27. *N. Barroni*, sp. nov. Mokattam Series: Wadi Khadáhid.
28. *Orbitoides dispansa* (Sow.). ? Bartonian or Mokattam Series: Jebel Abyad. Libyan Series: Jebel Krer.
29. *Orbitoides papyracea* (Boubée). Mokattam Series: Jebel Abyad. Libyan Series: Jebel Krer.
30. *O. ephippium* (Schlotheim). Mokattam Series: Jebel Abyad.

EXPLANATION OF PLATE XIII.

FIG. 1.—*Nummulites subdiscorbina*, De la Harpe. Mokattam Series: in nummulitic limestone top of Jebel Abyad, Sinai. No. 4,111. × 16.

FIG. 2*a*.—*Nummulites planulata* (Lam.).
FIG. 2*b*.—*N. variolaria* (Lam.).
} ? Bartonian or ? Mokattam Series: in foraminiferal limestone, Jebel Abyad, Sinai. No. 4,112. × 12.

FIGS. 3*a*, 4*a*.—*Operculina complanata* (Defr.), var. *canalifera*, d'Archiac.
FIGS. 3*b*, 4*b*.—*Nummulites Ramondi*, Defrance.
Libyan Series: in dolomitized foraminiferal limestone, junction of Wadi Baba and Wadi Shellál, Sinai. Nos. 4,135 and 4,113. × 16.

FIG. 5.—*Nummulites curvispira*, Savi & Meneghini. Wadi Khadáhid, Sinai. No. 3,598. × 4½.

FIGS. 6, 7.—Libyan Series: foraminiferal limestone, Jebel Krer, Sinai. No. 3,902. 6*a*, *Alveolina Boscii* (Defrance); 6*b*, *Nummulites Guettardi*, d'Arch. and Haime, var. *antiqua*, De la Harpe; 6*c*, 7*c*, *Orbitoides dispansa* (Sow.); 7*a*, *Heterostegina depressa*, d'Orb.; 7*b*, *Bigenerina? nodosaria*, d'Orb. × 16.

EXPLANATION OF PLATE XIV.

FIG. 1.—*Miliolina circularis* (Bornemann). Transverse section. Libyan Series: Jebel Krer, Sinai. No. 3,902. × 30.

FIG. 2.—*Alveolina decipiens*, Schwager. Transverse section. Libyan Series: Jebel Krer, Sinai. No. 3,902. × 15.

FIG. 3.—*Textularia agglutinans*, d'Orb. Longitudinal section. Libyan Series: junction of Wadi Baba and Wadi Shellâl, Sinai. No. 4,113. × 15.

FIG. 4.—*Bolivina punctata?*, d'Orb. Longitudinal, peripheral section. Mokattam Series: Jebel Abyad, Sinai. No. 4,111. × 30.

FIG. 5.—*Globigerina bulloides*, d'Orb. Section of test. Mokattam Series: Jebel Abyad, Sinai. No. 4,111. × 30.

FIG. 6.—*Globigerina conglobata*, Brady. Section of test. Mokattam Series: Jebel Abyad, Sinai. No. 4,111. × 30.

FIG. 7.—*G. cretacea?*, d'Orb. Section of test. Mokattam Series: Jebel Abyad, Sinai. No. 4,111. × 30.

FIG. 8.—*Discorbina globularis* (d'Orb.). Section of test. Mokattam Series: Jebel Abyad, Sinai. No. 4,111. × 30.

FIG. 9.—*D. rugosa* (d'Orb.). Section of test. Mokattam Series: Jebel Abyad, Sinai. No. 4,111. × 30.

FIGS. 10*a*, *b*.—*Truncatulina umbonifera* (Schwager). Mokattam Series: Wadi Khadáhid, Sinai. No. 3,598. × 30.

FIG. 11.—*Rotalia calcariformis* (Schwager). Section of test. Mokattam Series: Jebel Abyad, Sinai. No. 4,111. × 15.

FIG. 12.—*Operculina complanata* (Defrance), var. *canalifera*, d'Archiac. Libyan Series: junction of Wadi Baba and Wadi Shellâl, Sinai. No. 4,135. × 3.

FIG. 13.—*O. complanata* (Defr.), var. *discoidea*, Schwager. ? Bartonian or ? Mokattam Series: Jebel Abyad, Sinai. No. 4,112. × 3.

FIG. 14.—*Nummulites Gizehensis* (Forskål), var. *Lyelli*, d'Archiac & Haime. Section on the fifth and sixth whorls. Mokattam Series: Jebel Safariat, Sinai. No. 4,163. × 15.

FIG. 15.—*Nummulites Gizehensis* (Forskål), var. *Ehrenbergi*, De la Harpe. Section on the eleventh and twelfth whorls. Mokattam Series: Jebel Safariat, Sinai. No. 4,163. × 15.

FIGS. 16*a*, *b*, *c*.—*Nummulites Barroni*, sp. nov. 16*a*, superficial aspect of test; 16*b*, edge view; 16*c*, median section. Mokattam Series: Wadi Khadâhid, Sinai. No. 3,598. × 2.

NOTICES OF MEMOIRS.

THE MUSEUMS ASSOCIATION: ELEVENTH ANNUAL MEETING, CANTERBURY, JULY 9–12, 1900. President, Henry Woodward, LL.D., F.R.S., F.G.S., V.P.Z.S, P. Pal. Soc., of the British Museum (Natural History); Treasurer, Alderman W. H. Brittain, J.P., F.R.G.S. (Museum, Sheffield); General Secretary, E. Howarth, F.R.A.S., F.Z.S. (Museum, Sheffield).

THIS useful and deservedly successful Association—supported by the presence of the Right Rev. the Bishop of Dover; the Very Rev. the Dean of Canterbury; the Rev. Canon Routledge; the Worshipful the Mayors of Canterbury and of Dover; the Deputy-Mayor, Mr. Alderman Mason, J.P.; by F. Bennett-Goldney, Esq. (Hon. Curator of the Royal Museum, Canterbury); Mr. Sebastian Evans, M.A., LL.D.; Mr. Stephen Horsley, Sheriff; Mr. Henry Fielding, Town Clerk; and fifty Delegates and Associates from various Museums throughout the country—opened its public proceedings on Tuesday morning at 10 a.m. with an address of welcome by His Worship the Mayor of Canterbury, Alderman Geo. J. Collard, J.P.

Alderman W. H. Brittain—in the absence of the outgoing President of the Association—then proposed the election of Dr. Henry Woodward, F.R.S., of the Natural History Branch of the British Museum, as President for 1900–1901, and paid an earnest tribute to that gentleman's work in connection with Museums.

The election having been carried unanimously,

Dr. Woodward rose to return his thanks and proceeded to read his Presidential address.

It was, he said, a happy omen—he had almost said inspiration—which led the founders of that Association to invite its organizing Committee, twelve years ago, to meet in the ancient *Eboracum*, the city of "the White Rose of York," once the capital of Roman Britain, which, blazoned down the long roll of history for eighteen hundred years, still firmly stood its ground, like some ancient warrior, all scarred and weather-beaten by time, by wars, and by revolutions, a landmark in our history and a light to science. Such was the fair archiepiscopal city of York, the birthplace of the Museums Association, which in 1831 gave origin to the great British Association for the Advancement of Science, and still earlier (1822) founded the Yorkshire Philosophical Society. After visiting Liverpool, Cambridge, Manchester, London, Dublin, Newcastle, Glasgow, Oxford, Sheffield, and Brighton, the members of the Museums Association had set out this year upon a pilgrimage to Canterbury, the Mother-City of the English people—the "Cant-wara-byrig," the capital city of the "Cant," the "Angul," or corner of Britain nearest to the Continent, towards which the immigration of those Belgic tribes into Britain in pre-Roman times was directed, and the later invasion of Julius Cæsar, B.C. 54. The Cathedral, which dated back to A.D. 602, was recovered by St. Augustine, its first Archbishop, there having been, it was said, a church already on the spot built by early Roman Christians. Like York, Canterbury had been an archiepiscopal See from the earliest times to the present day, and many of its primates lay buried within its precincts.

But it was not his duty to descant upon the merits of their present happy meeting-place, or to attempt to record its history. Those were matters he could safely leave in far abler hands, for among their Vice-Presidents he saw the names of the Very Rev. the Dean of Canterbury, the Worshipful the Mayor (Mr. Alderman George Collard, J.P.), Mr. Alderman Mason, J.P., and many other gentlemen, including Mr. F. Bennett-Goldney, the Honorary Curator of the Royal Museum, Canterbury. They had also to be thankful for the assistance of Mr. Henry Mead as Local Secretary. Upon the kindness and hospitality of those gentlemen during their visit, he felt sure they might safely rely, and indeed their programme held out many agreeable promises of pleasant visits both here and in Dover during their brief sojourn in Kent. The newly-elected President thanked the members for the high compliment they had paid him in installing him in that office, and proceeded to refer to his forty-two years' association with the British Museum, and to the many changes and developments which had taken place there during that period under the management of its numerous present and past officers and assistants. Referring to various means by which additional interest may be introduced into public museums, the speaker said that among the objects commenced to be carried out by the new Director, Professor E. Ray Lankester, was the formation of a museum to illustrate animals under domestication. The Director hoped to be able to obtain examples of the various breeds of animals which were the result of the invention of man—giving rise to what in Nature would almost amount to the "origin of species." But it did not appear that those varieties could ever remain permanent without artificial environments. All the immense varieties of the dog, for example, would speedily disappear or degenerate into mongrels if not strictly preserved by man. The same was true of the various breeds of fancy pigeons; if neglected, the offspring would again revert to the common blue rock pigeon from which they had sprung. Breeds of horses and cattle, when removed from care and the influence of domestication, were also found to lose their distinctive points of difference, and to revert to the common wild form best adapted to its surroundings. Professor Lankester hoped to secure examples of some of those, and photographs of others to serve as records, as a basis for future investigations. Dr. Woodward pointed out that in order that they might benefit permanently by the great advances made of late in natural knowledge, they must be prepared to make great changes, and sacrifice many cherished ideas, and might find themselves travelling along new lines, guided by new lights, or, perchance, might have to make their own lines, and even to advance under hostile opposition to carry out their new ideas. This led the President to enter into various details of museum arrangement, in which he suggested several improvements and gave results of other scientists' and naturalists' observations in this direction. Dr. Woodward particularly referred to the most valuable set of publications of Monographs, Catalogues, and Guides, issued by the authority of the Trustees of the British Museum, of which he exhibited some examples on the table. Also to the use of printed descriptive labels for all the more important groups of animals, and for all objects of special interest and novelty exhibited to the public in the Museum Galleries.

The President dealt with the subject of arranging specimens in museums and the difficulty of displaying recent and fossil forms together in one series. He referred to an earlier discussion of this subject which took place at the British Association Meeting in Manchester in 1887. In adopting such a radical alteration in the arrangement of objects, first, there was 'public opinion' to be considered; secondly, in a great public museum like that of the

British Museum of Natural History there was the organization of the staff, which, like the collections, was divided into departments; thirdly, there was the cost of making such alterations, which was very great; and fourthly, there was the matter of convenience.

"*Public opinion*," said Dr. Woodward, "is, I find, very largely in favour of keeping the Geological and Zoological Collections distinct from one another, principally because the people who use the collections are still interested in them according to the special line of research in which they are engaged, and the books which they have been reading. They come expressly to see the Birds, or the Beetles, or Butterflies, the African Antelopes, or Recent Shells, and don't want to see the fossil ones. Or, again, they are interested in *Ammonites*, or in *Trilobites*, or Fossil Fishes, and wish to see what we have exhibited of one or other of these. For, after all, the human intellect is restricted, and we cannot, many at least of us, hope to attain to the wisdom of Solomon, who discoursed of trees from the cedars of Lebanon to the hyssop that springeth out of the wall, and spake also of beasts, and of fowls, and of creeping things, and of fishes. The necessities arising out of the greatness of the subject has made most of us *specialists*, and we are, as a rule, content to know one group fairly well. As a consequence, we rarely, nowadays, meet with the all-round Naturalist who has a wide knowledge of most branches of Zoology and of Botany. Many of the members of this Museums Association have, however, compulsorily, to keep up such an all-round acquaintance with Natural History, and not unfrequently to undertake the intelligent arrangement of an Art-Gallery and perhaps a Gallery of Antiquities as well. They have, in fact, to be more learned than the Professors of Natural History in the Queen's Universities, who less than 50 years ago were required to lecture on Geology, Mineralogy, Botany, and Zoology, in all their varied branches! and to give demonstrations also to their classes in the field.

"The organization of a Museum into Departments, each under its own special head, is almost fatal to any scheme of amalgamation, and although under the late Sir William Flower, and the present Director, Professor Ray Lankester, much has been done towards breaking down the hard lines of demarcation, still the Departments of Palæontology and Zoology remain as such to the present day.

"The late Director commenced in 1896 to remodel the Zoological Department, working specially at the *Mammalia*, up to the time of his retirement in September, 1898, and with the active co-operation of Mr. Richard Lydekker, F.R.S. (who has continued the task down to the present time). Still the great work remains unfinished.

"Sir William Flower's last efforts were devoted to complete the exhibition of Cetacea in the new whale-room, which contains models, skins, and skeletons of thirty-eight of these huge marine mammals. The present Director has just added *all the fossil forms*, so that in this one group the biologist is able to see the living and extinct members of the Cetacea placed side by side, and can realize how far such a plan is a success.

"In the other groups of the Mammalia Mr. Lydekker has been unable to introduce the whole of the fossil forms, and has been content to indicate their existence by drawings, by coloured casts, or by parts of specimens, wherever he could make room for them. Explanatory labels have been introduced in each group, and skeletons also of each type of mammal. Coloured maps showing the geographical distribution of each family are also placed with them. To do all this the actual number of exhibited specimens has of necessity been *greatly reduced.* This *limited exhibition* of recent and extinct forms together in one series had been advocated by me in 1887, and may be seen carried out, as far as I have been able to obtain specimens, in the palæontological galleries under my care."

* * * * * * * *

Dr. Woodward referred to the two great epoch-making events which had so widely affected all the sciences, and which saw the light just forty-two years ago, namely, the discoveries in prehistoric archæology, by which the age of man has been carried back into Newer Tertiary time, and the extinct Mammalia had been shown to have survived down to the human period, and to have been contemporary with early man and with many of the surviving forms of animals of to-day; uniting the latest chapter of geological history to the oldest records of our race, and joining the sciences of Geology and Archæology together. Secondly, the enunciation at the same period of Darwin's origin of species and the doctrine of evolution, which linked into one the whole chain of life from the earliest records in Archæan Rocks to the full tide of existences which now surround us.

* * * * * * * *

The President, in conclusion, advocated the desirability of the publication by the Association of a handbook giving an account of every provincial museum throughout the country, with full particulars as to each, not only as to its officers, organization, and its plan of arrangement, but also what were the chief features of its exhibits, and especially to print any records concerning 'types' and 'figured specimens' preserved in its collection and any other particulars of general public and scientific interest.

REVIEWS.

I.—The Eighth International Geological Congress, Paris, 1900. Livret-Guide des Excursions en France du viii^e Congrès Géologique International. Avec 372 figures dans le texte et 25 planches. (Paris, 1900.)

THE "Comité d'organisation du viii^e Congrès Géologique International," under the presidency of the venerable Professor Gaudry, has just issued a "Livret-Guide des Excursions en France du viii^e Congrès Géologique International." To judge from this publication, the preparations for the impending Congress, which is to meet at Paris from the 16th to the 28th August, have been exceedingly well made. The "Livret-Guide" forms a bulky octavo volume of over 900 pages, with no less than 372 beautiful text-figures and 25 plates (geological maps, sections, views, etc.).

The introduction contains notices of the geological, mineralogical, and palæontological museums and collections of Paris — Muséum d'Histoire Naturelle, Ecole des Mines, Sorbonne, Ecole Libre des Hautes Etudes Scientifiques, Collection Pellat—drawn up by the respective keepers.

The choice of the regions to be visited has been made in such a manner that the Guide contains, as a matter of fact, a description of all the 'terrains' of France, thus giving a summary of our actual knowledge of the detailed geology of the country. So that this book will be welcome not only to the members of the Congress, whether excursionists or not, but for several years to come it will remain a useful geological 'Baedeker' of France.

There will be two categories of excursions, 'Excursions générales' and 'Excursions spéciales.' In the latter the numbers are limited to twenty, being intended for specialists only, who are supposed to be at the same time good walkers and not to consider comfort as the primary condition of a scientific excursion. The following are the 'Excursions spéciales':—

August 31 to September 9: Alps of the Dauphiné and Mont-Blanc (Directors, MM. Marcel Bertrand and W. Kilian).
August 6 to 14: Aquitaine (Dir., M. Ph. Glangeaud).
August 6 to 14: Ardennes (Dir., M. Gosselet).
August 30 to September 6: Tertiary basins of the Rhône (Dir., M. Depéret).
August 4 to 14: Bretagne (Dir., M. Ch. Barrois).
August 29 to September 4: Caves of the Causses (Dir., M. E. Martel).
August 3 to 9: Gironde (Dir., M. E. Fallot).
August 30 to September 12: La Mure, Dévoluy, Diois, Valentinois (Directors, MM. Lory, Paquier, Sayn).
August 9 to 14: Mayenne (Dir., M. D. P. Oehlert).
August 11 to 14: Miocene of Touraine (Dir., M. G. Dollfus).
August 29 to September 6: Montagne-Noire (Dir., M. Bergeron).
August 29 to September 6: Mont-Dore (Dir., M. Michel Lévy).
September 11 to 20: Mont-Ventoux and Montagne de Lure (Directors, MM. W. Kilian and Léenhardt).
August 29 to September 8: Morvan (Directors, MM. Vélain, Péron, and Bréon).
August 31 to September 9: Pelvoux and Briançonnais (Dir., M. P. Termier).
September 3 to 8: Picardie (Directors, MM. Gosselet, Ladrière, and Cayeux).
September 23 to October 2: Provence (Directors, MM. Marcel Bertrand, Vasseur, and Zürcher).
August 4 to 14: Pyrenees—crystalline rocks (Dir., M. A. Lacroix).
August 30 to September 8: Pyrenees—sedimentary formations (Dir., M. L. Carez).

September 7 to 11 : Secondary and Tertiary formations of the Basses-Alpes (Dir., M. E. Haug).

August 11 to 14 : Turonien of Touraine and Cénomanien of the Mans (Dir., M. de Grossouvre).

Under the heading 'Excursions générales' are (1) three large excursions, viz. :—

August 29 to September 7 : Coal-basins of Central France (Directors, MM. Fayol and Grand'Eury).

August 30 to September 8 : Primary and Secondary formations of the Boulonnais and Normandy (Directors, MM. Gosselet, Munier-Chalmas, Pellat, Rigaux, Bigot, and Cayeux).

August 29 to September 15 : Central Massif of France (Directors, MM. Michel Lévy, Marcellin Boule, G. Fabre, and E. A. Martel).

(2) Short excursions which will enable members to visit, during the Congress, the Tertiary fossiliferous formations of the neighbourhood of Paris.

From the dates given above it will be seen that the excursions take place *before*, *during*, and *after* the Congress. The directors of the excursions are the authors of the respective notices on the same, which are issued in twenty-three separate fascicules for the convenience of the excursionists.

In connection with the above it may be mentioned that at the last meeting of the Geological Society of London on June 20, a letter was read from Professor Gaudry, the President of the Organizing Committee of the Congress, to the Foreign Secretary of the Geological Society, conveying a very warm and cordial invitation to the Fellows of the Geological Society to attend the Congress, and assuring to them a hearty welcome from their geological brethren of France. It is to be hoped that this generous invitation will find a ready response from our British Geologists.

II.—Catalogue of the Fossil Bryozoa in the Department of Geology, British Museum (Natural History). The Cretaceous Bryozoa. Vol. I. By Dr. J. W. Gregory, D.Sc., F.G.S. 8vo; pp. xiv, 457, 17 plates, text illustrated. (London: printed by order of the Trustees of the Museum, 1899.)

FOUR years ago we had the pleasure of noting (Geol. Mag., 1896, p. 378) the first of what it was hoped might be a series of Catalogues of the Fossil Bryozoa in the national collection. That volume, also by Dr. Gregory, dealt with the Jurassic forms, which it was seen would supply the key to those that came after. Now we have before us the first instalment of the Cretaceous Bryozoa. The work is on the same lines as its predecessor, with such changes in nomenclature (e.g. Diastoporidæ for Tubuliporidæ) as experience has shown to be necessary, and is severely technical, consisting as it does of descriptions of the species, with discussions as to synonymy, and so on. The general introduction to the Cretaceous Bryozoa, with other interesting questions, such as lists of localities with their horizons, have been deferred for a second volume, and we can only hope that though, greatly to the regret of his colleagues at the Museum, Dr. Gregory has taken himself to fresh fields, the work he has so ably begun may yet be carried to a successful end.

The Bryozoa are notoriously a difficult group, though they are a most fascinating study owing to the beauty of their forms, which must strike even the most casual observer on turning over the admirably executed plates which conclude the volume.

CORRESPONDENCE.

FORMATION OF MARITIME PEAT.

Sir,—It may interest some of the readers of this Magazine to learn that a remarkable illustration of the mode of formation of beds of maritime peat is at present to be seen on the shore in a small bay near the Bucket Rocks to the east of this town. During a heavy flood one day late in the past autumn great quantities of leaves were washed into the Tweed from the numerous woodlands, parks, and hedgerows adjoining its banks, and in course of time were drifted out to sea. A south-east wind prevailed at the time, and the flotilla of leaves, on reaching the quieter water of the sea off the river mouth, were gently wafted shorewards in the direction of the sheltered bay referred to. As they floated they were evidently first sorted out, in accordance with their buoyancy, and then were quietly deposited at the foot of the cliff as the tide fell. They form a sodden mass of leaves quite five feet in thickness at several places, which extends along the shore for several hundred yards.

An old resident, long acquainted with the coast there, tells me that the same thing happens almost every year; but that each year's deposit is generally washed seaward again, sooner or later, after it has been laid down.

As might be expected from the nature of the deposit, the constituents of which have been arranged solely with reference to their powers of flotation, it includes a small percentage of dried materials which the sea-water has floated from various parts of the shore. Bits of paper, straws, dried fronds of *Fucus vesiculosus* and *F. serratus*, coated with *Spirorbis*, and pieces of *Laminaria* encrusted with *Membranipora*, occur in small proportion, and there are a few fragments of corallines. *Talitrus locusta*, both dead and living, is rather common.

The mass is not divided by any beds of mud or sand. The general aspect of the deposit differs but little from that of such beds of maritime peat as occur, for example, at Elie in Fifeshire and at Maryport in West Cumberland, both of which are usually regarded as evidences of former changes of level of the land. Yet it must be obvious, from a consideration of the facts above noted, that similar deposits must frequently be laid down in the vicinity of large rivers, in quiet nooks both at the sea-level and beneath it, if the vegetable remains in the latter case have soaked long enough to become water-logged.

J. G. Goodchild.

Berwick, *July* 4, 1900.

OBITUARY.

JOHN YOUNG, LL.D., F.G.S.

Born 1823. Died March 13, 1900.

John Young was born at Lennoxtown, in the parish of Campsie, 1823. His father, Thomas Young, was employed in the wright-shop of Lennox Mill, the bleaching-field and calico-printing works of Dalglish, Falconer, & Co. When 10 years old he was taken from school to be a message-boy in the Bleachfield. This was before the employment of children was ameliorated and regulated by the Legislature; and then he was taken on in the Mill, where 16 hours a day (at sixpence a day and a penny an hour for over-work), whether in the hot or cold works (both extreme), were more than he could bear; and his mother took him away. Afterwards he was apprenticed for seven years to print-cutting.

He was in the employment of the firm for 26 years, until he went to live in Glasgow in 1859, but before then he utilized what little time his hard work allowed him for study, attending the Mechanics Institute and reading what books he could get to see on Geology, his favourite science, and becoming well known among geologists.

In 1855 the British Association met at Glasgow, under the presidency of the Duke of Argyll, and a collection of the rocks and fossils of the West of Scotland was to be an important feature at the meeting. Mr. Robert Dalglish, partner in the Bleachworks, etc., knew of John Young's geological taste and competence, and arranged to let his employé go to Glasgow to superintend and classify the collection. For five months he was engaged on this work, and was brought into contact with some of the leading geologists of the time. So thoroughly qualified was he for this task, that shortly afterwards the Senatus of Glasgow University offered him the position of Keeper of the Hunterian Museum. In 1859 he removed to Glasgow with his wife and young family, and entered on his new duties, living at the Old College in the High Street of Glasgow.

He successfully fulfilled an onerous duty when the College of Glasgow was removed from the High Street to Gilmorehill. He carefully packed and removed the thousands of specimens—pathological, physiological, and antiquarian—contained in the Hunterian Museum, arranging and classifying them in their new location, with the co-operation of his colleague, Professor John Young, M.D., the Head Keeper of the Museum.

The Campsie district in Stirlingshire, between Glasgow and Stirling, especially around Lennoxtown, his birthplace (about seven miles north-east of Glasgow), had always attracted John Young; indeed, at an early period he studied its features and its geological structure assiduously and with success. He made himself acquainted with all the natural and artificial exposures of its rocks and strata, learning the mineralogical nature of the greenstones and ash-beds of the trap-formation, and the fossil contents of the sedimentary limestones, shales, and sandstones, some of which, equivalent to the "Calciferous Sandstone Series," are intercalated with the trappean rocks.

From the Old Red Sandstone, lying below, he carefully noted the sequence of the several members of (1) the "Calciferous Sandstone Series," including the Ballagan Limestone Series and the Trap Series; and (2) the several members of the "Lower Limestone Series," belonging to the great Lower Carboniferous Formation, and equivalent in part to the Mountain Limestone of England. The successive members of this "Lower Limestone" group in ascending order and divisible by their constitution and their fossils, he defined as that of Mill Burn, of Balgrochen Burn, of Balglass Burn, of Craigen Glen, of the Main Limestone and Coal, of the Hosie Limestone, and of Corrie Burn. The Balquarhage Series, belonging to the "Upper Limestone," also occurs.

In the above-mentioned groups of strata there are several seams of coal, of not very good quality. There are some good cement-stones; and a large proportion of the Campsie shales contain useful ironstone. Others of them are good oil-shales, in which the crowded organisms, such as Entomostraca, have supplied, as he shows, the hydrocarbon. Marine shells are abundant in many of the strata, but in some limestones and shales they are wanting, only remains of plants, fishes, and Entomostraca remaining in evidence of what is regarded as estuarine conditions of these particular deposits. By further research John Young and his colleagues elucidated the relationship of these interesting strata of Campsie to those of other parts of Western Scotland and elsewhere. Faults, causing a displacement of the strata, were carefully observed by John Young in the Campsie valley (the greenstone dyke at Milton for instance), and the great Eddlewood fault in the Lanarkshire Coalfield.

The uppermost deposits in the region referred to belong to the Erratics of the Quaternary period, such as the boulder-till and the sands and gravels that were washed out of old moraines; and these have been cut into and variously modified by river-action since the last uprise of the country. Surface scratchings and other glacial markings are frequent. A striking monument to John Young's industry and acumen in glacial geology exists in the Hunterian Museum, where he accumulated and laid out carefully for inspection a well-selected and extensive series of boulders and striated stones (190 varieties) excavated from the local Boulder-till in digging the foundations of the noble University on the crown of Gilmore Hill. In the Museum there they now constitute a valued "memorial of the great variety of travelled rocks found on the site," as John Young intended (Trans. Geol. Soc. Glasgow, vol. iii, 1871, p. 304). Indeed, he showed that the hill itself comprises a characteristic succession of the Lower and Upper Limestone Series, mentioned above as having been elucidated by his researches at Campsie and elsewhere.

In collecting and determining the multitude of fossils from the Carboniferous strata, not only of the vicinity of Glasgow, but throughout the rich middle basin of Scotland, from the Firth of Clyde to the Firth of Forth, he greatly advanced his favourite science. He gained much experience in the discrimination of Lamellibranchiata and Brachiopoda, studying their shell-structure minutely under the microscope. Polyzoa were frequently described by him, and he made a long list of Foraminifera from the shales and limestones. In particular, he published (1874) an account of the discovery of the interesting *Saccammina Carteri* in the "Lower Limestone" Series of the Lanarkshire Coalfield and elsewhere. Of the Entomostraca of his finding, many he submitted for examination to his friends J. W. Kirkby and T. R. Jones, and his name was frequently used by them in the nomenclature of genera and species. The last instance of this friendly co-operation is in the treatment of the unique specimen found by him long ago at Robroyston, near Glasgow, and determined by his two friends Rupert Jones and Henry Woodward to be a peculiar phyllopod or phyllocarid, with the appellation of *Chænocaris Youngii* (Monogr. Pal. Soc., 1899, p. 181, pl. xxii, figs. 1*a–e*). Directions for collecting and mounting microzoa from the Carboniferous strata of West Scotland were clearly given by John Young in the Trans. Geol. Soc. Glasgow, vol. ii (1867), p. 185.

His published papers are numerous (see the Royal Society's Catalogue of Scientific Papers) in the Transactions of the scientific societies of Glasgow and Edinburgh, the Annals of Natural History, the Geological Magazine, and the Journal of the Geological Society. Many of them are joint papers, with his colleague John Young, M.D., Keeper of the Hunterian Museum, Robert Craig, James Armstrong, David Robertson, D. Corse Glen, and other Glasgow geologists. One of his last contributions in association with friends (Jones and Kirkby) appeared in the Trans. Edinburgh Geol. Soc., vol. vii (1899), treating of one of his favourite lines of research in the distribution of the Carboniferous Entomostraca, especially *Carbonia*.

The inestimable "Catalogue of the Western-Scottish Fossils," published in 1876 for the use of the British Association, bears much of the fruit of John Young's work, as indicated by Professor John Young, M.D., in his introductory and general notes in that volume. The lists of Ostracoda and Foraminifera were subsequently revised in the Trans. Geol. Soc. Glasgow, vol. ix (1891).

John Young was for many years an active member of the Glasgow Mechanics Institute, the Glasgow Geological Society, and an Associate of the Geological Society of Edinburgh; he was elected a Fellow of the Geological Society of London in 1874; and in 1883 was honoured with the award of the Murchison Donation Fund for his long-continued and successful researches in the fossil Polyzoa and in the shell-structures of other fossils. Lastly, the well-deserved Honorary Degree of LL.D. was conferred on him by the Glasgow University in April, 1893.

A man of conspicuous ability, fully appreciating the beauties of Nature and successfully elucidating some of her secrets, he had wonderful energy and perseverance. He was full of information, and willingly gave the benefit of it to all enquirers: indeed, he spread the knowledge of geology widely by his teachings in Glasgow and by his many communications to various journals. He was indeed one of the good old sort of North British naturalists and geologists, who are now unfortunately too rapidly diminishing in number.

T. R. J.

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

No. IX.—SEPTEMBER, 1900.

ORIGINAL ARTICLES.

I.—On Nepheline-Syenite and its Associates in the North-West of Scotland.

By J. J. H. Teall, M.A., F.R.S., Pres. G.S.
(Communicated by permission of the Director-General.)

In 1892 I described, in conjunction with my colleague Mr. Horne, a peculiar rock, essentially composed of orthoclase and melanite, under the name of borolanite.[1] The type-specimens came from the plutonic mass which lies to the north of Loch Borolan, in Sutherlandshire (1 in. sheet 101). During the preparation of the paper on borolanite our colleague Mr. Gunn discovered two dykes of a closely related rock traversing the Torridon Sandstone in the Coigach district of West Ross-shire. The rock of these dykes was described in an appendix to our paper. It contains nepheline and ægirine, in addition to orthoclase and melanite, and is therefore allied, both as regards mode of occurrence and mineralogical composition, to the Tinguaite group of Rosenbusch; but as melanite is an important constituent it was classed with the borolanites.

At the conclusion of our paper we say: "The affinities of borolanite are unmistakeable. It is a member of the foyaite (elæolite-syenite) family. The occurrence of melanite as an important accessory in certain rocks belonging to the nepheline-leucite group has long been recognized. In our rock we have melanite raised to the rank of an essential constituent. Borolanite, as we have already shown, is intrusive in the Cambrian rocks of Sutherlandshire. The nearest rocks in any way allied to it are the elæolite-syenites of the Christiania district, which are also intrusive in Lower Palæozoic strata."

Since this paper was written I have had the privilege of visiting the Christiania district, under the guidance of Professor Brögger, and the experience thus gained has been of the greatest service in a re-examination of the post-Cambrian igneous rocks of the north-west of Scotland — a re-examination rendered necessary by the preparation of the Geological Survey memoir on that district. Some of the results thus brought to light, especially the recognition of true nepheline-syenites, as well as other rocks closely allied to types described by Prof. Brögger in his classic memoirs on the Christiania

[1] "On Borolanite: an Igneous Rock intrusive in the Cambrian Limestone of Assynt, etc.": Trans. Roy. Soc. Edin., vol. xxxvii (1892), pp. 163–178.

district, appear to be of sufficient interest to justify a brief preliminary notice, which it is the purpose of this communication to supply.

The work of previous observers on the rocks in question is described in the paper on borolanite above referred to, and need not therefore be repeated in detail; but there is one name I desire especially to mention in the present connection, namely, that of Dr. Heddle. In one of his papers on the geognosy and mineralogy of Scotland[1] he gives chemical analyses of the porphyritic felspars and of the groundmass of a "hornstone porphyry" from the south-east spur of Ben Brachaid. Both agree very closely with albite in composition. Thus the credit of establishing the existence of rocks formed by the consolidation of an alkaline magma exceptionally rich in soda, in the Assynt district, unquestionably belongs to Dr. Heddle.

The post-Cambrian igneous rocks of the north-west of Scotland occur in two forms—as plutonic masses and as sills and dykes; or, in other words, as abyssal and hypabyssal rocks. No lavas or effusive rocks of any kind are known. The only important plutonic mass is the one stretching from Ledbeg for about five miles in a south-easterly direction, with an average width of about one mile. Cnoc na Sròine (1,306 feet) forms the culminating point. The dominant rock of this mass is a red granite or syenite, remarkably free from ferro-magnesian or any other dark-coloured constituents. It was described by Nicol as a red felspar porphyry, and by Murchison as a syenite. Dr. Heddle pointed out that true porphyritic structure is absent,[2] and that the rock is composed mainly of red felspar, often much stained and decomposed; quartz being always subordinate to the felspar and sometimes absent altogether.

The specimens in the Survey collection agree with Dr. Heddle's descriptions. Those in which quartz is present have the aspect of somewhat coarse-grained binary granites, while those in which it is absent resemble syenites. Ferro-magnesian constituents are extremely rare in the main mass of Cnoc na Sròine, but they occur abundantly in some of the peculiar rocks found on the margins. A specimen from the burn behind the inn at Aultnacallagach (3,082)[3] is a coarse-grained red granite or quartz-syenite, composed mainly of felspar, but containing also a few blebs of quartz and some insignificant dark specks representing a ferro-magnesian mineral. Under the microscope two felspars are recognizable. The plagioclase occurs in more or less idiomorphic crystals, which are often zoned and always twinned on the albite plan. The twin lamellæ are numerous and very narrow. The second felspar occurs in large, irregular plates, and shows moiré-structure under crossed nicols. It is often twinned on the Carlsbad plan, and frequently contains inclusions of idiomorphic plagioclase. Quartz occurs in

[1] Mineralogical Magazine, vol. v (1884), p. 141.

[2] A specimen in the Survey collection (3,081) from the summit of Cnoc na Sròine shows a half-porphyritic structure such as is occasionally found on the margin of Brögger's nordmarkite.

[3] The numbers in parentheses refer to the registered specimens in the collection of the Geological Survey.

irregular grains. The ferro-magnesian mineral is represented by minute scales of a bright green chlorite.

When the powder of the rock is placed in a Sollas' diffusion column three well-marked bands are formed: one corresponding to quartz, which is present only in small quantity (2·65); another corresponding to albite (2·62); and a third at a level just below the point at which orthoclase floats. Although the specific gravity of the plagioclase corresponds very closely with that of albite, the extinctions on M-flakes are not quite equal to albite—15° to 17° as against 19°. The difference is so slight that in the descriptions which follow the term albite[1] will be used. The second felspar, being slightly denser than orthoclase, is probably rich in soda, and may be cryptoperthite or anorthoclase, but the optical characters, so far as I have been able to determine them, agree with orthoclase, and in the absence of analyses I prefer to use that term. Of the two felspars albite is the more abundant.

Another specimen from Cnoc na Sròine (3,090) is very similar in general appearance to the one just described, but contains less quartz. Two felspars are recognizable under the microscope, but they are more intimately intergrown, and often assume the character of microperthite. Both are deeply stained with ferric oxide, and opaque iron-ore occurs as an accessory constituent.

Other red rocks from the same mass are true syenites without quartz, and these sometimes contain pseudomorphs after nepheline with accessory melanite (3,083). The felspars in these cases are either orthoclase or microperthite.

The more acid varieties of the red rocks have affinities with the nordmarkites of Professor Brögger. They resemble them in the abundance of alkali-felspars and in the paucity of both quartz and ferro-magnesian minerals. When the two felspars are intergrown microperthitically the resemblance is very close, but when the albite is independently developed as idiomorphic crystals it is not so close. Taking the mass as a whole, the alkali-granites or quartz-syenites appear to shade into quartzless syenites, and these again into nepheline-syenites.

In the red rocks which form the main mass of Cnoc na Sròine no fresh nepheline has been detected; but a coarse-grained dark-green rock (3,095) from the foot of the north slope of the mountain contains this mineral in abundance, and is, in fact, a true nepheline-syenite. The weathered surface is rough owing to the more rapid weathering of the nepheline, which has a dull green, waxy appearance. The alkali-felspar is developed in flat tables with conspicuous development of the clinopinacoid, and the crystals

[1] It may be of interest to mention that in the metamorphic rocks (albite-schists and gneisses) I have always found the albite to give the theoretical extinction of 19° on M-flakes. The mineral appears to be perfectly homogeneous and ideally pure, except as regards inclusions. But I have never observed the theoretical extinction of 19° in a plagioclase occurring as a normal constituent of an igneous rock. In the case above described the breadth of the band in the diffusion column, the zonal structure seen in the sections, and the slightly varying extinctions on the M-flakes, all indicate that the mineral is not perfectly homogeneous.

are often twinned on the Carlsbad plan. Under the microscope the rock is seen to be composed of nepheline and alkali-felspar in approximately equal proportions. A greenish biotite and melanite occur as accessory constituents. Both felspar and nepheline are present as large individuals, measuring half an inch or more across. The occurrence of melanite as an accessory constituent serves to emphasize the close relation between nepheline-syenite and borolanite.

The typical borolanites have been described in the paper above referred to. They are extensively developed to the east of Aultnacallagach in the low ridge on the north-eastern side of the road leading from Oykell Bridge to Inchnadampf, and occur also at other points on the borders of the plutonic mass. One specimen (3,737) may be briefly referred to as a type. It is a massive rock composed of white patches, measuring one-quarter to three-quarters of an inch across and often polygonal in outline, embedded in a dark, almost black matrix. The white patches correspond to the pseudo-leucites described by Derby, Hussak, and J. F. Williams. They are composed mainly of orthoclase, which is often micrographically intergrown with an alteration product after nepheline. Biotite and ægirine-augite occur sparingly in these patches. The matrix is composed of orthoclase and melanite with some ægirine-augite and biotite. Micrographic intergrowths of orthoclase and the alteration product after nepheline are also present.

The rocks most nearly allied to these peculiar borolanites are unquestionably the 'leucite-syenites' from the igneous complex of Magnet Cove, Arkansas, described by the late J. F. Williams,[1] whose early death was such a severe loss to American petrology. Williams speaks of these and other rocks of the complex as forming dykes; but the geological map of the district accompanying his memoir clearly shows that they do not occur as ordinary dykes. According to Dr. Washington[2] the complex represents a laccolite in which differentiation has produced a mass varying in composition from a highly basic jacupirangite at the centre to foyaite at the margin. The different types—foyaite, leucite-porphyry, shonkinite, ijolite, biotite-ijolite, and jacupirangite—succeed each other in concentric zones from the margin to the centre, the rock most nearly allied to borolanite coming second in the series, reckoning from the outside. This rock is described by Williams as "a hypidiomorphic granular combination of pseudo-leucite, eleolite, orthoclase, and basic silicates, which presents a more or less perfect granitic structure and is genetically connected with the eleolite-syenite dike rocks." The pseudo-leucites are composed mainly of orthoclase and nepheline, as are those of our borolanite, but they are more perfect in form. It must, however, be remembered that the borolanite area has never been searched for specimens showing the forms of

[1] "The Igneous Rocks of Arkansas": Annual Report of the Geological Survey of Arkansas for 1890, vol. ii.

[2] "Igneous Complex of Magnet Cove": Bull. Geol. Soc. Amer., vol. ii (1900), pp. 389–416.

leucite. Those specimens which have been collected frequently show polygonal outlines strongly suggestive of icositetrahedra, and it is highly probable that more perfect forms will be found. The groundmass of the leucite-syenite consists principally of eleolite, black garnets, and orthoclase. A green pyroxene, biotite, and sphene are also present. Melanite, according to Williams, "is found in varying quantities in the different specimens. In some it is almost entirely wanting, while in others it forms a very important factor. It is of a rich brown or yellowish-brown colour, decidedly zonal in its structure, and isotropic in its optical properties. . . . . In some cases more than half the area inclosed within the boundaries of the section consist of melanite material."

This description leaves no doubt that those portions of the 'leucite-syenite' of Magnet Cove in which melanite is most abundant are practically identical with the borolanite of Assynt. This conclusion is confirmed by a comparison of the chemical analysis of the borolanite dyke discovered by Mr. Gunn with that of the rock described by Williams.

	I.	II.
SiO_2	47·8	50·96
Al_2O_3	20·1	19·67
Fe_2O_3	6·7	7·76
FeO	·8	...
MgO	1·1	0·36
CaO	5·4	4·38
Na_2O	5·5	7·96
K_2O	7·1	6·77
H_2O (Ig.)	2·4	1·38
TiO_2	·7	·52
SO_3	·4	...
MnO	·5	tr.
BaO	·8	...
Cl	...	·25
	99·3	100·01

I. Borolanite dyke, Camas Eilean Ghlais. Analysis by Player.

II. 'Leucite-syenite,' Magnet Cove. Analysis by Noyes.

Another rock somewhat allied to borolanite is the ijolite of Ramsay and Berghell.[1] It is essentially composed of nepheline, pyroxene, and a titaniferous melanite (jiwaarite).[2]

In addition to borolanite there are some other interesting modifications of the syenitic magma, apparently detached from the main mass, near Ledbeg at the contact with the marble. One of these (4,288) is a dense, dark-green rock, composed of a green pyroxene and orthoclase or moiré-microcline with sphene as an important accessory; another (3,088), also dark in colour, is composed of ægirine-augite, orthoclase, pseudomorphs after idiomorphic nepheline, and rich brown sphene. Both are augite-syenites, one containing nepheline and the other not.

[1] "Die Gesteine von Jiwaara in Finland": Geol. Foren. Stockholm Forandl., xiii, (1891), p. 300.

[2] It is quite possible that some varieties of the melanite of the borolanite may be titaniferous, but in order to prove this the material analyzed would have to be very carefully examined under the microscope, as the mineral is not unfrequently crowded with minute inclusions of sphene.

The facts above described clearly prove that we have in the plutonic complex of Loch Borolan a connected group of rocks formed by the consolidation of alkaline magmas rich in soda. At one end of the series is the alkali-granite or quartz-syenite forming the main mass of Cnoc na Sròine, and at the other end of the series the basic augite-syenite, nepheline-syenite, and borolanite. The basic varieties occur on the margin and the acid varieties in the centre. This arrangement is the opposite of that occurring in the igneous complex of Magnet Cove.

To what extent the different rocks represent successive intrusions, differentiation *in sitû*, or the result of a modification in the composition of the original magma by the absorption of adjacent limestones, has not been clearly made out. It is quite possible that all three operations will have to be taken into account in explaining the phenomena observed. The evidence available suggests that the quartz-syenites shade into quartzless syenites, and these again into nepheline-syenites. Albite is abundant in the most acid rocks, either in the form of independent crystals or as microperthitic intergrowths with orthoclase. But as nepheline comes in, albite disappears, and in the more perfect types of nepheline-syenite no soda-felspar is recognizable. It is clear, even without chemical analyses, that the presence of nepheline is determined by the ratio of silica to alumina to soda. With excess of silica albite is formed, and when there is a deficiency of silica nepheline is produced. In the more acid rocks albite, or an extremely acid oligoclase, shows a strong tendency to idiomorphism, and precedes both orthoclase and quartz. In the less acid varieties it frequently occurs intimately intergrown with orthoclase.

There is no constancy in the order of appearance of nepheline and orthoclase. In some specimens idiomorphic nepheline occurs as inclusions in large patches of orthoclase (micropœcilitic structure), in others orthoclase is idiomorphic with respect to nepheline, while in the pseudo-leucites and even in the groundmass of certain borolanites the two minerals form beautiful micrographic intergrowths. Thus, nepheline may precede orthoclase, orthoclase may precede nepheline, or the two minerals may crystallize simultaneously. Similar relations between alkali-felspar and nepheline have been described by Professor Brögger as occurring in the laurdalites of the Christiania district.

But the series does not end with nepheline-syenite. This rock sometimes contains ægirine-augite and melanite. By an increase in the former it passes into augite-syenite, and by an increase in the latter into borolanite. The borolanites and augite-syenites may or may not contain nepheline.

The general result of this re-examination of the specimens collected at various times from the plutonic mass of Loch Borolan has been to confirm and extend the conclusion arrived at by Mr. Horne and myself as to the relations between the igneous rocks of Assynt and those of the Christiania district. Quartz-syenites, syenites, augite-syenites, and nepheline-syenites are all represented either in the main mass or in its immediate neighbourhood. But the resemblance extends still further to some of the hypabyssal rocks—the dykes and sills. A glance at the maps (Sheets 101 and 107) will show that the Cambrian area to the north of the plutonic mass is traversed by numerous sills and dykes. These belong to two strongly marked types — dark-coloured hornblendic rocks (camptonites or vogesites) and light-coloured felspathic rocks (felsites). A description of the hornblendic rocks has already appeared in the pages of this Magazine,[1] and they need not further be referred to at present. A full description of the felsites must be postponed until analyses are available, but one or two varieties may be briefly described, as they are clearly allied to certain peculiar rocks occurring in the Christiania district.

The first of these is a dyke from Poll an Droighinn, near Inchnadampf (2,324). The rock is a pale-green felsite, with somewhat obscure indications of porphyritic felspars and decided traces of parallel structure. Under the microscope it is seen to be composed of polysynthetic aggregates, representing original porphyritic alkali-felspars, streaks of microcrystalline quartz (scarce), and a crypto- or microcrystalline felspathic matrix *crowded with acicular microlites of œgirine.* Similar microlites occur in the polysynthetic aggregates, as they do in the phenocrysts in Professor Brögger's grorudite, but they are far less numerous than in the matrix, where they are often so thickly crowded together as to form a felt-like mass. The larger microlites are green, but the smaller ones are colourless; both show the characteristic optic characters of ægirine when isolated from the felspathic material. This rock is a variety of grorudite.

Another very interesting type of felsite, found by Mr. Peach, is intrusive in the Lewisian gneiss in a burn one-quarter of a mile north of the top of Sgònnan More (8,370). This consists of numerous phenocrysts of pink felspar, usually giving rectangular sections and measuring about a quarter of an inch across, embedded in a compact light-grey felsitic matrix. Under the microscope the phenocrysts are seen to consist of intergrowths of albite and orthoclase, similar to those observed in the plutonic mass of Cnoc na Sròine. The groundmass is a micro- or cryptocrystalline aggregate of alkali-felspar, containing a few minute, ragged prisms of ægirine. A little free quartz is probably present, but cannot be identified with certainty under the microscope. This rock contains much less ægirine than the typical grorudites, and in this respect more closely resembles the lindöites of Professor Brögger.

Analyses of these rocks will be made, and until this has been done a further discussion of their affinities seems scarcely desirable. This much is certain. They are composed mainly of alkali-felspar with some free quartz and ægirine, and they are closely allied to grorudites, from which they differ chiefly in containing rather less ægirine.

[1] "Notes on some Hornblende-bearing Rocks from Inchnadampf," by J. J. H. Teall: Geol. Mag., 1886, pp. 346–353.

The grorudites of Professor Brögger form the acid extreme of a well-defined rock-series of which, so far as the Christiania district is concerned, tinguaite is the basic extreme. No rocks answering to tinguaites in chemical composition have been found in the north-west of Scotland. The dykes discovered by Mr. Gunn in west Ross-shire, to which the term borolanite was extended, not without hesitation, as melanite is far less abundant than in typical borolanite, are composed mainly of nepheline, orthoclase, and ægirine, and therefore allied to tinguaites in mineralogical composition; but the rock analyzed contains over 5 per cent. of lime—a fact which sharply differentiates it from typical tinguaites. Another point which differentiates these dykes from tinguaites is their structure. Nepheline, ægirine, melanite, and biotite occur as idiomorphic crystals in large irregular patches of orthoclase (micropœcilitic structure) But if these dykes do not fit into the grorudite-tinguaite series they correspond very well with some of the more basic members of the plutonic mass of Cnoc na Sròine, with the nepheline-melanite syenites, just as the grorudite-like rocks correspond with the more acid portions of the same mass. It is probable, therefore, that both are aschistic, in Professor Brögger's sense, and that they represent the dyke forms of the magmas which gave rise to the plutonic mass.

In the foregoing account of this small but extremely interesting petrographical province, special emphasis has been laid on its relations to the Christiania district; but it might equally well be compared with other districts in which nepheline-syenites occur. Each of these districts has its own special features. The occurrence of borolanite is a peculiarity which the district in question shares, so far as we know at present, only with that of Magnet Cove.

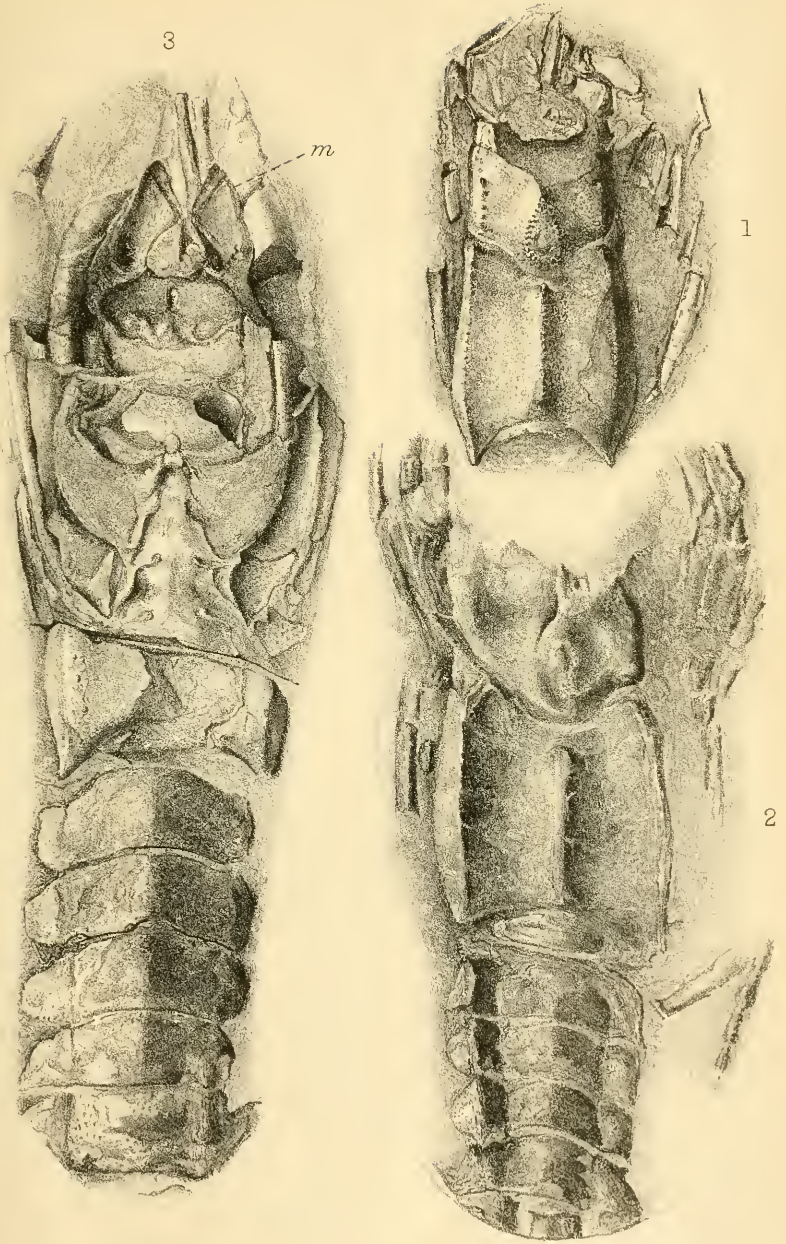
II.—Further Notes on Podophthalmous Crustaceans from the Upper Cretaceous Formation of British Columbia, etc.

By Henry Woodward, LL.D., F.R.S., F.G.S., etc., of the British Museum (Natural History).

(PLATES XV and XVI.)

In 1896 I described some decapod Crustaceans found in the Cretaceous formation of Vancouver and adjacent islands, British Columbia, which, with the approval of Dr. G. M. Dawson, C.M.G., F.R.S., the Director, had been most kindly placed in my hands for examination by Dr. J. F. Whiteaves, F.G.S., Palæontologist to the Geological Survey of Canada. They were referred by me to the genera *Callianassa*, *Homolopsis*, *Palæocorystes*, and *Plagiolophus* (see Quart. Journ. Geol. Soc., 1896, vol. lii, pp. 221–228, with 6 figures).

From the same source I have since received a further and much larger collection of specimens from the Nanaimo and Comox Group (Upper Cretaceous). Like the earlier series, all these Crustaceans are preserved in hard concretionary nodules, which render their examination in detail often extremely difficult and disappointing, as



G. M. Woodward & H. B. Potter.

West, Newman imp.

Decapod Crustaceans
U. Cretaceous Vancouver Island, B.C.

they split unevenly with a jagged fracture, and have also a tendency to divide up into cuboidal fragments.

The material which has now been placed in my hands may be summarized thus:—

No. 1. One specimen of a dark nodule, split into halves (3″ × 1¾″), exposing the cephalothorax and portions of the limbs of a Crustacean referred to *Linupārus* (*Podocrates*) *Vancouverensis* by Whiteaves (Pl. XV, Fig. 1), described in Trans. Roy. Soc. Canada, ser. II, vol. i (1895–6), sect. 4, pp. 132 and 133. Formation: from the Nanaimo Group (Upper Cretaceous), Museum Geol. Surv. Canada. Locality: from two miles up the Puntledge (called also the Comox) River, Vancouver Island; collected by the Rev. G. W. Taylor, 1889.

No. 3 (labelled also 58 in white paint). A large dark nodule, split in halves (6¾″ × 3¾″), exposing the dorsal aspect of a second specimen of *Linupārus* (*P.*) *Vancouverensis*, W., showing the cephalothorax and a portion of the base of the left antenna. The three characteristic longitudinal ridges, the small central pear-shaped area in front of the neck-furrow on the carapace, and five of the abdominal segments can also be seen (Trans. Roy. Soc. Canada, op. cit.). Formation: Upper Cretaceous. Locality: Hornby Island; coll. by W. Harvey, 1893.

No. 4. A long, dark, and rather cylindrical nodule (6½″ × 2½″), split in halves and also broken across transversely, exposing the interior of the cephalothorax and five segments of the abdomen of *Linupārus* (*P.*) *Vancouverensis*, W. (Pl. XV, Fig. 3). The upper surface of the carapace is not preserved, but the bases of the mandibles (*m.*) are exposed, the monodactylous walking-legs, and the bases of the antennules. The epimeral portions of the abdominal segments are serrated behind, and bear small tubercles on the surface. Formation: Upper Cretaceous. Locality: Comox River, Vancouver Island; coll. by J. B. Bennett, 1895.

No. 6. Half of a nodule only (7″ × 4¾″), containing an obscurely preserved Crustacean, *Linupārus* (*P.*) *Vancouverensis*, showing characteristic traces of the carapace and limbs and the nearly entire abdomen, including remains of the caudal appendages. The posterior borders of the epimera are spinous. The right antenna is preserved for a length of 2½ inches. Formation: Upper Cretaceous. Locality: Hornby Island; coll. by W. Harvey, 1895. (Specimen also marked No. 1 in ink.)

No. 55 *a* and *b*. Two sides of a dark egg-shaped nodule split open (4½″ × 3⅝″), exposing the dorsal aspect of a specimen of *Linupārus* (*P.*) *Vancouverensis*, W. (Pl. XV, Fig. 2), showing the carapace and the five abdominal segments, also the remains of the caudal appendages and the thoracic limbs. The three characteristic ridges are well seen, also the cervical furrow, with its pear-shaped tuberculated area just in front. Formation: Upper Cretaceous. Locality: Hornby Island; coll. by Mr. Robbins in 1896, Provincial Museum, Victoria, British Columbia.

A few additional specimens from the same series are referred to later on.

NOTES ON THE GENUS *Linupārus*, A. White, 1847.

Before proceeding further it seems desirable to say a few words upon the nomenclature of this genus, which, like the materials illustrating it, has greatly increased and become somewhat complicated.

In 1884 Dr. Whiteaves first called attention to these interesting Palinurids in the Transactions of the Royal Society of Canada (vol. ii, sect. 4, pp. 237, 238) under the provisional generic name of *Hoploparia* (?), with the specific designation of *Canadensis* for the form then under discussion, obtained from the Cretaceous of Highwood River, a tributary of the Bow River.

This fossil was again described by Dr. Whiteaves (in 1885) under the name of *Hoploparia* (?) *Canadensis* in "Contributions to Canadian Palæontology," 1885, vol. i, pp. 87–89, where it is figured for the first time (pl. xi). It appears that some time afterwards (1890) Dr. C. Schlüter, of Bonn, stated that the so-called *Hoploparia* (?) *Canadensis* was closely allied, if not identical with, his *Podocrates Dulmenensis*, a name proposed by Becks (without description), but described fully by Dr. Schlüter in 1862 (in the Zeitsch. der Deutsch. Geol. Gesellsch., xv, pp. 710–716, taf. xii). This genus *Podocrates* was also adopted by Fritsch & Kafka in their "Crustacea Böhm. Kreidform.," pp. 20, 21, taf. iii, figs. 1 and 2 and text-fig. 44, Prague, 1887.

In 1895 Dr. J. F. Whiteaves added a new species of Cretaceous Palinurid to the series of Crustaceans already recorded by him from the Cretaceous of Vancouver (Proc. and Trans. Roy. Soc. Canada, ser. II, vol. i, sect. 4, pp. 132, 133), under the name of *Podocrates Vancouverensis*, thus accepting and acknowledging the correctness of Dr. Schlüter's earlier determination in 1862.

Two years later, Dr. A. E. Ortmann described a new species of Palinurid, from the Upper Cretaceous of Dakota, under the generic name of *Linuparus*, Gray (1847), a monotypic genus containing only the single living Japanese species *Palinurus trigonus* of De Haan (see De Haan, in Siebold's "Fauna Japonica," Crustacea, 1841, p. 157, pls. xxxix and xl). This genus *Linupārus*,[1] attributed to Dr. John Edward Gray ("List of Crustacea in the British Museum," p. 70), as pointed out by the Rev. T. R. R. Stebbing, F.R.S. ("A History of Crustacea," 1893, p. 197), (spelt by him *Linupāris*), is *not* Dr. Gray's name, but was given by Adam White in 1847; "the characters of the new genus being left to be inferred from the known species (as described by De Haan), a very slovenly method of definition which is much to be deprecated" (Stebbing, op. cit.).

LINUPĀRUS VANCOUVERENSIS, Whiteaves, sp. (Pl. XV, Figs. 1–3.)

1841. *Palinurus trigonus*, De Haan, Fauna Jap. Crustacea, p. 157, pls. xxxix, xl.
1847. *Linuparus trigonus*, White (gen. emend.), List Crustacea Brit Mus., p. 70.
1857. *Thenops*, Bell, Foss. Malacost. Crust., pp. 33, 34, pl. vii: Pal. Soc. Mon., 1857.

[1] This name is an anagram on Fabricius's genus *Palinurus*, from which *Linupārus* was separated by Adam White, the real author of the "List of Crustacea in the British Museum," 1847.

1862. *Podocrates* (Becks, nom. nud.), Schlüter, Zeitsch. der Deutsch. Geol. Gesellsch., xiv, 1862, pp. 710–716, taf. xii.
1887. *Podocrates*, Fritsch & Kafka, Crust. Böhm. Kreidform., pp. 20, 21, taf. iii, figs. 1 and 2 and text-fig. 44.
1893. *Linupāris* (*sic*), Stebbing, Hist. Crustacea, p. 197.
1895. *Podocrates*, Whiteaves, Trans. and Proc. Roy. Soc. Canada, 1895, ser. II, vol. i, sect. 4, pp. 132, 133.
1897. *Linuparus*, Ortmann, Amer. Journ. Sci., ser. IV, vol. iv, pp. 290–297, figs. 1–4 in text.

At the meeting of the Royal Society of Canada, May, 1895, Dr. J. F. Whiteaves gave descriptions of the fossils from the Nanaimo group of the Vancouver Cretaceous series, and among others described a new species of Crustacean, of which description I subjoin a copy.

LINUPĀRUS (PODOCRATES) VANCOUVERENSIS, Whiteaves, sp.

"Carapace flattened, rectangular, longer than broad, marked by three low angular tuberculous or spinose longitudinal ridges, one in the median line and one near each of the lateral margins, and divided at about one-third the distance from the front by an obtusely subangular cervical groove, which is rather broad but not very deep. On the anterior portion or cephalic arch the lateral longitudinal ridges are well developed, and armed with larger and more spinose tubercles than those on the corresponding ridges of the posterior portion, one a little behind the mid-length on each ridge being larger than any of the others, but the central ridge is obsolete. In its place, just in advance of the cervical groove, there is an ovate lanceolate or narrowly spear-shaped area, which is elevated at the pointed end anteriorly, shallowly depressed posteriorly, and margined with a single row of small tubercles. Immediately in front of this area there is a pointed or spinose tubercle, almost in a line with the largest tubercle on each of the lateral ridges, and still farther forward there are two similar tubercles at a short distance from the anterior margin and about seven millimetres apart. On the posterior portion, or scapular arch, the three longitudinal ridges are minutely tuberculated, and extend from the posterior margin to the cervical groove, where they each terminate in a pointed tubercle larger than any of the rest, but the central ridge is shorter than either of the two lateral ridges. Anterolateral angles of the carapace each armed with a nearly straight but slightly divergent spine. Rostrum, central portion of the anterior margin, and position of the eyes unknown. External antennæ broad and flattened at their bases, inner antennæ cylindrical at theirs. Walking feet slender, as is usual in the genus. In addition to the spines and tubercles on the lateral ridges and elsewhere, as already described, the whole of the upper surface of the carapace is minutely granulose and apparently setose, numbers of minute objects, which seem to be detached setæ, being plainly visible under an ordinary lens."

"Two miles up the Puntledge River, Vancouver Island, Rev. G. W. Taylor, 1889: a good specimen of the carapace, with the rostrum and a small piece of the anterior broken off, but with considerable portions of the ambulatory feet and the bases of the inner and outer antennæ preserved. This interesting fossil is now in the Museum of the Geological Survey of Canada. [See Pl. XV, Fig. 1.]

[No. 3.] "Hornby Island, W. Harvey, 1893: a less perfectly preserved specimen, showing most of the carapace (but not the rostrum), portions of the ambulatory feet, and the dorsal aspect of five segments of the abdomen (their margins were denticulated).

"In 1884 (Trans. Roy. Soc. Canada) the writer [Dr. J. F. Whiteaves] described a long-tailed decapod crustacean from the Cretaceous rocks at the Highwood River in Alberta, under the provisional name *Hoploparia* (?) *Canadensis*. Dr. C. Schlüter, of Bonn, Germany, in a letter dated February 20, 1890, expresses the opinion, which appears to be well founded, that this species, which is figured on plate ii of the first part of the first volume of 'Contributions to Canadian Palæontology,' is a *Podocrates*, closely allied to, if not identical with, the *P. Dülmensis* of Becks. *P. Vancouverensis* seems to differ from that species in the much smaller proportionate size of the tubercles on the three longitudinal ridges on its carapace, especially posteriorly, and in the different arrangement of the distant spinose tubercles on the anterior moiety of its cephalic arch."

The publication of Dr. Ortmann's paper (American Journal of Science, ser. IV, vol. iv, 1897, pp. 290–297, figs. 1–4) makes us acquainted with another species of Palinurid, which he names *Linuparus atavus*, from the Upper Cretaceous of Cotton Wood Creek, Mead Co., South Dakota.

There is no doubt that this form is closely related generically with *P. Canadensis*, *P. Vancouverensis*, Whiteaves, and also with *P. Dulmenensis*, Schlüter, and that for all these species Adam White's genus *Linupārus* (1847) takes priority over the other genera to which they have heretofore been referred by various authors.

Formation: Upper Cretaceous.

Locality: Puntledge or Comox River (Fig. 1), Hornby Island (Fig. 2), Comox River (Fig. 3), British Columbia.

In the "Contributions to Canadian Palæontology" for 1885, vol. i, pp. 87–89, pl. xi, Dr. J. F. Whiteaves, F.G.S., published the following description of *P. Canadensis*, a decapod Crustacean from the Upper Cretaceous of Highwood River, Alberta, N.W.T., which we here reproduce:—

LINUPĀRUS (PODOCRATES) CANADENSIS, Whiteaves, sp.

Hoploparia (?) *Canadensis*, Whiteaves, 1884.[1]

"The fossil, which it is the more immediate object of this paper to describe, is a rather remarkable example of a macrourous decapod crustacean, collected by Mr. R. G. McConnell in 1882 from the Cretaceous shales of the Highwood River, a tributary of the Bow, ten miles west of the first fork.

"The specimen originally consisted of an elongate-oval and

[1] Trans. Roy. Soc. Canada, vol. ii (1884), sect. 4, pp. 237, 238.

flattened concretionary nodule of soft argillite, with a small piece broken off from one end, but enough of the matrix has been removed to show most of the carapace and the upper surface of a few of the abdominal segments. The anterior extremity of the carapace, with the rostrum, is unfortunately not preserved, and the tail, with some of the posterior abdominal segments, was broken off when the nodule was found. The ambulatory feet are preserved, but it was found to be scarcely possible to remove the soft shale from around them without running the risk of spoiling the specimen.

"The carapace, like that of most of the macroura, is elongated and comparatively narrow, with nearly parallel sides, and, when perfect, its length must have been about twice as great as its breadth. A little in advance of the mid-length a single, broadly V-shaped, deep, and rather wide cervical furrow crosses the carapace transversely. The posterior half of the carapace is depressed and rather distinctly three-keeled in a longitudinal direction. In the specimen collected by Mr. McConnell a central keel, or narrow but prominent raised ridge, about three times as broad posteriorly as it is anteriorly, and which is bounded on each side by a deep and angular furrow, extends from the posterior end of the carapace to the centre of the V-shaped (cervical) groove which transverses it. This central keel is much more strongly marked than the broad and comparatively obtuse lateral keels near the outer margin of each side. The surface of the posterior half of the carapace (and perhaps that of the anterior also) is covered with rather distant, small, isolated conical tubercles, which occasionally are surrounded by a minute annulus at the base; and the three keels each have a single series of larger conical tubercles, whose pointed apices are directed forward.

"In front of the transverse and V-shaped (cervical) furrow the carapace is very badly preserved, and the anterior margin with the rostrum is broken off. The two lateral and tuberculated keels appear to be prolonged to within a short distance of the front margin of the carapace, though they are somewhat less distinct in front of the (cervical) furrow than they are behind it. On the anterior side of the furrow the central keel is absent, and the median portion of this part of the carapace bears a number of comparatively large and prominent, distinct and conical tubercles, which are somewhat peculiarly arranged. Next to the furrow, and in advance of it, in the median line, there are five tubercles arranged in two convergent rows of two pairs and an odd one, which, if connected by lines, would have much the shape of an isosceles triangle, with its base near to the furrow. Between the space bounded by these five tubercles and each lateral keel there is a shallow, concave, and rather broad depression of the carapace. In front of these five tubercles, again, there are four others and still larger ones (the two anterior ones apparently of considerable size), arranged somewhat in the form of a square, any of whose sides would be greater than the base of the isosceles triangle indicated by the other five.

"The upper surface of each of the abdominal segments bears a tubercle in the centre, on its anterior edge, and another one on the margin of each of the sides. The most prominent characteristic of the species, in fact, is the possession of three widely distant, longitudinal, and tuberculated keels, which extend over nearly the whole length of the upper surface of the body." . . . .

"Judging by the invertebrate fossils alone, it would seem probable that the friable and fissile shales at Mill Creek, which hold typical examples of *Inoceramus problematicus*, may represent the 'Niobrara Group' of the Upper Missouri section. On similar evidence, also, the rocks of the two localities on the Waterton River, which have yielded respectively *Ostrea congesta* and *Volviceramus exogyroides*; those at the Highwood River, which contain *Inoceramus undabundus* and *Scaphites Warreni*; those on the north-west branch of the north fork of the Old Man River, from which *Inoceramus undabundus*, *Pholadomya papyracea*, *Scaphites Warreni*, and *S. vermiformis* were collected; and those at the entrance to the North Kootanie Pass, which are characterized by *Volviceramus exogyroides*, *Scaphites Warreni*, and *S. vermiformis*, would appear to be as nearly as possible the Canadian equivalents of the 'Fort Benton Group.'

"In conclusion, it may be remarked that the invertebrate fauna of the 'Belly River Series' seems to be essentially the same as that of the 'Laramie' of the United States and Canada, unless more than one formation has been confounded under the latter name, and that it is at present scarcely possible to separate the 'Lower Dark Shales' of Dr. Dawson's Bow and Belly River Report from the 'Fort Pierre and Fox Hills' Groups on purely palæontological grounds."[1]

Additional note on *Linupārus Canadensis* (Pl. XVI, Fig. 1), by H. Woodward.—No. 55 *c*. One half of a dark nodule ($6\frac{1}{2}'' \times 4''$), exposing the under side of a large Crustacean, showing the five sternites and the bases of the thoracic limbs. I have referred this specimen to Dr. Whiteaves' species *L. Canadensis*, with which it agrees in size, being one of the largest specimens of the fossil Palinurids from this locality.

It exhibits the under surface of the cephalothorax, with the sterna and the basal joints and portions of the five pairs of ambulatory appendages, one or more being nearly complete. The sternum forms a rather broad and somewhat triangular area, in front of which the mandibles and the labrum are seen, with the spinous stout basal joints of the long stiff antennæ. There are also traces of the antennules visible.

Each sternite, carrying the thoracic limbs, is ornamented with a pair of rounded, sub-central tubercles, except the first, which has only a single central one.

Upper Cretaceous: Hornby Island; collected by Mr. Robbins, preserved in the Provincial Museum at Victoria, B.C.

Here I would also place a second specimen, preserved in a half nodule, No. 7 (marked 2 in ink), which I refer to *L. Canadensis*. The half nodule measures $6'' \times 4''$, and displays one of the large antennæ and five of the walking-legs very well preserved. The

[1] Added from Dr. Whiteaves' Contrib. Canad. Palæont., vol. i (1885), p. 88.

surface of the appendages is rugose. Three of the body-segments can be seen. Locality: Hornby Island; W. Harvey, 1895.

Although not refigured, it seems desirable, in order to complete this record, to reproduce Dr. Whiteaves' description of this additional Cretaceous form.

"PALÆASTACUS (?) ORNATUS, Whiteaves.

Palæastacus (?) *ornata*, Whiteaves, 1887, Geol. and Nat. Hist. Surv. Can. Ann. Rep., N.S., vol. ii, p. 161 E.

Palæastacus (?) *ornata*, Whiteaves, 1889, Contrib. Canad. Palæont., vol. i, pt. ii, p. 183, pl. xxv, fig. 3.

"The foregoing was suggested as a provisional name for a rather remarkable specimen of a macrouran decapod which evidently belongs to the family *Astacomorpha* of Zittel [1885]. Of Cretaceous representatives of this family it seems to come nearest to such genera as *Palæastacus* and *Hoploparia*, though it differs from each in some important particulars. In many respects it appears to the writer to be still more nearly related to the recent fresh-water genera *Astacus* and *Cambarus*, but there is good reason for supposing that it will eventually prove to be the representative of a new generic type, which at present there is not sufficient material to define satisfactorily.

"Nearly the whole of the under surface of the cephalothorax of the specimen is buried in the matrix, the front margin of the carapace is very imperfect, the caudal plates, as well as the under part of the five abdominal segments, are broken off, and only small portions of the chelæ and of the other ambulatory legs are preserved or exposed.

"The carapace is moderately convex and slightly depressed, and not quite twice as long as broad. It is divided into two nearly equal parts by a single, well-marked, and deeply impressed cervical furrow, which is arched forward in a shallow, concave curve. Behind this furrow the lateral margins of the carapace are slightly expanded, the branchial region is moderately inflated, and the posterior margin is slightly concave in the middle. A short distance in advance of the cervical furrow, on the outer and lower portion of the carapace, on each side, there is a very short and transverse groove or narrow constriction, which may possibly be confluent with the neck-furrow on the strongly curved lateral margins of this part of the carapace. The exact outline of the anterior margin of the carapace cannot be ascertained, and the tip of the rostrum is broken off. The basal portion which remains is about seven or eight millimetres long. At the base it measures 5 mm. in breadth, and at the broken anterior extremity its breadth is 2 mm. Its outer margins are defined by two linear and acute, tuberculated, and raised longitudinal ridges, between which the surface is smooth and concavely excavated.

"The whole of the outer surface of the carapace is ornamented by rather distant, isolated tubercles. In its posterior moiety these tubercles are somewhat irregularly disposed, though there is a low, very narrow, and rather inconspicuous keel on the median line, on either side of which the cardiac region is comparatively smooth. On the anterior portion of the carapace the tubercles are grouped somewhat obscurely in two or three longitudinal rows on both sides of the narrow median keel, which is continued with greater or less distinctness up to the commencement of the rostrum.

"The anterior chelæ appear to have been short and robust, while their surface is distinctly tuberculated. The portions of the posterior ambulatory legs that happen to be preserved, on the other hand, are very slender, and their surface is minutely granulated. The abdominal segments are badly preserved, but their outer surface seems to have been smooth, though a narrow median keel can be traced throughout the greater part of their dorsal surface.

"Locality: Sounding Creek, Township 30, Range 8; west of the 4th Principal Meridian, 1886.

"At the same locality and date, five detached chelæ, apparently of a second species of decapod Crustacean, were collected in as many concretionary nodules. These claws resemble those of *P. ornatus* in the comparative shortness and robustness of their terminal segments, but the outer surface of the latter is finely granulated rather than coarsely tuberculated."

ERYMA DAWSONI, H. Woodw., sp. nov. (Pl. XVI, Fig. 2.)

Among the specimens which form a second collection sent by Dr. J. F. Whiteaves (24th September, 1898) from the Geological Survey of Canada, is the half of a nodule containing an Astacidean from the Upper Cretaceous of the north-east side of Hornby Island, British Columbia, collected by Mr. J. B. Bennett in 1898 (No. 55D).

The Crustacean is seen in profile on the split surface of a nodule, and exhibits the cephalothorax, with its stout pair of chelate limbs (or forceps) attached, and the remains of the four pairs of succeeding ambulatory legs, the six abdominal somites, and the telson, but the lateral lobe of the tail-fin was probably preserved in the other half of the nodule not sent. The branchiostegite (covering the branchiæ) is broad and tumid, and the branchiocardiac groove is strongly marked. Starting from the median dorsal line as a V-shaped furrow, about 12 millimetres from the posterior border, it bends rapidly forward, becoming deeper on each side, and reaches the lateral border 24 mm. in advance; here it unites, close to the hepatic lobe, with the equally deep but more transverse cervical furrow, which crosses the carapace 10 mm. nearer to the front. In advance of the cervical groove the postorbital ridge and spine can be seen, also the base of one of the antennules, with part of one of its flagella, beneath the somewhat short rostrum, and lower down the base of one of the outer and larger antennæ. The surface of the branchiostegite is marked by numerous small tubercles scattered irregularly over the surface. The branchial, cardiac, and hepatic regions are also similarly tuberculated, and very tumid. Length of carapace 48 mm., depth of side 25 mm. The ambulatory limbs are fairly long and slender; the chelate limbs measure about 60 mm. in length; length of penultimate

2

1

G. M. Woodward & H. B. Potter West, Newman imp.

Decapod Crustaceans
U. Cretaceous Comox & Hornby Id. B.C.

joint 35 mm., breadth 15 mm., length of ultimate joint 20 mm. The fingers are long and slender, the inner edge of the forceps being denticulated; wrist 6 mm. long by 10 mm. broad. The epimeral border of each abdominal segment is falcate in contour.

The general form and details of this Crustacean, so far as preserved, clearly mark its place among the Astacidea, or under the Astacomorpha (as defined by Huxley, 1881), and I would suggest that Oppel's name of *Eryma* is appropriate for it, seeing that it agrees very closely in the divisions of its carapace and its tuberculated surface, in the antennæ, the form of the first pair of forcipated chelæ, and the proportions of its abdomen, with *E. Perroni* and other Jurassic species.

Oppel observes[1] that no examples of the genus *Eryma* have been found in rocks younger than the Jurassic, and that the Astacidæ of the Chalk are placed in McCoy's genera *Hoploparia* and *Enoploclytia*, but in this instance the form in question agrees much more closely with Oppel's genus *Eryma* than with other forms. I therefore propose to relegate it to that genus, and to designate it by the specific name of *Dawsoni*, in honour of Dr. G. M. Dawson, C.B., F.R.S., the eminent Director of the Geological Survey of Canada, who has done such splendid work in the field in mapping the geology of British Columbia.

EXPLANATION OF PLATES XV AND XVI.

(All from the Upper Cretaceous formation, and drawn of the natural size.)

PLATE XV.

FIG. 1. *Linuparus Vancouverensis*, Whiteaves. Dorsal aspect of cephalothorax, showing some of the ambulatory legs. Puntledge or Comox River, Vancouver Island, British Columbia.

,, 2. *Linuparus Vancouverensis.* Hornby Island. Shows cephalothorax and abdomen united and smaller walking limbs.

,, 3. *Linuparus Vancouverensis.* Comox River. Shows inner surface of thorax, with the mandibles (*m.*) and the walking-legs; also bases of the antennules and upper surface of abdominal somites.

PLATE XVI.

FIG. 1. *Linuparus Canadensis*, Whiteaves. Under side of cephalothorax.

,, 2. *Eryma Dawsoni*, H. Woodw. Hornby Island. Specimen imbedded in a nodule seen in profile. Geological Survey Museum, Ottawa.

(*To be continued.*)

III.—FOSSIL MAMMALIA FROM EGYPT. Part II.

By CHAS. W. ANDREWS, D.Sc., F.G.S., British Museum (Nat. Hist.).

IN addition to the remains of the large Anthracotheroid (*Brachyodus africanus*) described in the first part of this paper (GEOL. MAG., Dec. IV, Vol. VI, 1899, p. 481), the collection of mammalian bones from the Lower Miocene of Moghara also includes portions of the skeleton of a small rhinoceros. Unfortunately this is very poorly represented, there being only an incomplete scapula and an atlas vertebra, and in the absence of any portion of the skull or teeth it is impossible to determine the species to which it may have belonged. As was pointed out in Part I, the age of the deposit is Burdigalien (Lowest Miocene), and it is therefore contemporary with the Sables de l'Orléanais and the fresh-water deposits of

[1] Palaeontol. Mittheilung., 1862, p. 22.

Eggenburg. From the latter no rhinoceros remains are recorded, but from the former several species seem to have been obtained. Of these only one, *Aceratherium aurelianense*, has been described and figured.[1] Gervais, on the authority of the Abbé Bourgeois,[2] has given a list of five species from the Sables de l'Orléanais, but none of these seem to be true Burdigalien forms, some being Middle Miocene, others Upper Oligocene. More recently Mermier[3] has described and figured a fine skull and mandible of an *Aceratherium* from the Burdigalien of Pont-de-Manne in Royans (Drôme), South-Eastern France. Of this species, to which the name *A. platyodon* has been given, nothing beyond the skull and mandible has been described and figured, so that it is not possible to compare the Egyptian specimens with it. Not improbably, when further remains are obtained from Moghara it will be found that this Egyptian rhinoceros is identical with *A. platyodon*, *A. aurelianense*, or with one of the other species which actually occur in the Sables de l'Orléanais, but seem to have been so far confused with forms from other horizons. The extreme hardness and generally good state of preservation of the Egyptian bones render it highly probable that excavations at Moghara would yield very complete and valuable specimens, and it is to be hoped that such a systematic search may sooner or later be made.

The *atlas* is somewhat smaller than that of any recent rhinoceros, but at the same time it is relatively longer; moreover, the cups for the occipital condyles are much deeper and are separated by a deeper notch, and the surfaces for articulation with the centrum of the axis are inclined to one another at a more acute angle than in any rhinoceros atlas with which I have been able to compare it. The transverse processes are much broken at their extremities, which seem to have been expanded to a considerable degree; near their bases they are perforated by a very oblique vertebrarterial canal, the ventral opening of which is near their middle point, the dorsal near their anterior border just external to the outer angle of the articular surface for the axis. A similar canal is seen in the atlas of some specimens of *R. bicornis*, but is absent in others, so that it cannot be regarded as a character of much importance. The neural arch is narrow from before back, and is perforated by a large foramen for the first spinal nerve; the impressions of the nuchal ligament are not strongly marked, probably indicating that compared with that of the recent horned rhinoceroses the skull was light.

The only atlas vertebra of any of the older forms of rhinoceros with which I have been able to compare this specimen is that of *R. schleirmacheri*, described and figured by Kaup, and of which there is a cast in the British Museum. From this atlas our specimen differs as widely and in the same points as from those of recent forms.

[1] Nouel, "Mémoire sur un nouveau Rhinocéros fossile," pls. i–v: Mém. de la Société d'agriculture, sciences, belles-lettres, et arts d'Orleans, viii, 1866, p. 241.

[2] Gervais: "Zool. et Pal. générales," ser. i (1867–9), p. 157.

[3] Mermier, "Sur la découverte d'une nouvelle espèce d'*Acerotherium*": Ann. Soc. Linn. Lyon., tom. xlii (1895), p. 163. Also, op. cit., tom. xliii (1896), pp. 225 and 257.

The dimensions of the atlas are:

	mm.
Greatest width across articulation for skull	140
Greatest width across articulation for axis	153
Antero-posterior width of base of the transverse process	94
Height of neural canal	70
Width of neural canal	62

In the imperfect right scapula, probably belonging to the same species, the supra-scapular border, the upper edge of the spine, and the upper portion of the glenoidal border have been broken away. The most notable points about this bone are: (1) the straightness of the coracoid border, which for the greater part of its length is parallel to the base of the spine; and (2) the comparative narrowness of the prescapular fossa. In both these points the fossil scapula resembles that of *R. bicornis* more nearly than those of other living species, but its coracoid border is still straighter and the spine is less inclined backward than in that species. In *R. unicornis* the width of the bone above the coracoid tuberosity is relatively considerably greater, the coracoid border more convex, and the prescapular fossa somewhat wider than in the fossil; but on the other hand, in the general backward curvature of the blade there is considerable similarity in the two forms. The scapula of *R. sondaicus* is widely different, being much more expanded and having a strongly convex coracoid border. In *R. simus* also the coracoid border is convex, the prescapular fossa wider, and the coracoid tuberosity much more massive. Another point which distinguishes this scapula from those of recent types is the form of the glenoid articulation, which is ovate, with the narrow end towards the coracoid border; in recent forms this surface is nearly circular, although in *R. indicus* there is some indication of an ovate form.

Comparison with fossil forms is difficult, owing to the fact that the scapula is seldom figured, and that there are scarcely any specimens in the Natural History Museum. Amongst the scapulæ of which figures are available our fossil seems to approach most nearly to that of *R. pachygnathus,* from the Upper Miocene of Pikermi, figured in Gaudry's "Animaux fossiles et Géologie de l'Attique," pl. xxxi, and from this it differs in much the same points as from the scapula of *R. bicornis.*

The scapula is too incomplete to give any accurate measurements, but its approximate dimensions are as follows :—

	mm.
Glenoid surface, long diameter	77
Glenoid surface, short diameter...	62
Width immediately above coracoid tuberosity	95
Approximate length	360

As was remarked above, the remains here noticed are far too incomplete and the material for comparison too scanty, for it to be possible to say more than that the bones are those of a rhinoceros; but at the same time the general similarity of the scapula to that of *R. bicornis* and *R. pachygnathus* suggests the probability that this Miocene type will prove to belong to the same series of which those species are members.

IV.—On the Constituents of the Sands and Loams of the Plateau Gravel occurring in the Pit Sections near Ash, Sevenoaks.

By Frederick Chapman, A.L.S., F.R.M.S.

I AM indebted to the Rev. Ashington Bullen, B.A. (London), F.G.S., for eight samples of sands and loams from the Plateau Gravel of Kent, which he has placed in my hands for examination with the microscope. They were carefully collected by Mr. B. Harrison, of Ightham; and for convenience they are here lettered A–H.

The sections of these and other pits, made under a grant from the British Association in 1895, are published in the Report of the British Association for that year.

A.—A greyish or mottled clay, at 3 ft. 6 in. The proportion of argillaceous material washed from this sample was 73 per cent., leaving a residuum of 27 per cent. of fine and coarse sand. The sandy residue consists of very fine angular quartz and pale glauconitic fragments. There is also a large proportion of accreted sand-grains, some of which simulate rhizopodal tests, if they are not actually such, and resemble genera which affect sandy and shallow marine areas.

B.—A pebbly loam, from Pit No. 2, at 3 ft. 6 in. ("Ash, 1896"). A large proportion of this material consists of well-rounded pebbles of flint, with an occasional subangular fragment. The sandy residue after washing is seen to be composed of angular chips of flint and quartz, with some ferruginous matter.

C.—A grey sandy loam from Pit No. 1, at 5 feet. This material is excessively fine. After the finest sand and clay was removed by washing, the residuum amounted to 45 per cent. A part of the washings was treated for heavy minerals, of which there is a noticeable quantity. The average size of these mineral particles is about ·05 mm. in diameter. They consist of (1) *Hornblende,* a few fragments, some with a decided blue tint suggestive of Riebeckite; (2) *Chlorite,* several flakes; (3) *Tourmaline,* numerous and in very perfect crystals grey to greenish-brown; (4) *Kyanite,* a few flakes; (5) *Glauconite,* numerous rounded granules; (6) *Zircon,* exceedingly common, some well-formed crystals with prism of 1st order and pyramids of 2nd order; also badly developed crystals with rounded angles, good examples of zoning, cavities, and inclusions; (7) *Rutile,* many examples, including both short and long prisms, of a fine red-brown colour. The above-mentioned minerals are much smaller than any others I have met with, either in the Bagshot Sands or the Lower Greensands, but in many respects are like those from the first-named deposits. The quartz grains are very minute and perfectly angular. There are also a few cherty and accreted fragments present.

D.—A pebbly loam, from Pit No. 2, at 8 feet. Somewhat similar to the preceding; with a difference in the character of the pebbles, which, although rounded, are split apparently by frost action. The fine sand is interesting on account of its diverse nature, consisting chiefly of angular fragments of quartz, with numerous subangular and partially rounded quartz and flint grains, and very rarely a probably wind-polished grain of quartz. A sponge-spicule was noticed in this sample.

E.—An umber-coloured clay, from Pit No. 2, at 8 feet. This specimen yielded a residuum, on washing away the fine argillaceous portion, of 42 per cent. This consists of fine angular quartz sand, and a smaller proportion of accreted particles, of an umber-brown colour.

F.—A bright ochreous yellow sandy rock, of fine texture, from Pit No. 2, at 8 feet. The fine argillaceous and ochreous portions of this rock were separated by decanting after stirring and allowing the washings to settle for 20 seconds. This gave a residuum of 72 per cent. The fine portion consists of minute grains of quartz, very angular, and associated with them were some flakes of limonitic material. A small proportion of the residue is much coarser and floats easily. It consists of tubular and reticulose or pitted fragments of a purple-brown colour, somewhat of the nature of 'race.' The reticulate surface may possibly be due to the impress of sand-grains. Some of the particles in this residue have a chalky appearance, and are doubtfully comparable with worn specimens of foraminifera; there are also a few fragmentary sponge-spicules. The rarer minerals are also present in some abundance in this sand, such as zircon, tourmaline, rutile, and kyanite.

G.—A pale ochreous sandy clay, from Pit No. 2, at 8 ft. 2 in. The residuum after washing was 40 per cent. The chief part of the sand consists of angular and subangular quartz grains, with a smaller quantity of flinty particles, and with a few larger accreted fragments of a dark umber colour. Some of the large quartz grains show evidence of wind-polishing.

H.—Sand with iron-oxide cemented to an eolith, from a pit at Ash in the gravel that occurs at 8 feet. The separated sand-grains carry a more or less thick covering of ferruginous cement. The finer sand-grains consist of sharply angular quartz fragments; the larger grains are angular, subangular, and rounded, or even highly polished, fragments of quartz, chert, and flint. Several of the particles noticed are of foraminiferal origin, consisting of pale glauconite. One very perfect cast, in apple-green glauconite, was here noticed, and identified as that of *Globigerina cretacea*, D'Orb.

Relics of minute marine fossils (some certainly from the Chalk) occur in the samples of loams and sands, D, F, and H. The sand-grains of flint, chert, glauconite, and quartz are referable, of course, to the Chalk, Greensands, and to some more ancient rocks, and may have passed through several stages of erosion and sedimentation before their deposition in these gravel-beds. The presence of the rarer 'heavy minerals' indicates very much older rocks as their real source; but they probably formed part of other beds in succession, as, for instance, in the Bagshot Sands, to which allusion is made in the note on B. Indeed, it has occurred to me that the brown clay-seam on the top of the Raised Beach at Aldrington, near Brighton, and which contains so many 'heavy minerals' in the residue,[1] has been derived, similarly to the plateau drift here described, from an older bed common to both areas.

V.—Palæolithic Flint Implements from the Chalk Downs of the Isle of Wight and the Valleys of the Rivers Western Yar and Stour.

By S. Hazzledine Warren, F.G.S.

In taking my first walk over West High Down, near Freshwater Bay, in May of last year, I found that the ground had been ploughed up by traction engines drawing heavy guns to some new forts on the Needles Point, then in course of construction. Thinking that there might be some Neolithic implements turned up, I examined the ruts, when almost the first thing I saw was a Palæolithic implement. It was ovate in form, $3\frac{1}{4}$ inches long by $2\frac{3}{8}$ inches broad, thin, very slightly twisted, well made and symmetrical though not elaborately finished, and ochreous and almost unabraded in condition. So far as I am aware, this is the first Palæolithic implement that has been found in the district.[2]

Not a single stone had been thrown down to make a road, and from the first I felt sure that it had been turned up on the spot. The following day I took a trowel with me, and discovered that there was a drift of stony clay; in this I found a Palæolithic core at a depth of 19 inches from the surface, though the width of my hole at that depth was scarcely larger than the size of the core.

Through a mutual friend I obtained the consent of the owner of the land, Mr. Granville Ward, of Weston Manor, Totland, and Northwood, Cowes, to dig further. The following sections will show the general character of the deposit.

Hole A, about 35 yards north of where the first implement was found, and at a slightly lower level.

	feet	inches.
4. Surface soil	1	0
3. Loam, with stones similar to those in the layer below ...	0	6–9
2. Layer of stones: composed of flint nodules; fractured, unabraded, whitened flints; fractured, red-stained, scratched, and brown abraded flints; Tertiary flint pebbles and ironstone; and Palæolithic implements ...	0	3
[1a. In places, over an area of from 1 to 3 square feet, the stained and scratched flints were found in the yellow clay below the layer of stones. Here implements were most abundant, the flakes sometimes almost touching each other.]		
1. Yellow clay, with yellowish white, or grey, fractured, unabraded flints, and some Tertiary flint pebbles and ironstone ... ... Seen to	1	9
	3	6

[1] Proc. Geol. Assoc., vol. xvi (1900), p. 266.

[2] For an account of the discoveries at the other extremity of the island, see T. Codrington, Quart. Journ. Geol. Soc., vol. xxvi (1870), p. 542; and Sir John Evans, "Ancient Stone Implements of Great Britain," 2nd ed. (1897), p. 626.

Hole B, very near where the first implement was found.

	feet	inches.
4. Surface soil	0	8
3. Layer of stones: composed of whitened, unabraded flint fragments; Tertiary flint pebbles and ironstone; some ochreous flint fragments; and Palæolithic implements	0	2–4
2. Yellow clay: full of small, yellowish-white, unabraded fragments of flint; flint nodules; a good many Tertiary pebbles; and some ironstone ... ... 1 ft. 3 in. to	1	10
1. Rolled chalk rubble, with a very uneven surface Seen to 2 ft. 4 in. to	1	9
	4	6

Between these two sections I found—

	feet	inches.
5. Surface soil	0	8
4. Layer of stones, as in hole B	0	2
3. Loam, as in hole A	0	9
2. Layer of stones, as in hole A	0	3
1. Yellow clay, as in holes A and B	touched	
	1	10

It is thus seen that the lower layer of stones and the loam above disappear just beyond where the upper layer of stones comes on. I have traced this upper layer for a distance of 80 or 100 yards to the south, while at some 70 yards beyond this point I found stony clay, with no definite stratification, to a depth of 2 ft. 6 in.; how much deeper it may be I do not know. The lower layer of stones I found to preserve its character over an area of more than 100 square yards, with no sign of its termination to the north or west.

The implements are generally abraded, sometimes only very slightly, but often to a considerable extent. Many of them are much altered and corroded, and rough and unpleasant to the touch. These are stained either of a dirty reddish-brown or yellow colour, and are often very blotchy in appearance. But in and above the lower layer of stones (bed 2 of hole A) many of them, though abraded on the edges, are not so altered; some of these are stained of a fairly rich red, but a larger number are nearly of their original colour. It is not improbable that these may belong to a later phase of the Palæolithic period than the corroded forms, but my collection is not large enough to warrant a definite conclusion on the matter. The Stoke Newington district, so admirably worked out by Mr. Worthington Smith, affords an excellent standard of comparison for three phases of the Palæolithic period. I have a considerable collection from that district, and the corroded implements from High Down certainly suggest a parallelism with the oldest of Stoke Newington; while the non-corroded examples suggest the latest or Le Moustier phase rather than the intermediate or River Drift proper, though no definite Le Moustier types have been found by me on High Down. One of those from the lower layer of stones on High Down, a pointed implement, 5 inches long by 2 inches broad, and possessing the peculiarity of being triangular in section, is similar in type to one of the Le Moustier period of Stoke Newington in my collection. Both owe their form, in great part, to the natural fracture of the flint, and are merely trimmed to a serviceable shape by a small number of blows.

The original ovate implement that I first found came from the upper layer of stones, and, like several others (flakes and cores) from that level, it is stained of a yellow colour, though not deeply altered, and practically unabraded; but one, a straight-edged scraper, belongs to the corroded series, and its surfaces are covered with the characteristic scratches. From bed 1A of hole A I have an excellent core, $3\frac{1}{2}$ inches long by $2\frac{1}{4}$ inches wide, showing three straight parallel facets, flaked with a skill that is rarely seen among earlier Palæolithic finds.

The corroded examples, like the earlier Palæolithic implements from Stoke Newington and elsewhere, nearly always bear evidence of having been twice abraded: once before, and again after, they received their ochreous patina; showing them to have been derived from an earlier drift.

The greatest depth at which I have dug an implement in the High Down drift is 3 ft. 6 in.; I have several from about 3 feet, but the greater number are from 1 ft. 6 in. to 2 feet.

The position in which this drift occurs is interesting and suggestive. The range of the chalk downs is breached down to sea-level at Freshwater Bay by the former course of the Western Yar. From this point westward the downs rise steadily to 483 feet above Ordnance Datum at the summit of East High Down, on which eminence the Tennyson memorial cross has been erected. From this point the ridge of the downs falls steeply to 361 feet O.D., and thence rises gradually to 462 feet O.D., the summit of West High Down, not far from the Needles Point. It is in the low part, between East and West High Down, that the Palæolithic drift occurs. So far as I can make out, the actual lowest point is 361 feet O.D.; but there is little or no drift here. The main mass of it occurs at from 75 to 150 yards to the west of the lowest point, and at a level of perhaps 4 or 5 feet above it. This spot I shall for convenience refer to as "the drift area."

This drift area extends only for about 75 yards from east to west, or along the ridge of the downs, but I have traced it for a much greater distance, both southward towards the sea and also northward down the steep dip slope of the chalk on to the ridge across the Eocene valley presently to be mentioned.

Opposite the drift area on the chalk downs is Headon Hill, 397 feet in height, formed of Oligocene strata capped by 30 feet of drift gravel. Between Headon Hill, the highest ground on the Tertiary area, and the drift area, there is a ridge across the intervening Eocene valley at about 270 to 280* feet[1] O.D. This ridge forms a water-parting between the stream flowing westward into Alum Bay and that flowing north-eastward into Totland Bay.

[1] The levels for this district are not published by the Ordnance Survey. Those with an asterisk are approximate aneroid levels taken by myself.

As already mentioned, the implementiferous clay drift extends down from the chalk downs on to this ridge, and I have found a number of rude, ochreous, and much abraded Palæolithic implements on a ploughed field here.

There can be little doubt that the gap in the chalk downs with its Palæolithic drift, the ridge across the Eocene valley, and the large mass of gravel capping Headon Hill, are closely connected with each other in their origin. The Headon Hill gravel is stratified in irregular, confused masses ; it is composed of flint nodules, often more or less battered and rolled on their projecting branches, fractured fragments of flint that are practically unabraded, together with a certain number of flint pebbles derived from the Tertiary beds, but no débris from strata below the chalk nor any foreign erratics. Headon Hill is now quite isolated, with the exception of the ridge at about 270* feet O.D. that connects it with the chalk downs, so that the gravel capping it is evidently a very early drift, possibly Pliocene, but certainly long anterior to the Palæolithic drift on High Down. It appears to me to be a terrestrial and not a marine deposit ; and to have been swept down along the line of the col, if I may so term it, that now forms the gap between East and West High Down, at a time when the chalk range was several hundred feet higher than it is now.

It seems to me that this is the simple and natural explanation of the Headon Hill gravel ; but I find a greater difficulty in explaining the Palæolithic drift on the downs. I at first thought that it belonged to a stream flowing northward into the old Solent River from land to the south that had since been destroyed by the sea. But there are various objections to this view. Firstly, the surface of the downs slopes southward from the drift area at about 365* feet O.D. down to about 290* feet O.D., where it is cut off by the present sea-cliff ; and has apparently continued to slope downwards to a still lower level before the sea had encroached to its present position. So that from the contours of the downs the difficulty of a stream flowing from the south is quite as great as that of one flowing from the north (or north-west), and from other considerations far greater. Secondly, the very abundant remains of Tertiary strata, in the shape of flint pebbles and ironstone, that are found in the drift, would necessitate the supposition of Tertiary outliers to the south, if it had come from that direction, which a glance at the geological structure of the district shows one to be an unjustifiable assumption ; without going back to a time long anterior to the Palæolithic drift. Supposing the drift to have come from the north or north-west, the difficulty is only one of some 90* feet, that is, the difference between the ridge of the Eocene valley and the level of the drift. And as the ridge is being cut back on both sides by the streams flowing westwards into Alum Bay and north-eastwards into Totland Bay, the difficulty is not a great one. Further, it appears to me that not only Alum Bay Chine itself, but the whole valley from the ridge westwards, which is only ⅔ mile long, is comparatively modern ; that it was formerly occupied by Tertiary beds, and that the drainage flowed eastwards and then north-eastwards through what is now Totland Bay into the old Solent River. At the time the Headon Hill gravel was deposited, at least, it is manifest that this valley could have had no existence, but that the base-level of the Headon Hill gravel at 360 to 370 feet O.D. was then the lowest ground at the foot of the chalk range, flanked by Tertiary beds. The great mass of this gravel would resist the forces of erosion much more powerfully than the soft Eocene sands, and thus gradually become isolated by the cutting away of those strata. If this view be correct, the Palæolithic drift on High Down belongs originally to an early stage in the formation of the Eocene valley, though it has, in part, been re-drifted at various later times.

I have also found Palæolithic implements in the gravels of the Western Yar. In Pleistocene times this river flowed about a mile to the south of Brightstone and Brook, then over what is now Compton Bay, and through the gap in the Chalk downs at Freshwater Bay, to join the old Solent River near Yarmouth. The Pleistocene gravels, with their accompanying brickearth, seen along the cliff section from Brightstone Grange Chine to Compton Bay, occur in terraces at from 60 to 120 feet O.D. The highest terrace is called 'Plateau Gravel' by the Geological Survey, but I cannot agree with thus giving it a separate title, especially as it has little in common with those drift deposits that usually go by that name. I have not been successful in finding any implements along the cliff here, but I think if they were carefully watched as falls take place from time to time, that implements would very probably be found in them, perhaps most abundantly in the upper terrace.

On the other side of Freshwater Gate I have found Palæolithic implements in a patch of gravel, not marked on the Survey Map, that caps an isolated knoll at about 95* feet O.D. It is evidently a remnant of a river terrace that has been almost entirely destroyed by denudation. Nearer Freshwater Church there is another knoll which forms the highest ground for some distance round. This is also capped by gravel, though not so coloured on the Survey Map. The elevation of this knoll is about 10 or 15* feet below the level of the other patch; but as the thickness of the gravel here appears to be only 4 or 5 feet, whereas the thickness in the other knoll is 10 feet or more, the level of the two very closely corresponds, and they are evidently remnants of the same terrace. There are also terraces at lower levels about Freshwater, but I have not at present succeeded in finding any implements on them.

Both the gravels of the cliffs near Brook and Brightstone, and also those of Freshwater, contain occasional pebbles of Palæozoic rocks. These, I think, have most probably been derived from Lower Cretaceous strata. In the gravels on the left bank of the old Solent River about Bournemouth erratics are far more numerous; and they have doubtless been derived from the west, as maintained by Mr. A. E. Salter.[1] In going over the gravels of that district

[1] Proc. Geol. Assoc., vol. xv (1898), p. 277; see also R. Godwin-Austen, Quart. Journ. Geol. Soc., vol. xiii (1857), p. 45.

I noticed in the Plateau Gravels from Canford Heath to beyond Talbot Village, and also on the isolated St. Catherine's Hill[1] near Christchurch, that erratic pebbles are very abundant, though flint forms the bulk of the gravel so far as the larger stones are concerned; but with the coarse grit (pieces of from $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter) a large proportion of its bulk is composed of those erratics. The same is the case with the gravels already mentioned belonging to the old Solent River that are exposed in the cliffs from Branksome to Southbourne, and in many pits about Bournemouth. But as soon as one crosses the ridge, capped by Plateau Gravel, into the valley of the Stour, one finds that the bulk of the grit is composed of flint with some quartz; indeed, I looked a long time before I found a single erratic in the grit, though I had found one or two of larger size. This was surprising to me, as I had previously thought that the lower terrace gravels were formed out of the materials of those at a higher level, merely relaid at a lower level as the excavation of the valley proceeded. But this is evidently not the case in this instance. One sees from the great difference in the composition of the grit that the gravels of Moordown and Winton, in the Stour valley, are quite independent in their origin of those of Canford Heath, from which one would naturally have imagined them to have been derived.

About Moordown there is a very well developed terrace at 70 or 80 feet above the River Stour, in which I have obtained a number of Palæolithic implements, both pointed and ovate. One is of a rather rare type, with an almost adze-like cutting edge, $1\frac{5}{8}$ inches wide, the whole blade being 6 inches long by $3\frac{1}{4}$ inches wide. I am not aware that Palæolithic implements have previously been recorded from this locality. Indeed, Sir John Evans, in the last edition of his "Ancient Stone Implements of Great Britain" (1897, p. 634), says: "In the basin of the Stour, which joins the Avon at Christchurch, but one discovery has been made." This, he proceeds to say, was in gravel dug near Wimborne Minster, but not *in sitû*. In the gravel of Little Down Common I also found a flake, though I visited the pit but once, and then for a short time only; I have no doubt that a more extended search would be fully rewarded. This gravel also belongs to the valley of the Stour, and the grit is wanting in erratics.

From the gravels of the Western Yar about Freshwater, I have obtained a number of much abraded brown flints, with battered edges, resembling the so-called 'Eolithic' implements from the chalk downs of Kent. I feel no little hesitation in attributing the majority of these to human agency. Both from Freshwater and elsewhere, I have Eolithic types (whether they be implements or not), the chippings upon which are contemporary with the River Drift series proper, that is, later than the earlier Palæolithic forms.[2]

[1] There is danger in visiting the pits on the summit of this hill, owing to the proximity of the rifle-butts, and there is nothing to warn one. I narrowly escaped being shot here in February last.

[2] I have some in which the chippings are contemporary with Neolithic implements.

So that the finding of a few Eolithic types, even supposing them to be truly worked by man, would not, apart from other evidence, prove any great antiquity. A certain number of undoubted implements, similar to the (derived) earlier Palæolithic types of the river gravels, have certainly been found in the high-level drift of Kent. I at first hoped that some light might be thrown on the question of Eolithic man by the drift on High Down; but I have, at present at least, no evidence to offer bearing very directly on this problem.

NOTICES OF MEMOIRS.

Sherborn's Index Animalium.—Report of a Committee, consisting of Dr. H. Woodward (Chairman), Mr. P. L. Sclater, the Rev. T. R. R. Stebbing, Mr. R. McLachlan, Mr. W. E. Hoyle, and Mr. F. A. Bather (Secretary), appointed to superintend the Compilation of an Index Animalium.

THE examination of the literature published from 1758 to 1800 inclusive has been continued by Mr. C. Davies Sherborn, to whom facilities have, as heretofore, been granted by the authorities at the British Museum (Natural History). Between July, 1898, and June, 1899, he has seen and indexed 1,528 volumes and tracts, and has now reduced the list of desiderata to about 500 items. Of these scarcely 100 are likely to be of any importance to the systematic zoologist; but every effort will be made to consult them, so as to be certain that everything has been recorded.

The Committee desires to express its grateful thanks for the loan of rare and valuable books, and for information concerning them, to the following:—The Hof-naturalien Kabinet of Vienna, Dr. Eduard Suess, and Dr. Steindachner; Dr. F. A. Jentink, of Leyden; Akademiker F. Schmidt, of St. Petersburg; the Stadt-Bibliothek of Zürich, Dr. Eschner, and Professor Renevier; the Hon. Walter Rothschild and Mr. Hartert; Sir Edmund Loder; Mr. Du Cane Godman and the late Mr. O. Salvin; Lord Walsingham and Mr. J. H. Durrant; Professor Amalitzky, of Warsaw; Prof. Anton Fritsch and Dr. Jan Perner, of Prague; Professor Alfred Newton; Mr. W. E. de Winton; Mr. Gerrit S. Miller, of Washington; Mr. A. C. Seward, of Cambridge; and Prof. H. A. Miers, of Oxford. Dr. Philippe Dautzenberg, of Paris, has also greatly aided the compiler in his efforts to obtain the loan of a rare catalogue. The editors of "Nature" and "La Feuille des jeunes Naturalistes" have lent valuable aid in publishing lists of desiderata. Of the generosity of the Vienna Kabinet, the Zürich Library, and Dr. Jentink, all of whom have sent over their treasures for inspection, the Committee cannot speak too highly.

Again the special and hearty thanks of the Committee are due to the Zoological Society of London for pecuniary assistance, which will, as in the past, greatly facilitate the work of procuring access to this rare literature.

The reference slips themselves are now in alphabetical order, and the work of checking previous reference books and of eliminating duplicate entries will be proceeded with as quickly as possible.

The following reports on dates of publication of various books have been published by Mr. Sherborn during the year:—

De Blainville, "Ostéographie": Annals and Mag. Nat. Hist. (7), ii, 1898.

Hübner, "Samml. europäischer Schmetterlingen": Annals and Mag. Nat. Hist. (7), ii, 1898.

C. d'Orbigny, "Dictionnaire Universel": Annals and Mag. Nat. Hist. (7), iii, April, 1899.

Humboldt & Bonpland, "Obs. de Zoologie": Annals and Mag. Nat. Hist. (7), iii, 1899.

Lichtenstein, "Catalogus rerum naturalium": Annals and Mag. Nat. Hist. (7), iii, 1899.

"The Dates of the Paléontologie Française": GEOL. MAG., 1899, pp. 223–225.

Temminck & Laugier, "Planches coloriées": Ibis, Oct., 1898.

It may also be mentioned that Mr. Sherborn has prepared an "Index to the generic and trivial names of animals described by Linnæus in the 10th and 12th editions of the *Systema Naturæ*," and the thanks of zoologists are due to the Manchester Museum, Owens College, for issuing this through Messrs. Dulau & Co., London, as its "Publication 25."

In the full belief that the first section of the Index (1758–1800) will soon be ready for publication as a tangible result of the compiler's labours, the Committee earnestly recommends its reappointment.

REVIEWS.

I.—THE SCIENTIFIC STUDY OF SCENERY. By J. E. MARR, M.A., F.R.S. 8vo; pp. 368. (London: Methuen & Co., 1900. Price 6s.)

NOT long ago we had the pleasure of noticing Mr. Marr's admirable introduction to "The Principles of Stratigraphical Geology," and now students of the physical side of that science are to be congratulated on a further contribution in book form from the same pen.

The volume is described in the Preface as "An introductory treatise on Geomorphology, a subject which has sprung from the union of geology and geography." It is a terrible word to hurl at the head of the unoffending general reader, whose interest in the subject the book is intended to arouse, and we fear that some readers will be so disheartened at the outset that they will lay down the book before reading the first chapter. Fortunately most people avoid the preface (we do so ourselves) and begin by looking at the illustrations, in which case the reader is sure to get interested and the author will be saved. Unfortunately 'physiology' (the obvious portmanteau word for physical geology) has already been annexed, and the meaning of the term 'physiography' has apparently expanded indefinitely, like the atmosphere, losing in attraction as it departs further and further from any 'solid ground.' But surely some more popular term might be found for the science of scenery.

After a brief introduction on the attributes of scenery, the author proceeds to discuss the nature of the earth's exterior, which he considers under the heads of Atmosphere, Hydrosphere, and Lithosphere; the greater part of chapter ii being taken up with the description of the mode of origin of the rocks composing the Lithosphere, and the changes they have subsequently undergone in position and structure.

In chapter iii we have a short essay on the production of dominant forms due to accumulation, elevation, depression, and sculpture, and the similarity in form assumed by the Atmosphere, Hydrosphere, and Lithosphere is strongly emphasized; we think, however, that the parallel instituted between the formation of cloud, sea, and earth-waves is open to misconception, and that the student might very easily close the book with the idea that the form of the earth-waves was originated by meteoric agents, as in the case of clouds and sea-waves, when he reads on p. 24, "similarly the earth-waves are carved out by the graving tools of nature, and the effects are generally similar to those produced on ocean-waves by the wind."

Chapter iv deals with the atmosphere, but is practically taken up with a description of the form and mode of origin of clouds. It is difficult, no doubt, in treating of a subject like Scenery for the author to decide exactly how much to take the reader into his confidence regarding the causes which produce the visible effective scenery, and we think that compared with the rest of the subjects dealt with in the book, the atmosphere has a distinct grievance with regard to the space allotted to it, though the description of the various forms of clouds is unusually clear and full.

In chapter v we have a description of the continents and ocean basins. In the consideration of their main features the author adopts Professor Lapworth's very suggestive views as propounded in his remarkable address to Section C at the Edinburgh Meeting of the British Association. If the exigencies of space permitted we should like to see the subject of this chapter dealt with at somewhat greater length. We have, for instance, no allusion to the Hemihedral Tetrahedral theory (of Lowthian Green, 1875, and J. W. Gregory, 1899), which alone attempts to account for the curious wedge-like termination of the continents to the south.

The three following chapters are devoted to the origin and structure of mountains, the first being confined to mountains of upheaval, among which the 'Laccolite' of Gilbert and the Alpine form of folding of Heim are taken as types; mountain uplift generally being classified under symmetrical, unsymmetrical (*sic*), and compound types. The second of this group treats of the sculpture of mountains, forestalling, somewhat, the subsequent chapter on the formation of valleys; and the last of the chapters on mountains deal very fully and clearly with the origin of certain forms. The observations on p. 82 regarding the tendency of vegetation to convert the typical concave denudation curve into a convex curve is, we believe, here suggested for the first time, and a study of photographs, depicting forest-clad valleys, appears completely to bear out this theory of Mr. Marr. Admirable as is the description of the development of a typical mountain range, it would, we think, be still more easily followed by the reader were orographical sketch-maps of the Monta Rosa and Scawfell districts added in a future edition.

In the chapters which follow on valleys, the reader is introduced to the latest American nomenclature of consequent, subsequent, obsequent, inconsequent, and antecedent valleys; corrasion, comminution, peneplain, etc. Many of these terms are, no doubt, useful, but it is interesting to note that the very inexpressive term 'watershed' is still retained, and that no Anglo-Saxon word has yet been coined to denote the course of a river represented by the German word 'Thalweg.'

Chapters xi and xii, which deal with lakes, are perhaps the most interesting in the book, our author himself having written largely on the subject, and being our greatest authority on our own lake district. In this connection we are glad to see Mr. Marr referring to the work of that excellent old author Jonathan Otley.

The chapters on Plains and Deserts are also very fully treated of, and a long way ahead of the chapters on these subjects usually found in textbooks; in fact, it is wonderful how much up-to-date information the author has compressed into his little book.

The chapters devoted to Ice are perhaps a little curtailed compared with other portions of the subject, and we would call attention to the scant notice given to the work of avalanches, although it has been estimated by Inspector Coaz that one-third of the snow which annually falls on the St. Gothard range is removed by avalanches. We should like also to see a reference to Heim's work on 'Gletscherkunde' and the observations of the Rhône Glacier Commission. Upon the vexed question of the coincidence of lake basins and ancient glaciers, we are glad to see Mr. Marr reminding his readers of a fact long ago pointed out by Sir Charles Lyell, viz., that in a region undergoing elevation glaciation will often prevent the water-ways from being kept open by rivers during the uplift; and in this way lakes may be formed. Such lakes, then, will be caused, not by the erosion of ice, but by the absence of erosion by water, owing to the presence of the ice.

The book has been designed to interest the general reader as well as to assist the student, and the changes of styles in neighbouring paragraphs are in consequence perhaps occasionally rather abrupt.

On the whole, if we might offer a suggestion on what is evidently a very conscientiously written work, it would be in favour of a somewhat less technical treatment, with, however, full references to works where the details of the subject may be consulted, bearing in mind the requirements of the intelligent general reader whom it is desired to convert into a student of the subject. That the writer is imbued with a true love of scenery is abundantly evident in many passages, and the feeling of the book is throughout conceived in the spirit of such classical exponents of the scientific beauties of scenery as Forbes, Tyndall, Ruskin, and Geikie; and in passages, as for instance on p. 201, in which the play of colours observed on Windermere is described, and again in his concluding chapter on the preservation of natural beauties, the author shows himself capable of the highest appreciation for the poetry of his subject.

The verbal slips in the book are few and insignificant. We would call attention to 'windward' on p. 264, for which 'leaward' is evidently intended; the letter S has been omitted in fig. 14, although alluded to in the legend; it would facilitate reference from the text if the plates were numbered; on p. 273 the reader might conclude that the hexagonal and rhombohedral systems were separate and distinct. In alluding to the evaporation of snow and camphor the process is referred to as 'sublimation.' In Watt's Dictionary of Chemistry sublimate is defined as "a body obtained in the solid state by the cooling of its vapour." Again, on p. 278 we have a curious sentence on the angle of accumulation of snow which concludes "the latter" (the aiguilles), "being at an elevation inferior to that of the topmost dome." Surely, as the Germans say, "das versteht sich."

The photographic illustrations have been carefully selected and excellently reproduced; they are all to the point, and fully described in the text, an innovation on the usual method, on which we beg to congratulate the author, as indeed we do most heartily on the whole work, and we recommend it most thoroughly to all true lovers of scenery, both general and scientific.

II. — Correlation between Tertiary Mammal Horizons of Europe and America. An Introduction to the more exact Investigation of Tertiary Zoögeography. Preliminary Study with Third Trial Sheet.—Two Presidential Addresses before the New York Academy of Sciences.—By Henry Fairfield Osborn. (Annals N.Y. Acad. Sci., vol. xiii, No. 1, pp. 1–72, July 21, 1900.)

We heartily agree with Professor Osborn that no-one can oppose the immediate adoption of the fundamental principle that the old and new world palæontology should be studied as a unit: although considerable time must elapse before a consensus of opinion can be arrived at, there is no doubt that the best way is to set to work *viribus unitis*. Professor Osborn has taken the lead, and well he may; for he is better acquainted with the Tertiary mammal horizons of Europe than any one of his European colleagues with those of the new world.

In 1897 and 1898 he drew up and circulated for criticism amongst old-world palæontologists two successive trial sheets "of the typical and homotaxial Tertiary horizons of Europe";

a third trial sheet was issued in connection with the first of the two addresses above quoted. We here transcribe the "Preliminary Table of European and American Tertiary Horizons," being an abbreviation of the third trial sheet.

Lyell's System.			Approximate American Parallels.
Pleistocene	Upper:	Post-Glacial	
	Middle:	Glacial and Interglacial	
	Lower:	Preglacial	? *Equus* beds.
Pliocene	Upper:	Sicilien	? Blanco.
	Middle	Astien.	
		Plaisancien.	
	Lower:	Messinien	Upper Loup Fork.
Miocene	Upper:	Tortonien	Loup Fork.
	Middle:	Helvetien	Lower Loup Fork and
	Lower:	Langhien	Upper John Day.
Oligocene	Upper:	Aquitanien	Lower John Day (*Diceratherium* Layer).
	Lower	Stampien, Infra Tongrien ...	White River.
Eocene	Upper:	Ligurien	Bridger and Uinta.
	Middle	Bartonien	Lower Bridger.
		Lutétien	Wind River.
	Lower:	Suessonien	Wasatch.
	Basal	Thanetien	Torrejon.
		Montien	Puerco.

"In all the levels above the Stampien the parallels are imperfectly established." "Our Pliocene record, as compared with the magnificent Pliocene of Europe, is extremely meagre, and our Miocene succession, rich as it is, is not as fully understood as the Miocene of France."

In Part I the parallels between Tertiary horizons are discussed.

The Burdigalien, Lower Miocene, calls for a few remarks. Gaudry was the first to place the *Calcaire de Montabuzard* and the *Sables de l'Orléanais* in a lower level than Sansan, '*Anthracotherium*' not being found and the ruminants being more evolved in the Sansan deposit. The Proboscidea and Monkeys appear for the first time, no trace of them being found in the Upper Oligocene (Saint-Gérand-le-Puy, etc.).

Owing to the extreme scarcity of the Burdigalien fossils in other than a few French museums, most palæontologists were prevented from forming an opinion of their own; the Burdigalien for these reasons was omitted from the "Table of Contemporary Deposits, with their Characteristic Genera of Mammalia," published in the Geological Magazine (1899, p. 61). The general tendency has been to leave the *Sables de l'Orléanais* in the same horizon as Sansan, La Grive, Steinheim, with which they were and still are supposed to share such characteristic Tortonien species as *Dinotherium bavaricum*, *Mastodon angustidens*, and *Anchitherium aurelianense*. The more recent researches of Depéret, the results of which are endorsed by Osborn, have confirmed Gaudry's views. Some vertebrates from the Burdigalien of Moghara (Lower Egypt) have of late been described by Andrews.

The Burdigalien fauna will doubtless appear more distinct when the remains of the above-mentioned genera and others have been more closely examined.

Both the Proboscideans from the *Sables de l'Orléanais,* mentioned above, are smaller than the species of the Tortonien from which their names have been borrowed; furthermore, the *Dinotherium* of the Burdigalien received a specific name (*D. Cuvieri,* Kaup) long ago. The late Abbé Bourgeois' collection in the College of Pontlevoy (Loir-et-Cher) contains, it is true, in addition to undoubted Burdigalien forms, several *Mastodon*-teeth from the Faluns of Pontlevoy and Thenay, which seem indistinguishable from those of *Mastodon angustidens.* The Faluns belong to the Helvetien, and the presence of Burdigalien forms must be accounted for by supposing that they have been derived from that deposit, the fauna, in fact, apparently including both derived and contemporary forms of terrestrial Mammalia.

The *Anchitherium* was named (*A. aurelianense*) after the specimens from the *Calcaire de Montabuzard*; the detailed descriptions are based on specimens from the Tortonien. The *Anchitherium* remains from the *Sables de l'Orléanais* will presumably prove to be a less specialized stage in the Equine series than those of the Tortonien.

As to the Suidæ from the *Sables de l'Orléanais,* they have been shown by H. Stehlin to be distinct from those of the Aquitanien as well as from the Tortonien Suidæ.

The Lagomorphous Rodent of the Burdigalien is not a *Titanomys,* for it has rootless cheek-teeth; it is not a *Prolagus,* for its lower cheek-teeth are five in number, not four. In the above characters and in the general conformation of the upper middle premolar, it agrees with *Lagopsis* and *Lagomys.* But it differs from *Lagomys* and from the only known species of *Lagopsis* (*L. verus* from the Tortonien) in the pattern of the anterior lower premolar.

Part II deals with the "Faunal Relations of Europe and America during the Tertiary Period and Theory of the successive invasions of an African Fauna into Europe." In the chapter "Tertiary Geographical Distribution" we notice the omission of two important papers bearing on the subject. Referring to the hypothetical "Continent Antarctica," the author says: "Following Blanford (1890), Forbes (1893) made the first strong plea for this continent." The first strong plea, and with several sounder arguments than some of those advanced in recent years, was made as long ago as 1867 by Rütimeyer,[1] whose masterly sketch is at the same time the strongest possible appeal to set zoogeography on a palæontological basis. Rütimeyer ultimately divides the world in a northern and southern division (op. cit., p. 15 and map), which do not quite coincide with the Northern and Southern Hemisphere, and are therefore in better agreement with the known facts than Huxley's *Arctogæa* and *Notogæa* (1868). Rütimeyer's dual division is also more consistent with the hypothesis of an Antarctic continent than Blanford's three divisions.

[1] "Über die Herkunft unserer Thierwelt. Eine zoogeographische Skizze" (1867).

Osborn's theory of successive invasions of an African fauna into Europe seems at first sight a very bold one. "It thus appears that the Proboscidea, Hyracoidea, certain edentata, the antelopes, the giraffes, the hippopotami, the most specialized ruminants, and among the rodents, the anomalures, dormice, and jerboas, among monkeys the baboons, may all have enjoyed their original adaptative radiation in Africa." Three, or rather four, successive migrations are supposed to have taken place, the first in the Upper Eocene, the last in the Upper Pliocene. A similar theory cannot, of course, be imagined if the permanence of continents and oceans is maintained, so that Osborn's theory is in the main a clever elaboration of the 'Lemuria' hypothesis, in its original form, as conceived by P. L. Sclater.[1] This is the second of the two papers above referred to as having been omitted by the author. A southern origin has, moreover, been advocated for the Proboscidea in Neumayr's "Erdgeschichte," and for the Cercopithecidæ in the GEOLOGICAL MAGAZINE (1896, p. 436), partly with the same arguments advanced by Osborn (p. 58).

But, if South Africa is a great centre of independent evolution (p. 57), and has supplied South America with the edentates, as well as the "stem forms of its Ungulates" (p. 54), why leave it in the Arctogæa, whilst 'Neogæa' is made to stand apart? This is our reason for objecting to 'Neogæa.' C. F. M.

III. — ANNUAL REPORT OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION FOR THE YEAR ENDING JUNE 30, 1897. 8vo; pp. 38 and 1,024. S. P. LANGLEY, Secretary Smithsonian Institution. (Washington, 1899.)

Part I. Report upon the Condition and Progress of the U.S. National Museum during the year ending June 30, 1897, by Charles D. Walcott, in charge of the U.S. National Museum. pp. 1–246.

Part II. Papers Describing and Illustrating Collections in the U.S. National Museum.

(A) Recent Foraminifera. A descriptive Catalogue of specimens dredged by the U.S. Fish Commission Steamer "Albatross," by James Flint, M.D., U.S. Navy, Hon. Curator Division of Medicine, U.S. National Museum. pp. 247–350, and 80 plates.

(B) Pipes and Smoking Customs of the American Aborigines, based on material in the U.S. National Museum, by Joseph D. McGuire, Ellicott City, Maryland. pp. 351–646, 4 plates, a frontispiece, and 239 figures in the text.

(C) Catalogue of the series illustrating the Properties of Minerals, by Wirt Tassin, Assistant Curator of Mineralogy. pp. 647–688.

(D) Te Pito Te Henua, known as Rapa Nui; commonly called Easter Island, South Pacific Ocean. Latitude, 27° 10′ S.; longitude, 109° 26′ W. By George H. Cooke, Surgeon U.S.N. pp. 689–724.

[1] "The Mammals of Madagascar": Quart. Journ. Science, vol. i, pp. 213–219 (1864). The four cautiously worded deductions at which Sclater arrived may be almost entirely endorsed at the present day.

(E) The Man's Knife among the North American Indians, a study in the collection of the U.S. National Museum, by Otis Tufton Mason, Curator Division of Ethnology. pp. 725–746, with 17 illustrations.

(F) Classification of the Mineral Collections in the U.S. National Museum, by Wirt Tassin. pp. 747–810.

(G) Arrow-points, Spear-heads, and Knives of Prehistoric Times, by Thomas Wilson, LL.D., Curator Division of Prehistoric Archæology, U.S. National Museum. pp. 811–988, 65 plates, and 201 illustrations in the text. pp. 989–1022 are devoted to a general index to the whole volume.

The Board of Regents of the Smithsonian Institution are to be congratulated upon the production of an imperial octavo volume of 1,062 pages, embracing a report upon the Museum, with seven memoirs describing and illustrating various sections of the National Collection, four of which are profusely and beautifully illustrated by 149 plates and 457 process-block illustrations in the text.

PART I.

The Report itself occupies 246 pages, and is drawn up by Mr. C. D. Walcott, the Acting Assistant Secretary in charge of the U.S. National Museum. The Departments are—ANTHROPOLOGY, with 17 curators and assistants; Animal BIOLOGY, with 27 curators and assistants and 3 honorary associates; Division of PLANTS (*National Herbarium*), with 8 curators and assistants; GEOLOGY and MINERALOGY, with 18 curators and assistants. The administrative staff is represented by Mr. S. P. Langley, the Secretary and Keeper; Mr. C. D. Walcott, Acting Assistant Secretary; Mr. F. W. True, Executive Curator; and a staff of ten officers, including a photographer, a registrar, two librarians, an editor, a chief of correspondence and documents, and a chief of buildings.

Here is a sample of the *work of the Museum.* During the year covered by this report nearly 27,000 geological and biological specimens, selected from the duplicates, were distributed to universities, colleges, and schools. The publications of the Museum were also distributed at home and abroad. Identification of specimens is also undertaken, except when analyses of geological specimens are desired; these the Museum cannot perform.

Letters containing requests for information on every conceivable topic are all carefully answered. These number from 12,000 to 15,000 a year. Public lectures are also frequently provided, or the lecture-hall placed at the disposal of Societies desiring to hold their meetings in the Museum.

To sum up, the aims of the U.S. National Museum are to promote the advancement of scientific research (1) through the medium of the collections exhibited; (2) by affording to specialists access to the 'reserve' collections; (3) by the identification of specimens; (4) through the agency of the library; (5) by the donation of specimens to educational institutions; (6) by the donation of its publications; (7) by its lecture courses; and (8) by imparting special information through correspondence. Such is an epitome of the work carried out by the U.S. National Museum under the direction of the Smithsonian Institution.

An annual report, however good and satisfactory, is generally admitted to be a somewhat dull but necessary document, and certainly not to be classed with novels and such light literature as holiday reading: but behind the report come seven admirably prepared memoirs, which the authors have endeavoured to render as attractive as possible, not only by the varied subjects treated of, but in several instances by the excellent and abundant illustrations given.

PART II.

(A) Dr. James M. Flint, of the U.S. Navy, furnishes a descriptive catalogue of the Foraminifera dredged by the U.S. steamer "Albatross." Materials from about 125 stations have been carefully studied, and specimens from more than one hundred localities have been preserved and identified. Fifty-eight localities are in the North Atlantic Ocean, twenty-one in the Gulf of Mexico, seven in the Caribbean Sea, one in the South Pacific, and five in the North Pacific. The depths vary from 7 to 2,512 fathoms. The illustrations are all made from mounted specimens on exhibition in the U.S. National Museum, and have a uniform enlargement of about fifteen diameters; by this plan they mark distinctly the relative size of the objects. The classification followed is that of the late Mr. H. B. Brady in his Report on Foraminifera collected by H.M.S. "Challenger."

The series are mounted expressly for the public, the specimens of each species being attached to the bottom of a shallow, concave, blackened disk of brass, arranged in concentric rows upon a large circular metal plate forming the stage of an ordinary microscope. The circular plate has a rotary and a to-and-fro movement by means of a friction roller and a rack and pinion, so that all the mounts may be successively brought under the microscope. The apparatus has been in use by the public, both by adults and children, and has stood very severe tests successfully for seven years, with only the occasional presence of an Attendant in the room.

Dr. Flint gives a description of what Foraminifera are, which would do admirably for a popular guidebook. He then proceeds to explain, simply and clearly, how these minute shells are to be mounted and how sections may be prepared. For the literature he refers to Carpenter's "Introduction to the Study of the Foraminifera," to Brady's Report on the Foraminifera collected by H.M.S. "Challenger," and to C. Davies Sherborn's "Index to the Genera and Species of the Foraminifera." Then comes an analytical key to the families, followed by a descriptive catalogue of the genera and species. The eighty plates are superb, and demonstrate what can be satisfactorily done by photography *direct*, without the intervention of any artist. The photographs are only 'processed,' and then printed on good plate paper.

The figures of *Astrorhiza* (plates i–iii), whose chambers and tubes are built up of agglutinated grains of sand, are remarkably effective, as are also those of *Pilulina Jeffreysi.* Where all are so excellent it would be difficult to specially select for praise certain plates; but we may mention *Reophax* (plates xvi–xviii), *Haplophragmium* (xix–xxi), *Ammodiscus* (xxiii), *Hormosina* (xxv), *Cyclammina* (xxvii), *Gaudryina* (xxxiii), *Clavulina* (xxxiv–xxxvi), *Biloculina* (xxxviii–xl), *Spiroloculina* (xlii, xliii), *Peneroplis* (xlix), *Orbitoides* (l–lii), *Nodosaria* (lv–lviii, superb), *Cristellaria* (lxvi, lxvii), *Pulvinulina* (lxxv), *Rotalia* (lxxvi). We agree with the author in thinking that some of the more minute forms, such as *Truncatulina, Anomalina, Discorbina, Uvigerina,* etc., would have shown to greater advantage if they had been magnified more highly, but the work is, as a whole, most excellent.

(B) Under the division of Ethnology Mr. Joseph D. McGuire gives us an interesting and well-illustrated memoir on "Pipes and Smoking Customs of the American Aborigines," based on materials in the U.S. National Museum and elsewhere. There are 239 illustrations of pipes in the text, a frontispiece, and 4 maps showing the distribution of objects over the United States.

Tobacco cannot be considered a geological product (although largely consumed by geologists!), yet the material out of which the ancient stone pipes of North America were manufactured is not without interest, from a strictly scientific point of view, to non-smokers among geologists and antiquaries. Indeed, in fig. 64 is depicted a fossil pipe from Pottawatomie, Kansas, made of the outer whorl of an Ammonite (probably *Schlœnbachia Peruviana* or *acuticarinata*), the shape of which probably attracted the curiosity of the Indians.

Another material largely used was 'Catlinite,' a red clay forming beds of considerable extent in Pipestone County, in the south-western part of Minnesota (named after the writer on the American Indians, George Catlin). In addition, we may quote banded green slate, steatite, greenstone, a concretion, volcanic tuff, sandstone, pipe of stalagmite, of mica, obsidian, jade, porphyry, and Oolitic limestone as among the materials used. But clay of various kinds (moulded and afterwards kilned) was also very largely in demand.

Of the figure pipes many were no doubt 'totems' of the tribes, as the hawk, dog, frog, turtle, raccoon, eagle, duck, pigeon, swan, snake, human hands and head. A pipe shaped like an elephant[1] is very puzzling, for it implies, if genuine, that the designer was acquainted with the animal, which seems incredible for a Mound-Indian of Iowa, or that it was of *later date,* in fact a European workman's fabrication of the same dishonest type as the 'antiquities' made by the celebrated English impostor known as 'Flint Jack.' Of other materials for the manufacture of pipes we may mention wood, wood and stone, wood and lead pipe, a combination of clay, copper, and wood, a pipe of willow, a pipe of bone, of copper, of lead, a combination of stone and bone, a bronze pipe, a brazed iron pipe,

[1] Could it have been a mammoth or a mastodon which the artist had seen, or was it a modern Indian elephant he had copied?

a tomahawk and pipe combined of iron or steel. The simplest form of pipe known is that in use in Ladak and Thibet, where the natives, in travelling, make a small, smooth hole in the ground, which they fill with tobacco, and then make a connecting hole through which they draw the smoke directly into the mouth, the ground itself serving the part of a pipe. The present writer was informed by Sir John Kirk that the Kaffirs in East Africa do precisely the same when travelling; the ground being first wetted, then the bowl is formed by the thumb being pressed vertically into the earth, and the tube for inhaling the smoke is made by the little finger, which is pressed in obliquely until it touches the base of the larger hole.

Of the religious, civil, military, trade, and domestic functions in which the 'calumet' or peace-pipe was introduced amongst the North American Indians, forming an important part of all such ceremonies, let those who are interested to learn, read Mr. Joseph McGuire's admirable memoir. We have room for only one quotation by way of illustration: "In 1682, when William Penn landed in New Jersey, he received the lighted calumet or pipe, which was smoked out of by all; the great sachem first taking a whiff, then William Penn, and subsequently the sachems and warriors and squaws of every tribe. A second smoke closed the bargain for the purchase of land; and 300 tobacco pipes, 100 hands of tobacco, 20 tobacco boxes, and 100 *jew's-harps* were a portion of the articles given in exchange" (p. 461). We had no idea that the jew's-harp, or indeed any other musical instrument, had been 'traded' by the Quakers to the North American Indians. It suggests that our quiet friends must have secretly had a taste for music, even two hundred years ago!

(C) The next memoir is a catalogue illustrating the properties of minerals, by Wirt Tassin, Assistant Curator, Department of Mineralogy, Smithsonian Museum.

The plan of arrangement followed deals with (1) chemical mineralogy, such as the chemical composition or atomic structure of a mineral and the chemical relations of the several kinds of minerals; and (2) physical mineralogy, which treats of those properties relating to form or molecular structure of a mineral, and the action of the various physical forces upon the several kinds of minerals.

Under chemical mineralogy the author treats of the elements, and explains that all minerals are composed of either an element alone or two or more elements in combination; that such combinations of simple substances may produce a new substance, differing from and possessing properties not the mean of those of its constituents. This is illustrated by the gases hydrogen and oxygen, which under proper conditions combine to form water, a liquid. Then follow examples of various minerals, as zinc and its combinations, tin and its combinations, lead and its combinations, sulphur and its combinations, iron and its combinations, and so on. The author next gives types of minerals and examples of native elements, as carbon, sulphur, the metals platinum, mercury, copper, silver, and gold, and the alloys of each. Next the variations in composition are considered, and the relation of water to composition and to physical properties; then the relation of composition to physical properties, such as density, magnetism, and lustre.

Physical mineralogy is next treated of, and we have a brief essay on the crystal, on crystallographic axes, on crystal form and crystal systems, etc.; characters relating to cohesion and elasticity, characters depending upon mass or volume; properties relating to heat, magnetism, and electricity; optical characters depending upon the action of light, etc., and characters depending upon the action of the senses, as touch, taste, odour; and lastly, on resistance to chemical action.

(F) By an accident of arrangement, Mr. Wirt Tassin's second part, "Classification of the Mineral Collections in the U.S. National Museum," has been separated by the interpolation of two other essays (D and E): we will, however, notice this part (F) next to part C. Classification 1, Elements. Of the seventy or more elements at present known to chemistry, but eighteen, excluding those occurring only in the gaseous state, are found native. With the native elements are included the native alloys, or compounds and mixtures of elements belonging to the same groups in the periodic system.

A list of these native elements is then given, with their native alloys and compounds, in groups, as (1) diamond, bort, carbonado, graphite, schungite, graphitoid, cliftonite; (2) sulphur (and its compounds), selenium, tellurium, etc.; (3) arsenic, etc., antimony, bismuth; (4) tin, lead; (5) iron, catarinite, etc.; (6) platinum, platiridium, iridium, osmiridium, palladium, etc.; (7) mercury, amalgam, copper, silver, gold, electrum, porpezite, rhodite.

These are followed by compounds of the elements, as (A) compounds of halogens-fluorine, chlorine, bromine, and iodine; (B) compounds of sulphur, selenium, and tellurium, also arsenic, antimony, bismuth, and germanium; (C) oxygen compounds; (D) compounds of organic origin (as mineral wax, fossil resins), asphaltum, mineral oils, coals, etc., and the salts of the organic acids, oxalates, and mellates. A full index of minerals is given at the end.

These papers by Mr. Wirt Tassin are likely to prove useful to the curators of minerals in other museums seeking a plan of arrangement for their collection. We can also strongly recommend (1) the admirable Introduction to the Study of Minerals, by L. Fletcher (price 3*d.*), British Museum (Natural History), with a guide to the Mineral Gallery (pp. 120, 8vo); (2) Introduction to a Study of Meteorites, by L. Fletcher (price 3*d.*, pp. 92, 8vo); (3) Introduction to a Study of Rocks, by L. Fletcher (price 6*d.*), British Museum (Natural History), (pp. 118, 8vo).

(D) Mr. George H. Cooke, surgeon, U.S. Navy, supplies us with an interesting account of Easter Island in the South Pacific Ocean. The U.S. steamer "Mohican" sailed from Callao, Peru, March 6th, 1868 (? 1886), under orders for a protracted cruise, on special duty, among the islands of the South Pacific, with instructions on her return passage to the South American coast to call at Easter Island, make certain investigations desired by the Smithsonian Institution, and especially to bring away one of the colossal stone images to be found upon the island. The stone image, stone crown, and stone head having been successfully transported over the island to the beach and thence transferred on board, the ship sailed on the last day of the year for Valparaiso, Chile, arriving on January 14th, 1887. There appears to be a misprint in the first *year* recorded here, for on p. 692 the author says: "The investigations upon which this report is based cover a period of *twelve days* from December 19 to December 30, 1886, inclusive."

On December 18th the extinct crater of Rana Kao was visited, and a general inspection was made of the stone huts, the painted slabs in their interior, the sculptured rocks, etc., and of the crater itself, in the immediate vicinity of which these objects of interest are located. Here numerous finished and unfinished images, some standing, others prostrate, were seen scattered over the slope of the crater and the great plain at its base, where there is every reason to believe once stood a populous town. The quarries, or 'workshops,' were also visited, and the many partly completed monoliths still attached to the original rock were examined. As in Egypt, where in the quarries at Syene, near the First Cataract, the largest obelisk still lies unfinished, so here, in one of the excavations on the outer slope of the crater, may be seen the largest of the stone images to be found on Rapa Nui in an incomplete condition, still adherent to the bed rock, and measuring 69 ft. 9 in. in length! carved in trachyte. Mr. Salmon and Mr. Brander seem at present to be the sole proprietors on the island, with a stock of 18,000 head of sheep and many cattle. The population now consists of 155 natives and 11 foreigners (two English, two Americans, one Frenchman, and six Tahitans), yet from 1850 to 1860 the number of inhabitants was said to be 20,000. In 1863 the Peruvians carried off 5,000 of the inhabitants to work the guano deposits of the Chincha Islands. Some few only of these returned alive, smallpox having broken out on the return voyage; it also ravaged the island, many deaths resulting therefrom.

With regard to the ancient inhabitants—the makers of the trachyte quarries, the builders of the stone houses, and the carvers of the colossal stone images—the number and extent of their works are so great that one is led to ask how they came suddenly to an end, which must have been the case judging by the large number of images in all stages of development seen at Rana Roraka, where the ancient town once existed, and in the quarries in an unfinished condition both inside and outside of the adjacent crater slopes. The present natives neither carve, nor quarry stone, nor build.

If we take note of the vast number of volcanic stones evenly scattered over the surface of the island, especially the eastern half, one is led to the inevitable conclusion that either the volcano of Rana Roraka, or one of the neighbouring volcanoes, suddenly became active and threw out these showers of stones, probably destroying many lives, and so stopped the labours of the workmen, which were thenceforth never resumed. Perhaps, too, the same calamity overthrew, by an earthquake, many of the idols (of which not one is now standing on its pedestal), laid waste the island, and wrought the destruction of the trees which once adorned it, and from the period of that disaster probably dates the decadence of the ancient people of Tepito Te Henua. The island contains several distinct craters, the highest point being 1,970 feet. The great crater of Rana Kao has a lake in its centre 300 feet in depth, with a circumference at its surface of $2\frac{1}{2}$ miles, so that good drinking water sufficient for a large population exists on the island.

(E) Mr. Otis Tufton Mason describes the man's knife among the North American Indians as illustrated by the collections in the U.S. National Museum. Knives, strictly speaking, are adapted for industrial purposes, and therefore belong to the category of *tools*, not weapons. If, however, a knife is used as a weapon for destruction, it should be classed as a dagger, but when employed as an edged tool it is properly described as a knife. The edge tool works by pressure, by friction, or by a blow. One used by means of a blow is an axe if the edge is in a line with the handle, and an adze if it lies across the handle; an edged tool working by friction is a scraper, but one working by pressure is a knife. Although the iron or steel-bladed knife has been only in the hands of Eskimo, of Canadians, and tribes of the United States and the North Pacific, for a century or two they seem to have thoroughly mastered its use as a tool. They are nearly all curved-bladed, and the hafting is always native, the blade alone (whether of steel or iron) being foreign. Before the possession of iron there is meagre evidence that any of these native races possessed other than the most trivial carvings in hard material. Their best works were in soft wood and slate, by means of the beaver's tooth or shark's tooth knives. Mr. Mason does not mention the use of flint or obsidian, but one knife with a glass blade from Patagonia is recorded.

(G) "Arrow-points, Spear-heads, and Knives of Prehistoric Times," by Dr. Thomas Wilson, Curator of Prehistoric Archæology, U.S. National Museum. Dr. Wilson's memoir is one of the most elaborate in this volume and covers 177 pages. It describes and illustrates spears and harpoons in the Palæolithic period; the origin of the bow and arrow; superstitions concerning arrow-points and stone implements. In the island of Guernsey the stone implements are called 'lightning-stones' and 'thunder-stones' (*pierre de foudre* or *pierre de tonnerre*), and are firmly believed in as a protection against fire. The flint mines and quarries in Europe and America are described; a most interesting account is given (illustrated by many plates) of the materials used in making arrow-points and spear-heads, showing the microscopic structure of the materials. The manufacture of arrow-points and spear-heads is explained, and the various scrapers, grinders, and straighteners used in making arrow and spear shafts. All the varied patterns of arrow-heads and spear-heads are arranged, classified, and elaborately figured, and some 25 types are enumerated. Flint knives are next considered. Large implements of arrow-point or spear-head form are described, and the making of arrow-points is shown. Sixty-five plates and 201 text-figures are devoted to the illustration of this valuable memoir. It is impossible to give an adequate idea of the beauty and excellence of the illustrations, but we commend Dr. Wilson's memoir to all who are interested in the subject of Prehistoric Archæology.

REPORTS AND PROCEEDINGS.

Geological Society of London.

June 20, 1900.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair.

The President announced that the Foreign Secretary had received the following letter from Professor A. Gaudry, F.M.G.S., President of the Organizing Committee of the Eighth International Geological Congress:—

"My dear Friend,—We have just published the Guide-book to the excursions in France of the International Geological Congress. It occupies over 1000 pages, and is full of beautiful illustrations and of geological sections and maps. The excursions will extend over the whole of France from the North as far as the Central Plateau, the Alps, and the Pyrenees. As you are the Foreign Secretary of the Geological Society of London, equally honoured and loved in England and in France, I think that no one is in a better position than you to beg of the Fellows of the Geological Society of London to come in large numbers to Paris. All our geologists will be honoured in seeing them, and will be happy to receive their opinions. To have any great authority it is necessary that an International Geological Congress should have your country—where Geology has been so magnificently studied—largely represented. You can tell our brethren of the Geological Society of London that the President of the Organizing Committee of the Congress of 1900 is the oldest of the Foreign Members inscribed upon their list, that he is a former recipient of the Wollaston Medal, a Foreign Member of the Royal Society of London, and that among his scientific acquaintance he has not a better friend than you. This will be as much as to tell them that I am attached to them by the bonds of deep gratitude, and that it will be a happiness for me to welcome them in our ancient city of Paris. I reckon upon you.—Yours most sincerely, Albert Gaudry."

The following communications were read:—

1. "On the Skeleton of a Theriodont Reptile from the Baviaans River (Cape Colony)." By Professor H. G. Seeley, F.R.S., F.L.S., V.P.G.S.

The fossil described in this paper was discovered by Mr. W. Pringle at Ealdon, in the bed of the Baviaans River, a tributary of the Great Fish River. It is now preserved in the Albany Museum. The slab containing it is of hard siliceous sandstone, and is 31 inches long by ten inches wide. It is split so as to expose a portion of the skull, the vertebral column and ribs as far as the pelvis, the scapula, part of the humerus, the femur, and parts of the tibia and fibula. The tail and left hind-limb, and apparently part of the right fore-limb, are lost, owing to the jointed condition of the rock. The bones have decomposed, and are represented by natural moulds from which a beautiful cast was obtained by means of a gelatine mould prepared in the Geological Department of the Natural History Museum, before the specimen was returned to Grahamstown. It indicates an animal about 2 feet long, exclusive of the tail, and standing probably about 8 inches high; it was not more than 6 inches wide in the fore part of the body. The animal was of great mobility, capable of easily bending the body, and, by straightening the limbs, of occasionally raising its height to 10 inches or more. It is a new type of Theriodont reptile, contributing important facts to the osteology of the group, and especially in regard to the natural association of the bones. It is possibly to be included in the Cynodontia, from which it differs in characters of the ilium, scapula, and skull.

2. "Fossils in the Oxford University Museum.—IV. Notes on some Undescribed Trilobites." By H. H. Thomas, Esq., B.A., F.G.S.

Two new species of *Dalmania* from the Wenlock Shales and one of *Olenus* from the Shineton Shales of Shropshire are described in this paper. The specimens on which the first species of *Dalmania* is founded were collected by the late Dr. Grindrod at Malvern Tunnel. The species has a strong resemblance to certain varieties of *D. caudatus*, especially those more nearly approaching *D. longicaudatus*; its nearest ally seems to be *D. nexilis*. Among its characters are spines round the head, the height of the head-shield, and the distance between the eyes. The type-specimen of the second species came from the Wenlock Shale of Builth. The Shineton specimen was presented to the Oxford Museum by the Right Rev. Bishop Mitchinson.

3. "On Radiolaria from the Upper Chalk at Coulsdon (Surrey)." By W. Murton Holmes, Esq. (Communicated by W. Whitaker, Esq., F.R.S., F.G.S.)

The radiolaria described in this paper were contained in the cavities of two small flints which were thrown out of the new cutting between Coulsdon Station and the new Merstham Tunnel on the L.B. & S.C. Railway. They were probably derived from the zone of *Holaster planus*. After treatment with hydrochloric acid, the material yielded silicified casts of foraminifera as well as radiolaria. The surface of the radiolaria is so much altered by corrosion that specific identification is in most cases impossible. Twenty genera have been recognized, and the organisms appear to belong to forty-one species of these genera. A list of the radiolaria is given, accompanied by a short description of each form, and four new species are described. The Discoidea appear to have the predominance, and the species of *Dictyomitra* come next in numerical order.

The next Meeting of the Society will be held on Wednesday, November 7th, 1900.

OBITUARY.

PROFESSOR M. LOUIS LARTET.

Born 1840. Died 1899.

Professor Louis Lartet was the son of a former distinguished Foreign Member of the Geological Society of London, Monsieur Edmund Lartet. In 1863 he assisted De Verneuil in the publication of two papers, and from 1864 to 1868 he published several others, chiefly on the Holy Land, leading up to his lengthy essay of 1869 on the Geology of Palestine and of the neighbouring countries, followed, three years later, by a shorter paper on the Palæontology. In 1877 his work was presented in a more elaborate form in the large quarto volume entitled "Geological Exploration of the Dead Sea, of Palestine, and of Idumea," with two geological maps, three plates of sections, and eight of fossils and of stone implements. By these works he is chiefly known. Professor Louis Lartet was elected a Foreign Correspondent of the Geological Society of London in 1882, and died in 1899.

SIR DOUGLAS S. GALTON, K.C.B., F.R.S., F.G.S.

Born 1822. Died March 10, 1899.

Douglas Galton was born in 1822 at Hadzor House, Worcestershire. At the age of 15 he went to the Royal Military Academy, and in 1840 got his commission in the Royal Engineers, greatly distinguishing himself and gaining the first prize in every subject of examination. He was engaged in the attempt to raise the "Royal George." He served on the Ordnance Survey and did much work in connection with railway engineering, metropolitan drainage, submarine cables, and the sanitary condition of the Army, serving on various Royal Commissions, etc. In 1860 he was made Assistant Inspector General of Fortifications, and in 1862 Assistant Under Secretary of State for War, a post which he held eight years, when he became Director of Public Works and Buildings (under the Board of Works), in which official capacity he served until 1875. He was General Secretary of the British Association from 1871 to 1895, and in the latter year he became President. In 1894 he was made Hon. Mem. Inst. C.E.; many other honours were conferred upon him, including various foreign orders. The later years of his life were specially devoted to sanitary science, for which he did very much, and his last official appearance in public was as president of a meeting of the Sanitary Institute, for the reading of a paper on the water-supply of London. He was then rather indisposed, though nothing serious was suspected; but he got weaker, and blood-poisoning set in. He was buried at Hadzor, Worcestershire. Douglas Galton was amongst the oldest Fellows of the Geological Society, having been elected in 1848, and served on the Council from 1870 to 1874.

FRANZ RITTER VON HAUER.

BORN, VIENNA, JAN. 30, 1822. DIED MARCH 20, 1899.

RITTER VON HAUER has been called the Nestor of Austrian geologists, having been for many years Director of the Geological Survey and Intendant of the Imperial Natural History Museum. He was born in Vienna in 1822, and educated there until he went to the Berg-Akademie at Schemnitz from 1839 to 1843. He afterwards became a mining official in Styria, and in 1846 was made Assistant to Haidinger at the Imperial Mineralogical Museum in his native city, when he began original palæontological work. He succeeded Haidinger as chief of the Museum, and held that post from 1867 to 1885. On the death of F. von Hochstetter he was made Curator of the Imperial Natural History Museum, in which post he did important work, retiring at last on account of old age and ill-health. He was the first to classify the Alpine sedimentary rocks on a strictly stratigraphical basis, and published a work on the Cephalopoda of the Triassic and Jurassic beds of the eastern Alpine regions. His general map of the Austrian Empire (in twelve sheets, published 1867–71, reaching a fourth and extended edition in 1884), and his account of the geology of that empire, published in 1875, crown his life's work. Franz Ritter von Hauer was elected a Foreign Correspondent of the Geological Society of London in 1863, a Foreign Member in 1871; and he was awarded the Wollaston Medal in 1882. He died on March 20, 1899. Von Hauer received many orders and honours, held various offices, and was revered as a teacher and leader in science.

CHARLES JULES EDME BRONGNIART.

BORN 1859. DIED APRIL 18, 1899.

M. CHARLES BRONGNIART was the grandson of the illustrious French Botanist, Adolphe T. Brongniart, who in 1841 received the Wollaston Medal from the Geological Society of London. He was an Assistant at the Museum of Natural History, Paris, and was one of the chief European authorities on Fossil Insects, on which he wrote a number of papers from 1876 onward. His principal work was published in 1893, in the form of two large quarto volumes with atlases of plates. One of these is the third volume of "Studies on the Coal-measures of Commentry," which is devoted to the Entomological Fauna of the Carboniferous epoch. The other is "Fossil Insects of Primary Times." Several of his papers appeared as translations in the GEOLOGICAL MAGAZINE. (See GEOL. MAG., 1879, Dec. II, Vol. VI, pp. 97–102, Pl. IV; 1885, Dec. III, Vol. II, pp. 481–491, Pl. XII; 1888, pp. 422–425, one page illustration; 1895, pp. 233–236.) It is sad that so distinguished a career, from which we had reason to expect so much more valuable work, should have been ended so early. Charles Brongniart was elected a Foreign Correspondent of the Geological Society of London in 1888, and died April 18, 1899, aged 40.

TOWNSHEND MONCKTON HALL, F.G.S.

Born March 22, 1845. Died July 1, 1899.

Townshend Hall was born at Torquay in 1845, and studied for a short time at Wadham College, Oxford. On leaving there he gave himself up to science, and especially to geology. A paper by him on the distribution of fossils in the North Devon Series was printed in the Quarterly Journal of the Geological Society (1867, vol. xxiii, pp. 371–381); but his chief contributions to the geology and mineralogy of his native county are in the Trans. Devon Association (of which he was a member from the first), and include papers on mineral localities, raised beaches, submerged forests, concentric lamination, mineral oil, classification of North Devon rocks, and various matters of local geology. He also contributed to the Geological Magazine and to the Mineralogical Magazine, and wrote several sketches of the Geology of Devonshire or parts thereof, and the "Mineralogists' Directory." He became, indeed, well known as our chief local authority on North Devon.

PROFESSOR ROBERT W. BUNSEN, Ph.D.

Born March 13, 1811. Died August 16, 1899.

Although Bunsen achieved his great reputation as a chemist, and held the Chair of Chemistry in the University of Heidelberg for many years, he wrote (especially in his earlier life) several papers on minerals and on mineral waters, as well as on various geological subjects, notably on the chemico-geology of Iceland. To the scientific world he is largely known for his work on spectrum analysis, resulting in the discovery of the elements cæsium and rubidium; whilst to the world at large he is known by the invaluable gas-burner that bears his name and the principle of which he discovered. Professor R. W. Bunsen was elected a Foreign Member of the Geological Society of London in 1856, holding the honorary distinction for 43 years. He died at the age of 88 years.

JOHN BALDRY REDMAN, F.G.S., Memb. Inst. C.E.

Born 1816. Died December 21, 1899.

John Baldry Redman was elected an Associate of the Institution of Civil Engineers in February, 1839, and a Member in March, 1846, his name being the earliest on the roll of over 6,300 Members and Associates at the time of his death. He was elected an F.G.S. in 1882. He did much service to geology by his important papers, read to the institution above-named, "On the Alluvial Formations, and the Local Changes, of the South Coast of England," and "The East Coast between the Thames and the Wash Estuaries," published in 1854 and 1865, which were the first systematic account of the changes along a great length of our coast, in this case from Norfolk southward to Dorsetshire. Much other work of the kind was also done by him, for instance in the Reports of the British Association Committee on Coast-erosion, and his knowledge was always at the disposal of those interested in the subject. He died at the good old age of 83.

WILHELM HEINRICH WAAGEN.

BORN JUNE 23, 1841. DIED MARCH 24, 1900.

THE celebrated palæontologist Wilhelm Heinrich Waagen was born at Munich, 23rd June, 1841, and educated there and at Zürich. In the latter place he specially studied natural history, for which he had early shown great taste.

In 1864 his first paper, "Der Jura in Franken, Schwaben, und der Schweiz," made its appearance, and gained a prize.

He established himself first at Munich, and for one year was natural history tutor to Prince Arnulph and Princess Therese of Bavaria. In December, 1870, Waagen was appointed palæontologist to the Indian Geological Survey. The Indian climate, however, did not suit him, and he was obliged to retire in August, 1875. The previous year he had contracted a fortunate and happy marriage with Sophie, Baroness von Gross-schedel.

Shortly after quitting India, Waagen settled in Vienna and became a Tutor at the University. The following year he went to Prag to occupy the Chair of Mineralogy and Geology at the German Technical High School. There, on the death of Barrande, he assisted in editing the continuation of the "Systême Silurien de Bohême," and in association with Professor J. Jahn wrote the section Crinoids for that work.

On Neumayer's death, Waagen became in 1890 Professor of Palæontology at the University of Vienna, a post which he held till his death on 24th March, 1900.

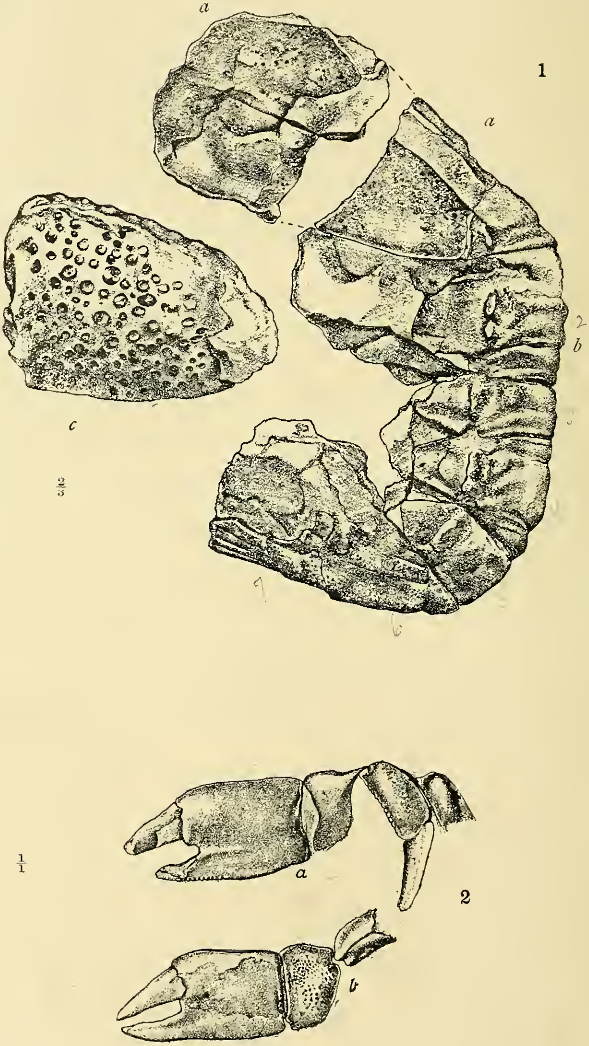
Waagen was by no means a prolific writer, less than a score of papers in various journals being written by him.

His principal works were on the Jurassic Cephalopoda of Kutch and on the Salt Range Fossils, both forming part of the "Palæontologica Indica," and the latter incomplete at the time of his decease.

Of the value of these works from a systematic point of view it is perhaps as yet too early to speak; but of his enthusiasm and industry, and of the fact that he greatly advanced our knowledge of Indian palæontology, there can be no doubt.

MISCELLANEOUS.

THE UNIVERSITY OF LONDON.—It gives us great pleasure to announce that the Senate of the University of London has conferred the degree of Doctor of Science upon Mr. C. W. Andrews, B.A., F.G.S., of the British Museum (Natural History), and has also awarded him the Sherbrooke Scholarship, founded by the late Lord Sherbrooke, Trust. Brit. Mus. This is the first occasion on which this scholarship has been presented.



G. M. Woodward del. S. Austin & Sons imp.

Cretaceous Crustacea, N.W. Territory of Canada.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VII.

No. X.—OCTOBER, 1900.

ORIGINAL ARTICLES.

I.—Further Notes on Podophthalmous Crustaceans from the Upper Cretaceous Formation of British Columbia, etc.

By Henry Woodward, LL.D., F.R.S., F.G.S., of the British Museum (Natural History).

(PLATE XVII.)

(*Concluded from the September Number, p.* 401.)

Hoploparia Westoni, sp. nov. (Pl. XVII, Figs. 1*a*, *b*, *c*.)

AMONG other specimens received from the Geological Survey of Canada are the fragmentary remains of a Crustacean (enumerated in Dr. Whiteaves' list as No. 10), comprising the abdomen (*a*), a small part of a carapace (*b*), and the penultimate joint of one of the chelate fore-limbs (*c*), occurring in detached fragments (probably parts of a concretionary nodule). They are labelled Red Deer River, Alberta Range 15, Township 23, west of the 4th principal meridian; collected by Mr. T. C. Weston, 1889. Although in so fragmentary a condition these specimens are of much interest, and are characteristic in their details.

The abdominal segments are united and display the characteristic markings and raised ridges on the segments seen in the living *Nephrops Norvegicus* and in *Hoploparia Saxbyi* and other English Cretaceous forms. The epimeral portions of each segment are roundly falcate, and divided from the tergum by a well-marked ridge. The sixth segment and the telson are more rugose and marked by parallel ridges. The cephalothoracic portion is too obscure for description; the surface is tuberculated. The penultimate joint of the great claw is very coarsely and strongly tuberculated, as much so as in *Enoploclytia* and in *Hoploparia scabra.*

Length of abdomen (measured along dorsal line), 5½ inches; width over third segment, 2¼ inches. Length of penultimate segment of great claw, 2¼ inches; breadth, 2 inches.

I have designated this form as *Hoploparia Westoni*, after the discoverer. The specimen is from the Upper Cretaceous of the North-West Territories.

Hoploparia Bennetti, sp. nov.

This species is based on a very imperfectly preserved specimen, No. 5 in list, contained in a dark nodule (measuring 5″ × 2″) split in halves very irregularly, and exposing the dorsal aspect of five posterior abdominal somites and the telson with two swimmerets on the left side still attached. The abdominal segments are smooth, and the epimera broadly falcate and pointed as in *Homarus*. Length of five abdominal segments, 40 mm.; length of telson, 13 mm.; breadth of abdomen, 25 mm.

The sternites are still attached to the abdomen, but the carapace has been removed, exposing the inner and upper surface of the cephalothorax, with the bases of five pairs of ambulatory appendages still attached. Length of cephalothoracic portion, 30 mm. Some of the small ambulatory legs on the left side are preserved nearly to their extremities, and the bases of the large (chelate) fore-legs can also be seen, one joint of which shows a tuberculated surface. Length of base of area of sternites, 25 mm.; greatest breadth, 15 mm. There is no trace whatever of the presence of large palinurid antennæ. This and the general character of the thoracic appendages and the form of the abdomen, resembling the modern *Homarus* rather than *Palinurus*, lead me to refer this fossil to the genus *Hoploparia*. I have added the specific name of *Bennetti* after its discoverer.

Formation: Upper Cretaceous.

Locality: Comox River; collected by Mr. J. Bennett in 1895.

Enoploclytia minor, sp. nov.

The evidence for this species consists of a nodule (4″ × 3″, No. 9 in Dr. Whiteaves' list, marked also 59 in white paint) split into two parts, but affording little comfort to the investigator. One can make out an imperfectly preserved carapace (cephalothorax), with a tuberculated surface from which two pairs of imperfectly preserved antennæ take their origin and the flagella of which can be indistinctly traced. These are followed by a pair of long and slender chelate appendages, with finely tuberculated surfaces, the fingers of the forceps being very attenuated as in *Enoploclytia Leachii*. Two pairs of slender ambulatory legs follow; these also have forcipated or chelate extremities. The abdominal segments are narrow and only imperfectly preserved.

The specimen is from the Upper Cretaceous of Hornby Island, and was obtained by Mr. W. Harvey in 1893.

Meyeria? Harveyi, sp. nov.

The evidence of this species rests on a single specimen exposed on the half of a fractured nodule ($3\frac{1}{2}$ inches × $2\frac{1}{2}$ inches), marked No. 8 in list. It is also marked 3 in ink. It was obtained by Mr. W. Harvey in 1895 at Hornby Island, and shows the remains of the abdominal somites and the long slender rugose fore-limbs of the cephalothorax ($2\frac{1}{4}$ inches in length by $\frac{1}{8}$ inch in thickness). They do not appear to have possessed forceps at their extremities, but were monodactylous. The form of the epimera of the abdomen agrees with *Meyeria vectensis* in shape.

From the Upper Cretaceous. Named after its discoverer, Mr. W. Harvey.

DECAPODA—BRACHYURA—CALLIANASSIDÆ.

CALLIANASSA, Leach, 1814.

Callianassa Whiteavesii, H. W., 1896. (Pl. XVII, Figs. 2*a*, *b*.)
Quart. Journ. Geol. Soc., vol. lii, p. 223, figs. 1, 2.

In addition to the Macrouran Decapods already noticed as received from Dr. J. F. Whiteaves, F.G.S., on behalf of the Geological Survey of Canada, I find the following:—

No. 2. Nodule in four pieces collected by the Rev. G. W. Taylor on the Puntledge or Comox River, Vancouver Island, in 1889.

The four parts of this nodule display on the split surfaces the remains of a *Callianassa*, or possibly parts of two individuals, but so broken up and detached as to be difficult to describe. The large fore-limbs are seen (in parts), and the smaller limbs and segments of the abdomen are also present, but in a very fragmentary state. These, no doubt, are referable to one and the same species, viz. *Callianassa Whiteavesii* (see Q.J.G.S., 1896, vol. lii, p. 223, figs. 1, 2).

Formation: Upper Cretaceous.

Locality: Comox River, Vancouver Island.

No. 11. Eight portions of nodules (*a* and *b*, *c* and *d* being counterparts; *e* and *f* are halves of distinct nodules; *g* and *h* are pieces of the rock itself, not nodules). *a* and *b*, *c* and *d*, *e* and *f* display the well-preserved flattened chelate hands of *Callianassa Whiteavesii* (Pl. XVII, Figs. 2*a*, *b*); *g* contains a fragment of a hand; *h* is not a Crustacean fragment, but an undoubted fish-bone.

All these specimens are from the North-West Territory, Township 30, Range 8, west of 4th principal meridian, and were collected by Mr. J. B. Tyrrell, F.G.S. (May 25th, 1886).

Note on North American Cretaceous Species of *Callianassa*.

Dr. J. F. Whiteaves calls my attention to a paper by Mr. W. M. Gabb in the Geological Survey of California, vol. i, Palæontology (1864, 4to), Section iv, Description of the Cretaceous Fossils, p. 57, pl. ix, figs. 1*a*, *b*, *c*. Here Mr. Gabb describes and figures three small Crustacean fragments, under the name of *Callianassa Stimpsoni*, from Chico Creek and Clayton, Contra Costa County, and also found near Canada de las Uvas from both divisions of the Californian Cretaceous. Pl. ix, fig. 1*a*, is correctly described as three segments of abdomen, and may very likely belong to a *Callianassa*, but figs. 1*b* and *c* are pieces of an ornamented chela and do not agree with any known *Callianassa*. *Callianassa Stimpsoni* may therefore properly remain on the list represented by fig. 1*a*, but the other figures do not belong to the same Crustacean, and should be separated from it in future. The chela may even have belonged to a Brachyuran decapod.

EXPLANATION OF PLATE XVII.

Fig. 1.—*Hoploparia Westoni*, H. Woodw., sp. nov. Upper Cretaceous: Red Deer River, Alberta Range, North-West Territories. (*a*) Parts of carapace or cephalothorax; (*b*) the segments of the abdomen; (*c*) the penultimate joint of one of the chelate fore-limbs. (One-third less than nat. size.)

Fig. 2.—*Callianassa Whiteavesii*, H. Woodw., 1896. Upper Cretaceous: North-West Territory. (*a*) Shows a complete fore-limb with its five-jointed chela; (*b*) another example with three joints united. (Drawn nat. size.)

II.—On a Granophyre Dyke intrusive in the Gabbro of Ardnamurchan, Scotland.

By Professor K. Busz, Ph.D., of Münster.

LAST year, while on an excursion to Scotland, I visited the Ardnamurchan peninsula, which, as is well known, consists to a great extent of rocks belonging to the gabbro family. On the road leading from the little village of Kilhoan, opposite the Isle of Mull, on the north coast, a small quarry has been opened for road-metal, which shows an exquisite section of a granophyre dyke intrusive in a dark and almost black fine-grained rock, which the microscopic examination proved to be a gabbro. This is, therefore, a similar occurrence to that of Barnavave, Carlingford, Ireland, which has been admirably described by Professor Sollas, and also that of Strath in the Isle of Skye, of which Mr. Harker has given us a detailed account. As occurrences of this kind seem to be rather rare and, as far as I am aware, hitherto not known from Ardnamurchan, I may be excused for calling your attention to the following short description of these rocks, although there is but little to be added to the results attained by the skilful researches of the above-mentioned authors, and it only shows again that on Ardnamurchan we are to expect very nearly the same geological phenomena as in the adjacent islands, in particular in Skye and Rum.

I will now describe, firstly, the gabbro and try to explain its alterations due to the intrusion of the granophyre dyke, and secondly, the granophyre, and the effect which the gabbro, through having been partly absorbed, had upon its composition.

1. *Gabbro.* The rock under consideration is, as far as I can judge, a dyke-rock, and is exactly like some of the dykes which occur in connection with the large gabbro masses of the Odenwald Mountains in Germany, which have been carefully examined and described by Professor Chelius, of Darmstadt. Owing to the very unfavourable weather and the fact of the whole neighbourhood being covered by deep moorland, I was unable to trace the extension of the dyke, and can therefore now only give an account as to how it is exposed in the quarry. The centre of the latter shows the dyke to a width of about two yards, and it is then covered on both sides by débris, so that the entire thickness is certainly greater. The composition and structure of the rock is not the same in all its parts.

The main mass consists of a rock almost black and of a fine sugar-grained structure, similar to some dense quartzites, and contains no microscopically visible excretions. By the aid of a lens, however, the rock is seen to consist of small grains of a grey and black colour.

The structure as exhibited in the microscope is exquisitely panidiomorphic, according to Rosenbusch's nomenclature, the essential constituents being felspar and pyroxene, both in grains of about equal size. Both in structure and composition it coincides exactly with those dyke-rocks of the Odenwald district which Chelius named beerbachite, after the village Beerbach, where they occur, and so this rock may also be termed beerbachite.

The felspar, according to its optical orientation, is very nearly a pure anorthite, the maximum extinction angle on the basal plane being between 33° and 34°. It is perfectly clear and colourless, and exhibits no traces of decomposition or any alteration whatever, and only in some parts contains a number of inclusions, which are principally small grains of pyroxene and magnetite, often accumulating in the centre. Pyroxene is present in two varieties, the one being diallage, the other common augite, both about in equal quantities.

The diallage shows the characteristic structure parallel to the orthopinacoid, and contains numberless thin needle-shaped inclusions of black or brown colour, which are imbedded parallel to the vertical axis as well as to the basal plane, thus producing two intersecting systems of striation; in some instances they accumulate in the centre, leaving the margin almost free. The colour of the crystals is dull grey, owing to these inclusions. In sections perpendicular to the vertical axis they appear as minute black points, giving the crystals a dust-like appearance.

The common augite is very pale greyish-green, and almost colourless in thin slices. It contains only very few inclusions, principally grains of magnetite, and can therefore easily be distinguished from diallage. There is no rhombic pyroxene present in this rock.

The third essential constituent is magnetite, occurring in grains as well as in octahedral crystals, of the same size as the pyroxene and felspar individuals. There are also a few larger patches of quite an irregular form and intergrown with the other constituents. Olivine is rare; it appears in grains, which through decomposition are always partly, and sometimes entirely, altered into green serpentine with magnetite dust. There are only very few accessories; they consist of thin colourless needles of apatite and small light-brown patches of biotite, the latter usually intergrown with augite.

This gabbro, as mentioned before, does not exhibit the same composition and structure throughout. There exists also a porphyritic variety, which may be termed gabbro-porphyry, or in this case beerbachite-porphyry. This variety, however, was not found *in situ*; but numerous xenoliths, to adopt Professor Sollas's term, in the granophyre show this structure. Although having to refer to these xenoliths later on, I will give here a short description of them, in order to show how the porphyritic variety differs from the fine-grained gabbro. The colour of both is the same, the only difference being small black patches as a rule not more than half a centimetre in diameter. They are formed of crystals or crystalline aggregates of triclinic felspar, showing distinctly the cleavage and the twinning lamellæ. Their colour being the same as that of the rock, they are not easily discernible at a first glance.

The groundmass is in many parts of exactly the same composition and appearance as in the fine-grained gabbro, only the felspar individuals are in so far somewhat different as they exhibit a more lath-shaped form.

In other parts rhombic pyroxene appears in considerable quantity, and generally in large crystals, showing the characteristic pleochroism of *hypersthene*—pale green, yellow, pink—and the parallel extinction; the individuals are not homogeneous, but show a poikilitic structure, being intergrown with numerous, irregularly disseminated, lath-shaped, plagioclase crystals.

The microscopic examination of the porphyritic plagioclase crystals shows that they are also nearly pure anorthite, like the plagioclase in the groundmass and in the above-described beerbachite, the maximum extinction angle being about 34° on the basal plane. The black colour is due to a great quantity of black dust-like inclusions (similar to the plagioclase in some diorites from Sweden, commonly known as black Swedish granite). They are in some parts of the crystals more densely distributed than in others, and so give them a cloudy appearance.

We have now to consider how these constituents of the gabbro have been altered by the intrusion of the granophyre dyke. The latter, of a grey colour, is on an average one foot wide, and has been almost vertically intruded into the surrounding gabbro. It contains a great number of xenoliths, which belong to the fine-grained gabbro as well as to the porphyritic variety. A detailed description of the granophyre will follow later on; for the present it may suffice to say that the acid magma has absorbed a great quantity of the gabbro, and the xenoliths can be studied in every stage of absorption.

The alteration of the plagioclase can be studied best on the xenoliths of the gabbro-porphyry. On the margin towards the granophyre they first lose their transparency, and the outer zone becomes a dull greyish-brown similar to decomposed orthoclase in granite; the examination by crossed nicols shows that actually a gradual alteration into orthoclase has taken place, the zones being like those in the *Bytownite* from Barnavave, not sharply defined, but gradually passing into one another. The centre of the crystals does not show much of this alteration, there being only more or less thin threads of the brownish substance. Further away from the line of junction, where the granophyre meets the gabbro, the plagioclase hardly shows any alteration at all.

Much more conspicuous are the alterations which have taken place in the augite — a fact quite in accordance with the observations made by Professor Sollas and Mr. Harker. Here, as in the Barnavave gabbro, there are principally three different products of alteration, those being green, rarely brownish-green hornblende, biotite, and granular augite, to which in some cases steatite may be added. The last-named occurs only in the gabbro-porphyry, and is the alteration product of the rhombic pyroxene. Near the junction line of the two rocks the outer zone of the hypersthene assumes a green colour and becomes less transparent; this alteration increases towards the granophyre until the entire hypersthene substance is changed into very finely striated and distinctly, though not strongly, pleochroic steatite of a light-green colour.

The alteration of both diallage and augite seems to begin with the excretion of round or oval-shaped grains of magnetite or titanic iron-ore, sometimes in such quantities that the augite seems to be nothing but an agglomerate of them; then there appears on the margin a broader or narrower border of green or brownish-green hornblende, which in the end entirely replaces the augite. This hornblende shows mostly the characteristics of uralite, but there also occasionally occur well-defined crystals which show no signs of the fibrous structure so characteristic of uralite, and to judge from their peculiar brownish-green colour they may perhaps be identical with the variety called barkevikite. The formation of biotite is less common and generally occurs in connection with green hornblende, intergrown with which it forms reddish-brown lamellæ or irregular patches. Also the alteration described by Professor Sollas as the breaking up of the crystals into numerous granules has been observed in some cases, always accompanied by the formation of magnetite; in this case a perfect recrystallization has taken place.

These are, in short, the results of the examination of the gabbro and the gabbro-porphyry.

We must now turn to the granophyre. It is a rather fine-grained rock of grey colour. According to its macroscopic appearance it might be termed a microgranite or aplite. It contains numerous black patches of gabbro of various size up to several inches in diameter, and is spotted with minute black specks; felspar crystals are visible in great numbers, and reach up to 2 mm. diameter.

Under the microscope the rock presents a somewhat peculiar appearance, due to the remarkable way in which quartz occurs. It forms, as a rule, small crystals, with usually well-defined outlines, whereas the orthoclase appears as the interstitial matter. The quartz crystals are perfectly clear and contain but few inclusions, amongst those many sharply defined, small crystals of zircon, only terminated by the tetragonal pyramid.

The orthoclase, owing to decomposition, is of a dull grey colour. It not only appears, as mentioned before, filling up the spaces between the quartz crystals, but also forms rectangular crystals up to two millimetres in size; the greater part of the rock, in fact, is made up of such larger crystals, while quartz and the interstitial orthoclase form a kind of groundmass.

The orthoclase crystals exhibit in the centre a fairly fresh appearance, and are sometimes even quite colourless, while the outer zone shows exactly the same features as the felspar of the groundmass. Under crossed nicols this clear centre in many cases is seen to consist of twinned triclinic felspar, showing the same optical properties as that in the gabbro. These parts may therefore undoubtedly be regarded as remains of xenocrysts of the gabbro-plagioclase, which by the effect of the acid magma have on their outer parts been transformed into orthoclase; this alteration has often gone so far that nothing of the plagioclase material is left, and only the still clear appearance of the centre of the crystals indicates that originally plagioclase has been present. By this we are led to the following consideration as regards the solidification of the granophyre. The acid magma, when intruding into the gabbro mass, has broken up a great quantity of the basic rock, and being in a state of high temperature and great fluidity was able to absorb a great part of the gabbro xenoliths. The plagioclase xenocrysts had also been partly absorbed when the solidification of the rock began to take place, the first separation being the orthoclase, which crystallized in parallel intergrowth with what had been left of the plagioclase crystals. Thus a very acid magma being left, quartz crystallized next in small crystals, whereas the interstitial orthoclase, filling up the spaces between the quartz individuals, must be considered the last excretion.

As further constituents of the granophyre, hornblende, pyroxene, mica, and magnetite are to be mentioned. They are present in considerable quantity, and disseminated throughout the whole mass of the rock. They must, however, not be regarded as originating from the granophyre magma, but are either xenocrysts of the adjacent gabbro, or result from the absorption of basic material.

Augite, occurring as diallage or as common augite, shows all the same features as in the gabbro rock, with the difference that the alteration here appears in a more advanced stage. Often the whole of the augite or diallage crystal has been entirely altered into green, uralitoid hornblende, whereas in other cases one or several grains of the unaltered substance remain enclosed in the alteration product. A decomposition of the uralite into a chloritic substance can often be observed.

There is also another variety of hornblende present, showing a darker, brownish-green colour and also a more intense pleochroism. It occurs in irregular patches and also in well-defined crystals, which exhibit the characteristic cleavages and the outlines of the hornblende prism. They are, therefore, not uralite, but must be considered as separations, or recrystallizations, which can only originate out of the granophyrio magma after it had been altered by the absorption of the basic rock. This conclusion is corroborated by the fact that such hornblende crystals can often be observed on the junction line between the two rocks.

The hornblende shows the peculiar colouring which can often be observed in the variety named barkevikite, the outer part being brownish-green, which gradually changes towards the centre into reddish-brown. Biotite appears always in connection with hornblende.

From this description the granophyre is seen to be very similar to the one of Barnavave, in Ireland, which Professor Sollas described as a diallage-amphibole-augite-granophyre.

To sum up the results of the examination of the rocks from Ardnamurchan—

1. The gabbro is presumably a dyke-rock, belonging to the group which has been termed *beerbachite*, and also partly a porphyritic variety of the same—*beerbachite-porphyry.*

2. It was solidified before the intrusion of the granophyre, as the latter contains a great number of xenoliths of it, which have undergone great alterations through the action of the acid magma.

3. The granophyre has absorbed a considerable quantity of the basic material, thereby altering its own composition and giving rise to the crystallization of hornblende and mica, two constituents which we have to consider as not belonging to the original granophyre magma.

4. In the solidification of the granophyre two stages can be distinguished, the first giving rise to the formation of the rectangular orthoclase crystals, which crystallized in parallel intergrowth with the plagioclase xenocrysts, the second forming a kind of groundmass in which fresh quartz crystallized, while the orthoclase filled up the remaining spaces.

III.—On the Age of the Raised Beach of Southern Britain as seen in Gower.[1]

By R. H. Tiddeman, M.A., F.G.S., of H.M. Geological Survey.

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

GOWER has a reputation for its caves with their bone-beds, and for its raised beaches, but to the matter of its Glacial Drifts very little attention has been paid.

Some of the caves were known to and noted by Dean Buckland.[2] The caves were long and diligently explored by Colonel Wood of Stout Hall, and the results carefully collated by Dr. Falconer. A great number of the bones are exhibited in the Swansea Museum. Mr. Starling Benson, who lived at Swansea, has left an account of Bacon Hole, and Dr. Falconer has incidentally alluded to other caves in describing the animal remains.

These three observers noted the fact that the cave fauna, which included *Hyæna*, *Elephas antiquus*, and *Rhinoceros hemitœchus*, was found in bone-beds in the shore caverns and rested on or above a cemented shelly conglomerate, which was evidently a raised beach, for it formed a floor across the cave at from 10 to 30 feet above the level of the present beach. This conglomerate was found to contain shells which could not be distinguished from those of the littoral zone on the present beach.

It was recognized that the beach must have been made when the sea was at that higher level, and that the bones could not have been accumulated until the coast had been raised above the old beach-level. But the further reasoning, which was chiefly concerned with the age of the bones, was that, the beach being evidently rather recent, the bones must be more recent. Falconer did not appear quite content with this, and called in Prestwich to assist in finding out what relation, if any, the bone-deposits and raised beach bore to the Glacial deposits.

Prestwich appears to have worked from the west along the coast to Bacon Hole, but not to the east. He reported: "With respect to

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

[2] "Reliquiæ Diluvianæ."

the point I had particularly in view, viz., the relation of the Gower caves to the Boulder-clay, I am as yet unable to form a decided opinion. I got the Boulder-clay within a mile of the raised beach, but on opposite sides of the Point of Rhos-sili the subject requires further and more lengthened inquiry." On this Falconer summed up as follows:—

1. That the Gower caves have probably been filled up with mammalian remains since the deposition of the Boulder-clay.

2. That there are no mammalian remains found elsewhere in the ossiferous caves of Britain referable to a fauna of a more ancient geological date.

It is very singular how near these two eminent men were to making a discovery for which they were even looking. To the east of the rich colony of caves between Minchin Hole and Bacon Hole, at which they were specially working, the Drift-beds come on in force, and the succession which they were looking for might have been very well seen.

It is true that the proper succession was gradually hammered out by explorations in other places by the Victoria Cave Exploration Committee, by the late Dr. Hicks in the caves of North Wales, and at a later day by the Rev. G. C. H. Pollen, but their researches and the facts evolved by them received a long and well-sustained fire of hostile criticism which has not long come to an end.

The survey of Gower has now established, I think I may say, incontestably—

1. That the raised beach is Pre- or Interglacial.

2. That the bone-beds which rest upon it in the caves are continuous with the earlier 'head' or débris which lies above it along the coast, and which consists of limestone fragments.

3. That Glacial Drift again lies over this.

4. This in turn is often covered by a later deposit of 'head.'

Frequently, immediately above the raised beach is a deposit of sand which is probably blown sand. It contains in places land-snails which are abundant on the blown sands of Glamorganshire. It is of a foxy-red colour, and its lower part is often cemented together into calcareous concretions, containing little nodules of manganese and iron. The sand is interesting in this way, that it is seen in many places where sand could not blow now. The upheaval of the coast implied by the raised beach would necessarily subject a wide fringe of foreshore to the action of the sun and wind, and the blown sand would result. It is just where we might reasonably expect it.

The section is not always complete. Sometimes the Drift is absent, sometimes it rests on rock, sometimes one member is absent, sometimes another, but this represents the succession in which they always occur when present. It is astonishing how very regular they are, considering the steep irregularity of the cliffs and coasts.

It will of course be suggested that the Drift may have slipped down from the cliffs above on to the 'head.' This hypothesis is fairly negatived by the very strong contrast in material between the 'head' and the overlying Drift. The latter is full of rounded stones of Carboniferous Sandstone and Old Red pebbles and fragments, with scarcely a trace of limestone, whilst on the contrary the underlying débris contains nothing but fragments of limestone. The change is exceedingly sudden, and forbids the possibility of the Drifts resting on the cliffs for long previously, and later slipping down on to the débris. Scattered boulders would certainly have occurred in the débris.

The Drift is evidently the ordinary Glacial Drift of Glamorganshire, such as abounds further to the north-east, nor can we doubt that it is about the same age as that which sealed up in the Victoria Cave at Settle, and other caves, the fauna which has been so abundant in the caves of Gower, a fauna which if not Pre-Glacial was certainly Interglacial.

On the other hand, the discovery of the antiquity of the raised beach, which does not appear to have been even hinted at, is one which, from the wide range of that physical feature, must necessarily be of importance. It will assist in building up the relations of late formations to the Glacial Period into a consecutive system, and establish relations with other successions in lands to which Glacial phenomena have not extended.

IV.—Note on the Age of the English Wealden Series.[1]

By G. W. Lamplugh, F.G.S., of H.M. Geological Survey.

In recent discussions arising from the renewed attempts to define more closely the boundary between the Jurassic and Cretaceous systems in Russia, Germany, Belgium, and France, and also in North America, constant reference has been made to the English Wealden deposits as affording a standard of comparison. But, meanwhile, doubt has been thrown, by palæontologists who have studied certain portions of the Wealden flora and fauna, on the hitherto accepted classification of these English deposits with the Lower Cretaceous, on the grounds that the fossils showed strong Jurassic affinities. This opinion has been expressed by the late Professor O. C. Marsh in regard to the reptiles, by Dr. A. Smith Woodward in regard to the fish, and by A. C. Seward in regard to the plants. To prevent further confusion it is therefore desirable that certain facts which have been overlooked in this discussion, though for the most part already published, should be restated, since these facts seem sufficient to prove that, at any rate, the greater portion of the English Wealden series must remain as part of the Lower Cretaceous.

It has not always been sufficiently borne in mind that the accumulation of the Wealden Series must have required a period of very long duration. The sands of the Hastings Beds may indeed have been deposited rather rapidly, but the shaly clays, with layers of shells and cyprids, interstratified with these sands, indicate slower sedimentation, and the great mass of Weald Clay, reaching 1,000 feet in thickness, must represent an epoch of great length. Hence,

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

since it is universally acknowledged that the fresh-water conditions did not set in until the closing stages of the Jurassic period, it seems inevitable from this consideration alone that such conditions persisted into Lower Cretaceous times.

Again, nearly all the 'Wealden' fossils in which Jurassic affinities have been observed have been obtained from the lower part of the Wealden Series, i.e. from the Hastings Beds, and very little is known respecting the corresponding fossils from the Weald Clay, which probably represents the major portion of the Wealden period.

Moreover, the argument from the Jurassic affinities of the land and fresh-water fossils alone inspires no confidence, since if we eliminate the Lower Wealden fossils from the Lower Cretaceous lists our knowledge is practically limited to the marine life of this period; and it may be legitimately asked whether the land and fresh-water fossils of the Hastings Beds are not, after all, of the character proper to the lowermost part of the Cretaceous, wherein a close relationship to the immediately preceding period seems quite appropriate.

It is from the stratigraphical evidence, however, that the Lower Cretaceous age of at least the greater portion of the English Wealden Series can be most satisfactorily established by its relation to the marine sequence which must form the ultimate basis of the classification. The marine beds directly overlying the Weald Clay in the South of England represent only the latest stage (Aptien) of the Lower Cretaceous period; and although there is a sharp line of demarcation at their base, this seems to denote a rapid change of conditions and not a lengthy time-interval, since the incoming of marine or brackish-water shells near the top of the Wealden strata in Dorset, Hampshire, and Surrey, foreshadowing the termination of the fresh-water episode, indicates that the series is practically complete, and had undergone little, if any, erosion in these parts before the deposition of the overlying marine strata. Such erosion may, however, have taken place locally towards the easterly and westerly terminations of the basin of deposition, where the topmost beds of the Wealden Series are not found.

In the Speeton Clay, where the Lower Cretaceous marine sequence is fully represented, the equivalents of the Lower Greensand and Atherfield Clay of the South of England are comprised within a relatively narrow compass in the sparingly fossiliferous upper part of the sequence;[1] and therefore, by far the greater portion of the Lower Cretaceous period, if represented at all in the South of England, must be represented in the Wealden Series. The portion of the Speeton Clay unrepresented by marine sediments in the south includes the lower part of the zone of *Belemnites Brunsvicensis* and the whole of the zone of *Bel. jaculum*, both undoubtedly Lower Cretaceous (*Barrémien, Hauterivien,* and *Valanginien*), together with the whole of the zone of *Bel. lateralis*, the fauna of which shows Jurassic affinities. Furthermore, in tracing this marine series southward from Yorkshire, through Lincolnshire into Norfolk, the author

[1] See Summary of Progress of the Geological Survey for 1897, p. 129.

has found that in the latter county the lower zones are apparently absent, and the remaining portion, representing, probably, the lower part of the zone of *Bel. Brunsvicensis*, is characterized by the presence, among the marine fossils, of plant remains, chiefly fragments of a Wealden fern, *Weichselia* (*Mantelli*?), and by other indications of fluviatile influence, suggesting the beginning of a lateral change into Wealden conditions.[1]

With the well-recognized gradual development of fresh-water conditions in the Purbeck beds of the Wealden area towards the close of the Jurassic period, and somewhat similar indications of the reversal of this process in the top of the Weald Clay during the later stages of the Lower Cretaceous, and with the above-mentioned evidence for a lateral passage of part of the Lower Cretaceous marine sediments of the North of England into estuarine deposits further south, there seems every reason to believe that in the fresh-water or estuarine strata of the English Wealden the whole of the time-interval between the Portlandian and Aptien stages is represented, and that it would be equally erroneous to classify the series entirely with the Jurassic system or entirely with the Cretaceous if the hitherto recognized boundary of these systems in the equivalent marine deposits of other areas is to be maintained.

The deposits classed as Wealden in Belgium, Germany, and France appear to be much more restricted in vertical range than the English series, and to represent different parts of the period in different places, but nowhere to imply the same long continuance of fresh-water conditions in a single area.

NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science. Seventieth Annual Meeting, held at Bradford, September 5–12, 1900.

List of Papers read in Section C (Geology).

Professor W. J. Sollas, F.R.S., President.

President's Address. (See p. 449.)

Professor W. B. Scott.—Notes on the Geology and Palæontology of Patagonia. (See p. 470.)

Professor J. Joly, F.R.S.—On the Viscous Softening of Rock-forming Minerals at Temperatures below their Normal Melting Points.

——— On the Geological Age of the Earth, as indicated by the Sodium-contents of the Sea.

——— Some Experiments on Denudation by Solution in Fresh and Salt Water.

——— On the Inner Mechanism of Marine Sedimentation.

Vaughan Cornish.—On Tidal Ripplemarks above Low-water Mark.

Dr. H. Woodward, F.R.S.—Remarks on a Table of Strata. (p. 474.)

Professor J. Milne, F.R.S.—Report of the Committee for Seismological Observations.

[1] See Survey Mem. "Borders of the Wash," o.s., sheet 69, pp. 21–25.

C. Reid, F.R.S. — Geological Notes on the Upway Disturbance (Appendix to the above Report).

S. W. Cuttriss.—The Caves and Potholes of Ingleborough and the District.

Rev. W. Lower Carter. — Report on the Underground Waters of North-West Yorkshire—the Sources of the Aire.

A. R. Dwerryhouse.—Report of the Committee on the Movement of Underground Waters of Craven. I. The Ingleborough District.

E. Greenly.—On Ancient Land-surfaces of Anglesey and Carnarvonshire.

——— On the Form of some Rock-bosses in Anglesey.

Dr. G. Abbott.—The Concretionary Types in the Magnesian Limestone of Durham.

Prof. T. Groom.—Pebbles of the Hollybush Conglomerate. (p. 471.)

——— On the Igneous Rocks associated with the Cambrian System of Malvern. (See p. 473.)

The President.—On a Concealed Coalfield beneath the London Basin.

R. H. Tiddeman.—On the Formation of Reef Knolls.

J. Lomas.—On the Construction and Uses of Strike Maps.

W. Gibson.—On Rapid Changes in the Thickness and Character of the Coal-measures of Staffordshire.

A. Smith Woodward.—Report of the Committee on the Registration of Type-specimens.

Rev. J. F. Blake.—Suggestions in regard to the Registration of Type Fossils. (See p. 471.)

C. B. Wedd.—The Outcrop of the Corallian Limestone of Elsworth and St. Ives.

H. Bolton.—Report of the Committee on Caves at Uphill, near Weston-super-Mare.

R. Lloyd Praeger.—Report of the Committee for the Exploration of Irish Caves.

Joint discussion with Section K on the Conditions during the Growth of the Forests of the Coal-measures. The discussion was opened by Mr. A. Strahan and Mr. J. E. Marr, F.R.S., on behalf of Section C, and by Mr. R. Kidston and Mr. A. C. Seward, F.R.S., on behalf of Section K.

Dr. E. D. Wellburn.—On the Fossil Fishes of the Yorkshire Coalfield.

——— On the Fish Fauna of the Millstone Grits of Great Britain.

J. J. H. Teall, F.R.S., Pres. G.S.—On the Plutonic Complex of Cnoc na Sroine, and its bearing on current Hypotheses as to the Genesis of Igneous Rocks.

Professor K. Busz.—On a Granophyre Dyke intrusive in the Gabbro of Ardnamurchan, Scotland. (See p. 436.)

Professor H. A. Miers, F.R.S.—Report of the Committee on the Present State of our Knowledge of the Structure of Crystals.

Dr. Wheelton Hind.—Report of the Committee on Life Zones in British Carboniferous Rocks.

Miss Igerna B. J. Sollas, B.Sc.—On *Naiadites* from the Upper Rhætic of Redland, Bristol.

F. W. Harmer.—The Influence of the Winds upon Climate during past epochs: a Meteorological Explanation of some Geological Problems.

Dr. J. Monckman.—Notes on some recent Excavations in the Glacial Drift in Bradford.

J. E. Wilson.—On a Glacial Extra-Morainic Lake occupying the Valley of the Bradford Beck.

A. Jowett and H. B. Muff.—Notes on the Glaciation of the Keighley and Bradford Districts.

J. W. Stather.—The Source and Distribution of the Far-travelled Boulders of East Yorkshire.

——— On the Glacial Phenomena of the North-East Corner of the Yorkshire Wolds.

R. H. Tiddeman.—Raised Beaches of Gower, South Wales, and their relation to the Glacial Deposits. (See p. 441.)

Professor P. F. Kendall.—Report of the Committee on the Erratic Blocks of the British Isles.

Professor A. P. Coleman. — On a Ferriferous Horizon in the Huronian north of Lake Superior.

——— Final Report of the Committee on the Pleistocene Beds of Canada.

J. R. Dakyns.—Notes on the Glacial Geology of Snowdon.

R. D. Oldham.—Beach Formation in Thirlmere Reservoir. (See p. 473.)

——— Basal (Carboniferous) Conglomerate of Ullswater and its Mode of Formation.

Professor W. W. Watts.—Report of the Committee for the Collection and Preservation of Geological Photographs.

W. H. Crofts.—New Dock-sections at Hull.

A. C. Seward, F.R.S.—On the Jurassic Flora of the Yorkshire Coast.

G. W. Lamplugh.—The Age of the English Wealden Strata. (p. 443.)

P. M. C. Kermode.—Report of the Committee on the Irish Elk in the Isle of Man.

There was an excellent exhibition of geological specimens in the Museum adjoining the Section Room.

Papers read in other Sections bearing upon Geology.

Section A (Mathematical and Physical Science).

J. W. Gifford.—A Quartz-Calcite Symmetrical Doublet.

Professor A. W. Bickerton.—Cosmic Evolution.

Section B (Chemistry).

H. M. Dawson, D.Sc.—On the Influence of Pressure on the Formation of Oceanic Salt Deposits.

W. Ackroyd.—On a Limiting Standard of Acidity for Moorland Waters.

Section D (Zoology, including Physiology).

President's Address (Dr. R. H. Traquair, M.D., LL.D., F.R.S., F.G.S.).—The Bearings of Fossil Ichthyology on the Problem of Evolution. (See p. 463.)

Index Animalium.—Report by Committee: Dr. H. Woodward, F.R.S. Chairman; C. Davies Sherborn, Reporter. (See p. 473.)

Plankton Investigation.

Professor W. B. Scott.—The Miocene Fauna of Patagonia.

J. Stanley Gardiner.—Investigations upon the Coral Reefs of the Indian Region (Report).

Section E (Geography).

Vaughan Cornish.—On Snow Ripples and *Sastrugi.*

J. E. Marr, F.R.S.—The Origin of Moels, and their subsequent Dissection.

Dr. H. R. Mill.—The Treatment of Regional Geography.

E. G. Ravenstein.—Foreign and Colonial Surveys.

J. Milne, F.R.S.—Large Earthquakes recorded in 1899.

Report of Committee on Physical and Chemical Constants of Sea Water.

R. T. Günther.—On the possibility of obtaining more Reliable Measurements of the Changes of the Land-level of the Phlegræan Fields.

Section F (Economic Science and Statistics).

Professor W. Saunders, LL.D.—Results of Experimental Work in Agriculture in Canada under Government Organization.

Section G (Mechanical Science).

J. Watson.—Water Supply, with a Description of the Bradford Waterworks.

J. H. Glass.—The Coal and Iron Ore Fields of Shansi and Honan, and Railway Construction in China.

Section H (Anthropology).

President's Address (Professor John Rhys, M.A.).—The Prehistoric Ethnology of the British Islands.

J. Paxton Moir.—Stone Implements of the Natives of Tasmania.

Professor E. B. Tylor, F.R.S.—The Stone Age in Tasmania as related to the History of Civilization.

D. G. Hogarth.—The Cave of Psychro in Crete.

A. M. Bell.—On the occurrence of Flint Implements of Palæolithic type on an old Land-surface in Oxfordshire, near Wolvercote and Pear-tree Hill, together with a few Implements of various Plateau types.

A. C. Haddon, Sc.D., F.R.S.—Relics of the Stone Age in Borneo.

Section K (Botany).

Dr. D. H. Scott, F.R.S.—On the presence of seed-like organs in certain Palæozoic Lycopods.

———— The Primary Structure of certain Palæozoic Stems referred to *Araucarioxylon.*

A. C. Seward, F.R.S., and Elizabeth Dale.—On the Structure of *Dipteris conjugata*, Rein, with notes on the geological history of the Dipteridinæ.

Professor Bower, F.R.S.—Illustrations of Sand-binding Plants.

W. C. Worsdell.—The Origin of Modern Cycads.

II.—British Association for the Advancement of Science. Bradford, 1900.

Address to the Geological Section, by Professor W. J. Sollas, D.Sc., LL.D., F.R.S., President of the Section. (Slightly abridged.)

Evolutional Geology.

THE close of one century, the dawn of another, may naturally suggest some brief retrospective glance over the path along which our science has advanced, and some general survey of its present position from which we may gather hope of its future progress; but other connection with geology the beginnings and endings of centuries have none. The great periods of movement have hitherto begun, as it were, in the early twilight hours, long before the dawn. Thus the first step forward, since which there has been no retreat, was taken by Steno in the year 1669; more than a century elapsed before James Hutton (1785) gave fresh energy and better direction to the faltering steps of the young science; while it was less than a century later (1863) when Lord Kelvin brought to its aid the powers of the higher mathematics and instructed it in the teachings of modern physics. From Steno onward the spirit of geology was catastrophic; from Hutton onward it grew increasingly uniformitarian; from the time of Darwin and Kelvin it has become evolutional. The ambiguity of the word 'uniformitarian' has led to a good deal of fruitless logomachy, against which it may be as well at once to guard by indicating the sense in which it is used here. In one way we are all uniformitarians, i.e. we accept the doctrine of the "uniform action of natural causes," but, as applied to geology, uniformity means more than this. Defined in the briefest fashion it is the geology of Lyell. Hutton had given us a "Theory of the Earth," in its main outlines still faithful and true, and this Lyell spent his life in illustrating and advocating; but, as so commonly happens, the zeal of the disciple outran the wisdom of the master, and mere opinions were insisted on as necessary dogma. What did it matter if Hutton, as a result of his inquiries into terrestrial history, had declared that he found no vestige of a beginning, no prospect of an end? It would have been marvellous if he had! Consider that when Hutton's "Theory" was published William Smith's famous discovery had not been made, and that nothing was then known of the orderly succession of forms of life, which it is one of the triumphs of geology to have revealed; consider, too, the existing state of physics at the time, and that the modern theories of energy had still to be formulated; consider also that spectroscopy had not yet lent its aid to astronomy, and the consequent ignorance of the nature of nebulæ: and then, if you will, cast a stone at Hutton. . . . .

Our science has become evolutional, and in the transformation has grown more comprehensive: her petty parochial days are done, she is drawing her provinces closer around her, and is fusing them together into a united and single commonwealth—the science of the earth.

Not merely the earth's crust, but the whole of earth-knowledge is the subject of our research. To know all that can be known about our planet, this, and nothing less than this, is its aim and scope. From the morphological side geology inquires not only into the existing form and structure of the earth, but also into the series of successive morphological states through which it has passed in a long and changeful development. Our science inquires also into the distribution of the earth in time and space; on the physiological side it studies the movements and activities of our planet; and not content with all this, it extends its researches into ætiology and endeavours to arrive at a science of causation. In these pursuits geology calls all the other sciences to her aid. In our commonwealth there are no outlanders; if an eminent physicist enter our territory we do not begin at once to prepare for war, because the very fact of his undertaking a geological inquiry of itself confers upon him all the duties and privileges of citizenship. A physicist studying geology is by definition a geologist. Our only regret is, not that physicists occasionally invade our borders, but that they do not visit us oftener and make closer acquaintance with us.

Early History of the Earth: First Critical Period.

If I am bold enough to assert that cosmogony is no longer alien to geology, I may proceed further, and taking advantage of my temerity pass on to speak of things once not permitted to us. I propose therefore to offer some short account of the early stages in the history of the earth. Into its nebular origin we need not inquire—that is a subject for astronomers. We are content to accept the infant earth from their hands as a molten globe ready made, its birth from a gaseous nebula duly certified. If we ask, as a matter of curiosity, what was the origin of the nebula, I fear even astronomers cannot tell us. There is an hypothesis which refers it to the clashing of meteorites, but in the form in which this is usually presented it does not help us much. Such meteorites as have been observed to penetrate our atmosphere and to fall on to the surface of the earth prove on examination to have had an eventful history of their own, of which not the least important chapter was a passage through a molten state; they would thus appear to be the products rather than the progenitors of a nebula.

We commence our history, then, with a rapidly rotating molten planet, not impossibly already solidified about the centre, and surrounded by an atmosphere of great depth, the larger part of which was contributed by the water of our present oceans, then existing in a state of gas. This atmosphere, which exerted a pressure of something like 5,000 lb. to the square inch, must have played a very important part in the evolution of our planet. The molten exterior absorbed it to an extent which depended on the pressure, and which may some day be learnt from experiment. Under the influence of the rapid rotation of the earth the atmosphere would be much deeper in equatorial than polar regions, so that in the latter the loss of heat by radiation would be in excess. This might of itself lead to convectional currents in the molten ocean. The effect on the atmosphere is very difficult to trace, but it is obvious that if a high-pressure area originated over some cooler region of the ocean, the winds blowing out of it would drive before them the cooler superficial layers of molten material, and as these were replaced by hotter lava streaming from below, the tendency would be to convert the high- into a low-pressure area, and to reverse the direction of the winds. Conversely, under a low-pressure area, the in-blowing winds would drive in the cooler superficial layers of molten matter that had been swept away from the anticyclones. If the difference in pressure under the cyclonic and anticyclonic areas were considerable, some of the gas absorbed under the anticyclones might escape beneath the cyclones, and in a later stage of cooling might give rise to vast floating islands of scoria. Such islands might be the first foreshadowings of the future continents. Whatever the ultimate effect of the reaction of the winds on the currents of the molten ocean, it is probable that some kind of circulation was set up in the latter. The universal molten ocean was by no means homogeneous: it was constantly undergoing changes in composition as it reacted chemically with the internal metallic nucleus: its currents would streak the different portions out in directions which in the northern hemisphere would run from N.E. to S.W., and thus the differences which distinguish particular petrological regions of our planet may have commenced their existence at a very early stage. Is it possible that as our knowledge extends we shall be able by a study of the distribution of igneous rocks and minerals to draw some conclusions as to the direction of these hypothetical lava currents? Our planet was profoundly disturbed by tides, produced by the sun, for as yet there was no moon; and it has been suggested that one of its tidal waves rose to a height so great as to sever its connection with the earth and to fly off as the infant moon. This event may be regarded as marking the first critical period, or catastrophe if we please, in the history of our planet. The career of our satellite, after its escape from the earth, is not known till it attained a distance of nine terrestrial radii; after this its progress can be clearly followed. At the eventful time of parturition the earth was rotating, with a period of from two to four hours, about an axis inclined at some 11° or 12° to the ecliptic. The time which has elapsed since the moon occupied a position nine terrestrial radii distant from the earth is at least fifty-six to fifty-seven millions of years, but may have been much more. Professor Darwin's story of the moon is certainly one of the most beautiful contributions ever made by astronomy to geology, and we shall all concur with him when he says, "A theory reposing on *veræ causæ,* which brings into quantitative correlation the length of the present day and month, the obliquity of the ecliptic, and the inclination and eccentricity of the lunar orbit, must, I think, have strong claims to acceptance."

The majority of geologists have long hankered after a metallic nucleus for the earth, composed chiefly, by analogy with meteorites, of iron. Lord Kelvin has admitted the probable existence of some such nucleus, and lately Professor Wiechert has furnished us with arguments—"powerful" arguments Professor Darwin terms them—in support of its existence. . . . .

The outer envelope of the earth which was drawn off to form the moon was, as we have seen, charged with steam and other gases under a pressure of 5,000 lb. to the square inch; but as the satellite wandered away from the parent planet this pressure continuously diminished. Under these circumstances the moon would become as explosive as a charged bomb, steam would burst forth from numberless volcanoes, and while the face of the moon might thus have acquired its existing features the ejected material might possibly have been shot so far away from its origin as to have acquired an independent orbit. If so, we may ask whether it may not be possible that the meteorites, which sometimes descend upon our planet, are but portions of its own envelope returning to it. The facts that the average specific gravity of those meteorites which have been seen to fall is not much above 3·2, and that they have passed through a state of fusion, are consistent with this suggestion.

Second Critical Period: "*Consistentior Status.*"

The solidification of the earth probably became completed soon after the birth of the moon. The temperature of its surface at the time of consolidation was about 1170° C., and it was therefore still surrounded by its primitive deep atmosphere of steam and other gases. This was the second critical period in the history of the earth, the stage of the "consistentior status," the date of which Lord Kelvin would rather know than that of the Norman Conquest, though he thinks it lies between twenty and forty millions of years ago, probably nearer twenty than forty.

Now that the crust was solid there was less reason why movements of the atmosphere should be unsteady, and definite regions of high and low pressure might have been established. Under the high-pressure areas the surface of the crust would be depressed; correspondingly, under the low-pressure areas it would be raised; and thus from the first the surface of the solid earth might be dimpled and embossed.

Third Critical Period: *Origin of the Oceans.*

The cooling of the earth would continuously progress, till the temperature of the surface fell to 370° C., when that part of the atmosphere which consisted of steam would begin to liquefy; then the dimples on the surface would soon become filled with superheated water, and the pools so formed would expand and deepen till they formed the oceans. This is the third critical stage in the history of the earth, dating, according to Professor Joly, from between eighty and ninety millions of years ago. With the growth of the oceans the distinction between land and sea arose—in what precise manner we may proceed to inquire. . . . .

The ocean when first formed would consist of highly heated water, and this, as is well known, is an energetic chemical reagent when brought into contact with silicates like those which formed the primitive crust. As a result of its action saline solutions and chemical deposits would be formed; the latter, however, would probably be of no great thickness, for the time occupied by the ocean in cooling to a temperature not far removed from the present would probably be included within a few hundreds of years.

The Stratified Series.

The course of events now becomes somewhat obscure, but sooner or later the familiar processes of denudation and deposition started into activity, and have continued acting uninterruptedly ever since. The total maximum thickness of the sedimentary deposits, so far as I can discover, appears to amount to no less than 50 miles, made up as follows :—

	Feet.	
Recent and Pleistocene ...	4,000	... ... Man.
Pliocene	5,000	... ... Pithecanthropus.
Miocene	9,000	
Oligocene	12,000	
Eoceue	12,000	... ... Eutheria.
Cretaceous	14,000	
Jurassic	8,000	
Trias	13,000	... ... Mammals.
Permian	12,000	... ... Reptiles.
Carboniferous	24,000	... ... Amphibia.
Devonian	22,000	... ... Fish.
Silurian	15,000	
Ordovician	17,000	
Cambrian	16,000	... ... Invertebrata.
Keweenawan	50,000	
Penokee	14,000	
Huronian	18,000	

Geologists, impressed with the tardy pace at which sediments appear to be accumulating at the present day, could not contemplate this colossal pile of strata without feeling that it spoke of an almost inconceivably long lapse of time. They were led to compare its duration with the distances which intervene between the heavenly bodies; but while some chose the distance of the nearest fixed star as their unit, others were content to measure the years in terms of miles from the sun.

Evolution of Organisms.

The stratified rocks were eloquent of time, and not to the geologist alone, they appealed with equal force to the biologist. Accepting Darwin's explanation of the origin of species, the present rate at which form flows to form seemed so slow as almost to amount to immutability. How vast, then, must have been the period during which by slow degrees and innumerable stages the protozoon was transformed into the man! And if we turn to the stratified column what do we find? Man, it is true, at the summit, the oldest fossiliferous rocks 34 miles lower down, and the fossils they contain already representing most of the great classes of the Invertebrata, including Crustacea and Worms. Thus the evolution of the Vertebrata alone is known to have occupied a period represented by a thickness of 34 miles of sediment. How much greater, then, must have been the interval required for the elaboration of the whole organic world! . . . .

Geologic Periods of Time.

Before proceeding to the discussion of estimates of time drawn from a study of stratified rocks, let us first consider those which have been already suggested by other data. These are as follows:— (1) Time which has elapsed since the separation of the earth and moon, fifty-six millions of years, minimum estimate by Professor G. H. Darwin. (2) Since the "consistentior status," twenty to forty millions (Lord Kelvin). (3) Since the condensation of the oceans, eighty to ninety millions, maximum estimate by Professor J. Joly.

It may be at once observed that these estimates, although independent, are all of the same order of magnitude, and so far confirmatory of each other. Nor are they opposed to conclusions drawn from a study of stratified rocks; thus Sir Archibald Geikie, in his Address to this Section last year, affirmed that, so far as these were concerned, 100 millions of years might suffice for their formation. There is, then, very little to quarrel about, and our task is reduced to an attempt, by a little stretching and a little paring, to bring these various estimates into closer harmony. . . .

A review of the facts before us seems to render some reduction in Dr. Joly's estimate imperative. A precise assessment is impossible, but I should be inclined myself to take off some ten or thirty millions of years.

We may next take the evidence of the stratified rocks. Their total maximum thickness is, as we have seen, 265,000 feet, and consequently, if they accumulated at the rate of one foot in a century, as evidence seems to suggest, more than twenty-six millions of years must have elapsed during their formation.

Obscure Chapter in the Earth's History.

Before discussing the validity of the argument on which this last result depends, let us consider how far it harmonizes with previous ones. It is consistent with Lord Kelvin's and Professor Darwin's, but how does it accord with Professor Joly's? Supposing we reduce his estimate to fifty-five millions: what was the earth doing during the interval between the period of fifty-five millions of years ago and that of only $26\frac{1}{2}$ millions ago, when, it is presumed, sedimentary rocks commenced to be formed? Hitherto we have been able to reason on probabilities; now we enter the dreary region of possibilities, and open that obscure chapter in the history of the earth previously hinted at. For there are many possible answers to this question. In the first place, the evidence of the stratified rocks may have been wrongly interpreted, and two or three times the amount of time we have demanded may have been consumed in their formation. This is a very obvious possibility, yet again our estimate concerning these rocks may be correct, but we may have erroneously omitted to take into account certain portions of the

Archæan complex, which may represent primitive sedimentary rocks, formed under exceptional conditions, and subsequently transformed under the influence of the internal heat of the earth. This, I think, would be Professor Bonney's view, Finally, Lord Kelvin has argued that the life of the sun as a luminous star is even more briefly limited than that of our oceans. In such a case, if our oceans were formed fifty-five millions of years ago, it is possible that after a short existence as almost boiling water they grew colder and colder, till they became covered with thick ice, and moved only in obedience to the tides. The earth, frozen and dark, except for the red glow of her volcanoes, waited the coming of the sun, and it was not till his growing splendour had banished the long night that the cheerful sound of running waters was heard again in our midst. Then the work of denudation and deposition seriously recommenced, not to cease till the life of the sun is spent. Thus the thickness of the stratified series may be a measure rather of the duration of sunlight than of the period which has elapsed since the first formation of the ocean. It may have been so—we cannot tell —but it may be fairly urged that we know less of the origin, history, and constitution of the sun than of the earth itself, and that, for aught we can say to the contrary, the sun may have been shining on the just-formed ocean as cheerfully as he shines to-day.

Time required for the Evolution of the Living World.

But, it will be asked, how far does a period of twenty-six millions satisfy the demands of biology? Speaking only for myself, although I am aware that eminent biologists are not wanting who share this opinion, I answer, "amply." But it will be exclaimed, "surely there are 'comparisons in things.'" Look at Egypt, where more than 4,000 years since the same species of man and animals lived and flourished as to-day. Examine the frescoes and study the living procession of familiar forms they so faithfully portray, and then tell us, how comes it about that from changes so slow as to be inappreciable in the lapse of forty centuries you propose to build up the whole organic world in the course of a mere twenty-six millions of years? To all which we might reply that even changeless Egypt presents us with at least one change — the features of the ruling race are to-day not quite the same as those of the Pharaohs. But, putting this on one side, the admitted constancy in some few common forms proves very little, for, so long as the environment remains the same natural selection will conserve the type, and, so far as we are able to judge, conditions in Egypt have remained remarkably constant for a long period.

Change the conditions, and the resulting modification of the species becomes manifest enough; and in this connection it is only necessary to recall the remarkable mutations observed and recorded by Professor Weldon in the case of the crabs in Plymouth Harbour. In response to increasing turbidity of the sea-water these crabs have undergone or are undergoing a change in the relative dimensions of the carapace, which is persistent, in one direction, and rapid enough to be determined by measurements made at intervals of a few years.

Again, animals do not all change their characters at the same rate: some are stable, in spite of changing conditions, and these have been cited to prove that none of the periods we look upon as probable, not twenty-five, not a hundred millions of years, scarce any period short of eternity, is sufficient to account for the evolution of the living world. If the little tongue-shell, *Lingula*, has endured with next to no perceptible change from the Cambrian down to the present day, how long, it is sometimes inquired, would it require for the evolution of the rest of the animal kingdom? The reply is simple: the cases are dissimilar, and the same record which assures us of the persistency of the *Lingula* tells us in language equally emphatic of the course of evolution which has led from the lower organisms upwards to man. In recent and Pleistocene deposits the relics of man are plentiful: in the latest Pliocene they have disappeared, and we encounter the remarkable form *Pithecanthropus*; as we descend into the Tertiary systems the higher mammals are met with, always sinking lower and lower in the scale of organization as they occur deeper in the series, till in the Mesozoic deposits they have entirely disappeared, and their place is taken by the lower mammals, a feeble folk, offering little promise of the future they were to inherit. Still lower, and even these are gone; and in the Permian we encounter reptiles and the ancestors of reptiles, probably ancestors of mammals too; then into the Carboniferous, where we find amphibians, but no true reptiles; and next into the Devonian, where fish predominate, after making their earliest appearance at the close of the Silurian times; thence downwards, and the vertebrata are no more found—we trace the evolution of the invertebrata alone. Thus the orderly procession of organic forms follows in precisely the true phylogenetic sequence: invertebrata first, then vertebrates, at first fish, then amphibia, next reptiles, soon after mammals, of the lowlier kinds first, of the higher later, and these in increasing complexity of structure till we finally arrive at man himself. While the living world was thus unfolding into new and nobler forms, the immutable *Lingula* simply perpetuated its kind. To select it, or other species equally sluggish, as the sole measure of the rate of biologic change, would seem as strange a proceeding as to confound the swiftness of a river with the stagnation of the pools that lie beside its banks. It is occasionally objected that the story we have drawn from the palæontological record is mere myth or is founded only on negative evidence. Cavils of this kind prove a double misapprehension, partly as to the facts, partly as to the value of negative evidence, which may be as good in its way as any other kind of evidence.

Geologists are not unaware of the pitfalls which beset negative evidence, and they do not conclude from the absence of fossils in the rocks which underlie the Cambrian that pre-Cambrian periods were devoid of life; on the contrary, they are fully persuaded that the seas of those times were teeming with a rich variety of invertebrate forms. How is it that, with the exception of some few species found in beds immediately underlying the Cambrian, these have left behind no vestige of their existence? The explanation does not lie in the nature of the sediments, which are not unfitted for the preservation of fossils, nor in the composition of the then existing sea-water, which may have contained quite as much calcium carbonate as occurs in our present oceans; and the only plausible supposition would appear to be that the organisms of that time had not passed beyond the stage now represented by the larvæ of existing invertebrata, and consequently were either unprovided with skeletons or at all events with skeletons durable enough for preservation. If so, the history of the earlier stages of the evolution of the invertebrata will receive no light from palæontology; and no direct answer can be expected to the question whether, eighteen or nineteen millions of years being taken as sufficient for the evolution of the vertebrata, the remaining available eight millions would provide for that of the invertebrate classes which are represented in the lowest Cambrian deposits. On *à priori* grounds there would appear to be no reason why it should not. If two millions of years afforded time enough for the conversion of fish into amphibians, a similar period should suffice for the evolution of trilobites from annelids, or of annelids from trochospheres. The step from gastrulas to trochospheres might be accomplished in another two millions, and two millions more would take us from gastrulas through morulas to protozoa.

As things stand, biologists can have nothing to say either for or against such a conclusion: they are not at present in a position to offer independent evidence; nor can they hope to be so until they have vastly extended those promising investigations which they are only now beginning to make into the rate of the variation of species.

Unexpected Absence of Thermal Metamorphosis in Ancient Rocks.

Two difficulties now remain for discussion: one based on theories of mountain chains, the other on the unaltered state of some ancient sediments. The latter may be taken first. Professor van Hise writes as follows regarding the pre-Cambrian rocks of the Lake Superior district: "The Penokee series furnishes an instructive lesson as to the depth to which rocks may be buried and yet remain but slightly affected by metamorphosis. The series itself is 14,000 feet thick. It was covered before being upturned with a great thickness of Keweenaw rock. This series at the Montreal River is estimated to be 50,000 feet thick. Adding to this the known thickness of the Penokee series, we have a thickness of 64,000 feet. . . . . The Penokee rocks were then buried to a great depth, the exact amount depending upon their horizon and upon the stage in Keweenaw time, when the tilting and erosion, which brought them to the surface, commenced.

"That the synclinal trough of Lake Superior began to form before the end of the Keweenaw period, and consequently that the Penokee rocks were not buried under the full succession, is more than probable. However, they must have been buried to a great depth—at least several miles—and thus subjected to high pressure and temperature, notwithstanding which they are comparatively unaltered."[1]

I select this example because it is one of the best instances of a difficulty that occurs more than once in considering the history of sedimentary rocks. On the supposition that the rate of increment of temperature with descent is 1° F. for every 84 feet, or 1° C. for every 150 feet, and that it was no greater during these early Penokee times, then at a depth of 50,000 feet the Penokee rocks would attain a temperature of nearly 333° C.; and since water begins to exert powerful chemical action at 180° C. they should, on the theory of a solid cooling globe, have suffered a metamorphosis sufficient to obscure their resemblance to sedimentary rocks. Either, then, the accepted rate of downward increase of temperature is erroneous, or the Penokee rocks were never depressed, in the place where they are exposed to observation, to a depth of 50,000 feet. Let us consider each alternative, and in the first place let us apply the rate of temperature increment determined by Professor Agassiz in this very Lake Superior district: it is 1° C. for every 402 feet, and twenty-five millions of years ago, or about the time when we may suppose the Penokee rocks were being formed, it would be 1° C. for every 305·5 feet, with a resulting temperature at a depth of 50,000 feet of 163° C. only. Thus the admission of a very low rate of temperature increment would meet the difficulty; but, on the other hand, it would involve a period of several hundreds of millions of years for the age of the "consistentior status," and thus greatly exceed Professor Joly's maximum estimate of the age of the oceans. We may therefore turn to the second alternative. As regards this, it is by no means certain that the exposed portion of the Penokee series ever was depressed 50,000 feet: the beds lie in a synclinal, the base of which indeed may have sunk to this extent, and entered a region of metamorphosis; but the only part of the system that lies exposed to view is the upturned margin of the synclinal, and as to this it would seem impossible to make any positive assertion as to the depth to which it may or may not have been depressed. To keep an open mind on the question seems our only course for the present, but difficulties like this offer a promising field for investigation.

The Formation of Mountain Ranges.

It is frequently alleged that mountain chains cannot be explained on the hypothesis of a solid earth cooling under the conditions and for the period we have supposed. This is a question well worthy of consideration, and we may first endeavour to picture to ourselves the conditions under which mountain chains arise. The floor of the ocean lies at an average depth of 2,000 fathoms below the land, and is maintained at a constant temperature, closely approaching 0° C., by the passage over it of cold water creeping from the polar regions. The average temperature of the surface of the land is above zero, but we can afford to disregard the difference in temperature between it

[1] Tenth Annual Report U.S. Geol. Survey, 1888–89, p. 457.

and the ocean floor, and may take them both at zero. Consider next the increase of temperature with descent, which occurs beneath the continents: at a depth of 13,000 feet, or at the same depth as the ocean floor, a temperature of 87° C. will be reached on the supposition that the rate of increase is 1° C. for 150 feet, while with the usually accepted rate of 1° C. for 108 feet it would be 120° C. But at this depth the ocean floor, which is on the same spherical surface, is at 0° C. Thus surfaces of equal temperature within the earth's crust will not be spherical, but will rise or fall beneath an imaginary spherical or spheroidal surface according as they occur beneath the continents or the oceans. No doubt at some depth within the earth the departure of isothermal surfaces from a spheroidal form will disappear; but considering the great breadth both of continents and oceans this depth must be considerable, possibly even forty or fifty miles. Thus the sub-continental excess of temperature may make itself felt in regions where the rocks still retain a high temperature, and are probably not far removed from the critical fusion-point. The effect will be to render the continents mobile as regards the ocean floor; or, *vice versâ*, the ocean floor will be stable compared with the continental masses. Next it may be observed that the continents pass into the bed of the ocean by a somewhat rapid flexure, and that it is over this area of flexure that the sediments denuded from the land are deposited. Under its load of sediment the sea-floor sinks down, subsiding slowly, at about the same rate as the thickness of sediment increases; and, whether as a consequence or a cause, or both, the flexure marking the boundary of land and sea becomes more pronounced. A compensating movement occurs within the earth's crust, and solid material may flow from under the subsiding area in the direction of least resistance, possibly towards the land. At length, when some thirty or forty thousand feet of sediment have accumulated in a basin-like form, or, according to our reckoning, after the lapse of three or four millions of years, the downward movement ceases, and the mass of sediment is subjected to powerful lateral compression, which, bringing its borders into closer proximity by some ten or thirty miles, causes it to rise in great folds high into the air as a mountain chain.

It is this last phase in the history of mountain-making which has given geologists more cause for painful thought than probably any other branch of their subject, not excluding even the age of the earth. It was at first imagined that during the flow of time the interior of the earth lost so much heat, and suffered so much contraction in consequence, that the exterior, in adapting itself to the shrunken body, was compelled to fit it like a wrinkled garment. This theory, indeed, enjoyed a happy existence till it fell into the hands of mathematicians, when it fared very badly, and now lies in a pitiable condition neglected by its friends.[1]

For it seemed proved to demonstration that the contraction consequent on cooling was wholly, even ridiculously, inadequate to

[1] With some exceptions, notably Mr. C. Davison, a consistent supporter of the theory of contraction.

explain the wrinkling. But when we summon up courage to inquire into the data on which the mathematical arguments are based, we find that they include several assumptions the truth of which is by no means self-evident. . . . .

We shall boldly assume that the contraction at some unknown depth in the interior of the earth is sufficient to afford the explanation we seek. The course of events may then proceed as follows. The contraction of the interior of the earth, consequent on its loss of heat, causes the crust to fall upon it in folds, which rise over the continents and sink under the oceans, and the flexure of the area of sedimentation is partly a consequence of this folding, partly of overloading. By the time a depression of some 30,000 or 40,000 feet has occurred along the ocean border the relation between continents and oceans has become unstable, and readjustment takes place, probably by a giving way of the continents, and chiefly along the zone of greatest weakness, i.e. the area of sedimentation, which thus becomes the zone of mountain-building. It may be observed that at great depths readjustment will be produced by a slow flowing of solid rock, and it is only comparatively near the surface, five or ten miles at the most below, that failure of support can lead to sudden fracture and collapse; hence the comparatively superficial origin of earthquakes.

Given a sufficiently large coefficient of expansion—and there is much to suggest its existence—and all the phenomena of mountain ranges become explicable: they begin to present an appearance that invites mathematical treatment; they inspire us with the hope that from a knowledge of the height and dimensions of a continent and its relations to the bordering ocean we may be able to predict when and where a mountain chain should arise, and the theory which explains them promises to guide us to an interpretation of those worldwide unconformities which Suess can only account for by a transgression of the sea. Finally, it relieves us of the difficulty presented by mountain formation in regard to the estimated duration of geological time.

Influence of Variations in the Eccentricity of the Earth's Orbit.

This may perhaps be the place to notice a highly interesting speculation which we owe to Professor Blytt, who has attempted to establish a connection between periods of readjustment of the earth's crust and variations in the eccentricity of the earth's orbit. Without entering into any discussion of Professor Blytt's methods, we may offer a comparison of his results with those that follow from our rough estimate of one foot of sediment accumulated in a century.

Table showing the time that has elapsed since the Beginning of the Systems in the first column, as reckoned from Thickness of Sediment in the second column, and by Professor Blytt in the third:—

	Years.	Years.
Eocene	4,200,000	3,250,000
Oligocene	3,000,000	1,810,000
Miocene	1,800,000	1,160,000
Pliocene	900,000	700,000
Pleistocene	400,000	350,000

It is now time to return to the task, too long postponed, of discussing the data from which we have been led to conclude that a probable rate at which sediments have accumulated in places where they attain their maximum thickness is one foot per century.

Rate of Deposition of Sediment.

We owe to Sir Archibald Geikie a most instructive method of estimating the existing rate at which our continents and islands are being washed into the sea by the action of rain and rivers: by this we find that the present land surface is being reduced in height to the extent of an average of $\frac{1}{2400}$ foot yearly.[1] If the material removed from the land were uniformly distributed over an area equal to that from which it had been derived, it would form a layer of rock $\frac{1}{2400}$ foot thick yearly, i.e., the rates of denudation and deposition would be identical. But the two areas, that of denudation and that of deposition, are seldom or never equal, the latter as a rule being much the smaller. Thus the area of that part of North America which drains into the Gulf of Mexico measures 1,800,000 square miles; the area over which its sediments are deposited is, so far as I can gather from Professor Agassiz' statements, less than 180,000 square miles, while Mr. McGee estimates it at only 100,000 square miles. Using the larger number, the area of deposition is found to measure one-tenth the area of denudation; the average rate of deposition will therefore be ten times as great as the rate of denudation, or $\frac{1}{240}$ foot may be supposed to be uniformly distributed over the area of sedimentation in the course of a year. But the thickness by which we have measured the strata of our geological systems is not an average but a maximum thickness; we have therefore to obtain an estimate of the maximum rate of deposition. If we assume the deposited sediments to be arranged somewhat after the fashion of a wedge with the thin end seawards, then twice the average would give us the maximum rate of deposition: this would be one foot in 120 years. But the sheets of deposited sediment are not merely thicker towards the land, thinner towards the sea, they also increase in thickness towards the rivers in which they have their source, so that a very obtuse-angled cone, or, better, the down-turned bowl of a spoon, would more nearly represent their form. This form tends to disappear under the action of waves and currents, but a limit is set to this disturbing influence by the subsidence which marks the region opposite the mouth of a large river. By this the strata are gradually let downwards, so that they come to assume the form of the bowl of a spoon turned upwards. Thus a further correction is necessary if we are to arrive at a fair estimate of the maximum rate of deposition. Considering the very rapid rate at which our ancient systems diminish in thickness when traced in all directions from the localities where they attain their maximum, it would appear that this correction must be a large one. If we reduce our already corrected estimate by one-fifth, we arrive at a rate of one foot of sediment deposited in a century. . . . .

[1] According to Professor Penck $\frac{1}{3600}$ foot.

It may be objected that in framing our estimate we have taken into account mechanical sediments only, and ignored others of equal importance, such as limestone and coal. With regard to limestone, its thickness in regions where systems attain their maximum may be taken as negligible; nor is the formation of limestone necessarily a slow process. The successful experiments of Dr. Allan, cited by Darwin, prove that reef-building corals may grow at the astonishing rate of six feet in height per annum.

In respect of coal there is much to suggest that its growth was rapid. The Carboniferous period well deserves its name, for never before, never since, have carbonaceous deposits accumulated to such a remarkable thickness or over such wide areas of the earth's surface. The explanation is doubtless partly to be found in favourable climatal conditions, but also, I think, in the youthful energy of a new and overmastering type of vegetation, which then for the first time acquired the dominion of the land. If we turn to our modern peat-bogs, the only carbonaceous growths available for comparison, we find from data given by Sir A. Geikie that a fairly average rate of increase is 6 feet in a century, which might perhaps correspond to one foot of coal in the same period.

The rate of deposition has been taken as uniform through the whole period of time recorded by stratified rocks; but lest it should be supposed that this involves a tacit admission of uniformity, I hasten to explain that in this matter we have no choice; we may feel convinced that the rate has varied from time to time, but in what direction, or to what extent, it is impossible to conjecture. That the sun was once much hotter is probable, but equally so that at an earlier period it was much colder; and even if in its youth all the activities of our planet were enhanced this fact might not affect the maximum thickness of deposits. An increase in the radiation of the sun, while it would stimulate all the powers of subaërial denudation, would also produce stronger winds and marine currents; stronger currents would also result from the greater magnitude and frequency of the tides, and thus while larger quantities of sediment might be delivered into the sea they would be distributed over wider areas, and the difference between the maximum and average thickness of deposits would consequently be diminished. Indications of such a wider distribution may perhaps be recognized in the Palæozoic systems. Thus we are compelled to treat our rate of deposition as uniform, notwithstanding the serious error this may involve. . . . .

If one foot in a century be a quantity so small as to disappoint the imagination of its accustomed exercise, let us turn to the Cambrian succession of Scandinavia, where all the zones recognized in the British series are represented by a column of sediment 290 feet in thickness. If 1,600,000 years be a correct estimate of the duration of Cambrian time, then each foot of the Scandinavian strata must have occupied 5,513 years in its formation. Are these figures sufficiently inconceivable?

In the succeeding system, that of the Ordovician, the maximum thickness is 17,000 feet. Its deposits are distributed over a wider area than the Cambrian, but they also occupied longer time in their formation; hence the area from which they were derived need not necessarily have been larger than that of the preceding period.

Great changes in the geography of our area ushered in the Silurian system: its maximum thickness is found over the Lake district, and amounts to 15,000 feet; but in the little island of Gothland, where all the subdivisions of the system, from the Llandovery to the Upper Ludlow, occur in complete sequence, the thickness is only 208 feet. In Gothland, therefore, according to our computation, the rate of accumulation was one foot in 7,211 years.

With this example we must conclude, merely adding that the same story is told by other systems and other countries, and that, so far as my investigations have extended, I can find no evidence which would suggest an extension of the estimate I have proposed. It is but an estimate, and those who have made acquaintance with 'estimates' in the practical affairs of life will know how far this kind of computation may guide us to or from the truth.

III.—The Bearings of Fossil Ichthyology on the Problem of Evolution; being the Address to the Zoological Section. By Ramsay H. Traquair, M.D., LL.D., F.R.S., President of the Section. (Slightly abridged.)

I HAVE been told that an idea is prevalent in the minds of recent biologists that the results of Palæontology are so uncertain, so doubtful, and so imperfect, that they are scarcely worthy of serious attention being paid to them. The best answer I can make to such an opinion, if it really does exist, is to try to place before you some evidence that Palæontology is not mere fossil shell hunting, or the making up of long lists of names to help the geologists to settle their stratigraphical horizons, but may present us with abundance of matter of genuine biological interest.

Since the days of Darwin, there is one subject which more than all others engrosses the attention of scientific biologists. I mean the question of Evolution, or the Doctrine of Descent. From the nature of things it is clear that the voice of the palæontologist can only be heard on the morphological aspect of the question, but to many of us, including myself, the morphological argument is so convincing that we believe that even if the Darwinian theory were proved to-morrow to be utterly baseless, the Doctrine of Descent would not be in the slightest degree affected, but would continue to have as firm a hold on our minds as before.

Now as Palæontology takes us back, far back, into the life of the past, it might be reasonably expected that it would throw great light on the descent of animals, but the amount of its evidence is necessarily much diminished by two unfortunate circumstances. First, the terrible imperfection of the geological record, a fact so obvious to anyone having any acquaintance with geology that it need not be discussed here; and secondly, the circumstance that save in very exceptional cases only the hard parts of animals are preserved, and those too often in an extremely fragmentary and disjointed condition. But though we cannot expect that the palæontological record will ever be anything more than fragmentary, yet the constant occurrence of new and important discoveries leads us to entertain the hope that, in course of time, more and more of its pages will become disclosed to us.

Incomplete, however, as our knowledge of Evolution as derived from Palæontology must be, that is no reason why we should not appraise it at its proper value, and now and again stop for a moment to take stock of the material which has accumulated.

You are all already acquainted with the telling evidence in favour of Evolution furnished by the well-known series of Mammalian limbs, as well as of teeth, in which the progress, in the course of time, from the more general to the more special is so obvious that I cannot conceive of any unprejudiced person shutting his eyes to the inference that Descent with modification is the reason of these things being so. Suppose, then, that on this occasion we take up the palæontological evidence of Descent in the case of fishes. This I do the more readily because what original work I have been able to do has lain principally in the direction of fossil ichthyology; and again, because it does seem to me that it is in this department that one has most reason to complain of want of interest on the part of recent biologists, even, I may say, of some professed palæontologists themselves. I shall in the main limit myself to the consideration of Palæozoic forms.

Here I may begin by boldly affirming that I include the Marsipobranchii as fishes, in spite of the dictum of Cope that no animal can be a fish which does not possess a lower jaw and a shoulder-girdle. Why not? The position seems to me to be a merely arbitrary one; and it is, to say the least, not impossible that the modern Lampreys and Hags may be, as many believe, the degenerate descendants of originally gnathostomatous forms.

To the origin of the Vertebrata Palæontology gives us no clue, as the forerunners of the fishes must have been creatures which, like the lowest Chordata of the present day (Tunicata, *Balanoglossus*, *Amphioxus*), had no hard parts capable of preservation. And though I shall presently refer again to the subject, I may here affirm that, so far as I can read the record at least, it is impossible to derive from Palæontology any support to the view, recently revived, that the ancient fishes are in any way related to Crustacean or merostomatous ancestors.

What have we, then, to say concerning the most ancient fishes with which we are acquainted?

The idea that the minute bodies known as Conodonts, which occur from the Cambrian to the Carboniferous, are the teeth of fishes and possibly even of ancient Marsipobranchs may now be said to be given up. They are now accepted by the most reliable authorities as appertaining to Invertebrata such as Annelides and Gephyrea.

More recently, however, Rohon[1] has described from the Lower

[1] "Ueber untersilurische Fische": Mélanges Géol. et Paléont., vol. i (St. Petersburg, 1899), pp. 9–14.

Silurian of the neighbourhood of St. Petersburg small teeth (*Palæodus* and *Archodus*) associated with Conodonts, and which seem to be real fish teeth, but not of Selachians, as is shown by the presence of a pulp cavity surrounded by non-vascular dentine. It is impossible to say anything more of their affinities.

Obscure and fragmentary fish remains have been obtained by Walcott, and described by Jaekel, from rocks in Colorado supposed to be of Lower Silurian or Ordovician age.[1] But doubts have been thrown on their age, and the fossils themselves, which have, it must be owned, a very Devonian look about them, are so extremely fragmentary that they do not help us much in our present purpose.

It is not till we come to the Upper Silurian rocks that we begin to feel the ground securely under our feet, though we may be certain, from the degree of specialization of the forms which we there find, that fishes lived in the waters of the globe for long ages previously.

Characteristic of the 'Ludlow bone-bed' are certain minute scales on which Pander founded the family Cœlolepidæ, having a flat or sculptured crown, below which is a constricted 'neck,' and then a base usually perforated by an aperture leading into a central pulp cavity.

The genera *Thelodus, Cœlolepis*, and others were founded on these dermal bodies, and complete specimens of *Thelodus* have now been found in the Upper Silurian rocks of the South of Scotland, from which it is evident that the fish, though somewhat shark-like, can hardly be reckoned as a true Selachian.[2] *Thelodus Scoticus*, Traq., has a broad flattened anterior part corresponding to the head and forepart of the body, very bluntly rounded in front, and passing behind into right and left angular flap-like projections, which are sharply marked off from the narrow tail, which is furnished with a deeply cleft heterocercal caudal fin. Under the flap-like lateral projections are representatives of pectorals; no other fins are present, neither do we find any teeth or jaws, nor any trace of internal skeleton; and it is only a few days since Mr. Tait, collector to the Geological Survey of Scotland, pointed out to me in a recently acquired specimen a right and left dark spot at the outer margins of the head near the front, which spots may indicate the position of the eyes. A previously unknown genus, *Lanarkia*, Traq., also occurs in which the creature has the very same form, but instead of having the skin clothed with small shagreen-like scales, possesses in their place minute, sharp, conical, hollow spines, without base and open below. What we are to think of those two ancient forms, apparently so primitive and yet undoubtedly also to a great extent specialized, we shall presently discuss.

Let us now for a moment look at the genus *Drepanaspis*, Schlüter, from the Lower Devonian of Gmünden in Western Germany. We

[1] Bulletin Geol. Soc. America, vol. iii (1892), pp. 153–171.

[2] R. H. Traquair, "Report on Fossil Fishes collected by the Geological Survey in the Silurian Rocks of the South of Scotland": Trans. Roy. Soc. Edin., vol. xxxix (1899), pp. 827–864.

[3] R. H. Traquair: Geol. Mag., April, 1900.

have here a strange creature whose shape entirely reminds us of that of *Thelodus,* having the same flat broad anterior part, bluntly rounded in front and angulated behind, to which is appended a narrow tail ending in a heterocercal caudal fin, which is, however, scarcely bilobate. But here the dermal covering, instead of consisting of separate scales or spinelets, shows a close carapace of hard bony plates, of which two are especially large and prominent —the median dorsal and the median ventral—other large ones being placed around the margins, while the intervening space is occupied by a mosaic of small polygonal pieces. The position of the mouth, a transverse slit, is seen just at the anterior margin; it is bounded behind by a median mentum or chin-plate, but no jaws properly so called are visible, nor are there any teeth. Then on each margin near the front of the head is a small round pit, exactly in the position of the dark spot seen in some examples of *Thelodus,* which, if not an orbit, must indicate the position of some organ of sense. Again, the tail is covered with scales after the manner of a 'ganoid' fish, being rhombic on the sides, but assuming the form of long deeply imbricating fulcra on the dorsal and ventral margins. The position of the branchial opening, or openings, has not yet been definitely ascertained.

All these plates are closely covered with stellate tubercles, and we cannot escape from the conclusion that they are formed by the fusion of small shagreen bodies like those of *Thelodus,* and united to bony matter developed in a deeper layer of the skin.

If the angular lateral flaps of *Thelodus* represent pectoral fins, then we would have the exceedingly strange phenomenon of such structures becoming functionally useless by enclosure in hard unyielding plates, though still influencing the general outline of the fish. Be that as it may, can we doubt that in *Drepanaspis* we have a form derived by specialization from a Cœlolepid ancestor?

This *Drepanaspis* throws likewise a much desired light on the fragmentary Devonian remains known since Agassiz's time as *Psammosteus.* These consist of large plates and fragments of plates, composed of vaso-dentine, and sculptured externally by minute closely-set stellate tubercles, exactly resembling the scales of some species of *Thelodus.* These tubercles are also frequently arranged in small polygonal areas, reminding us exactly of the small polygonal plates of *Drepanaspis,* and, like them, often having a specially large tubercle in the centre. That *Psammosteus* had an ancestry similar to that of *Drepanaspis* can also hardly be doubted.

Finally, in the well-known *Pteraspis* of the Upper Silurian and Lower Devonian formations we have a creature which also has the head and anterior part of the body enveloped in a carapace, to which a tail covered with rhombic scales is appended behind, and, though the caudal fin has never been properly seen, such remains of it as have occurred distinctly indicate that it was heterocercal in its contour. The plates of the carapace have a striking resemblance in general arrangement to those of *Drepanaspis,* though the small polygonal pieces have disappeared, and there is a prominent pointed rostrum in front of the mouth; and it is to be noted that the small round apertures usually supposed to be orbits are in a position quite analogous to that of the sensory pits in *Drepanaspis*. The plates of the carapace of *Pteraspis* are not, however, tuberculated, but ornamented by fine close parallel ridges, the microscopic structure of which, along with their frequent lateral crenulation, leaves no doubt in our minds that they have been formed by the running together in lines of *Thelodus*-like shagreen grains. An aperture supposed to be branchial is seen on the plate forming the posterior angle of the carapace on each side.

Until these recent discoveries concerning the Cœlolepidæ and Drepanaspidæ, *Pteraspis* and its allies, *Cyathaspis*, and *Palæaspis* constituted the only family included in the order Heterostraci of the sub-class Ostracodermi, distinguished, as shown by Lankester, by the absence of bone lacunæ in the microscopic structure of their plates. It is now, however, clear that we can trace them back to an ancestral family in which the external dermal armature was still in the generalized form of separate shagreen grains or spinelets.

But the Ostracodermi are usually made to include two other groups or orders, namely the Osteostraci and the Asterolepida.[1]

The Osteostraci are distinguished from the Heterostraci by the possession of lacunæ in their bone structure, and by having the eyes in the middle of the head-shield instead of at the sides. *Cephalaspis*, which occurs from the Upper Silurian to the top of the Devonian, is the best known representative of this division. Instead of a carapace, we find a large head-shield of one piece, though its structure shows evidence of its having been originally composed of a mosaic of small polygonal plates, and it is also to be noted that the surface is ornamented by small tubercles, there frequently being one larger in size in the centre of each polygonal area. The posterior external angles of the shield project backwards in a right and left pointed process or *cornu*, scarcely developed in *C. Murchisoni*, internal to which, and also organically connected with the head-shield, is a rounded flap-like structure, which strongly reminds us of the lateral flaps of the Cœlolepidæ. The body is covered with scales, which on the sides are high and narrow; there is a small dorsal fin, and the caudal, though heterocercal, is not bilobate. It is scarcely necessary for me to add that we find just as little evidence of jaws or of teeth as in the case of the Heterostraci.

The association of the Heterostraci and Osteostraci in one sub-class of Ostracodermi has been strongly protested against by Professor Lankester and Dr. O. M. Reis, but here the Scottish Silurian strata come to the rescue with a form which I described last year under the name of *Ateleaspis tessellata*, and of which some more perfect examples than those at my disposal at that time have recently come to light through the labours of Mr. Tait, of the Geological Survey of Scotland.

[1] To these I myself recently added a fourth, the Anaspida, for the remarkable Upper Silurian family of Birkeniidæ, but as these throw no light as yet on the problem of Descent they may at present be only mentioned.

Here we have a creature whose general form reminds us strongly of *Thelodus*, but whose close affinity to *Cephalaspis* is absolutely plain, were it only on account of the indications of orbits on the top of the head.

The expanded anterior part which here represents the head-shield of *Cephalaspis* shows not the slightest trace of cornua, but forms posteriorly a gently rounded lobe on each side, clearly suggesting that the cornual flaps of *Cephalaspis* are homologous with and derivable from the lateral expanses in the Cœlolepidæ. This cephalic covering is composed of numerous small polygonal plates like those of which the head-shield in *Cephalaspis* no doubt originally consisted, and the minute tubercles which cover their outer surfaces also suggest that the superficial layer was formed by the fusion of Cœlolepid scales. The body is covered with rhombic scales, sculptured externally with tubercles and wavy transverse ridges, and arranged in lines having the same general direction as the scutes of *Cephalaspis*, from which we may infer that the latter originated from the fusion of scales of similar form. The fins are as in *Cephalaspis*, there being one small dorsal situated far back, and a heterocercal caudal, which is triangular in shape, and not deeply cleft into upper and lower lobes as in the Cœlolepidæ. Finally, the scales, on microscopic examination, show well-developed bone lacunæ in their internal structure.

That *Ateleaspis* belongs to the Osteostraci there is thus not the smallest doubt, but its general resemblance to the Cœlolepidæ in its contour anteriorly led me to regard it as an annectent form, and consequently to believe that there is after all a genuine genetic connection between the Heterostraci and the Osteostraci. And I have not seen reason to depart from that opinion even though *Ateleaspis* turns out to be still closer to *Cephalaspis* than was apparent in the original specimens.

If this be so, then *Cephalaspis*, as well as *Pteraspis* and its allies, is traceable to the Cœlolepidæ, shark-like creatures in which, as we have already seen, the dermal covering consists of small shagreen-like scales, or of minute hollow spines, and consequently all theories as to the arthropod origin of the Ostracodermi, so far as they are founded on the external configuration of the carapace in the more specialized forms, must fall to the ground. And from the close resemblance of these scales of *Thelodus* to Elasmobranch shagreen bodies—for forty-five years they had been, by most authors, actually referred to the Selachii—I concluded that the Cœlolepidæ owed their origin to some form of primitive Elasmobranchs. That is, however, not in accordance with the view of the late Professor Cope, that the Ostracodermi are more related to the Marsipobranchii, and that, from the apparent absence of lower jaw, they should be placed along with the last-named group in a class of Agnatha, altogether apart from the fishes proper. And Dr. Smith Woodward, who is inclined to favour Cope's theory, has expressed his view that the similarity of the Cœlolepid scales to Elasmobranch shagreen is no proof of an Elasmobranch derivation, but that such structures, representing the simplest form of dermal hard parts, may have originated independently in far distant groups.[1] Knowing what we do of the occurrence of strange parallelisms in evolution, it would not be safe to deny such a possibility. But as to a Marsipobranch affinity, I would point out that the apparent want of lower jaw among the hard parts which nature has preserved for us is no proof of the absence of a Meckelian cartilage among the soft parts which are lost to us for ever; and also, as Professor Lankester has remarked, that there is no evidence whatever that any of the creatures classed together as Ostracodermi were monorhinal like the Lampreys. The only fossil vertebrate having a single median opening, presumably nasal, in the front of the head is *Palæospondylus*, but, whatever be the true affinities of this little creature, at present the subject of so much dispute, I think we may be very sure that it is not an Ostracoderm.

The Devonian 'Antiarcha' or Asterolepida, of which *Pterichthys* is the best known genus, are also usually placed in the Ostracodermi, with which they agree in the possession of a carapace of bony plates, in the absence of distinct lower jaw or teeth, in the non-preservation of internal skeleton, and in having a scaly tail furnished with a heterocercal caudal fin, and, as in the Cephalaspidæ, also with a small dorsal. But they have in addition a pair of singular jointed thoracic limbs, evidently organs of progression, which are totally unlike anything in the Osteostraci or in the Heterostraci, or indeed in any other group of fishes. These limbs are covered with bony plates and hollow inside, but though I once fancifully compared them in that respect with the limbs of insects, I must protest strongly against this expression of mine being quoted in favour of the arthropod theory of the derivation of the Vertebrata!

Nor do I think that there is any probability in the view published by Simroth nine years ago,[2] namely, that *Pterichthys* may have been a land animal which used its limbs for progression on dry ground, and that the origin of the heterocercal tail was the bending up of the extremity of the vertebral axis caused by its being dragged behind the creature in the act of walking. That view was promulgated before the discovery of the membranous expanse of the caudal fin in this genus.

But though the Asterolepida are apparently related to and inclusible in the Ostracodermi, the geological record is silent as to their immediate origin, no intermediate forms having been found connecting them more closely with either the Heterostraci or the Osteostraci. In the possession of bone lacunæ and of a dorsal fin they have a greater resemblance to the latter, but it may be looked upon as certain that they could have had no direct origin from that group.

As regards the Ostracodermi as a sub-class, they become extinct at the end of the Devonian epoch, and cannot be credited with any

[1] Geol. Mag., March, 1900.
[2] "Die Entstehung der Landthiere"; Leipzig, 1891.

share in the evolution of the fishes of more recent periods, not even if we restore the Coccosteans or Arthrodira to their fellowship. To the latter most enigmatical group, which I shall still continue to look upon as fishes, I shall make some reference further on.

(To be continued in our next Number.)

IV.—Notes on the Geology and Palæontology of Patagonia. By Professor W. B. Scott, Princeton University.[1]

FOR the past four years Princeton University has been conducting explorations in Patagonia under the direction of Mr. J. B. Hatcher. The large expenses of the undertaking have been defrayed by the generosity of friends in New York and Baltimore, and Mr. J. Pierpont Morgan has given the sum of £5,000 for the publication of the important results which Mr. Hatcher has obtained.

The oldest sedimentary formation observed is a marine Cretaceous found in the Cordillera; the Ammonites of this horizon have been studied by Mr. Stanton, and he reports that they indicate Gault age and show close relationship to the Uitenhage beds of South Africa.

The oldest marine Tertiaries are given in the section near the Straits of Magellan, and my assistant, Dr. Ortmann, informs me that the fossils point to a late Eocene or Oligocene age for these beds, which he has called the Magellanian beds. These are overlain by the great Patagonian formation, which is of wide extent, of marine origin, and richly fossiliferous. The 200 species of marine invertebrate fossils obtained from this horizon have been studied by Dr. Ortmann, and lead to some very interesting conclusions. In the first place they unequivocally demonstrate the Miocene age of the beds (not Cretaceous and oldest Eocene as Ameghino has maintained), and in the second place they display the closest resemblance to the Miocene of Australia and New Zealand, pointing to a shore connection with those countries in Miocene times. The Patagonian and supra-Patagonian stages are shown not to be distinguishable.

The Santa Cruz beds, a fresh-water and terrestrial formation, overlie and partially dovetail in with the Patagonian. They contain an incredibly abundant and varied mammalian fauna, of which a vast collection was brought home. This fauna has only a very remote connection with the Miocene mammals of the northern hemisphere, and strongly confirms Rütimeyer's contention of a southern centre of distribution. The presence of numerous carnivorous marsupials (there are no true Carnivora) is additional evidence of a connection, direct or indirect, with Australia. Unconformably overlying the Santa Cruz is another marine formation, discovered by Mr. Hatcher and by him named the Cape Fairweather beds. The fossils indicate the Pliocene age of these beds.

Mr. Hatcher's labours have thus resulted in proving that Patagonian geology is in complete accord with the system established for the northern hemisphere, and that it is not of such exceptional character as has been supposed.

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

V.—The Pebbles of the Hollybush Conglomerate, and their bearing on Lower and Cambrian Palæogeography.[1] By Professor Theodore Groom, M.A., D.Sc.

THE Malvern Hills are commonly supposed to have formed part of an old coast during the deposition of the Lower Palæozoic beds. A preliminary examination of the materials of the Hollybush Conglomerate by the author does not support this view.

The most abundant pebbles consist of quartz; these vary from a coarse mosaic of crystals to a fine quartz-schist. Most of the varieties are probably of metamorphic origin; some appear to be merely vein-quartz, and some represent the quartzose portions of granites and other rocks. Red granites and granophyres, often crushed, are tolerably abundant; these often contain microcline. Mica-schist and chlorite-schist occur rarely. Very abundant are different varieties of felsite. These appear to be mostly micro- or cryptocrystalline, and often micrographic, rhyolites, compact or porphyritic; sometimes banded, and occasionally spherulitic. Some of the varieties may represent crushed intrusive felsites. Far rarer than the rhyolites are microlithic andesites, or andesitic basalts. Other pebbles, and the grains of the groundmass, consist of materials derivable from the rocks mentioned above.

The resemblance of these materials to the rocks of the Malvern range is sufficiently close to prove the Pre-Cambrian age of the latter. But striking differences in microscopic structure and in the proportionate numbers of corresponding rocks in the two series, and the absence of any relation between the local nature of the conglomerate and that of the Archæan mass nearest to it, can hardly be explained except on the assumption that the range itself did not furnish the materials.

The stratigraphical relations of the conglomerate and Archæan mass, moreover, appear to indicate that the Malvern Hills—the southern portion at least—in Cambrian times formed part of an area of deposition, and not of denudation.

The author maintains, then, that the Malvern Hills did not form a coastline in Cambrian times, a conclusion which is in agreement with his former contention that they arose at a much later date.

VI.—Suggestions in regard to the Registration of Type Fossils.[1] By the Rev. J. F. Blake, M.A., F.G.S.

WHEREAS:

1. There is now in existence, and has been for some time, a Committee of the British Association "to consider the best methods for the registration of all type-specimens of fossils in the British Isles."

2. There is as yet in course of production no general register of such specimens.

3. The original types are in many, perhaps the majority of, cases either lost, inaccessible, or inadequately preserved or described.

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

4. Many names in common use have a foreign origin, which have not been adopted after actual comparison with the original foreign types.

5. Palæontological nomenclature consequently still remains burdened with names of uncertain value.

It is therefore advisable that:

1. The above-named Committee recognize and register a new class of 'types,' which may be either original or adopted, but which satisfy certain conditions laid down to ensure their having a definite value.

2. A register be published annually of such types, so that an author in using a name may have the option of quoting this register, instead of the original author's name.

3. This register should give references (1) to the author or authors, and their publications thereupon, who have first satisfied the required conditions; (2) to the museum where the type is deposited.

4. The limitation of types, registered by the British Association, should have reference to the type-specimens, whatever their origin, which are deposited in museums within the United Kingdom (possibly to be enlarged at a future date to the British Empire).

5. The Committee should, from time to time, determine the conditions required for registration, but should be in no way responsible for the validity of the 'species' to which the type may be said to belong, nor for the name under which it is registered, which registration should apply to the 'specific' name only, and not be affected by its reference later to another genus; the only care of the Committee, beyond seeing that the required conditions are satisfied, being to secure that identical diagnoses are not registered under different names, and that the same name is not used at different times for different diagnoses.

The suggested conditions for registration are as follows:—

1. A single specimen must be selected as the type, but two or more co-types may be admitted, which are identical in all other respects save in the preservation of different necessary characters.

2. The exact horizon and locality of the specimen thus selected must be known.

3. All the commonly called 'specific' characters required, in the class to which it belongs, must be known by the type or by the co-types together, and also described, and also the generic ones when the genus is not obvious. [N.B.—The determination whether this condition is carried out in any particular case will rest with the member of the Committee charged with the class.]

4. All characters capable of numerical statement, including size, proportion of parts or lines, angle, etc., must be so given. [N.B.—Adequate figures may suffice for this.]

5. The type-specimen must be permanently placed in a public museum in the United Kingdom.

N.B.—It is not necessary that the type-specimen in the above sense should be the first anywhere described under the registered name, but only the first that satisfies the above conditions.

It is suggested that registered types should be quoted as B 1, B 13—e.g. *Terebratula biplicata*, B 1, or *Phacops caudatus*, B 13—B standing for British, and the number for that of the year of the century. Specimens differing notably from the type, but included in the same species, might be quoted as (B 1).

VII.—On the Igneous Rocks associated with the Cambrian Beds of Malvern.[1] By Professor Theodore Groom, M.A., D.Sc.

The igneous rocks of the Cambrian beds of the Southern Malverns have commonly been regarded as of volcanic origin. The author, after a careful examination of the rocks under the microscope, and of the ground, concludes that the scoriæ and tuffs previously described are non-existent, and that the whole of the igneous rocks are probably intrusive. They consist of sills and small laccolites of basic and ultra-basic olivine diabase and olivine basalt, in which olivine is often extremely abundant, and of bosses and dykes of peculiar amphibole bearing andesites and andesitic basalts. Intrusion probably took place in Ordovician times.

VIII.—Beach Formation in the Thirlmere Reservoir. By R. D. Oldham, F.G.S., Geological Survey of India.[1]

Readers of Mr. Marr's book on the "Scientific Study of Scenery" will recall the comparison made by the author between the irregular and angular outline of the Thirlmere Lake Reservoir, due to the submergence of a land surface shaped by subaërial denudation, and the more gracefully curved outline of the natural lakes, where wind, waves, and streams have combined to round off the angularities by wearing away the prominences and filling up the re-entering angles. This reproach seems to the author to be somewhat exaggerated, as the shore-lines of the Cumberland Lakes have only been partially remodelled by wave action and delta formation, and the original outlines due to simple submergence are still to be seen. However this may be, the reproach, such as it is, is in process of removal. All along the shore of the Thirlmere Lake incipient beach erosion is to be seen, and towards the northern end of the lake, where the shores close in and are exposed to the force of the waves driven along the length of the lake by the prevailing southerly winds, typical beaches and beach-curves are being developed. [Lantern-slides showing the as yet incompleted transition from the irregular outlines produced by submergence to the regular curves of beach-formation were exhibited, and attention drawn to this interesting opportunity of witnessing the gradual formation and growth of a beach.]

IX.—Report of the Committee appointed to compile an Index Animalium: Dr. Henry Woodward (Chairman), Mr. W. E. Hoyle, Mr. R. MacLachlan, Dr. P. L. Sclater, Rev. T. R. R. Stebbing, and Mr. F. A. Bather (Secretary).[1]

The Committee has the honour to report that this work has made very satisfactory progress in the hands of Mr. C. Davies Sherborn, and that the literature down to the year 1800 has now

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

been sought out and indexed. The manuscript of this portion will be ready for the printer in a few weeks, and the Committee is considering the best form of publication and estimating the cost. Meanwhile the indexing of literature after 1800 is being continued. At this stage the Committee would be glad to receive suggestions or offers of help for the publication of this great work, since the sums hitherto so generously awarded to it are only sufficient for the necessary current expenses, which continue as before. The Committee therefore earnestly requests its reappointment with a grant of £100.

The following report on dates of publication has been issued by Mr. Sherborn during the year: Lacepède's "Tableaux des Mammifères et des Oiseaux," *Natural Science*, December, 1899. The Committee desires to thank M. Gadeau de Kerville, Dr. Rudolph Burckhardt, of Basel, Mr. F. Justen (Dulau & Co.), and the Smithsonian Institution of Washington for assistance concerning rare books wanted by the compiler.

X.—Woodward's Table of British Stratigraphical Geology and Palæontology; showing the Economic Products of each Formation.[1]

DR. HENRY WOODWARD exhibited on behalf of Mr. Horace Woodward and himself a coloured Table of British Strata, showing the major and minor subdivisions of the strata, with their thicknesses, the characteristic fossils met with in each, also their economic products, and the places throughout the British Isles where the several formations are exposed at the surface and can be studied. The Table will be published by Messrs. Dulau & Co., 37, Soho Square, W.

REVIEWS.

Summary of Progress of the Geological Survey of the United Kingdom for 1899. pp. 214. (London: printed for H.M. Stationery Office, 1900. Price 1*s*.)

THIS, the third issue of the "Summary of Progress," has the merit of being a trifle shorter than the previous number; and contains, as an Appendix, a very useful "Catalogue of Types and Figured Specimens from the Eocene and Oligocene Series preserved in the Museum of Practical Geology," compiled by Mr. H. A. Allen. We hope that further instalments of this Catalogue will be published at as early a period as possible.

With regard to the "Summary" of the field-work, we venture to rejoice if it is a few pages shorter, because there is a tendency to print an excessive amount of detail, and thereby to obscure the character of the work done. Those interested in the progress of science want to know clearly and readily the advances which have been made, not simply the observations made, by officers of the

[1] Exhibited and explained before the British Association in Section C (Geology), at the Bradford Meeting, September, 1900.

Geological Survey, and it should be more distinctly shown how far the observations recorded are new, or simply confirmatory of what others have made known. No doubt, to a large extent, it is the very detail itself which is new, but this for the most part is interesting only to the geologist who knows the ground or is working at it, and the greater part might perhaps profitably be kept for the memoirs illustrating the maps.

The field-work has ranged over most of the formations, with the exception of Cambrian and Permian. The pre-Cambrian rocks of the counties of Ross and Inverness have received a good deal of attention: they include certain displaced masses of Lewisian gneiss and the schists known as the "Moine series." The "Dalradian or younger schists of the Scottish Highlands" receive separate treatment, and it is remarked that we may conveniently retain the provisional name "Dalradian" for the younger schists of the region east of the line of the Great Glen. If it shall be shown, as seems probable, that the Moine-schists of the north-west pass into and form part of the Dalradian series of the Central Highlands, a step will be gained towards the solution of the problem as to the age and origin of the schists of both regions. We know that the Moine-schists of the north-west have been pushed into their present positions, and probably have acquired their present crystalline characters, since Cambrian time. The Survey has detected bands of what appear to be Arenig rocks wedged in among the schists and grits along the southern border of the Highlands. It thus seems possible that the plication and metamorphism of the Highland schists were not concluded until Lower Silurian time, and that these schists may have originally consisted partly of older Palæozoic as well as pre-Cambrian sediments.

In the island of Arran evidence which tends to support the above suggestions has been obtained. A strip of rocks that can be separated from the ordinary schists of the island has been found to be well developed in the valley known as North Glen Sannox. It crosses the glen from south to north at a distance of rather more than a mile from the sea. It is upwards of a mile and a half long, and from 100 to 400 yards broad, having its narrower width at the northern end. The rocks in this strip of ground, so far as can be seen, are not separated by any structural line from the ordinary schistose grits of the Highland series, which they follow with no apparent break. Nor do they differ in degree of metamorphism from the contiguous Highland schists. A closer examination, however, reveals some characteristic features which have not been met with among the schists, but which precisely resemble those already detected in the supposed Arenig rocks of the Highland border. They consist of black shales or schists and cherts, with some intercalations of igneous rock, which probably include both volcanic and intrusive bands.

In the section on Silurian rocks we have some interesting references to the igneous rocks, and to the establishment of the eruptive nature of what were believed to be tuffs and agglomerates in the south-east of Ireland. Vigorous efforts have been made to determine the relative ages of the great groups of grits and slates in Devonshire and Cornwall. Important details are given of the work done in the Coalfields of North Staffordshire and South Wales. The discovery of Rhætic fossils in the island of Arran is of great interest, although it appears that the specimens were not found actually *in sitú*, but enclosed in a coarse conglomerate that fills a volcanic vent, probably of Tertiary age. Other fossils, of Rhætic aspect, have been found in Skye, and some interesting records are given of the strata in South Wales, where evidence has been noticed of the local recurrence in Rhætic beds of the sedimentary conditions which attended the deposition of the Keuper Marls.

Brief references are given to work in Jurassic and Cretaceous areas, and a list of fossils from the Sandgate beds near Midhurst is worthy of mention.

The further work on the Tertiary igneous rocks of Skye leads to the belief that the great gabbro laccolite has a maximum thickness of about 3,000 feet or more. The survey of the Cuillin Hills has been nearly completed. The detailed study of the western part of the range shows the great complexity of its structure, and the very considerable part played by portions of the basaltic lavas entangled in the gabbro and highly metamorphosed. The gabbro itself consists of numerous distinct intrusions in the form of wedges, sheets, and tongues.

Many interesting facts relating to the Glacial Drifts and newer deposits have been gathered. Especially noteworthy is the conclusion that the raised beach of the Gower promontory in South Wales, between Bacon Hole and Mumbles Head, is pre-Glacial or Interglacial. The bone-beds which rest upon the raised beach in the caves are continuous with a layer of 'head' which overlies the beach. Glacial Drift lies upon these deposits.

Records of the petrographical and palæontological work and lists of publications are given at the end of this "Summary of Progress," which displays throughout the evidence of much painstaking and enthusiastic labour.

CORRESPONDENCE.

FINE SECTION OF BOULDER-CLAY AT CRICH.

Sir,—Geologists interested in the glacial deposits of the Midland Counties will no doubt be glad to hear that a very fine section of Boulder-clay, which rests upon a striated floor of Mountain Limestone, is now to be seen in Derbyshire near the village of Crich (Matlock Baths). The presence near this place of a great mass of Boulder-clay containing erratics foreign to the county has been known for a number of years. Recently the quarry cutting into this clay has been re-worked, a steam navvy having been set to work to clear the clay off the limestone. Mr. Arnold-Bemrose and I visited the quarry on November 25, 1899, and found that an excellent section of 'till' resting upon limestone was exposed. The 'till' reached a thickness of at least 40 feet in places, and rested upon a striated floor of limestone rock. The Boulder-clay is a tough reddish or bluish deposit, with streaks or patches of sand, sandy gravel, or sandy clay. The whole deposit is thickly studded with boulders, both large and small, most of which are finely polished, striated, and grooved. Limestone, gritstone, sandstone, and quartzite are the most common rocks, but toadstone and various greenstones and granites are by no means rare. On the last occasion on which we visited the quarry we found that the clay had been cleared off the limestone over a large area, exposing a floor finely striated, polished, and grooved over its whole extent. The striations run N. 20° W., indicating an ice-flow coinciding roughly in direction with the neighbouring Derwent Valley. Mr. Arnold-Bemrose and I have been at work for some years examining the numerous Boulder-clay deposits and erratics this ice-flow has left behind it at points higher up the valley than Crich, and we hope to be in a position to deal somewhat fully with the glaciation of North Derbyshire in the near future. The deposits formed by the ice which crossed the watershed into the Wye Valley near Buxton have already been traced over large areas south of the Trent. In these deposits the boulders are "such as would be brought down by glaciers descending the valleys of the Wye, Derwent, and other northerly and westerly tributaries of the Trent, debouching into and crossing the valley of the latter river." [1]

R. M. Deeley.

38, Charnwood Street,
Derby.

OBITUARY.

PROFESSOR HANS BRUNO GEINITZ.

Born October 16, 1814. Died January 28, 1900.

H. B. Geinitz was born at Altenburg on October 16, 1814, and studied at the Universities of Berlin and Jena, taking the degree of Ph.D. in 1837, with a thesis on the Muschelkalk of Thuringia. He went to Dresden in 1838 to take part in the work of the Royal Technical High School, in which he became Professor of Mineralogy and Geognosy in 1850, maintaining his connection with that establishment until 1894. In 1857 he was made Director of the Royal Mineralogical and Geological Museum, which post he also held until 1894. His work related chiefly to Saxony, and to it we are specially indebted in regard to the palæontological relations of that kingdom, but it also extended over other parts of Europe. Amongst his more notable works are those on the Fossils of the Coal-measures of Saxony, on the Cretaceous Formations of Saxony, comparing them with those of England, on the Animal Remains of the Dyas, and on the Elbthalgebirge of Saxony, and these are the more valuable from being well illustrated. He was one of the editors of the "Neues Jahrbuch für Mineralogie und Geologie" from

[1] Q.J.G.S., 1886, p. 440.

1863 to 1879. Professor Hans Bruno Geinitz was elected a Foreign Member of the Geological Society of London in 1857, and was Murchison Medallist in 1878.

ALPHONSE MILNE-EDWARDS.

BORN OCTOBER 13, 1835. DIED APRIL 21, 1900.

BY the unexpected death of Milne-Edwards a gap has been created in the foremost ranks of noted palæontologists and zoologists that it will be hard to fill; indeed, so long has his familiar name been a household word with us that it is still impossible to realize our loss.

Sprung from English stock, being the grandson of Bryan Edwards, M.P., a West Indian planter who settled at Bruges, Alphonse Milne-Edwards, son of the celebrated Henri Milne Edwards (1800–1885), was born in Paris, 13th October, 1835, and in his career followed closely in his father's footsteps.

He took his degree of Doctor of Medicine in 1860 and of Science in 1861; became an Assistant Naturalist at the Muséum d'Histoire Naturelle in 1862; Assistant Professor at the École supérieure de Pharmacie in 1864, and Professor there in 1865; Assistant Professor of the Zoological Laboratory of the École des Hautes Études in 1869, and Director in 1880; he was also appointed Professor of Zoology at the Muséum d'Histoire Naturelle in 1876, and finally its Director in 1892. He was elected a member of the Academy of Science, Section Anatomy and Zoology, in 1879, and of the Academy of Medicine in 1885. He was elected a foreign member of the Zoological Society of London in 1876, and in 1882 a Foreign Correspondent of the Geological Society.

His earliest papers were physiological, but he next turned to the study of Crustacea, both recent and fossil, while in 1863 he published his first paper on fossil birds, entitled "Mémoir sur la distribution géologique des Oiseaux fossiles." Three years later the first part of his monumental work, "Recherches anatomiques et paléontologiques pour servir à l'histoire des Oiseaux fossiles de la France," was issued, a work which when completed in 1871 extended to two volumes of text and two of plates. In it he showed the possibility of forming a classification of birds by means of their "long bones." Concurrently there appeared (1866–73) his "Recherches sur la Faune ornithologique éteinte des Îles Mascareignes et de Madagascar."

While these are the more important of his palæontological works they by no means represent a tithe of his scientific writings. He was associated with his father in bringing out the "Recherches pour servir à l'histoire naturelle des Mammifères" (1868–74), and with Grandidier in the volumes (1878–81) on Birds in the latter's "Histoire physique, naturelle, et politique de Madagascar." He was also keenly interested in the question of the distribution of animal life at great depths in the ocean, and it was at his instance and under his superintendence that the submarine surveying vessels the "Travailleur" and "Talisman" were sent out by the French Government; his work receiving acknowledgement in 1884 in the award of the gold medal of the Société Géographique de France. Of minor papers on zoological and palæontological subjects contributed to various scientific journals and the proceedings of different learned societies, he must be credited with upwards of one hundred and fifty, dealing with nearly every group of the animal kingdom.

This busy and useful life was brought to a close after a short illness on 21st April, 1900. Alphonse Milne-Edwards will be as sincerely mourned by us as by his own countrymen, for the man of science belongs to the world.

JAMES THOMSON, F.G.S.

Born December 18, 1823. Died May 14, 1900.

It is well known that the natural taste or instinct of observing and trying to explain the manifold phenomena of Nature, animate and inanimate, is strongly developed in many individuals; and that, in spite of great and various difficulties, it has produced good results to the scientist in particular and to society in general.

The late Mr. James Thomson, of Glasgow, was a notable example of the energy and persistence in the line of research that he chose to follow, in the long uphill struggle of hard work against penury and family misfortune. Snatching a few hours from early morning sleep, he got a little schooling; and this was all the basis he had for a scanty education. His strong self-reliance helped him much in after-life, but became inseparable from his self-opinionatedess, when advised by the Editors of the Scientific Journals in which the results of his workings on the structure of corals were published. Not fully appreciating grammatical accuracy, and sadly wanting in a knowledge of Latin, which language naturalists use for genera and species, his mistaken obstinacy led to disagreements and disappointments between him and his willing literary helpers in Glasgow and London. For some years he had taken up the study of the fossil corals abounding in the Carboniferous Limestone of Western Scotland; indeed, in his native town he had noticed, when a boy, these fossils in the "Bed of Kilmarnock Water." Ultimately, a goodly set of memoirs were produced (upwards of twenty before 1883, and others since), enriched with illustrations of the peculiar structures of the several kinds of corals described therein. Of these illustrations, very many were delicate outlines produced by a process kept secret by Mr. Thomson, who (like Dr. J. A. R. Hunter-Selkirk, of Braidwood), having a small water-power at hand, applied it to cutting and slicing of thousands of Carboniferous fossils. To the polished surfaces of the corals, Mr. Thomson probably applied such a solvent as removed the matrix, but left the organic tissue of walls and septa sufficiently prominent to serve for impressions and printings, and for transference to copper-plates and lithographs. His last two papers on the Scotch Carboniferous Corals in the Transactions of the Geological Society of Glasgow (vol. xi, pt. 1, 1897) are especially illustrated by this process.

Mr. Thomson had a good general knowledge of geology, and his natural acumen in that research was shown in his account of the

Campbeltown district in Cantire in 1867; in his "Geology of Islay," published in 1877; and in his paper on the Geology of Arran, read in 1875. The last-named, which had to withstand much criticism, was ultimately printed in 1897 (Trans. Geol. Soc. Glasgow, vol. xi). His geological knowledge was acquired by assiduous application, and supported by a clear-sighted persistence in his own views, as shown by his paper on Arran. His characteristic intenseness and earnestness of purpose are traceable from an early date.

Born at Kilmarnock, the twelfth child of poor parents, his life of hard work began early. Before he was seven years old he insisted on seeking work in order to help his parents. At last, with some knowledge of carpet-weaving, he got employment in Glasgow. Here, as a youth, his intense earnestness to learn something of geology is stated to have made him listen at a keyhole to a lecture on Coal in very cold weather. In his progress in life he became a commercial traveller; and in this business he continued until over seventy years of age.

Any leisure time that occurred he always devoted to his studies; gathering personal knowledge of natural history and geological facts during his long wanderings over the British Islands, and in some parts of the Continent; collecting fossils and getting them named by experts in museums, and wherever possible. In 1884 he went to Canada with the British Association; and in North America widened his experiences in the mineral and metalliferous districts of Idaho. (Trans. Geol. Soc. Glasgow, 1884.)

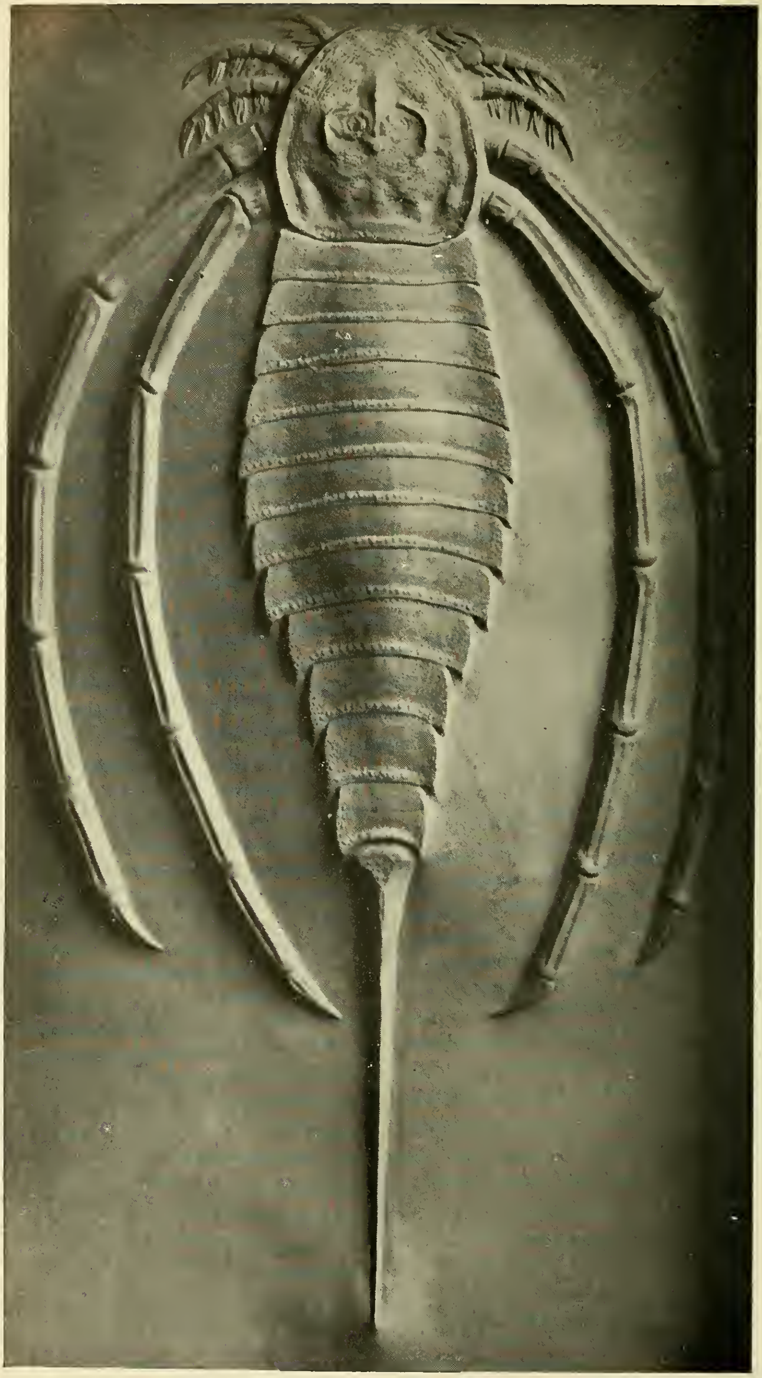
Mr. Thomson had long known the value of well-arranged collections and of really classified natural-history objects to students; and he had made up his mind that, when he should have got sufficient meaus to guarantee a small competence, he would hand over his museum to his native town.

He knew the personal pleasure of adding treasure to treasure to a growing collection, if really valued in view of the ultimate recognition and explanation of the endless phenomena in nature, and thus often pointing to facts and notions of either material or philosophical value to his fellow-man. With this view, Mr. Thomson liberally gave his great collection to Kilmarnock; and Mr. James Dick has munificently provided for its proper housing in the Library and Museum Buildings at Elmbank.

Mr. James Thomson was an old member of the Glasgow Geological Society, and was an honorary fellow of societies at Jena and Liége. In 1868 he was elected a fellow of the Geological Society of London. On February 9, 1899, he was presented with the Freedom of the Burgh of Kilmarnock; but not being well in health, he was represented by his son, Dr. Gemmell Thomson, of Ayr.

Thus, another of the fine old stalwart, self-educated, and strong-willed North-men has passed away; rough and hard in some aspects, but good-hearted, and ambitious to be in the front with those that know and help others to know. James Thomson's death leaves a gap among scientists to be filled up by some earnest student in the present generation.

T. R. J.



Restoration of *Stylonurus Lacoanus* (Claypole).

Length nearly five feet. Original from the Upper Devonian (Catskill Group), Pennsylvania, United States.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VII.

No. XI.—NOVEMBER, 1900.

ORIGINAL ARTICLES.

I.—Restoration of *Stylonurus Lacoanus*, a Giant Arthropod from the Upper Devonian of the United States.[1]

By Professor Charles E. Beecher, Ph.D., of Yale University, New Haven, U.S.A.

(PLATE XVIII.)

IN the animal kingdom the attribute of bigness has come to be regarded as one of the prerogatives of the vertebrates. On this account, invertebrates seldom receive credit for having a size of more than a fraction of a cubit, and are looked upon as objects to be held in the hand or viewed under a lens. As a matter of common experience, and probably also of congratulation, large invertebrates *are* rare, and some whole classes cannot furnish a single individual measuring more than a few inches in greatest diameter.

In a list of arthropod giants the subject of the present note must be included, and will take equal rank with the Giant Spider-Crab of Japan (*Macrocheira Kaempferi*) and the great 'Seraphim' of the Scotch quarrymen (*Pterygotus anglicus*). The former can safely claim to be the largest representative of the Brachyurans that has ever existed, and to the latter may be accorded the same distinction among the Merostomes.

The living species of the Merostomata comprise only the American and Moluccan Horse-shoe Crabs, *Limulus polyphemus* and *L. moluccanus*. The latter sometimes attains a length of three feet and measures eighteen inches across the carapace. To find other species in this order worthy of comparison with the huge Brachyuran of Japan it is necessary to go back to the Palæozoic forms, and among these the larger species of *Pterygotus* and the *Stylonurus* here noticed fill all the requirements. It should be borne in mind, however, that these statements are based upon comparative lengths and breadths. If bulk alone were considered, the common lobster (*Homarus americanus* and *H. vulgaris*) should be mentioned, though in length and extent of limbs it would be considerably smaller.

Concerning the size of the Scotch 'Seraphim,' Dr. H. Woodward[2] states that "From our present knowledge of the almost perfect

[1] Reprinted from the American Journal of Science, vol. x, August, 1900, pp. 145–150.

[2] H. Woodward, "A Monograph of the British Fossil Crustacean belonging to the Order Merostomata," pt. i, 1866; pt. iv, 1872, pp. 1–264, pls. i–xxxvi: Palæontographical Society, vol. xix.

remains of *Pterygotus anglicus*, and on the evidence of the numerous detached portions of this extinct genus, we are justified in concluding that it attained a length of six feet and a breadth of nearly two feet at the widest part of its body." This huge Merostome has been found in the Lower Old Red Sandstone of Scotland, at a horizon nearly equivalent to the one furnishing the remains of *Stylonurus* in America. Thus what seem to be the two largest species of this class were contemporaries, though not associates.

Historical.

The first specimen found in America that can be referred to the genus *Stylonurus* was collected by the writer about 1870, and loaned to Professor James Hall. It remained in his hands unnoticed until 1884, when he described it as *Eurypterus Beecheri*.[1] The specimen preserves the abdomen and portions of two of the large posterior limbs. No species of *Eurypterus* known possessed such greatly elongated limb joints, and there seems to be no good reason for not referring it to *Stylonurus*, in which there is a normal character. The specimen of *Stylonurus Beecheri* is uncompressed, and apparently retains the proportions of form and convexity as in life. On this account it was of considerable importance in the restoration of the larger species.

In 1882 Hall was furnished with a plaster cast of the carapace of a large arthropod by Dr. Cook, then State Geologist of New Jersey. The original specimen was from the Catskill group at Andes, Delaware County, New York, and had been sent to the museum at Rutgers College, New Brunswick, New Jersey. Professor D. S. Martin[2] made the first reference to this species in some remarks on "A New Eurypterid from the Catskill Group," before the New York Academy of Sciences, October 16, 1882, an abstract of this note appearing in the transactions of the same society some time after June, 1883. In this abstract the species is neither described nor figured, and Hall is not mentioned in any connection. Martin states that he saw the specimen (= cast sent to Hall) in the State Museum at Albany, and it bore the name *Stylomurus excelsior* (evidently a misprint for *Stylonurus*).

The next reference to this form in point of time and the first publication of a generic and specific name, accompanied with a description and accurate illustration, was given by E. W. Claypole,[3] in a paper read before the American Philosophical Society, Sept. 21, 1883, under the title "Note on a large Crustacean from the Catskill Group of Pennsylvania." It is stated on the signature containing this paper that it was printed Nov. 2, 1883. Claypole's description

[1] J. Hall, "Note on the Eurypteridæ of the Devonian and Carboniferous Formations of Pennsylvania": Second Geol. Surv. Penn., PPP, 1884.

[2] D. S. Martin, "A New Eurypterid from the Catskill Group": Trans. N.Y. Acad. Sci., vol. xi (1882–1883).

[3] E. W. Claypole, "Note on a large Crustacean from the Catskill Group of Pennsylvania": Proc. Amer. Phil. Soc., vol. xxi, April, 1883, to January, 1884.

was based upon a second specimen found in Wyoming County, Pennsylvania, which preserves about three-fourths of the cephalothorax, and belonged to the collection of R. D. Lacoe, of Pittston. This was given the name *Dolichocephala Lacoana*, and rightly classified with the Merostomata. It therefore appears that, up to this time, the name *Stylonurus excelsior* was simply *nomen nudum*, and as such cannot be recognized as valid.

In 1884 Hall[1] published his description and figure of the New York specimen in the thirty-sixth Annual Report of the New York State Museum, in a paper entitled "Description of a New Species of *Stylonurus* from the Catskill Group."[2] It is here that the New York specimen was first figured and a description given, and the date of publication of this paper is the one to be considered in deciding the claims of *Stylonurus excelsior* as Hall's species.

At the Philadelphia meeting of the American Association for the Advancement of Science, September, 1884 (Proc. A. A. A. S., vol. xxxiii, published 1885), Hall[3] presented a note on *Stylonurus excelsior*, merely referring to its occurrence, and citing Martin's abstract with page and month of publication. This citation is repeated by Hall in each of his notices of this species, for only by thus establishing the species could he have any claim to priority. As already mentioned, Martin's paper does not attempt any description of this form, and Hall is not mentioned. Hall further says: "The carapace is described and figured in the 36th Report of the N.Y. State Museum of Natural History," without reference to plate, page, or year, and it is therefore quite possible that this description was not published until after the meeting of the Association. In any case, it appeared some months later than Claypole's paper, and the name *Dolichocephala Lacoana* has priority over *Stylonurus excelsior*, and must be recognized.

Claypole failed to point out the affinities of this form with *Stylonurus*, and proposed a new generic term for his species. Although there are differences that may prove of generic value when more complete specimens of the American species have been studied, yet at the present time there seem to be no strong reasons why the specimen in question should not be considered as belonging to *Stylonurus*, and it is upon this ground that the present restoration is attempted.

Material available for a Restoration.

Restorations of extinct organisms are largely exhibits of mental architecture, based upon the personal interpretation of a certain

[1] J. Hall, "Description of a New Species of *Stylonurus* from the Catskill Group": Thirty-sixth Ann. Rep. N.Y. State Mus. Nat. Hist., 1884.

[2] J. Hall & J. M. Clarke, "Trilobites and other Crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung, and Catskill Groups": Geol. Surv. of the State of New York, Palæontology, vol. vii (1888).

[3] J. Hall, "Note on the Eurypteridæ of the Devonian and Carboniferous Formations of Pennsylvania, with a supplementary note on *Stylonurus excelsior*": Proc. Am. Assoc. Adv. Sci., vol. xxxiii (1885), Philadelphia Meeting (held September, 1884).

number of real things. Some statement, therefore, should be given of the character and amount of the material that has been collated to furnish a restoration of *Stylonurus Lacoanus.*

(1) The specimen of the cephalothorax described by Hall shows the complete outline and upper surface of this part, and a cast from the original was taken to represent this portion in the restoration. (2) The type of *S. Lacoanus*, Claypole, includes a large part of the cephalothorax of an individual nearly the same in size as the preceding. (3) Dr. J. M. Clarke discovered that this specimen also preserved considerable evidence as to the nature of the appendages, and he succeeded in developing what appear to be the chelate antennæ, the first pair of gnathopods, and the mandibular bases of at least three others. (4) The length and number of joints in the limbs are taken from the English species *S. Logani* and *S. Powriei*, of which quite complete, though smaller, individuals have been described by Woodward.[1] (5) The outline and proportions of the abdomen follow closely those of the English forms and of *S. Beecheri*, the latter giving the natural convexity. (6) A portion of a large abdominal segment found by the writer in the Chemung group at Warren, Pennsylvania, and apparently belonging to a nearly related species, has an ornamentation closely approaching that on the cephalothorax of the type, and was used to elaborate the sculpture over the abdomen of the restoration. (7) The form and character of the telson spine correspond to *S. Logani* and also to some large fragments found by F. A. Randall at Warren and Ackley, Pennsylvania, in the Chemung group, and probably belonging with the abdominal somite already mentioned.

With the data furnished by the foregoing material, the restoration was undertaken. The first model in relief was constructed in clay, and from it a plaster mould was taken. A number of casts have been made since, and a photograph of one of them is represented in the accompanying plate (Plate XVIII).

In this connection, it may be suggested that the type-specimen of *Stylonurus* (?) (*Echinocaris* ?) *Wrightianus* (Dawson, sp.) represents two proximal joints of one of the large crawling feet of a form related to *Stylonurus*, and not two somites of the abdomen as indicated by Hall.[2] Any reference is at present somewhat uncertain, owing to lack of positive knowledge, and the fact that the specimen in question was first described as a plant (*Equisetides*[3]), then referred to the Phyllocarida (*Echinocaris*[4]), and lastly appeared as a possible Merostome, shows how this form may be interpreted by different observers. No one can doubt its arthropod nature, on account of

[1] Loc. cit.

[2] J. Hall: Note to explanation of plate xv of paper on Geology of Yates County, N.Y., by B. H. Wright: Thirty-fifth Ann. Rep. N.Y. State Mus. Nat. Hist., published 1884.

[3] J. W. Dawson, "Notes on New Erian (Devonian) Plants": Quart. Journ. Geol. Soc. London, vol. xxxvii (1881).

[4] T. R. Jones & H. Woodward, "Notes on Phyllopodiform Crustaceans, referable to the Genus *Echinocaris*, from the Palæozoic Rocks": Geol. Mag., n.s., Dec. III, Vol. I, September, 1884.

the characteristic surface markings. Its elliptical or ovoid section without any flattening of the epimera, the very considerable overlapping of the joints, and the configuration of the suture, are more strongly indicative of the nature and requirements of a limb than of abdominal segments.

The Relief Model.

In this restoration the animal is represented as lying on a slab, with the entire dorsal surface exposed. The cephalothorax has an axial length of 25 cm. and a width of 22 cm.

The chelate antennæ were doubtless carried in a folded position, as in most related genera, and seldom were visible from the dorsal side. They are, therefore, not shown. The three pairs of short gnathopods, serving partly as swimming organs, are seen extending outward from the antero-lateral margins of the cephalothorax. Several of their distal joints are each provided with a pair of flat, ridged, spinous processes, and a similar spine at the termination of the limb.

The two pairs of great crawling feet extend outward and backward from the postero-lateral margins of the cephalothorax. The anterior pair expose 109 cm. of length, and the posteror pair about 108 cm. The elements of the limbs are represented as grooved, as this character seems necessary to give the needed strength to long slender joints, and also because a similar conformation is present in *S. Beecheri*.

The abdomen measures 30 cm. in greatest width at the fifth segment, and 66 cm. in length exclusive of the telson. The posterior abdominal segments are represented without detachable epimera, as this feature is not as yet known to be constant for the genus, although present in some species.

The telson spine agrees proportionally in length with the same member in *S. Logani* and *S. Powriei* as described by Woodward,[1] and was given a slight upward curvature as in *Limulus*. It measures 54 cm. in length and 7·5 cm. across at the proximal end.

Altogether the animal as restored has a length of nearly five feet (147 cm.), and with the legs extended it would measure about eight feet (242 cm.) across.

It is not intended to claim any high degree of accuracy for this restoration, but merely to represent in some graphic form an animal approximating in size and character an individual of the species *Stylonurus Lacoanus*. Its size alone was the chief incentive for attempting a reconstruction, and some sacrifice of exact detail may well be allowed in order to make any presentation of this magnificent arthropod.

[1] Loc. cit.

II.—On *Hyperodapedon Gordoni.*

By Prof. Rudolf Burckhardt, Ph.D., of the University of Basel, Switzerland.

(PLATE XIX.)

THE fossil to be discussed in the present memoir is the specimen which formed part of the classical material used in the discussion which was carried on amongst British geologists during the second half of the present century. So important a controversy could hardly be restricted to the geographical limits of England alone.

In the question of the age of the Elgin Sandstones, considered by Sir Roderick Murchison to be Palæozoic, it was Huxley who pronounced upon it finally,[1] after the discovery of and in his subsequent description of *Hyperodapedon*.[2] His decision in this geological controversy was given on the evidence derived from a far less perfect specimen than the one represented on Plate XIX. It also supplied Huxley with an opportunity for speculations concerning the affinities of the animal with *Sphenodon*, from New Zealand, a reptile which Dr. Günther had just then presented in all its scientific aspects. On the other hand, these speculations carried Huxley far out upon an ocean of geographical as well as of geological hypotheses.

A second specimen, which was obtained much later, afforded Huxley a welcome opportunity to supplement his earlier description of *Hyperodapedon* as regards its most prominent differences from *Sphenodon*, the details of its skull and diverse other anatomical points of no less importance. The motives which have impelled me to undertake a re-examination of the subject may appear scarcely obvious and require some explanation.

During the perusal of the literature relating to the Rhynchocephalians I was confronted very frequently by differences, essentially anatomical in character, tending to a separation of the Rhynchosauridæ from the Sphenodontidæ. In the first place I was unable to assign any valid reason for a closer relationship existing between them, whilst, on the other hand, the Rhynchosaurians appeared to me to possess characters important enough to justify the conclusion of a complete connection between Chelonians and the remaining Theromorphæ. Further investigation into the literature of the subject and the material available disclosed so many enigmas, that I at last decided to visit London and obtain permission to study the original specimens in the Natural History Section of the British Museum.

According to Huxley's illustration of the skull I expected the original object to be only a cast of the coarsest description, but in this I was speedily undeceived after a personal inspection, and to my great delight I perceived that I had one of the choicest of originals before me which grace the grand collection of fossil reptiles in the British Museum.

[1] Quart. Journ. Geol. Soc., 1859, vol. xv, p. 460.
[2] Op. cit., 1887, vol. xliii, pp. 675–693, pls. xxvi–xxvii.

R. Burckhardt del.

Hyperodapedon Gordoni, Huxley; ventral aspect. One-fifth nat. size. The right anterior extremity being absent, the left, which is preserved in the counterpart, has been added to this plate. Original in the British Museum (Natural History).

I very much doubt whether it would have been possible to comply with my request in a more generous manner than was done by the respected Keeper of the Geological Department of the British Museum, Dr. Henry Woodward, F.R.S., to whom, as to Drs. A. Smith Woodward and C. W. Andrews, of the same Department, and to Mr. G. A. Boulenger, F.R.S., of the Zoological Department, it gives me the utmost pleasure to tender my heartiest thanks for their ever ready assistance and advice.

As might be supposed, a re-preparation of such a valuable original object was totally out of the question, though I have no doubt that, if performed with the necessary care, many minute anatomical details would be brought to light.

In my drawings, therefore, I filled in with black all those parts which were left untouched by the chisel like the rest of the matrix of the stone. The artist employed on Huxley's sketch has failed to convey any precise information as to which is stone and which is bone, and has produced as structures shapes which only existed in the imagination of the mason as having belonged to the skull itself.

In my drawing of the skeleton *in sitû* I have carefully confined myself to a representation of the exposed portions of the actual bones, thus avoiding the risk of reproducing anything foreign to it on the face of the stone. This ought to remove all doubts that may exist as regards serious mistakes, especially where parts are concerned which are of importance.

An ordinary photographic reproduction of the fossil would not have been a great gain for the student, as the observer would have been under the necessity of making out the details of the actual fossil for himself, not to mention the disturbing effect of countless ochre spots which are distributed all over the surface of the matrix.

Plate XIX is a photographic reproduction of the entire skeleton, reduced to $\frac{1}{5}$ of its natural size, from the original in the British Museum. With the exception of the distal part of the left limb, which is better preserved on the counterpart, no other portions of the skeleton are seen on that slab. I therefore have transferred it from that side on to the plate also, as otherwise I should have had to dispense with its reproduction altogether. This plan, moreover, had the advantage of completing the representation of the skeleton in one view.

It should also be pointed out here that in consequence of having had recourse to photographs, the lower part of the leg, and the foot, are diminished in size by $\frac{1}{5}$ on account of the focal distance from the main portions of the skeleton, which further tends to increase the disparity already existing between the two extremities.

For a general description of the skeleton I would refer the reader to Huxley's memoir (see Quart. Journ. Geol. Soc., 1887, vol. xliii, pp. 675–693, pls. xxvi and xxvii, and 8 text-figures). To this I am obliged to add merely that I feel by no means sure of his statement that the præsacral portion of the vertebral column terminates with the 23rd vertebra, or even with the 22nd; but of this I feel confident, that there are not twenty-four vertebræ, as asserted by that author, who also gives the number in *Sphenodon* as twenty-five. Apart from this, the entire pelvic region appears to me to be scarcely well enough preserved to positively assign to it two sacral vertebræ.

Whether the above inference was possible from the first specimen at Huxley's disposal, or not, I do not know, as he does not express himself on this point in his first description of this portion of the skeleton of *Hyperodapedon* in Quart. Journ. Geol. Soc., 1859, vol. xv, p. 460. From analogy in *Sphenodon*, Huxley has estimated the length of its tail to be about 110 mm., though no reliable data are obtainable from the fossil itself. I would also wish to remark here that the sacral vertebræ are only $\frac{3}{4}$ the length of the hindmost thoracic vertebræ, and from this fact alone it may be seen that Huxley's computation of the length of the tail appears to be an over-estimate.

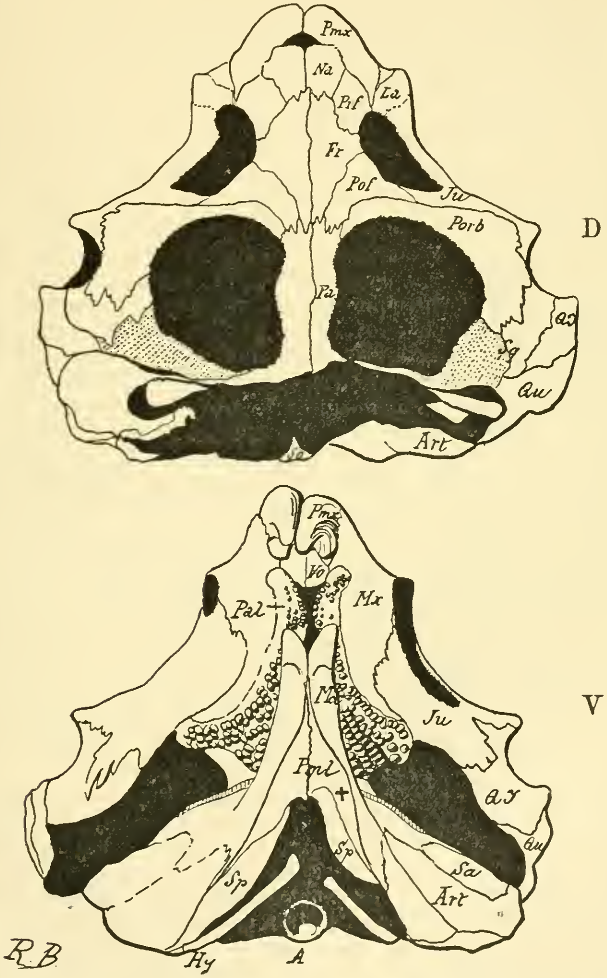
Of the remaining portions, the shoulder-girdle alone calls for some remarks here. The position assigned by Huxley to the interclavicle is the correct one, but there is an error as regards the spatulate shape of its posterior margin which requires modification. Posteriorly the episternum terminates in quill-like processes, separated from each other by a deep incision, as is the case in a great number of Lacertilians. Besides this, but noticeable only on the right side, its clavicular margin bifurcates into two pointed projections, as in *Rhynchosaurus*. The bone which Huxley designated the coracoid is really composed of two parts, the coracoid and the præcoracoid.

The most important part of this fossil is its skull, and it is here principally that I dissent from Huxley's interpretations. I therefore felt compelled to refigure and re-describe it, a proceeding to which I shall add also those inferences which I have been enabled to draw from other fragmentary specimens deposited in the British Museum (Natural History).

The general topography of the skull has been admirably rendered by Huxley. As a further adjunct to his admission that, although *Hyperodapedon* was essentially terrestrial in habits, yet it had at the same time a predilection for leading an aquatic life, may be mentioned the anomalous position of the orbits, which are so strangely directed upward and situated forward as to deserve to be specially pointed out here.

The first attempt towards a more precise knowledge of the component parts of the skull than that by Huxley was by Dr. A. Smith Woodward, who partly traced the boundaries of the nasals, the postorbitals, the jugular and other bones. It has been a great satisfaction to me, as the result of my endeavours to make out the sutures, to find myself so entirely in accord with Dr. Smith Woodward, without any deviations whatever, the more so as I did not consult his sketch at the time. Numerous fresh details having come to light, during a more protracted study of the fossil, a fresh illustration of the skull cannot be dispensed with under the circumstances. I have therefore executed the accompanying drawings from photographs taken by myself.

In these figures I have also blackened those parts of the matrix which have not yet been laid bare, in order to avoid any misconceptions arising from the supposed shape of the most important parts of the slab.



Outlines of the skull of *Hyperodapedon Gordoni*, dorsal (*D*) and ventral (*V*) aspects, from photographs and drawings by the author. One-half nat. size. *A.* atlas; *Art.* articular; *Fr.* frontal; *Hy.* hyoid; *Ju.* jugal; *La.* lachrymal; *Md.* mandibular; *Mx.* maxillary; *Na.* nasal; *Pa.* parietal; *Pal.* palatal; *Pmx.* premaxillary; *Porb.* postorbital; *Pof.* postfrontal; *Prf.* præfrontal; *Pspl.* præsplenial; *Qu.* quadratum; *QT.* quadratojugal; *Sa.* supra-angular; *So.* supraoccipital; *Sp.* splenial; *Vo.* vomer. The cross shows the centrum of crushing, which disordered the surrounding bones.

The general impression which these figures convey is that, even on a more complete development of the skull than has already been executed, the dorsal side, at any rate, would not present very massive proportions. Yet, the surfaces of the bones themselves are of a very hard and dense structure, and are possessed of ridges and protuberances which leave no doubt as to their homogeneity with the respective bones, even where their sutures are more indistinct. These anatomical characters are especially well defined on the maxillary and the jugular.

The sutures form slightly serpentine lines, except between the parietal and the præfrontal, where they are serrated. The præmaxillaries, which enclose the nasal cavity, as mentioned elsewhere, terminate caudally in blunted points, which are broken off, but the original form of which is preserved still as an imprint on the præfrontal. The margin of the nasal impinges somewhat on the median contours of the præmaxillaries, apparently to lend them additional strength, and to prevent their breaking out easily. Laterally they are held in position similarly, by a coarsely indented margin of the maxillary.

The limits of the lachrymals are more difficult of determination; firstly, because their ventral sides are embedded in the stone, and secondly, because their dorsal surfaces are damaged. Their existence, however, cannot well be doubted, if we may judge from analogy in *Rhynchosaurus*, where they are most clearly defined.

I fully concur with Dr. Smith Woodward in his determination of the middle of the cranium, although the lateral margin of the præfrontal appears to me to be clearly enough circumscribed.

Features actually new as to their interpretation appear again only behind the orbit, where the postorbital is conspicuous both by its shape, its position, and by being entirely excluded from participation in the orbital foramen. It forms the whole of the anterior portion, and part of the lateral contour of the temporal fossa. Its posterior end is unfortunately broken off, but no doubt can be entertained as regards its original shape, from the evidence supplied by the surface of its underlying squamosal, on which the outlines of its margin can be identified distinctly.

The squamosal itself is in a very imperfect state of preservation. It is connected with the præorbital, and participates in the formation of the supratemporal foramen; a ramus of the quadrato-jugular ascends to the latter, on the outer side of the squamosal. The squamosal is represented in its greater part only by the mould which it has left in the stone. It is quite probable that a posterior temporal fossa was formed by the squamosal and a branch of the quadrate bone, but on this point the information to be obtained from literature is of too vague a nature to allow our arriving at any definite conclusions thereon.

The quadrate itself is a broadish, disk-like bone, deepened in the centre. Its complete immobility can be ascertained from the fact that it is joined to the squamosal and the quadrato-jugular by suture. It could not have participated in the formation of the lateral temporal foramen; that office was reserved to the quadrato-jugular lying in front of it, which in its turn is connected again with the peculiarly shaped jugular. This latter bone borders the anterior portion of the temporal fossa, and forms, as far at least as it is exposed, the base of its posterior limits. Two strongly developed longitudinal ridges stretched across it, of which the lateral one, which is the shorter of the two, is projected towards the quadrato-jugular by means of rough spines. Its normal situation on the skull is preserved only on the left side, from which it has been figured. Leaning against it and to the front of it, is the maxillary, which I found to deviate considerably from previous descriptions. The maxillary is edentulous, and separated from the exclusively dentigerous palate-bone by a distinct suture, which is not only the case in this skull, but I have been enabled to verify it in another separate fragmentary bone in excellent preservation. Only a narrow branch of it separates the anterior margin of the palatine from the præmaxillaries, without any indication of a ridge on the inner nasal foramen. Dorsad it interlocks by means of a small angle only with the præmaxillary and the lachrymal bone.

Not more than three bones are discernible in the roof of the mouth.

The vomers join each other along the median line, but both their anterior as well as their posterior margins are covered in this case by matrix. On the right side they are in their natural relationship to the palatal bone, the maxillary, and the præmaxillary. Not so on the left, where the original contact has been disturbed by crushing in such a manner that Huxley was tempted to suggest the existence of inner nares in this particular place. For my own part I find it most difficult to adopt this view, as I opine that they are more likely to be found in the gap between the posterior margin of the palate-bones, if the lower jaw could be separated from the rest of the skull.

The palatine bones themselves are curved, thinnish plates, with their anterior margins rounded off. Their posterior margins articulate with the subcircular pterygoids, of which only the right one is completely preserved.

The mandibular ramus is composed of several separate bones similar to many other reptiles. They do not articulate on their margins by means of jointed sutures, but overlap each other like flakes, and therefore render a clear and precise description somewhat difficult. No doubt can prevail about the mandibulars. Their curved sulci, placed at a short distance from the apices, appear to me to be a good indication of the limits to which the horny sheaths come in close contact with the bone, which, however, is not so far as might have been assumed at first sight. Their posterior margin is very indistinct, through injury to the outer crust of the bone, and can therefore only be guessed. The mandibulary at this place is in contact with two bones, one of which I take to be the articular, from the fact that it articulates with the quadrate bone, whilst the other, the supra-angular, though represented only by its impression, nevertheless agrees with Owen's statement in regard to the corresponding bone in *Rhynchosaurus.* The ventral margin of the inframaxillaries is formed by the splenials. It is these latter which contribute principally to the formation of the symphysis, at least externally. Indeed, they are so strongly united as to form a process on their posterior margin.

The angulary is not preserved here, but it is present in *Hyperodapedon minor*,[1] in which a portion of the coronoid bone seems to be also partly preserved. In the latter species the position of the opercular can be made out with tolerable clearness. It reaches to about the middle of the inferior ridge of the lower jaw.

The remains of the hyoidal bones have already been referred to by Huxley.

(*To be continued.*)

III.—A Summary of our Present Knowledge of Extinct Primates from Madagascar.

By C. I. Forsyth Major, M.D., F.Z.S.

Although the present summary covers the same ground reviewed only a few months ago by the junior bearer of the name which will always be gratefully and prominently remembered in connection with the scientific conquest of Madagascar,[2] the following lines will show that, short as the interval has been, the new additions are not unimportant.

If it might be regretted that many of the new facts are being served out, as it were, by driblets, this in most cases is scarcely to be avoided, as many of the specimens on which the evidence rests are very fragmentary, and besides dispersed in various Museums. In the case of more complete materials, the preparation for publication requires, for obvious reasons, a longer time, so that the provisional sifting of the material may not be out of place, were it only to keep as much as possible within reasonable limits the often unavoidable increase of synonymy.

As far as the remains recorded by M. G. Grandidier[2] are concerned, mention is made in the present notice only of those about which I have something new to say.

I. MEGALADAPIS.

At the December meeting of the Zoological Society[3] I briefly noticed under the name of *Megaladapis insignis* a new species of this genus, based on fragments of the upper and lower jaw, which I have fully described in another place.[4] The Geological Department of the British Museum has since acquired the anterior portion of another skull of the same species, probably ♀, which shows that in the adult condition, at any rate, this animal was devoid of upper

[1] I wish to give this name to a fragment mentioned by Huxley, Q.J.G.S., 1859, p. 146, and specifically different from *H. Gordoni*.

[2] Guillaume Grandidier, "Sur les Lémuriens subfossiles de Madagascar": C. R. Ac. Sci. Paris, 28 Mai, 1900.

[3] Proc. Zool. Soc. London, 1899, p. 988.

[4] "Extinct Mammalia from Madagascar. I. *Megaladapis insignis*, sp.n.": Phil. Trans. Roy. Soc. London, vol. cxciii (1900), p. 47.

incisors. This is another agreement with the recent Malagasy genus *Lepidolemur*, attested also by the similarity in the pattern of the molars. The strongly curved nasals of this *Megaladapis* protrude forward more than in any other Lemuroid.

Dr. v. Lorenz has of late[1] published under the name of *Megaladapis brachycephalus*, sp.n., the upper and the side view of the skull of a *Megaladapis* taken from photographs which had been communicated to various museums and zoologists by the collector, Sikora, who had discovered the remains in a cave near Fort Dauphin on the south-east coast. This skull is, in my opinion, of the same species as the above-mentioned remains in the British Museum, which are from the same locality. In the same paper[2] Dr. Lorenz publishes another photograph, representing the side view of a Lemurine skull from the same cave near Fort Dauphin; the figure is briefly described, and named "*Mesoadapis destructus*, gen. nov. spec. nov." The original of the photograph had been previously acquired by the British Museum,[3] and will be described in detail shortly. It belongs to a young individual of *Megaladapis insignis*: the three cheek-teeth visible are the deciduous molars; the caniniform tooth, exhibited in profile in the photograph, is the anterior protruding portion of the permanent canine. This skull confirms the opinion formerly expressed by me, viz., that young specimens of *Megaladapis* would show a much closer approach to the ordinary Lemurine type than the adult in the conformation of the brain cavity and its walls.[4] From what has been stated above, the synonymy of the species is as follows:—

MEGALADAPIS INSIGNIS, Maj.[5]
Syn. *Megaladapis brachycephalus*, Lor.[6]
Palæolemur destructus, Lor.[7]
Mesoadapis destructus, Lor.[8]

From the well-known locality Ambolisatra, on the south-west coast of Madagascar, G. Grandidier has described two femora, the larger of which he considers as belonging to *Megaladapis madagascariensis*, whilst the smaller is provisionally called *Megaladapis* (?) *Filholi*.[9] Both the bones share the same general characters, viz., shortness and extreme antero-posterior flattening; but the differences, as has been pointed out by Mr. Grandidier, are sufficient to warrant their being referable to two different although closely allied genera.

[1] Ludwig Ritt. Lorenz v. Liburnau, "Über einige Reste ausgestorbener Primaten von Madagaskar": Denkschr. Akad. Wiss. Wien., lxx (1900), p. 8, pl. ii.
[2] Op. cit., p. 10, pl. iii, fig. 3.
[3] Dr. v. Lorenz, when writing his paper, was not aware of this circumstance.
[4] Phil. Trans. Roy. Soc. London, B, vol. clxxxv (1894), p. 27; Proc. Roy. Soc. London, vol. lxii (1897), p. 49.
[5] Proc. Zool. Soc. London, December 19, 1899, p. 989.
[6] Op. cit., 1900, p. 8, pl. ii.
[7] Anzeiger Akad. Wiss. Wien., 1900, No. 1, p. 8 (*teste* Lorenz).
[8] Denkschr. Akad. Wiss. Wien., lxx (1900), p. 10, pl. iii, fig. 1.
[9] Bull. Mus. d'hist. nat. Paris, 1899, No. 6, pp. 272–275.

The smaller of the two bones does not seem to me to be out of proportion with the skull of *Megaladapis madagascariensis*; if this supposition is right, the larger femur may prove to belong to *Peloriadapis*, a new genus allied to *Megaladapis*, based by G. Grandidier on some teeth from the same locality.[1]

A decided approach towards the Nycticebinæ, especially the West African *Perodicticus* and *Arctocebus*, is the flattening of the shaft of both these femora, and the slight curvature with the concavity forwards, together with the large head and the very large plate-like 'lesser' trochanter of the smaller of the two, a specimen of which, from the same locality, is in the British Museum. These resemblances may or may not be an indication of closer relationship; on the other hand, the locomotion can scarcely have been the same in the two groups. If the sluggish Nycticebinæ are to some extent comparable in their habits and locomotion with the Bradypodidæ, the clumsy *Megaladapis* can scarcely be supposed to have been climbers at all. The remarkable shortness and flattening of the *Megaladapis* femur calls to mind the same bone of aquatic Mammalia; the elevated position of its orbit would point in the same direction.

As to the affinities of *Megaladapis* with other Lemuroids, I now hold that its specializations are not a sufficient reason for its being removed into a separate family. There are in the first place undoubted affinities in the pattern of the cheek-teeth with *Lepidolemur* and also with the Indrisinæ. Relying chiefly on the vertebral column, Mivart long ago submitted that *Lepidolemur* "seems to be that genus of the Lemurinæ which most approximates to the Indrisinæ."[2] In this I fully concur, as the characters of the molars and the leg-bones point in the same direction. On the other hand, Winge has insisted on the relationship of *Chiromys* with the Indrisinæ, and in my opinion he is, as usual, right here also. It will thus be possible to show that these four groups, at first sight so very different from each other, because each of them is specialized in a different direction, are closely related to each other, and presumably had a common origin. There are, besides, reasons for the assumption—the molar pattern for one—that they were derived from a common stem with the Cebidæ. Whether this is the right view, the future will show.

II. PALÆOCHIROGALUS.

Another recent addition to our knowledge of extinct Malagasy Lemurids is equally due to M. G. Grandidier. He describes and figures two teeth, which "recall in their general form the two last upper molars of *Chirogalus*," and accordingly calls them *Palæochirogalus Jullyi* (nov. gen. et nov. sp.).[3] These teeth, from the marshes of Sirabé, belong, in my opinion, to an extinct form of the genus *Lemur*, the figure to the right representing the first or second left upper true molar, whilst the figure to the left appears to be the

[1] Bull. Mus. d'hist. nat. Paris, 1899, No. 6, p. 275; No. 7, p. 344.
[2] Proc. Zool. Soc. London, 1873, p. 490.
[3] Bull. Mus. d'hist. nat. Paris, 1899, No. 7, p. 345.

posterior upper deciduous molar. A peculiar feature of these teeth is the strong development of the antero-external cusp. Von Lorenz has figured, after photographs received from Sikora, the upper and side view of an imperfect skull of apparently the same species, from the cave of Andrahomana, near Fort Dauphin.[1]

III. NESOPITHECUS and allies.

Under various generic denominations, viz., *Lophiolemur*, Filh. (1895), *Nesopithecus*, Maj. (1896), *Globilemur*, Maj. (1897), *Bradylemur*, G. Grandid. (1899), *Protoindris*, Lor. (1900), a certain number of more or less fragmentary skulls and lower jaws of apparently very closely allied extinct Primates from Madagascar have been briefly noticed during the last few years.

It is quite possible that, when more completely known, these remains may in fact deserve to be classed in more than one genus; on the other hand, some of the specific names will be reduced to synonyms; for the present, or at least for the purpose of the present notice, this is unessential. Should they prove to belong to one genus, the name *Lophiolemur* would have the priority, or rather probably *Archæolemur*, a name based by Filhol on some leg-bones from Belo on the west coast;[2] the few characters given of the humerus of *Archæolemur* agree with those of two species of *Nesopithecus*. The primary question, however, refers to their relationship with other Primates.

The first noticed of all these remains is the cranial portion of a skull, which I described and figured in 1893,[3] approximating it to *Hapalolemur*; the name *Globilemur* assigned to it dates from 1897.[4] In the marshes of Sirabé (Central Madagascar) I subsequently found the anterior portion of a skull and other remains, which I shortly described under the name of *Nesopithecus Roberti*, establishing for them a separate family of Anthropoidea, "intermediate in some respects between the South American Cebidæ and the Old-World Cercopithecidæ, besides presenting characters of its own." [5]

Meanwhile Filhol had published the new genus *Lophiolemur* (*L. Edwardsi*), chiefly on two mandibular rami discovered long ago by M. A. Grandidier at Ambolisatra (south-west coast).[6] These rami, which I have been able to examine owing to the kindness of Professor Filhol, are undoubtedly closely related, if not generically identical, with *Nesopithecus*; it seemed to me that their molars were slightly more lophodont than in the latter genus. G. Grandidier, in his turn, has discovered at Belo an upper and a lower jaw, the characters of which justify in his opinion the creation of the new genus *Bradylemur* (*B. robustus*), related to *Lophiolemur* and to *Nesopithecus*.[7]

[1] Op. cit., p. 14.
[2] Bull. Mus. d'hist. nat. Paris, 1895, No. 1, p. 13.
[3] Proc. Zool. Soc. London, 1893, p. 532.
[4] Proc. Roy. Soc. London, vol. lxii (1897), p. 46.
[5] Geol. Mag., Dec. IV, Vol. III, October, 1896, p. 436.
[6] Loc. cit., p. 13.
[7] Bull. Mus. d'hist. nat. Paris, 1899, No. 7, pp. 346–348, with five text-figures.

A beautifully preserved skull in the British Museum, from a cave near Fort Dauphin (south-east coast), briefly described by me under the name of *Nesopithecus australis*,[1] showed first of all that *Globilemur* is a member of this group and probably not generically distinct from *Nesopithecus*,[2] and that *Nesopithecus* shared with the lemurs, especially those of Madagascar, a certain number of cranial characters. It also shows that I was mistaken in supposing that *Nesopithecus Roberti* had the orbits separated from the temporal fossæ by a bony wall; and although the absence of the latter is not, strictly speaking, a character which can find a place in the diagnosis of lemurs, as distinguished from the monkeys, it certainly is a more primitive feature than the presence of a bony septum. And so are the lemurine features of the *Nesopithecus* skull, viz., the conformation of the *basis cranii*, especially of the bulla tympanica, the character of the malar bone reaching the lachrymal, etc.

One lemurine feature of *Nesopithecus*, the position of the lower caniniform tooth, which does not bite in front of the upper, may be considered to be a transition between the condition exhibited by the New World monkeys on the one side and the Old World monkeys on the other. This on the following grounds.

The commonly received view that the lower caniniform tooth of recent Lemuridæ is not a 'canine' but a premolar, because it is not placed in front but behind the upper canine, dates from Geoffroy Saint-Hilaire. Objections have been raised from time to time, e.g. by Moseley and Ray Lankester,[3] and about the same time by Dönitz.[4] The latter pointed out that the tooth in question is not situated in the diastema between the upper canine and the upper anterior premolar, but acts with its cusp against the *inner* side of the upper canine. Similar remarks have been of late made by Von Lorenz.[5] A. Grandidier, on his side, believes that the presence in young Indrisinæ of a *canine de lait*, which is not replaced, settles the question once for all in favour of Geoffroy Saint-Hilaire's view.[6] However, this tooth of Indrisinæ being the evident homologue of the outer of the three incisiform teeth of other Lemuridæ, or rather of its deciduous predecessor, it proves nothing more or less than does this supposed 'lower canine' of other members of the family.

[1] Proc. Zool. Soc. London, 1899, p. 988. *Protoindris globiceps*, Lorenz (Denkschr. Akad. Wiss. Wien., lxx, 1900, p. 11, pl. iii, fig. 2), is based on a photograph from Mr. Sikora representing the reduced side view of the type of *Nesopithecus australis*.

[2] It is possible that my *Globilemur Flacourti* from the neighbourhood of Nossi-Vé on the south-west coast may prove to be specifically identical with *Bradylemur Bastardi*, G. Grand. (Bull. Mus. d'hist. nat. Paris, 1900, No. 5, p. 215), from Ambolisatra.

[3] Journ. Anat. & Physiol., iii, 1868, pp. 73–80 (1869).

[4] "Über die Eckzähne der Lemuriden": Sitzungsber. Ges. Naturf. Freunde, Berlin, 15th December, 1868, p. 32.

[5] Op. cit., p. 7.

[6] "Histoire physique, naturelle, et politique de Madagascar," Mammifères, i, p. 32, footnote 3 (1876).

The lower caniniform tooth of Mammalia is generally anterior to the upper caniniform; if, however, for some reason or other the upper premolar series should become lengthened, or the lower premolar series shortened, the position of the lower 'canine' may be altered. Bateson has described and figured an instance of the first kind. A skull of *Ateles marginatus* in the British Museum (No. 1,214*b*, collected by Bates) exhibits the unusual number of four premolars on either side of the upper jaw. "As a consequence the lower canines bite on and *partly behind* the upper canines."[1] The skull is before me: on the right side the lower canine, in fact, acts on the inner side of the upper canine; on the left side its position is almost normal.

The Cercopithecidæ, and in general all the monkeys with only two premolars, are evidently derived from older forms with three premolars. As often happens, the loss of the lower premolar may have preceded in time that of the upper jaw, so that we may imagine a transitional stage in which there were three premolars above and two below. In that case the lower canine might slide slightly backwards, and would in that case act on the inner side of the upper canine; this is precisely the condition of things in *Nesopithecus* and also in the majority of recent Lemuridæ. When finally one of the three upper premolars comes to be lost, the lower 'canine' might come again to occupy its original position in front of the upper, as is the case in all Old World monkeys.

There are, therefore, as good reasons for the assumption that the caniniform lower tooth of *Nesopithecus* and of most of the Lemuridæ is the homologue of the lower 'canine' of Old World monkeys, as for the generally received view. *Nesopithecus* has approached nearer than most of the Lemuridæ to the monkeys by retaining only two lower incisors. For, of course, as a consequence of the hypothesis propounded here, the six incisiform lower teeth of the majority of Lemuridæ would have to be considered as the homologues of the six lower incisors of the majority of Placentalia. This constitutes, for the present, its weak point, because most of the Tertiary Lemuridæ are supposed to have—and *Adapis* certainly has—only four lower incisors.

It is obvious that the position of *Nesopithecus* in the system cannot be discussed without reference to the relations between lemurs and monkeys generally. The general question being too large for discussion here, I must limit myself to the following remarks.

A. Milne-Edwards and A. Grandidier have, contrary to Mivart, considered the Lemuroidea as forming a distinct order. Although in the "Histoire de Madagascar," up to the present day, the description of the Indrisinæ alone has been published, this was believed to fully settle the question at issue. The Indrisinæ being, as far as brain development is concerned, the highest of recent lemurs, and thus approaching, more than the rest, the Anthropoidea, the conclusions as to their relationship with the latter, derived from the comparison

[1] W. Bateson: "Materials for the Study of Variation, etc.," 1894, pp. 206, 207, fig. 38.

of their other characters, seemed *a fortiori* to apply to all the other lemurs.

The careful and detailed comparisons between Indrisinæ and Anthropoidea[1] show in fact a great amount of difference between both in all the organs. But it would be an error to infer from this, without closer examination, that the same holds good with regard to all the Lemurids. In osteological characters, *Lepidolemur* and, to a somewhat lesser extent, *Chirogale*, range with the Indrisinæ; but the genera *Lemur* and *Hapalolemur*, to limit myself to Malagasy Lemuridæ, tell quite another tale. Take, for instance, the humerus. In most of the features of this bone, which have been pointed out as characteristic of the monkeys in opposition to the Indrisinæ, *Lemur* and *Hapalolemur* range on the side of the former, and this applies with greater force still to the humerus of *Nesopithecus*. The same holds good, more or less, for most parts of the skeleton, but I have purposely quoted the humerus as an example, because it is one of the few bones known of the Tertiary *Adapis*. Filhol describes it in *Adapis* as approaching closely to the '*Makis*,' having in view, I suppose, first of all the genus *Lemur*. At any rate the description and the figures of the *Adapis* humerus agree very nearly with the same bone of *Lemur* and *Hapalolemur*.

Part of the Lemuridæ therefore come in their skeleton closer to the monkeys than is generally believed,[2] and *Nesopithecus* goes a step farther in the same direction. In the latter we may distinguish four sets of characters.

1. Primitive characters which *Nesopithecus* shares with *Adapis* and with part at least of the Lemuridæ generally; e.g., cerebellum not overlapped; large bulla tympanica, tympanic ring free; orbits not closed behind by a bony septum; entepicondylar foramen of the humerus. These two last characters might with almost equal reason find a place under 2.

2. Characters which *Nesopithecus* has in common with the less specialized lemurs and with monkeys as well, and which nevertheless are comparatively primitive, for I submit that in a certain number of characters the monkeys are less specialized than numbers of lemurs; e.g., more or less vertical insertions of lower incisors, many features of the appendicular skeleton.

3. Simian characters, absent in the Lemuridæ, and which *Nesopithecus* shares exclusively with the monkeys, and some of them more particularly with the Cercopithecidæ; e.g., voluminous brain, with the arrangement of the convolutions approaching those of monkeys; steep facial profile of the skull; orbits directed straight

[1] "Histoire physique, naturelle, et politique de Madagascar," Mammifères, i (1876).

[2] "If, in accordance with the traditional views of zoologists, the Lemurs are still considered to be members of this order [i.e. Primates], they must form a sub-order apart from all the others, with which they have really very little in common except the opposable hallux of the hind foot, a character also met with in the Opossums, and which is therefore of very secondary importance."—Flower & Lydekker: "An Introduction to the Study of Mammals, living and extinct," 1891, p. 680.

forward; position of the lachrymal foramen inside the orbit (at least in one species, viz. *N. Roberti*); conformation of the internal pair of upper incisors; number of lower incisors; limb-bones as a whole in several features intermediate between monkeys and lemurs (entepicondylus of humerus strongly developed and directed backwards, etc.).

4. Characters which, being proper to *Nesopithecus*, mark its specialization; e.g., preponderance of ante-molars over the true molars, especially in the upper jaw; blade-shaped premolars; beginning of lophodonty in the true molars, the latter character being apparently more pronounced in some species than in others.

The first three sets of characters united are precisely such as must have been possessed by the immediate ancestors of the Cercopithecidæ. It is therefore difficult to imagine that the simian characters of *Nesopithecus* do not indicate any nearer relationship to the Cercopithecidæ, but that they have been independently developed in the former as a sort of simian mimicry.

The position thus taken up by the writer will have to be expressed in classification by giving up the two separate suborders of Primates, thus going one step farther than Mivart. *Nesopithecus*, with *Hadropithecus* (see below), appear to form a side-branch of the evolving line from lemurs to monkeys, branching off close below the Cercopithecidæ.

IV. HADROPITHECUS.

A further interesting addition to our knowledge of extinct Malagasy Primates is *Hadropithecus stenognathus*, Lorenz.[1] I understand from Dr. v. Lorenz that he now holds this genus to be closely related to *Nesopithecus*, a view with which I fully agree. The imperfect mandible upon which the genus is based shows the number of teeth to be the same as in *Nesopithecus*, viz., on each side six cheek-teeth, of which the three posterior are undoubtedly true molars, and two incisors inserted in a still more erect position than in the latter genus; in fact, they are well-nigh vertical. Of the cheek-teeth, the true molars preponderate in horizontal extension over the ante-molars, the opposite being the case in *Nesopithecus*.

In their pattern the true molars are not very different from those of the last-named genus, the difference appearing to be mainly the result of a more hypselodont character in the teeth of *Hadropithecus*. The posterior premolar of the latter is almost molariform, and the ante-molars as a whole are not blade-shaped, a character which gives quite a peculiar appearance to the dentition of *Nesopithecus*, recalling to mind the Plagiaulacidæ, as well as *Thylacoleo* and *Potorous* (*Hypsiprymnus*).

[1] "Uber einige Reste ausgestorbener Primaten von Madagaskar": loc. cit., pp. 2–8, pl. i, figs. 1–7.

IV.—Pleistocene Shells from the Raised Beach Deposits of the Red Sea.

By R. Bullen Newton, F.G.S., of the British Museum (Natural History).

(PLATES XX–XXII.)[1]

An interesting collection of shells, numbering more than fifteen hundred specimens, obtained by the officers of the Geological Survey of Egypt from the raised beach deposits of the Red Sea, has recently been examined by the writer at the request of Captain Lyons, R.E., the Director-General of the Survey.

With the exception of certain specimens collected by Dr. Hume from the western shore of the Gulf of Akaba, this important collection was acquired by Mr. Thomas Barron, F.G.S., from various localities situated on the western side of the Red Sea and the Gulf of Suez during the survey of that region in the years 1897–1898.

The majority of the shells belong to modern species and are well preserved, many of them retaining their original colour-markings and other characteristic features. The species exhibit the true Red Sea or Indo-Pacific facies, with a very slight commingling of Mediterranean forms, a fact which confirms the work of most previous observers, who recognize marked differences in the two faunas. A few of the specimens are quite unknown in present seas, whilst others date their origin from Miocene times, but as all are accompanied by undoubted modern species they must be admitted as their contemporaries in time. Among such may be mentioned *Alectryonia Virleti*, *Chlamys latissima*, *Chlamys Reissi*, *Pecten Vasseli*, *Lithophaga Avitensis*, *Cassis lævigata*, etc. This association of modern and extinct forms has already been observed by Professor Mayer-Eymar, Dr. Theodore Fuchs, and others in deposits of similar age near Cairo (Wadi Mellaha, etc.) and to the north of Suez (Bitter Lakes, etc.).

The marine portion of the terrace beds surrounding the Bitter Lakes resembles the raised beaches of the Red Sea in possessing a fauna of Indo-Pacific character, whereas the Cairo deposits contain an assemblage of species bearing a large percentage of Mediterranean or Atlantic forms: facts which indicate that in former times the Mediterranean extended further southwards and the Red Sea further northwards than now obtains.

In dealing with the age of these deposits it seems apparent that they should be regarded as Pleistocene on account of the large number of recent species they contain, and the comparative scarcity of extinct forms. This is in agreement with the views of most authors, who, although under different designations, acknowledge the same horizon, as, for instance, "Saharian" of Mayer-Eymar; "Recente Ablagerungen (Pseudo-Sarmatischen Ablagerungen)" of Fuchs; and "Jüngere Meeresbildungen" of Fraas. It should be mentioned, however, that Fraas only uses his term in connection

[1] These plates will appear with Part II in the December number.

with the Red Sea beach deposits, recognizing the Wadi Mellaha beds as of Miocene age, whilst Neumayr and Beyrich both regard them as Pliocene.

Some importance may be attached to the identification of *Pecten Vasseli*, a species originally described by Fuchs from the terrace formation of the Bitter Lakes, and which is doubtless the same shell referred to by Fraas under the name of *Pecten radula*, var. *subfossilis*, found in the beach deposits near Kosseir. Examples of this species, with its peculiar dichotomizing ribs and minute striated sculpture, are represented from the following localities in this collection: (*a*) Raised beach, Northern Wadi Gueh, Camp 6, 240 feet above sea; (*b*) raised beach north of Kosseir; (*c*) Upper Coral terrace (*Pecten*-bed) between Nebk and Sherm, South-East Sinai. At (*c*) *Pecten Vasseli* is associated with *Chlamys latissima*; at (*a*) with a fragment of *Chlamys opercularis*; and at (*b*) with modern Red Sea forms, *Codakia exasperata*, etc., and some extinct ones, such as *Lithophaga Lyellanus*. In its typical locality this shell is found with *Circe pectinata* and other familiar Red Sea species (see Fischer *post* "Literature"), although not known in the living state.

Among the more abundant shells of modern species in this collection, and which occur repeatedly at various localities, are: *Conus nussatella*, *Natica melanostoma*, *Strombus fasciatus*, *Turbo radiatus*, *Anadara antiquata* and *radiata*, *Chama nivalis*, *Circe pectinata*, *Codakia exasperata*, etc.

List of the Pleistocene Mollusca from the Raised Beach Deposits of the Red Sea, collected by Mr. Thomas Barron, F.G.S.

The identification of the following species has been carried out after careful comparison with the finely arranged series of modern shells in the Zoological Department of the British Museum. To Mr. Edgar Smith, the Assistant Keeper of that section of the Museum, the writer records his indebtedness for much help, especially with regard to some of the more difficult determinations that have arisen during the progress of this work. The classification of the families is that adopted at the British Museum, and originally suggested by Pelseneer in his "Introduction à l'étude des Mollusques" (Ann. Soc. Roy. Malac. Belgique, 1894, vol. xxvii, pp. 31–243).

The following explanation of bracketed names, etc., quoted under "Distribution," should be noted:—(B.M.) = British Museum (Recent Shell Department); (Barron) = a small collection of unnumbered specimens from Ras Gharib and Jebel Zeit, sent separately by Mr. Barron in August, 1898; (Tryon, Issel, etc.) = authorities for distribution of the species, *vide* "Literature" appended.

Class GASTEROPODA.

Family PATELLIDÆ.

Helcioniscus variabilis, Krauss.

Patella variabilis, Krauss: Die Südafrikanischen Mollusken, 1848, p. 35, pl. iii, fig. 12.

Distribution.—Natal (Tryon); Red Sea (B.M.). Coll. Geol. Surv. Egypt: 50 foot beach deposit at Gemsah (No. 2,043, Box No. 63*j*).

Family HALIOTIDÆ.

Haliotis cruenta, Reeve.

Haliotis cruenta, Reeve: Conchologia Iconica, vol. iii (1846), pl. xv, fig. 56.

Distribution.—Gulf of Suez and New Zealand (B.M.). Coll. Geol. Surv. Egypt: Ras Gharib (Barron); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

Family FISSURELLIDÆ.

Capiluna [1] Ruppelli, G. B. Sowerby.

Fissurella Ruppelli, G. B. Sowerby: Proc. Zool. Soc. London, 1834, pt. ii, p. 128; Conchological Illustrations, 1841, pl. lxxviii, fig. 65, and pl. lxxx, fig. 75.

Distribution.—Near Suez and beach deposits of Red Sea (Issel); Red Sea to Cape of Good Hope (Tryon); Aden, Red Sea, Mauritius, East Africa, Mergui (E. A. Smith). Coll. Geol. Surv. Egypt: Ras Gharib (Barron); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*); beach against old island west of Camp 51, south of Gharib lighthouse (Nos. 2,021–2,030, Box No. 57*j*).

Capiluna Ruppelli, var. Barroni, var. nov. (Pl. XXII, Figs. 1–4.)

The above varietal designation is applied to a number of forms which are nearly circular in outline, besides being more conical and elevated than the typical species. Sculpture characters, however, are identical; the numerous raised beaded ribs and riblets exhibiting the usual beautiful structure of this shell. The oblong perforation is also normal, and shows a slight enlargement at the posterior end. The basal margin is denticulated and laterally excavated. Size variable. Dimensions of largest specimen: height, 15 mm.; length and width, 18 mm.

This variety is represented by about a dozen specimens which were found associated with the true *C. Ruppelli*. It is to be seen in an unnamed condition in the Recent shell section of the British Museum, labelled as from the Red Sea, although the specimens have all the appearance of coming from the beach deposits of that area. Probably the form is extinct.

Distribution.—Coll. Geol. Surv. Egypt: Ras Gharib (Barron); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

Emarginula incisura, A. Adams.

Emarginula incisura, A. Adams: Proc. Zool. Soc. London, 1851, p. 84.

Distribution.—Apparently unknown. Coll. Geol. Surv. Egypt: Ras Gharib (Barron); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

[1] *Capiluna*, Gray, 1857 = *Glyphis*, Carpenter, 1856, *non* Agassiz, 1843; *vide* Harris & Burrows, Paris Basin Eocene Mollusca (Geol. Assoc.), 1891, p. 111.

Scutum unguis, Linnæus.

Patella unguis, Linnæus: Systema Naturæ, 10th ed. (1758), p. 783 (= *Parmaphorus granulatus*, Blainville, *vide* Issel).

Distribution.— Red Sea to Cape of Good Hope, Australia, Philippines, etc. (Tryon); Gulf of Suez, south of Réunion, and Red Sea deposits (Issel). Coll. Geol. Surv. Egypt: Ras Gharib (Barron); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,098–2,105, Box No. 20*j*).

Family TROCHIDÆ.

Trochus (Cardinalia) virgatus, Gmelin.

Trochus virgatus, Gmelin: Systema Naturæ, 13th ed. (1790), p. 3,580.

Distribution.—Beach deposits on western borders of Red Sea (Gray & Frembley); Red Sea and Indian Ocean (Tryon). Coll. Geol. Surv. Egypt: Ras Gharib (Barron); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

Trochus (Infundibulops) erythræus, Brocchi.

Trochus erythræus, Brocchi: Catalog. una ser. Conchiglie Africana, etc., 1819–1823 (*fide* Tryon).

Distribution.—Beach deposits of Red Sea and in the Gulfs of Akaba and Suez (Issel); Red Sea (Tryon); Aden, Red Sea, Gulf of Suez (E. A. Smith). Coll. Geol. Surv. Egypt: Jebel Zeit (Barron).

Trochus (Lamprostoma) maculatus, Linnæus.

Trochus maculatus, Linnæus: Systema Naturæ, 10th ed. (1758), p. 756.

Distribution.—Beach deposits of the Red Sea (Gray & Frembley and Issel); recent forms from the Red Sea (Issel); Indian Ocean to the Philippines (Tryon). Coll. Geol. Surv. Egypt: Jebel Zeit (Barron); raised beach 80 feet above sea at Camp 6, north of Wadi Gueh, west of Kosseir (Nos. 1,649 and 1,650, Box No. 78*j*).

Clanculus Pharaonius, Linnæus. (Pl. XX, Figs. 4, 5.)

Trochus Pharaonius, Linnæus: Systema Naturæ, 10th ed. (1758), p. 757.

Distribution.—Beach deposits of the western borders of Red Sea (Gray & Frembley); Red Sea, Gulfs of Akaba and Suez (Issel); Red Sea (Tryon); Red Sea, Aden, Gulfs of Suez and Akaba (E. A. Smith). Coll. Geol. Surv. Egypt: Ras Gharib and Jebel Zeit (Barron).

Priotrochus obscurus, Wood.

Trochus obscurus, W. Wood: Index Testaceologicus, 1828, Suppl. pl. v, fig. 26.

Distribution.—Indian Ocean (Fischer); South Africa (B.M.). Coll. Geol. Surv. Egypt: raised beach east of Jebel Esh (Nos. 2,172–2,190, Box No. 64*j*).

Family TURBINIDÆ.

Turbo radiatus, Gmelin. (Pl. XX, Fig. 1.)

Turbo radiatus, Gmelin: Systema Naturæ, 13th ed. (1790), vol. i, pt. 6, p. 3,594 (= *Chemnitzianus*, Reeve).

Distribution.—Red Sea, Madagascar, and Philippines (Tryon); Red Sea, Persian Gulf, and Madagascar (E. A. Smith). Coll. Geol. Surv. Egypt: Ras Gharib (Barron); raised beach 80 feet above sea at Camp 6, north of Wadi Gueh, west of Kosseir (Nos. 1,655–1,657, Box No. 81*j*); beach east of Gharib (Nos. 2,227–2,254, Box No. 17*j*); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*; Nos. 2,090–2,105, Box No. 20*j*); raised beach, Camp 6, Wadi Gueh (No. 1,594, Box No. 28*k*; No. 1,587, Box No. 49*k*; Nos. 1,559 and 1,561, Box No. 60*k*; Nos. 1,574, etc., Box No. 62*k*).

Family NERITIDÆ.

Nerita albicilla, Linnæus.

Nerita albicilla, Linnæus: Systema Naturæ, 10th ed. (1758), p. 778.

According to Tryon this species includes *sanguinolenta*, Menke; *marmorata*, Reeve; and *crassilabrum*, E. A. Smith.

Distribution.—Beach deposits of Red Sea (Issel); Red Sea to Philippines (Tryon); Aden, Red Sea, Indian and Pacific Oceans (E. A. Smith). Coll. Geol. Surv. Egypt: beach south of Gharib (Nos. 2,227–2,254, Box No. 17*j*); beach against old island west of Camp 51, south of Gharib lighthouse (Nos. 2,021–2,030, Box No. 57*j*); raised beach 80 feet above sea, Camp 6, Wadi Gueh (No. 1,569, Box No. 31*k*; No. 1,612, Box No. 58*k*); raised beach, Camp 6, Wadi Gueh (Nos. 1,574, etc., Box No. 62*k*).

Family HIPPONYCIDÆ.

Hipponyx barbatus, G. B. Sowerby.

Hipponyx barbatus, G. B. Sowerby: Proc. Zool. Soc. London, 1835, p. 5.

Distribution.—Mazatlan, Galapagos Islands, Polynesia, Japan, Cape of Good Hope (Tryon); Society Islands (B.M.). Coll. Geol. Surv. Egypt: Ras Gharib (Barron); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

Family CYPRÆIDÆ.

Cypræa annulus, Linnæus.

Cypræa annulus, Linnæus: Systema Naturæ, 10th ed. (1758), p. 723.

Distribution.—Gulf of Akaba, Mediterranean and beach deposits of Red Sea (Issel); Indian and Pacific Oceans, and fossil in Southern Europe (Tryon); Aden (E. A. Smith). Coll. Geol. Surv. Egypt: raised beach, Wadi Gueh, Camp 6 (No. 1,568, Box No. 29*k*); raised beach east of Jebel Esh (Nos. 2,172–2190, Box No. 64*j*).

Cypræa Arabica, Linnæus.

Cypræa Arabica, Linnæus: Systema Naturæ, 10th ed. (1758), p. 718.

Distribution.—Beach deposits of Red Sea (Gray & Frembley, Issel); Gulf of Akaba and Ras Benass (Issel); Indian and Pacific Oceans (Tryon); Aden (E. A. Smith). Coll. Geol. Surv. Egypt: beach east of Gharib (Nos. 2,227–2,254, Box No. 17*j*).

Cypræa caurica, Linnæus.

Cypræa caurica, Linnæus: Systema Naturæ, 10th ed. (1758), p. 723.

Distribution.—Beach deposits of Red Sea (Gray & Frembley); Gulf of Akaba (Issel); Indian and Pacific Oceans (Tryon); Aden (E. A. Smith). Coll. Geol. Surv. Egypt: east of Gharib (Nos. 2,227–2,254, Box No. 17*j*).

Cypræa cylindrica, Born.

Cypræa cylindrica, Born: Testacea Mus. Cæsarei Vindobonensis, 1780, pl. viii, fig. 10.

Distribution.—Amboina, etc. (B.M.); Ceylon, Australia, New Caledonia (Tryon). Coll. Geol. Surv. Egypt: raised beach, Camp 6, Wadi Gueh (Nos. 1,591 and 1,567, Box No. 30*k*).

Cypræa erosa, Linnæus.

Cypræa erosa, Linnæus: Systema Naturæ, 10th ed. (1758), p. 723.

Distribution.—Beach deposits of Red Sea (Gray & Frembley, Issel); Gulf of Akaba (Issel); Indian and Pacific Oceans (Tryon); Aden (E. A. Smith). Coll. Geol. Surv. Egypt: raised beach 80 feet above sea, Camp 6, north of Wadi Gueh, west of Kosseir (Nos. 1,649 and 1,650, Box No. 78*j*; Nos. 1,591 and 1,567, Box No. 30*k*); 50 foot beach, Gemsah (No. 2,038, Box No. 62*j*).

Cypræa fimbriata, Gmelin.

Cypræa fimbriata, Gmelin: Systema Naturæ, 13th ed. (1790), vol. i, pt. 6, p. 3,420.

Distribution. — Indian Ocean to Australia (Tryon); Aden (E. A. Smith). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

Cypræa isabella, Linnæus.

Cypræa isabella, Linnæus: Systema Naturæ, 10th ed. (1758), p. 722.

Distribution.—Beach deposits and recent forms in Red Sea (Issel); Indian and Pacific Oceans (Tryon); Aden (E. A. Smith). Coll. Geol. Surv. Egypt: Ras Gharib (Barron); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*); raised beach, Camp 6, Wadi Gueh (Nos. 1,591 and 1,567, Box No. 30*k*).

Cypræa turdus, Lamarck.

Cypræa turdus, Lamarck: Hist. Nat. Anim. sans Vert., vol. vii (1822), p. 392.

Distribution.—Beach deposits on the western borders of the Red Sea (Gray & Frembley); Gulf of Akaba and Indian Ocean (Issel); Aden (E. A. Smith); Persian Gulf (Tryon). Coll. Geol. Surv. Egypt: beach east of Gharib (Nos. 2,227–2,254, Box No. 17*j*); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*); 50 foot beach at Gemsah (Nos. 2,031–2,057, Box No. 58*j*).

Cypræa vitellus, Linnæus.

Cypræa vitellus, Linnæus: Systema Naturæ, 10th ed. (1758), p. 721.

Distribution.—Aden (E. A. Smith); beach deposits, western shores of Red Sea (Gray & Frembley); Indian Ocean, Australia, New Caledonia (Tryon). Coll. Geol. Surv. Egypt: raised beach, Camp 6, Wadi Gueh (Nos. 1,574, etc., Box No. 62*k*).

Family NATICIDÆ.

Natica (Mammilla) melanostoma, Gmelin.

Nerita melanostoma, Gmelin: Systema Naturæ, 13th ed. (1790), vol. i, pt. 6, p. 3,674.

Distribution. — Beach deposits of Red Sea (Fraas, Gray & Frembley); Red Sea and Indian Ocean (Issel); Mauritius, Madagascar, East Indies, Polynesia (Tryon); Aden, Red Sea, Indian Ocean, and parts of the Pacific (E. A. Smith). Coll. Geol. Surv. Egypt: Jebel Zeit (Barron); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*); recent beach south of Gharib lighthouse (Nos. 2,198–2,216, Box No. 53*j*); 50 foot beach at Gemsah (Nos. 2,031–2,057, Box No. 58*j*).

Family CERITHIIDÆ.

Cerithium cæruleum, G. B. Sowerby.

Cerithium cæruleum, G. B. Sowerby: Thesaurus Conchyliorum, vol. ii (1855), p. 866, pl. clxxix, figs. 61, 62.

Distribution.—Red Sea (Issel); Red Sea and Indian Ocean (Tryon); Aden, Red Sea, Indian Ocean, China, Tonga Islands (E. A. Smith). Coll. Geol. Surv. Egypt: Jebel Zeit (Barron); recent beach south of Gharib lighthouse (Nos. 2,198–2,216, Box No. 53*j*); raised beach, Camp 6, Wadi Gueh (Nos. 1,559 and 1,561, Box No. 60*k*; Nos. 1,574, etc., Box No. 62*k*).

Cerithium columna, G. B. Sowerby.

Cerithium columna, G. B. Sowerby: Genera of Shells, 1834, No. 42, fig. 7.

Distribution. — Mauritius, Philippines to Central Polynesia (Tryon); Aden, Red Sea, Indian Ocean, Philippines, etc. (E. A. Smith). Coll. Geol. Surv. Egypt: Ras Gharib (Barron).

Cerithium erythræonense, Lamarck.

Cerithium erythræonense, Lamarck: Hist. Nat. Anim. sans Vert., vol. vii (1822), p. 70 (=*tuberosum*, Reeve, and *omissum*, Bayle).

Distribution.—Desert of Attaka, Suez, Gulf of Akaba, Red Sea, Madagascar (Issel); Red Sea (Tryon). Coll. Geol. Surv. Egypt: Ras Gharib (Barron); beach east of Gharib (Nos. 2,227–2,254, Box No. 17*j*); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,090–2,105, Box No. 20*j*); recent beach south of Gharib lighthouse (No. 2,204, Box No. 24*j*); raised beach, Camp 6, Wadi Gueh (Nos. 1,559 and 1,561, Box No. 60*k*).

Cerithium Ruppelli, Philippi.

Cerithium Ruppelli, Philippi: Zeitsch. Malakozoologie, 1848, p. 22.

Distribution.—Gulf of Suez (Issel); Red Sea (Tryon); Red Sea, Aden, Seychelles (E. A. Smith). Coll. Geol. Surv. Egypt: Recent beach between Jebel Mellaha and Jebel Zeit (Nos. 2,162–2,167, Box No. 21*j*); 50 foot beach at Gemsah (Nos. 2,031–2,057, Box No. 58*j*); beach against old island west of Camp 51, south of Gharib lighthouse (Nos. 2,021–2,030, Box No. 57*j*).

Vertagus asperum, Linnæus (var.).

Murex asper, Linnæus: Systema Naturæ, 10th ed. (1758), p. 756.

Distribution.—I. of France (B.M.); beach deposits of the Red Sea (Issel). Coll. Geol. Surv. Egypt: raised beach, Camp 6, Wadi Gueh (Nos. 1,574, etc., Box No. 62*k*).

Vertagus fasciatus, Bruguière.

Cerithium fasciatum, Bruguière: Encyclop. Méthodique, 1792, vol. i (vers.), p. 474.

Distribution.—Red Sea, Gulf of Akaba, Indian Ocean, Philippines (Issel, Tryon). Coll. Geol. Surv. Egypt: Jebel Zeit (Barron);

50 foot beach at Gemsah (Nos. 2,031–2,057, Box No. 58); raised beach east of Jebel Esh (Nos. 2,172–2,190, Box No. 64*j*).

Vertagus Kochi, Philippi.

Cerithium Kochi, Philippi: Zeitsch. Malakozoologie, 1848, p. 21.

Distribution.—East coast of Africa (Tryon); Aden, Red Sea, Indian Ocean, Japan (E. A. Smith). Coll. Geol. Surv. Egypt: Jebel Zeit (Barron); raised beach east of Jebel Esh (Nos. 2,172–2,190, Box No. 64*j*).

Vertagus recurvus, G. B. Sowerby.

Cerithium recurvum, G. B. Sowerby: Thesaurus Conchyliorum, vol. ii (1855), p. 854, pl. clxxvi, figs. 16–18.

Distribution. — Red Sea (Tryon). Coll. Geol. Surv. Egypt: beach east of Gharib (Nos. 2,227–2,254, Box No. 17*j*); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2098, Box No. 18*j*); 50 foot beach at Gemsah (Nos. 2,031–2,057, Box No. 58*j*); raised beach east of Jebel Esh (Nos. 2,172–2,190, Box No. 64*j*).

Pirenella mammillata, Risso.

Cerithium mammillatum, Risso: Hist. Nat. Europe Méridionale, vol. iv (1826), p. 158.

Tryon includes in this species *conica* of Blainville, *cinerascentis* of Pallas, *Cailliaudi* of Pot. & Mich.

Distribution.—Mediterranean and Red Sea (Tryon); Alexandria, Suez, Egypt (B.M.). Coll. Geol. Surv. Egypt: Recent beach south of Gharib lighthouse (No. 2,217, Box No. 52*j*; Nos. 2,198–2,216, Box No. 53*j*); beach against old island west of Camp 51, south of Gharib lighthouse (Nos. 2,021–2,030, Box No. 57*j*).

Family MODULIDÆ.

Modulus tectum, Gmelin.

Trochus tectum, Gmelin: Systema Naturæ, 13th ed. (1790), vol. i, pt. 6, p. 3,569.

Distribution.—Red Sea, Mauritius, Indian Ocean, Sandwich and Viti Islands (Tryon). Coll. Geol. Surv. Egypt: east of Gharib (Nos. 2,227–2,254, Box No. 17*j*).

Family VERMETIDÆ.

Vermetus, sp. indet.

Distribution.—Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

Family TURRITELLIDÆ.

Turritella trisulcata, Lamarck.

Turritella trisulcata, Lamarck: Hist. Nat. Anim. sans Vert., vol. vii (1822), p. 58.

Distribution.—Gulf of Suez and in the beach deposits of the Red Sea (Issel); Red Sea (Tryon). Coll. Geol. Surv. Egypt: Gemsah, 50 foot beach (Nos. 2,031–2,057, Box No. 58*j*); east of Jebel Esh (Nos. 2,172–2,190, Box No. 64*j*).

Family STROMBIDÆ.

Strombus fasciatus, Born. (Pl. XX, Fig. 3.)

Strombus fasciatus, Born: Testacea Mus. Cæsarei Vindobonensis, 1780, p. 278 (= *lineatus*, Lam.).

Distribution.—Red Sea, Gulf of Akaba, and beach deposits of the Red Sea (Issel); Red Sea to Philippines (Tryon). Coll. Geol. Surv. Egypt: Recent beach between Jebel Mellaha and Jebel Zeit (No. 2,159, Box No. 10*j*, and Nos. 2,162–2,167, Box No. 21*j*); east of Gharib (Nos. 2,227–2,254, Box No. 17*j*); south of Gharib lighthouse (Nos. 2,198–2,216, Box No. 53*j*); Gemsah, 50 foot beach (Nos. 2,031–2,057, Box No. 58*j*); east of Jebel Esh (Nos. 2,172–2,190, Box No. 64*j*); camp north of Wadi Gueh, west of Kosseir, 80 feet above sea (Nos. 1,655–1,657, Box No. 81*j*); Ras Gharib and Jebel Zeit (Barron); raised beach 80 feet above sea, Camp 6, Wadi Gueh (No. 1,571, Box No. 38*k*); raised beach, Camp 6, Wadi Gueh (No. 1,572, Box No. 52*k*, and Nos. 1,574, etc., Box No. 62*k*).

Strombus floridus, Lamarck.

Strombus floridus, Lamarck: Hist. Nat. Anim. sans Vert., vol. vii (1822), p. 211.

Distribution.—Beach deposits near Kosseir (Fraas); Kosseir and Akaba Gulf (Issel); Zanzibar, Japan, Australia to Viti Islands (Tryon); Red Sea, Indian Ocean, Philippines (E. A. Smith). Coll. Geol. Surv. Egypt: raised beach 80 feet above sea, Camp 6, Wadi Gueh (No. 1,871, Box No. 38*k*); raised beach, Camp 6, Wadi Gueh (Nos. 1,574, etc., Box No. 62*k*).

Strombus fusiformis, G. B. Sowerby.

Strombus fusiformis, G. B. Sowerby: Thesaurus Conchyliorum, vol. i (1847), pl. ix, figs. 91, 92.

Distribution.—Gulf of Akaba and beach deposits of the Red Sea (Issel); Aden, Red Sea, Indian Ocean, North Australia (E. A. Smith). Coll. Geol. Surv. Egypt: Gemsah, 50 foot beach (Nos. 2,031–2,057, Box No. 58*j*); Ras Gharib and Jebel Zeit (Barron).

Strombus tricornis, Lamarck.

Strombus tricornis, Lamarck: Hist. Nat. Anim. sans Vert., vol. vii (1822), p. 201.

Distribution.—Red Sea, Kosseir, East Indies, etc. (Issel); Red Sea, Bourbon, Seychelles, Philippines (E. A. Smith). Coll. Geol. Surv. Egypt: raised beach 80 feet above sea at Wadi Gueh, Camp 5 (No. 1,607, Box No. 84*j*). A large cast in sandstone of most probably this species from raised beach north of Kosseir (No. 2,137, Box No. 30*j*); another cast which may have belonged to this species or to *S. Bonelli*, Brongniart, from raised beach 380 feet above sea near Camp 7, Wadi Shigeleh (No. 1,613, Box No. 65*k*).

Canarium dentatum, Linnæus, var. erythrynum, Chemnitz.

Strombus dentatus, Linnæus: Systema Naturæ, 10th ed. (1758), p. 745.
Strombus erythrynum, Chemnitz: Conchylien-Cabinet, vol. xi (1795), p. 146, pl. cxcv, figs. 1,874, 1,875.

Distribution.—Red Sea to Australia (Tryon); Red Sea, Indian Ocean, etc. (E. A. Smith). Coll. Geol. Surv. Egypt: east of Gharib (Nos. 2,227–2,254, Box No. 17*j*); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2098, Box No. 18*j*); Ras Gharib (Barron); 50 foot beach, Gemsah (No. 1,626, Box No. 65*k*).

Canarium gibberulum, Linnæus. (Pl. XX, Fig. 2.)

Strombus gibberulus, Linnæus: Systema Naturæ, 10th ed. (1758), p. 744.

DISTRIBUTION. — Beach deposits near Kosseir (Fraas, Gray & Frembley); Red Sea (Issel); Red Sea, Zanzibar to Philippines (Tryon); Aden, Red Sea, Indian Ocean, etc. (E. A. Smith). Coll. Geol. Surv. Egypt: raised beach 80 feet above sea, Camp 6, Wadi Gueh (Nos. 1,655–1,657, Box No. 81*j*, and No. 1,571, Box No. 38*k*); raised beach, Camp 6, Wadi Gueh (No. 1,598, Box No. 59*k*, and No. 1,574, etc., Box No. 62*k*); Jebel Zeit (Barron).

Pterocera millepeda, Linnæus.

Strombus millepeda, Linnæus: Systema Naturæ, 10th ed. (1758), p. 743.

DISTRIBUTION.—Red Sea and Indian Ocean (Issel); Indian Ocean to Philippines (Tryon). Coll. Geol. Surv. Egypt: 50 foot beach at Gemsah, south of Jebel Zeit (No. 1,819, Box No. 54*j*).

Family LAMPUSIIDÆ (= TRITONIDÆ).

Lampusia pilearis, Lamarck.

Triton pileare, Lamarck: Hist. Nat. Anim. sans Vert., vol. vii (1822), p. 182.

DISTRIBUTION. — Beach deposits of the Red Sea (Gray & Frembley, Issel); Red Sea to Philippines (Tryon); Aden, Red Sea, Indian and Pacific Oceans, etc. (E. A. Smith). Coll. Geol. Surv. Egypt: 50 foot beach at Gemsah, south of Jebel Zeit (Nos. 2,031–2,057, Box No. 58*j*).

Apollon tuberculatum, Broderip.

Ranella tuberculata, Broderip: Proc. Zool. Soc. London, 1832, p. 179.

DISTRIBUTION.—Red Sea, Indian Ocean, etc. (Tryon). Coll. Geol. Surv. Egypt: Recent beach between Jebel Mellaha and Jebel Zeit (Nos. 2,162–2,167, Box No. 21*j*); raised beach, Wadi Gueh, Camp 6 (No. 1,587, Box No. 49*k*).

Family CASSIDIDÆ.

Cassis (Casmaria) nodulosa, Gmelin.

Buccinum nodulosum, Gmelin: Systema Naturæ, 13th ed. (1790), vol. i, pt. 6, p. 3,479.

(Vars. = **torquata**, Reeve, *vide* Tryon.)

DISTRIBUTION. — Red Sea (Issel); Port Jackson, Australia (Tryon); Aden, Red Sea, Mozambique, Andaman Islands (E. A. Smith). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,090–2,105, Box No. 20*j*).

Cassis (Semicassis) lævigata? Defrance.

Cassis lævigata, Defrance: Dict. Sci. Nat. (Paris), 1817, p. 210 (= *saburon*, Hörnes, *non* Lamarck).

This species is represented by casts only, hence its identification is a little doubtful.

DISTRIBUTION.—Miocene: Vienna Basin. Pliocene: Italian Basin. Coll. Geol. Surv. Egypt: raised beach east of Jebel Esh (Nos.

2,172–2,190, Box No. 64*j*); raised beach 380 feet above sea near Camp 7, Wadi Shigeleh (No. 1,642, Box No. 42*k*).

Family DOLIIDÆ.

Dolium variegatum, Lamarck.

Dolium variegatum, Lamarck: Hist. Nat. Anim. sans Vert., vol. vii (1822), p. 261.

Distribution.—Gulfs of Suez and Akaba (Issel); North Australia (Tryon). Coll. Geol. Surv. Egypt: raised beach 2 or 3 feet above sea-level at Gemsah Bay, near Jebel Zeit, collected by Dr. Hume.

Dolium (Perdix) perdix, Linnæus.

Buccinum perdix, Linnæus: Systema Naturæ, 10th ed. (1758), p. 734.

Distribution.—Beach deposits on the western shores of the Red Sea (Gray & Frembley); Indian Ocean to Polynesia (Tryon); West Indies, West Africa, Indian and Pacific Oceans (E. A. Smith). Coll. Geol. Surv. Egypt: beach near Dahab, Sinai (No. 4,325, Box No. 48*l*).

Family FASCIOLARIIDÆ.

Fusus polygonoides, Lamarck.

Fusus polygonoides, Lamarck: Hist. Nat. Anim. sans Vert., vol. vii (1822), p. 129.

Distribution.—Red Sea (Issel); Eastern seas (B.M.); East Indies (Tryon). Coll. Geol. Surv. Egypt: Ras Gharib (Barron); Recent beach south of Gharib lighthouse (No. 2,203, Box No. 23*j*); beach against old island west of Camp 51, south of Gharib lighthouse (Nos. 2,021–2,030, Box No. 57*j*); raised beach 380 feet above sea near Camp 7, Wadi Shigeleh (No. 1,642, Box No. 42*k*).

Latirus turritus, Gmelin.

Voluta turrita, Gmelin: Systema Naturæ, 13th ed. (1790), vol. i, pt. 6, p. 3,456.

Distribution.—Red Sea, Philippines, Australia, Polynesia (Tryon). Coll. Geol. Surv. Egypt: raised beach, Camp 6, Wadi Gueh (No. 1,597, Box No. 55*k*).

Family TURBINELLIDÆ.

Melongena (Volema) paradisiaca, Reeve.

Pyrula paradisiaca, Reeve: Conchologia Iconica, vol. iv (1847), fig. 17 (= *Pyrula nodosa*, Lamarck).

Distribution.—Desert of Attaka and Red Sea (Issel); Red Sea and Ceylon (Tryon); Aden, Red Sea, Mozambique, Natal, Ceylon, Bourbon (E. A. Smith). Coll. Geol. Surv. Egypt: Recent beach between Jebel Mellaha and Jebel Zeit (No. 2,159, Box No. 10*j*); 50 foot beach at Gemsah (Nos. 2,031–2,057, Box No. 58*j*).

Vasum cornigerum, Lamarck. (Pl. XX, Fig. 12.)

Turbinella cornigera, Lamarck: Hist. Nat. Anim. sans Vert., vol. vii (1822), p. 105.

Distribution.—Beach deposits near Kosseir (Fraas); Red Sea and Indian Ocean (Issel); Philippines (Tryon). Coll. Geol. Surv. Egypt: raised beach 80 feet above sea, Camp 6, north of Wadi Gueh, west of Kosseir (Nos. 1,653, 1,654, Box No. 80*j*); raised beach, Camp 6, Wadi Gueh (No. 1,595, Box No. 32*k*).

Family MITRIDÆ.

Mitra Bovei, Kiener.

Mitra Bovei, Kiener: Spécies Général Icon. Coq. Vivantes, monograph *Mitra*, p. 9, pl. ii, fig. 5.

DISTRIBUTION.—Red Sea (Issel, Tryon); beach deposits of the Red Sea (Issel). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

Mitra (Chrysame) rubiginea, A. Adams.

Mitra rubiginea, A. Adams: Proc. Zool. Soc. London, 1854, p. 134.

DISTRIBUTION.—Mauritius and New Caledonia (Tryon). Coll. Geol. Surv. Egypt: Recent beach between Jebel Mellaha and Jebel Zeit (Nos. 2,162–2,167, Box No. 21*j*).

Mitra (Chrysame) Ruppelli, Reeve.

Mitra Ruppelli, Reeve: Conchologia Iconica, vol. ii (1844), pl. xxiii, fig. 179.

DISTRIBUTION.—Beach deposits of the Red Sea (Issel); Gulf of Akaba (Issel); Red Sea (Tryon). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea, Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

Family BUCCINIDÆ.

Pisania ignea, Gmelin.

Buccinum igneum, Gmelin: Systema Naturæ, 13th ed. (1790), vol. i, pt. 6, p. 3,494.

DISTRIBUTION.—Red Sea to Philippines (Tryon). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea, Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

Columbella fasciata, G. B. Sowerby.

Columbella fasciata, G. B. Sowerby: Cat. Shells Coll. Tankerville, Appendix, 1829, p. 25.

DISTRIBUTION.—Java (Tryon). Coll. Geol. Surv. Egypt: 50 foot beach, Gemsah (Nos. 2,031–2,057, Box No. 58*j*); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

Nassa pulla, Linnæus.

Buccinum pullus, Linnæus: Systema Naturæ, 10th ed. (1758), p. 737.

DISTRIBUTION.—Red Sea (Issel); Red Sea to Philippines (Tryon); Aden, Red Sea, Java, Philippines (E. A. Smith). Coll. Geol. Surv. Egypt: east of Gharib (Nos. 2,227–2,254, Box No. 17*j*); raised beach, Camp 6, Wadi Gueh (No. 1,587, Box No. 49*k*).

Nassa (Alectryon) glans, Linnæus.

Buccinum glans, Linnæus: Systema Naturæ, 10th ed. (1758), p. 737.

DISTRIBUTION.—Japan, Philippines, Australia (Tryon). Coll. Geol. Surv. Egypt: Ras Gharib (Barron).

Family MURICIDÆ.

Murex ternispina, Lamarck.

Murex ternispina, Lamarck: Hist. Nat. Anim. sans Vert., vol. vii (1822), p. 158.

DISTRIBUTION. — Red Sea to Philippines (Issel, Tryon); Red Sea, Indian Ocean, China, Philippines, Japan (E. A. Smith). Coll.

Geol. Surv. Egypt: beach against old island west of Camp 51, south of Gharib lighthouse (Nos. 2,021–2,030, Box No. 57*j*).

Chicoreus anguliferus, Lamarck. (Pl. XX, Fig. 11.)

Murex anguliferus, Lamarck: Hist. Nat. Anim. sans Vert., vol. vii (1822), p. 171.

Distribution.—Gulf of Akaba and beach deposits of the Red Sea (Issel); Red Sea and Indian Ocean (Tryon); Aden, Red Sea, Persian Gulf, Indian Ocean, Seychelles, Ceylon (E. A. Smith). Coll. Geol. Surv. Egypt: Recent beach south of Gharib lighthouse (No. 2,201, Box No. 22*j*).

Sistrum cancellatum, Quoy & Gaimard.

Murex cancellata, Quoy & Gaimard: Dumont d'Urville's "Voyage l'Astrolabe," vol. ii (1832), p. 563, pl. xxxvii, figs. 15, 16.

Distribution.—Philippines to Sandwich Islands (Tryon). Coll. Geol. Surv. Egypt: beach east of Gharib (Nos. 2,227–2,254, Box No. 17*j*).

Sistrum elatum, Blainville.

Purpura elata, Blainville: Nouv. Ann. Mus. (Paris), vol. i (1832), p. 207, pl. xi, fig. 1.

Distribution.—Philippines, etc. (Tryon); Red Sea, New Holland, Philippines (E. A. Smith). Coll. Geol. Surv. Egypt: Ras Gharib (Barron); beach east of Gharib (Nos. 2,227–2254, Box No. 17*j*); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*); recent beach between Jebel Mellaha and Jebel Zeit (Nos. 2,162–2,167, Box No. 21*j*); 50 foot beach, Gemsah (Nos. 2,031–2,057, Box No. 58*j*).

Family CORALLIOPHILIDÆ.

Magilus antiquus, De Montfort.

Magilus antiquus, De Montfort: Conchyliologie Systématique, vol. ii (1810), p. 42.

Piercing a coral, *Cœloria Arabica.*

Distribution.—Red Sea (Issel, Tryon). Coll. Geol. Surv. Egypt: Jebel Zeit (No. 780, Box No. 49*j*); beach east of Gharib (Nos. 2,227–2,254, Box No. 17*j*).

Family OLIVIDÆ.

Oliva (Carmione) inflata, Lamarck.

Oliva inflata, Lamarck: Hist. Nat. Anim. sans Vert., vol. vii (1822), p. 429.

Distribution.—Beach deposits of the Red Sea (Issel); Red Sea, East Africa, Madagascar, Seychelles (Tryon); Red Sea, Persian Gulf, Madagascar, Zanzibar, Mauritius, Ceylon, etc. (E. A. Smith). Coll. Geol. Surv. Egypt: Recent beach between Jebel Mellaha and Jebel Zeit (Nos. 2,162–2,167, Box No. 21*j*); shore and raised beach, Ras Mohamed, Sinai (No. 3,530, Box No. 45*l*).

Oliva (Ispidula) ispidula, Linnæus.

Voluta ispidula, Linnæus: Systema Naturæ, 10th ed. (1758), p. 730.

Distribution.—Indian Ocean, Philippines (Tryon). Coll. Geol. Surv. Egypt: raised beach east of Jebel Esh (No. 2,172–2,190, Box No. 64*j*).

Ancilla cinnamomea, Lamarck.

Ancillaria cinnamomea, Lamarck: Hist. Nat. Anim. sans Vert., vol. vii (1822), p. 413 (= *crassa* and *albisulcata*, G. B. Sowerby, *vide* Tryon).

Distribution.—Red Sea (Issel); Red Sea, Persian Gulf, Zanzibar (Tryon); Aden (E. A. Smith). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,090–2,105, Box No. 20*j*).

Ancilla (Sparella) acuminata, G. B. Sowerby.

Ancillaria acuminata, G. B. Sowerby: Thesaurus Conchyliorum, vol. iii (1866), pl. ccxiv, figs. 66, 67.

Distribution.—Red Sea, Aden, Indian Ocean (E. A. Smith); Red Sea, Zanzibar (Tryon). Coll. Geol. Surv. Egypt: raised beach, Camp 6, Wadi Gueh (Nos. 1,574, etc., Box No. 62*k*).

Family PLEUROTOMIDÆ.

Pleurotoma Garnonsi, Reeve. (Pl. XX, Fig. 10.)

Pleurotoma Garnonsi, Reeve: Conchologia Iconica, vol. i (1843), pl. i, fig. 4.

Distribution.—Red Sea to Java (Tryon). Coll. Geol. Surv. Egypt: Gemsah, 50 foot beach (Nos. 2,031–2,057, Box No. 58*j*).

Family TEREBRIDÆ.

Terebra Babylonia, Lamarck.

Terebra Babylonia, Lamarck: Hist. Nat. Anim. sans Vert., vol. vii (1822), p. 287.

Distribution.—China, Viti Islands (Tryon). Coll. Geol. Surv. Egypt: Jebel Zeit (Barron).

Terebra cancellata, var. **columellaris**, Hinds.

Terebra cancellata, Quoy & Gaimard: Dumont d'Urville's "Voyage l'Astrolabe," vol. ii (1832), p. 471, pl. xxxvi, figs. 27, 28.

Terebra columellaris, Hinds: Proc. Zool. Soc. London, 1843, p. 151.

Distribution. — Moluccas, Philippines, Viti Islands, Sandwich Islands (Tryon). Coll. Geol. Surv. Egypt: Jebel Zeit (Barron).

Terebra consobrina, Deshayes.

Terebra consobrina, Deshayes: Proc. Zool. Soc. London, 1859, p. 305.

Distribution.—Red Sea (Issel, Tryon). Coll. Geol. Surv. Egypt: Recent beach between Jebel Mellaha and Jebel Zeit (Nos. 2,162–2,167, Box No. 21*j*); Gemsah, 50 foot beach (Nos. 2,031–2,057, Box No. 58*j*); Sinai (Box No. 3,516*l*).

Terebra crenifera, Deshayes.

Terebra crenifera, Deshayes: Proc. Zool. Soc. London, 1859, p. 298 (= *cingulifera*, Lamarck, *vide* Tryon).

Distribution. — Philippines, New Ireland, Viti Islands, China (Tryon); China Sea (B.M.). Coll. Geol. Surv. Egypt: 50 foot beach at Gemsah (Nos. 2,031–2057, Box No. 58*j*).

Terebra duplicata, Linnæus. (Pl. XX, Fig. 6.)

Buccinum duplicatum, Linnæus: Systema Naturæ, 10th ed. (1758), p. 742.

Distribution.—Beach deposits of the Red Sea (Gray & Frembley, Issel); Gulf of Akaba, Zanzibar, China, Madagascar, Moluccas (Issel, Tryon). Coll. Geol. Surv. Egypt: east of Gharib (Nos. 2,227–2,254, Box No. 17*j*); Gharib lighthouse, 20 feet above sea (Nos. 2,090–2,105, Box No. 20*j*); Gemsah, 50 foot beach (Nos. 2,031–2,057, Box No. 58*j*); Jebel Zeit (Barron).

Terebra (Subula) maculata, Linnæus. (Pl. XX, Fig. 7.)

Buccinum maculatum, Linnæus: Systema Naturæ, 10th ed. (1758), p. 741.

Distribution.—Gulf of Suez, Gulf of Akaba, Society Islands, Moluccas, Australia (Issel, Tryon). Coll. Geol. Surv. Egypt: lower coral reef north of Ras Mohamed or Ghazlandi Bay (No. 3,502, Box No. 41*l*).

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

V.—Note on the Horizon and Locality of Sowerby's Type-Specimen of *Nautilus truncatus.*

By G. C. Crick, F.G.S., of the British Museum (Natural History).

NAUTILUS TRUNCATUS was described and figured by J. Sowerby in the "Mineral Conchology," vol. ii, p. 49, pl. cxxiii, April, 1816, his description and remarks being as follows:—

"*Spec. char.* Thick, flatted, plain, umbilicate; back flat, mouth elongated, four-angled: siphuncle nearest to the inner margin of the septum.

"*Syn.* Lister, 1048.

"Thickness rather less than half the diameter; the sides are rather conical and even. Mouth above half the diameter of the shell, long, narrowest towards the back, siphuncle oval. Septa very numerous, not recurved towards the umbilicus.

"A fine specimen of this species is figured by Lister, measuring ten inches in the longest diameter; no doubt, when perfect it is sometimes much larger: mine is eight inches, I figure a part of it, as sufficient; the remainder is a broken continuation of it. I have never seen the last chamber. This is composed of a mixture of dark lias limestone and pyrites, found at Keynsham, S.E. of Bristol. It is also said to be found in the blue lias of Bath, etc. Lister does not say where his specimen was found; his figure shows about three whorls, mine did not expose them; possibly when the shell is removed the whorls may be uncovered. Mine has fragments of the shell of considerable thickness about it, indicating that it was smooth when perfect."

Sowerby's type-specimen, of which only a portion was figured, is now in the British Museum collection (register No. 44,117*a*). In his remarks, Sowerby says he had never seen the last chamber, by which statement he must mean that he had not seen the *whole* of the last chamber, for half of the unfigured portion of the specimen is an internal cast of a portion of the body-chamber, the rest being composed of internal casts of the last four loculi[1] or cameræ. The umbilicus was evidently closed.[2]

In his "Supplemental Index" (p. 251) to vol. ii of Sowerby's "Mineral Conchology," Farey gives for this species the localities "Bath W, and Keynsham."

[1] Usually called 'air-chambers.'

[2] The specimen figured by Lister evidently had an open umbilicus, and, judging by the figure, it was, I believe, from the Calcareous grit, and is referable to J. de C. Sowerby's *Nautilus hexagonus* (Min. Conch., vol. vi, 1826, p. 55, pl. dxxix, fig. 2).

On account of the horizon and locality that Sowerby ascribed to this specimen, the species has been usually regarded as of Lower Liassic age, but the matrix differs entirely from that of the Ammonites from Keynsham that are in the British Museum collection, and Mr. Etheridge, who is well acquainted with the rocks at Keynsham, after examining the specimen, tells me that it is certainly not from that locality. Moreover, if the specimen had been found at Keynsham it seemed to me most probable that there would be examples of the species in the Bristol Museum, but Mr. Bolton, the Curator of that Museum, having at my request looked over all the Liassic Cephalopoda there, tells me that he cannot find an example of *Nautilus truncatus*.

During an examination of some Jurassic Nautili in the British Museum, Mr. S. S. Buckman, some time since, suggested to me that the specimen was not from the Lias, but possibly from "the Fullers' Earth in the neighbourhood of Midford, containing *Rhynchonella* like *varians*." With reference to this suggestion I can only state that there is no record of a *Nautilus* from the Fullers' Earth in H. B. Woodward's Memoir on the Lower Oolitic rocks of England and Wales (Mem. Geol. Survey), and so far as I am aware no example has yet been recorded from that deposit.

Fortunately there are remains of other fossils in the infilling of the body-chamber of the specimen; these include *Rhynchonella*, *Myacites*, *Astarte*, *Isocardia*, *Ostrea*, a Gasteropod (probably *Eulima*), and a portion of a fish-tooth which Dr. Smith Woodward has identified as *Strophodus*.

The matrix of the specimen, the mode of preservation, and the associated fossils led me to think that the fossil was of Cornbrash age. I therefore carefully examined the Cornbrash Nautili in the British Museum collection. With one exception these came from a small pit,[1] which was temporarily opened some years ago in the neighbourhood of Bedford, where they occurred with such characteristic Cornbrash fossils as '*Ammonites*' *discus*, *Waldheimia obovata*, *Nucleolites clunicularis*, *Holectypus depressus*, *Pygurus Michelini*, etc., and on comparison I found them to agree in all respects so perfectly with Sowerby's type-specimen that there cannot be the slightest doubt as to the identity of the species. The largest example of this species in the collection is about 13½ inches in diameter.

My conclusions, then, with regard to Sowerby's type are (i) that it is not of Liassic age, (ii) that it did not come from Keynsham, and (iii) that it came from the Cornbrash, but from what locality I do not venture to suggest.

Mr. E. T. Newton, of the Geological Survey, and Prof. J. F. Blake, who has quite recently made a special study of the Cornbrash, have examined the fossil, and I am pleased to be allowed to state that both support me in my conclusions as to the age of the specimen.

[1] This pit was known to the writer as the "Midland Railway Pit"; it was on the south-western side of the town, on the small piece of ground on the western side of, and adjoining, the main line of the Midland Railway, and between the Kempston Road and the river. I believe the stone was excavated for building a wall at the northern end of the Ampthill Tunnel.

NOTICES OF MEMOIRS.

British Association for the Advancement of Science, Bradford, 1900.

Address to the Zoological Section. By Ramsay H. Traquair, M.D., LL.D., F.R.S., President of the Section. (Slightly abridged.)

(*Concluded from the October Number, p.* 470.)[1]

Coming now to say a word regarding the Elasmobranchii, it is plain from the fin-spines found in Upper Silurian rocks that they are of very ancient origin, and that if we only knew them properly they would have a wonderful tale of evolution to tell. But their internal skeleton is from its nature not calculated for preservation, and for the most part we only know those creatures from scattered teeth, fin-spines, and shagreen, specimens showing either external configuration or internal structure being rare, especially in Palæozoic strata. But from what we do know, there is no doubt that the ancient sharks were less specialized than those of the present day, and that the recent Notidanids still preserve peculiarities which were common in the Selachii of past ages.

If we ask whether the fossil sharks throw any light on the disputed origin of the paired limbs, whether from the specialization of right and left lateral folds, or whether that type of limb called 'archipterygium' by Gegenbaur, consisting of a central jointed axis with pre- and post-axial radial cartilage attached, was the original form, I fear we get no very definite answer from Elasmobranch palæontology. The paired fins of the Upper Devonian shark, *Cladoselache*, as described by Bashford Dean, Smith Woodward, and others, seem to favour the lateral fold theory, and Cope pointed to the right and left series of small intermediate spines which in some Lower Devonian Acanthodei (*Parexus* and *Climatius*) extend between the pectorals and ventrals as evidence of a former continuous lateral fin. So also, if I am right in looking on the lateral flaps of the Cœlolepidæ as fins, the evidence of these ancient Ostracodermi would be in the same direction.

But, on the other hand, we have the remarkable group of Pleuracanthidæ, extending from the Lower Permian back to the Upper Devonian, in which the paired fins are represented by an 'archipterygium' which in the pectoral at least is biserial.

From this biserial 'archipterygium' in the Pleuracanthidæ, Professor A. Fritsch, ten years ago,[2] derived the tribasal arrangement of modern sharks, much according to the Gegenbaurian method, effecting, however, a compromise with the lateral fold theory by assuming that the Pleuracanth form originated from one, consisting of simple parallel rods, like that described in *Cladoselache*.

[1] The reader is requested to note the following errata in the part of this Address published in our last number, namely, at p. 465, line 30, for "Under" read "Unless," and in line 31 delete the semicolon after "pectorals."

[2] "Fauna der Gaskohle und der Kalksteine der Permformation Böhmens," vol. iii, pt. 1 (Prague, 1890), pp. 44–45.

In my description of the pectoral fin of the Carboniferous *Cladodus Neilsoni*,[1] I have shown that the cartilaginous structures apparently present an uniserial archipterygium intermediate between the arrangement in *Pleuracanthus* and that in the modern sharks, but I felt compelled to acknowledge that the specimen might also be interpreted in exactly the opposite way, namely, as an example of a transition from the 'ptychopterygium' of *Cladoselache* to the Pleuracanth and Dipnoan limb. And so, in fact, this fin of *Cladodus* is claimed in support of their views by both parties in the dispute.

When we add that Semon emphatically denies that there is any proof for considering that the pectoral fin of *Cladoselache* is primitive in its type,[2] and that Campbell Brown, in his recent paper on the Mesozoic genus *Hybodus*,[3] supports Gegenbaur's theory, it will be seen that Elasmobranch palæontology has not as yet uttered any very clear or decided voice on the question as to whether the so-called archipterygium is the primary form of paired fin in the fish, or only a secondary modification. We shall now inquire if we can obtain any more light on the subject from the Crossopterygii and Dipnoi.

The Crossopterygii are a group of Teleostomous fishes characterized externally by their jugular plates and lobate paired fins, and represented in the present day only by the African genera *Polypterus* and *Calamoichthys*, which together form the peculiar family Polypteridæ. The Crossopterygii appear suddenly in the middle of the Devonian period, their previous ancestry being unknown to us.

Four families[4] are known to us in Palæozoic times—the Osteolepidæ, Rhizodontidæ, Holoptychiidæ, and Cœlacanthidæ—but it is only with the first three that we have at present to deal. The Osteolepidæ and Rhizodontidæ, which appear together in Middle and die out together in Upper Palæozoic times, resemble each other very closely. In both we have the paired fins, more especially the pectoral, obtusely or subacutely lobate; there are two separate dorsal fins, one anal, and the caudal, which is usually heterocercal, though in some genera it is more or less diphycercal. In both the teeth are conical and have the same complex structure, the dentine being towards the base thrown into vertical labyrinthic folds, exactly as in the Stegocephalian Labyrinthodonts, and this along with the lung-like development of the double air-bladder in the recent Polypteridæ has given rise to the view that from these forms the Stegocephalia have originated. The nasal openings must have been on the under surface of the snout, as in the Dipnoi.

Of these two so closely allied families we must conclude that the Osteolepidæ are the more primitive, as in them the scales are acutely rhombic and usually covered with a thick layer of ganoine, while

[1] Trans. Geol. Soc. Glasgow, vol. xi, pt. 1 (1897), pp. 41–50.

[2] "Die Entwickelung der paarigen Flossen des *Ceratodus Forsteri*"; Jena, 1898.

[3] "Ueber das Genus *Hybodus* und seine systematische Stellung": Palæontographica, vol. xlvi (1900).

[4] *Five*, if we include the singular and still imperfectly known Tarrasiidæ of the Lower Carboniferous.

in the Rhizodontidæ they are rounded, deeply imbricating, and normally devoid of the ganoine layer, which, however, occasionally recurs on the scales of *Rhizodopsis* and the fin-rays of *Gyroptychius.*

What, then, of the structure of the paired fins? Fortunately, in the Rhizodont genera *Tristichopterus* and *Eusthenopteron* the internal skeleton of the lobe was ossified, and what we see clearly exhibited in the pectoral of some specimens is striking enough. We have a basal piece attached to the shoulder-girdle and followed by a median axis of four ossicles placed end to end. The first of these shows on its postaxial margin a strong projecting process, while to its preaxial side, close to its distal extremity, a small radial piece is obliquely articulated, and a similar one is joined also to the second and third segments of the axis. The arrangement in the ventral fin is essentially similar.

In fact, we have in the Rhizodontidæ a short uniserial 'archipterygium,' and the question is, Has this been formed by the shortening up and degeneration of an originally elongated and biserial one, or on the other hand, do we find here a condition in which the stage last referred to has not yet been attained? This question is inseparable from the next, whether the Rhizodonts or the Holoptychians form the most advanced type.

The Holoptychiidæ resemble the Rhizodontidæ extremely closely in their external head-bones, in their rounded, deeply imbricating scales, and in the form and arrangement of their median fins. But the teeth show a more complex and specialized structure than those of the Rhizodontidæ; the simple vertical vascular tubes formed by the repeated folding of the dentine in that family being connected by lateral branches around which the dentine tubules are grouped in such a way as to give rise in transverse sections to a radiating arborescent appearance; hence the term 'dendrodont.' In this respect, then, the Holoptychiidæ show an advance on the Rhizodontidæ—what then of the paired fins? While the ventral remains subacutely lobate, as in the previous family, the pectoral has now assumed an elongated *acutely lobate* shape, with the fin-rays arranged along the two sides of a central scaly axis exactly as in the Dipnoi; and though the internal skeleton has not yet been seen, yet, judging by analogy, we cannot escape the belief that it was in the form of a complete biserial 'archipterygium.'

What, then, is the condition of affairs in the oldest known Dipnoan?

The oldest member of this group with whose configuration we are acquainted is *Dipterus,* which likewise appears in the middle of the Devonian period simultaneously with the Osteolepidæ, Rhizodontidæ, and Holoptychiidæ. In external form it closely resembles a Holoptychian, having a heterocercal caudal fin, two similarly placed dorsals, one anal, and circular imbricating scales, which, however, have the exposed part covered with smooth ganoine. But now we have the ventrals as well as the pectorals acutely lobate in shape, and presumably archipterygial in structure; the top of the head is covered with many small plates, there is no longer a dentigerous maxilla, the skull is autostylic, and the palatopterygoids and the mandibular splenial are like those of *Ceratodus* and bear each a tooth-plate with radiating ridges.

Now, comparing *Dipterus* with the recent *Ceratodus* and *Protopterus*, the first conclusion we are likely to draw is, that the older Dipnoan is a very specialized form, that its heterocercal tail and separate dorsals and anal are due to specialization from the continuous diphycercal dorso-ano-caudal arrangement in the recent forms, that the Holoptychiidæ were developed from it by shortening up of the ventral archipterygium, as well as by the changes in cranial structure, and that the Rhizodontidæ and Osteolepidæ are a still more specialized series in which the pectoral archipterygium has also shared the fate of the ventral in becoming shortened up and uniserial.

Five years ago, however, M. Dollo proposed a new view to the effect that the process of evolution had gone exactly in the opposite direction;[1] and after long consideration of the subject I find it difficult to escape from the conclusion that this view is more in accordance with the facts of the case, though, as we shall see, it also has its own difficulties.

I have already indicated above that we are, on account of the more specialized structure of the teeth, justified in considering the Holoptychians, with their acutely lobate pectorals, a newer type than the Rhizodonts, even though they did not survive so long in geological time. What, then, of the question of autostyly?

We do not know the suspensorium of *Holoptychius*, but that of the Rhizodontidæ was certainly hyostylic, as in the recent *Polypterus*. Now, as there can be no doubt that the autostylic condition of skull is a specialization on the hyostylic form, as seen also in the Chimæroids and in the Amphibia, to suppose that the hyostylic Crossopterygii were evolved from the autostylic Dipnoi is, to say the least, highly improbable; in my own opinion, as well as in that of M. Dollo, it will not stand. And if we assume a genetic connection between the two groups it is in accordance with all analogy to look on the Dipnoi as the children and not as the parents of the Crossopterygii.

M. Dollo adopts the opinion of Messrs. Balfour and Parker that the apparently primitive diphycercal form of tail of the recent Dipnoi is secondary, and caused by the abortion of the termination of the vertebral axis as in various 'Teleostei,' so that no argument can be based on the supposition that it represents the original 'protocercal' or preheterocercal stage. Very likely that is so, but it is not of so much importance for the present inquiry, as both in the Osteolepidæ and Rhizodontidæ we find among otherwise closely allied genera some which are heterocercal, others more or less diphycercal. *Diplopterus*, for example, differs from *Thursius* only by its diphycercal tail, and in like manner among the Rhizodontidæ *Tristichopterus* is heterocercal, *Eusthenopteron* is nearly diphycercal, and

[1] "Sur la Phylogénie des Dipneustes": Bull. Soc. belge géol. paléont. hydr., vol. ix (1895).

there can be no doubt that in spite of this their caudal fins are perfectly homologous structures.

But of special interest is the question of the primitive or non-primitive nature of the continuity of the median fins in the recent Dipnoi. Like others I was inclined to believe it primitive, and that the broken-up condition of these fins in *Dipterus* was a subsequent specialization, and in fact gave the series *Phaneropleuron*, *Scaumenacia*, *Dipterus macropterus*, and *D. Valenciennesii* as illustrating this process of differentiation. This view, of course, draws on the imperfection of the geological record in assuming the existence of ancient pre-Dipterian Dipnoi with continuous median fins, which have never yet been discovered. But Dollo, using the very same series of forms, showed good reason for reading it in exactly the opposite direction.

The series is as follows :—

1. *Dipterus Valenciennesii*, Sedgw. & Murch., from the Orcadian Old Red, and the oldest Dipnoan with whose shape we are acquainted, has two dorsal fins with *short* bases, a heterocercal caudal, and one short-based anal.

2. *Dipterus macropterus*, Traq., from a somewhat higher horizon in the Orcadian series, has the base of the second dorsal much *extended*, the other fins remaining as before.

3. In *Scaumenacia curta* (Whiteaves), from the Upper Devonian of Canada, the first dorsal has advanced considerably towards the head, and its base has now become elongated, while the second has become still larger and more extended, though still distinct from the caudal posteriorly.

4. In *Phaneropleuron Andersoni*, Huxley, from the Upper Old Red of Fifeshire, the two dorsal fins are now fused with each other and with the caudal, forming a long continuous fin along the dorsal margin, while the tail has become nearly diphycercal, with elongation of the base of the lower division of the fin. But the anal still remains separate, narrow, and short-based.

5. In the Carboniferous *Uronemus lobatus*, Ag., the anal is now also absorbed in the lower division of the caudal, forming likewise on the hæmal aspect a continuous median fin behind the ventrals. There is also a last and feeble remnant of a tendency to an upward direction of the extremity of the vertebral axis.

6. In the recent *Ceratodus Forsteri*, Krefft, the tail is diphycercal (secondary diphycercy), the median fins are continuous, the pectorals and ventrals retain the biserial archipterygium, but the cranial roof-bones have become few.

7. In *Protopterus annectens*, Owen, the body is more eel-like, and the paired fins have lost the lanceolate leaf-like appearance which they show in *Ceratodus* and the older Dipnoi. They are like slender filaments in shape, with a fringe on one side of minute dermal rays; internally they retain the central jointed axis of the 'archipterygium,' but according to Wiedersheim the radials are gone, except it may be one pair at the very base of the filament.

8. Finally, in *Lepidosiren paradoxa*, Fitz., the paired fins are still

more reduced, having become very small and short, with only the axis remaining.

From this point of view, then, *Dipterus*, instead of being the most specialized Dipnoan, is the most archæic, and the modern *Ceratodus*, *Protopterus*, and *Lepidosiren* are degenerate forms; and instead of the Crossopterygii being the offspring of *Dipterus*-like forms, it is exactly the other way, the Dipnoi owing their origin to Holoptychiidæ, which again are a specialization on the Rhizodontidæ, though they did not survive so long as these in geological time. Consequently the *Ceratodus* limb, with its long median segmented axis and biserial arrangement of radials, is not an archipterygium in the literal sense of the word, but a derivative form traceable to the short uniserial type in the Rhizodonts. But from what form of fin *that* was derived is a question to which palæontology gives us no answer, for the progenitors of the Crossopterygii are as yet unknown to us.

Plausible and attractive as this theory undoubtedly is, and though it relieves the palæontologist from many difficulties which force themselves upon his mind if he tries to abide by the belief that the Dipnoan form of limb had a selachian origin, and was in turn handed on by them to the Crossopterygii, yet it is not without its own stumbling-blocks.

First as to the dentition, on which, however, M. Dollo does not seem to put much stress, it is impossible to derive *Dipterus directly* from the Holoptychiidæ, unless it suddenly acquired, as so many of us have to do as we grow older, a new set of teeth. The dendrodont dentition of *Holoptychius* could not in any way be transformed into the ctenodont or ceratodont one of *Dipterus*: both are highly specialized conditions, but in different directions. Semon has recently shown that the tooth-plates of the recent *Ceratodus* arise from the concrescence of numerous small simple conical teeth, at first separate from each other.[1] Now this stage in the embryo of the recent form represents to some extent the condition in the Uronemidæ of the Carboniferous and Lower Permian, which stand quite in the middle of Dollo's series.

Again, the idea of the origin of the Dipnoi from the Crossopterygii in the manner sketched above cuts off every thought of a genetic connection between the biserial archipterygium in them and in the Pleuracanthidæ, so that we should have to believe that this very peculiar type of limb arose independently in the Selachii as a parallel development. It may be asked, Why not? We may feel perfectly assured that the autostylic condition of the skull in the Holocephali arose independently of that in the Dipnoi, as did likewise a certain amount of resemblance in their dentition. But those who from embryological grounds oppose any notion of the origin of the Dipnoi from 'Ganoids' might here say, if they chose, If so, why should not also the same form of limb have been independently evolved in Crossopterygii?

Accordingly, while philosophic palæontology is much indebted to M. Dollo for his brilliant essay, and though we must agree with him

[1] "Die Zahnentwickelung des *Ceratodus Forsteri*"; Jena, 1899

in many things, such as that the Crossopterygii were not derived *from* the Dipnoi, and that the modern representatives of the latter group are degenerate forms, yet as to the *immediate* ancestry of the Dipnoi themselves, and the diphyletic origin of the so-called archipterygium, we had best for the present keep an open mind.

In his "Catalogue of the Fossil Fishes" in the British Museum (vol. ii, 1891) Dr. Smith Woodward, following the suggestion of Newberry in 1875, classified the Coccosteans or 'Arthrodira' as an extremely specialized group of Dipnoi. At first I was much taken with that idea, but after looking more closely into the subject I began to doubt it extremely. My own opinion at present is that the Coccosteans are Teleostomi belonging to the next order, Actinopterygii; but Professor Bashford Dean, of New York, will not have them to be even 'fishes,' but places them in a distinct class of 'Arthrognatha,' which he places next to the Ostracophori (=Ostracodermi), even hinting at a possible union with them, whereby the old 'Placodermata' of McCoy would be restored. It will, therefore, be better to leave them out of consideration for the present, pending a thorough re-examination of their structure and affinities.

We come then to the great order of Actinopterygii, to which a large number of the fishes of later Palæozoic age belong, as well as the great mass of those of Mesozoic, Tertiary, and modern times. Of these we first take into consideration the oldest sub-order, namely, the Acipenseroidei or Sturgeon tribe, in which the dermal rays of the median fins are more numerous than their supporting ossicles, while the tail is, in most, completely heterocercal. The oldest family of Acipenseroids with which we are acquainted is that of the Palæoniscidæ, which, in addition to well-developed cranial and facial bones, has the body normally covered with rhombic ganoid scales furnished with peg-and-socket articulations. It endures up to the Purbeck division of the Jurassic formation, and in the Carboniferous *Cryphiolepis*, the Lower Permian *Trissolepis*, and the Jurassic *Coccolepis* we find the same degeneration of the rhombic scales into those of a circular form and imbricating arrangement, which we find repeated in other groups of 'Ganoids.'

In these Palæozoic times we notice also a side branch of the Palæoniscidæ, constituting the family Platysomidæ, in which, while the median fins acquire elongated bases, the body becomes shortened up and deep in contour. A most interesting series of forms can be set up, beginning with *Eurynotus*, which, though it has the platysomid head contour and a long-based dorsal, has only a slight deepening of the body, and still retains the palæoniscid squamation and a short-based anal fin. In *Mesolepis*, which resembles *Eurynotus* in shape, being only slightly deeper, we have now the characteristic platysomid squamation, and the base of the anal fin is considerably elongated. *Platysomus* has a still more elongated anal fin, and the body is rhombic; while in *Cheirodus* the body is still deeper in contour, with peculiar dorsal and ventral peaks, long fringing dorsal and anal fins, while the ventrals seem to have disappeared altogether. Here also, as in the allied genus *Cheirodopsis*, the separate cylindroconical teeth characteristic of the family are, on the palatal and splenial bones, replaced by dental plates, reminding us of those of the Dipnoi. Certainly the Platysomidæ seem to me to form a morphological series telling as strongly in favour of Descent as any other in the domain of palæontology.[1]

If we now return to the Palæoniscidæ we find that they dwindled away in numbers in the Jurassic rocks, and finally became extinct at the close of that epoch. But already in the Lias (leaving the Triassic Catopteridæ out of consideration for the present) we find that they have sent off another offshoot sufficiently distinct to be reckoned as a new and separate family, namely, the Chondrosteidæ, in which the path of degeneration, in all but the matter of size, seems to have been entered on.

In the genus *Chondrosteus*, though the palæoniscid type is clearly traceable in the cranial structure, there is marked degeneration as regards the amount of ossification, and though the suspensorium is still obliquely directed backward the toothless jaws are comparatively short, and the mouth seems now to have become tucked in under the snout as in the recent sturgeon. Then the scales have entirely disappeared from the skin except on the upper lobe of the heterocercal caudal fin, where they are still found arranged exactly as in the Palæoniscidæ.

Chondrosteus in fact conducts us to the recent Acipenseroids—the Polyodontidæ (Paddle-fishes) and Acipenseridæ (Sturgeons). So the sturgeons and paddle-fishes of the present day would seem to be the degenerate, though bulky, descendants of the once extensively developed group of Palæoniscidæ, even as the modern Dipnoi are degenerated from those of Palæozoic times.

In the Upper Permian occurs the genus *Acentrophorus*, whose fellowship with *Semionotus*, *Lepidotus*, and all the rest of the series of Mesozoic semi-heterocercal 'Ganoids' is at once obvious. If we look at the configuration of a typical Jurassic member of this series, such as *Lepidotus* or *Eugnathus*, we shall at once see that we are a stage nearer the modern osseous fish. Though the scales are bony, rhombic, and ganoid, we are struck by the 'Teleostean'-like aspect of the external bones and plates of the head, the rays of the dorsal and anal fins are fewer and correspond in their number to that of the internal supports or 'interspinous' bones, while in the caudal we see the semi-heterocercal or abbreviate-heterocercal condition.

Then, if we refer to the tail of *Lepidosteus* itself, we shall observe how few are its rays and how evident it is that we have here to do only with the lower lobe of the original palæoniscoid caudal fin. For a convincing corroboration of this we have only to look at the tail of the embryo *Lepidosteus* as described and figured by Professor A. Agassiz to see that it in reality passed through an Acipenseroid stage, and the last we see of the upper lobe of this tail is in the form of a filament which projects from the top of the original lower lobe and then disappears.

[1] R. H. Traquair, "Structure and Affinities of the Platysomidæ": Trans. Roy. Soc. Edin., vol. xxix (1879), pp. 343–391.

Again, in these Lepidosteid forms we have a repetition of the same tendency for the thick rhombic, peg-and-socket articulating scales to become rounded and imbricating, as we saw in the Crossopterygii and again in the Palæoniscidæ. To such an extent does this go that in the recent *Amia*, whose skeletal structure so clearly shows it to belong to this group, the rounded scales are so thin and flexible that after it was removed from the Clupeoid family, or Herrings, and placed among the 'Ganoids," it was considered to be the type of a distinct sub-order of 'Amioidei.'

As the Acipenseroids dwindled away after the close of the great Palæozoic era, and are now scantily represented only by the degenerate paddle-fishes and sturgeons, so the Lepidosteid series, flourishing greatly in the Trias and Jura, in their turn declined in the Cretaceous, and in the Tertiary period became about as much a thing of the past as they are now, the North American *Lepidosteus* and *Amia*, of which remains of extinct species have also been found in Eocene and Miocene rocks, only remaining. These two genera, can, however, hardly be called 'degenerate.'

But that the fishes which succeeded the Lepidosteids in populating the seas and rivers of the globe were evolved from them there can be no reasonable doubt, while it is equally clear that they branched off at an early period, as already in the Trias we find the first representatives of the order of Isospondyli, which contains our familiar Herrings, Salmonids, Elopids, Scopelids, etc. For Dr. Smith Woodward has not only definitely placed the Jurassic Leptolepidæ and Oligopleuridæ in the Isospondyli, but also the Pholidophoridæ, which appear in the Trias and extend to the Purbeck. And it is of special interest that in the Pholidophori the scales are still brilliantly ganoid, and mostly retain the peg-and-socket articulation, while in the allied Leptolepidæ, although they have become thin and circular, a layer of ganoine mostly remains.

With the Isospondyli we now get fairly among the bony fishes of modern type—Teleostei as we used to call them—to which other sub-orders are added in Cretaceous and Tertiary times, and which in the present day have assumed an overwhelming numerical preponderance over all other fishes. The prevalent form of scale among these is thin, rounded, deeply imbricating, and with the posterior margin either plain (cycloid) or serrated (ctenoid). But that these 'cycloid' and 'ctenoid' scales are modifications from the rhombic osseous 'ganoid' type we cannot doubt after what we have seen. It is indeed strange that the same tendency to the change of rhombic into circular overlapping scales should have occurred independently in more than one group.

Incompletely as I have treated the subject, it cannot but be acknowledged that the palæontology of fishes is not less emphatic in the support of Descent than that of any other division of the animal kingdom. The modern type of bony fish, though not so 'high' in many anatomical points as that of the Selachii, Crossopterygii, Dipnoi, Acipenseroidei, and Lepidosteoidei of the Palæozoic and Mesozoic eras, is more specialized in the direction of the fish proper.

REVIEWS.

A Treatise on Zoology. Edited by E. Ray Lankester. Part III: The Porifera and Cœlenterata. By E. A. Minchin, M.A., G. Herbert Fowler, B.A., Ph.D., and Gilbert C. Bourne, M.A., with an Introduction by E. Ray Lankester. pp. vi and 368, with 227 figures in the text. (London: Adam & Charles Black, 1900.)

PROFESSOR LANKESTER is to be congratulated on the speedy appearance of another part of his "Treatise on Zoology," and it is to be devoutly hoped that the remaining eight parts will appear with even greater rapidity if the work is to be completed before the first volumes are out of date.

The present part is of special interest to students of comparative morphology, since it contains a chapter by the editor on the much vexed subject of the cœlom. Speculations concerning the origin and homologies of the variously developed body-cavities found among the Metazoa have so long been associated with Professor Lankester's name that an article giving his latest views on this subject will command careful attention from all, even although some may be of the opinion that the present state of our knowledge concerning these cavities is not sufficient to justify all his conclusions. As an argument against the too previous introduction of the cœlom as a feature of classificatory value, we may compare the use made of it in the present work with that adopted by Sedgwick in his recent textbook: the latter authority would exclude the Platyhelmia, the Nematoidea, the Nemertina, and the Rotifera from his Cœlomata, whereas Lankester includes all these in his grade Cœlomocœla, a term which he proposes to substitute for the well-known Cœlomata.

With reference to these new terms, of which there are several, we should have thought that Professor Lankester's long experience as a teacher would have shown him the futility and undesirability of overburdening a science with new words, especially when they only serve to replace terms long sanctioned by use, solely on the grounds that his new words are more expressive than the old ones. If we were once to commence to replace all the old morphological terms at present in use which, being invented by our more fanciful forefathers, are now found through our increasing knowledge to be deprived of some of their meaning, we should find ourselves lost, like the modern systematist, in a maze of words, and all solid work would be at a standstill. While we would deplore the mere substitution of terms like Cœlomocœla for Cœlomata and Enterocœla for Cœlenterata, we find no objection to the invention of terms to express fresh ideas, and it is possible that the term Phlebœdesis, as applied to the origin of the body-cavity in the Arthropoda and Mollusca, may be found a very useful one. At any rate, Professor Lankester's exposition of his theory of Phlebœdesis is very instructive.

This volume is about equally divided between the Porifera and the Cœlenterata, a division which appears to us to be somewhat unfair, for the components of the latter group differ so much more from one another than do the various classes of the Porifera, that in our opinion they should have been allotted a larger space. At the same time we should not like this to have been done at the expense of Professor Minchin's article, which appears to be a most admirable one, and one that will long serve as a valuable introduction to the study of the Porifera. This article contains a large amount of original observations and many new figures, but so great is Professor Minchin's modesty that only those who have worked at sponges will recognize the new matter. In dealing with the histology we are glad to see that Professor Minchin throws considerable doubt upon the special sense-organs and nerve-cells as described by Stewart, Sollas, and von Lendenfeld, and we could only wish that Mr. Fowler, in dealing with the so-called ganglionic cells of the last-mentioned observer in the Hydroids, had been equally bold.

The great difficulty in these composite textbooks is to mete out equal treatment to the various groups of animals dealt with, as each writer has his own ideas on the style of article required, and we are afraid that both the articles on the Hydromedusæ and the Anthozoa suffer somewhat from a comparison with that on the Porifera. Those on the Hydromedusæ and the Scyphomedusæ especially appear to be far too condensed and hardly critical enough for this ambitious work; the illustrations of these parts, too, are for the most part very antiquated.

Perhaps the part which appeals most nearly to the palæontologist will be that dealing with the Anthozoa by Mr. Bourne. Here, at any rate, no fault can be found with the age of the illustrations, almost all of which appear to have been specially drawn for the article. Unfortunately, owing to the adoption of the half-tone process, the printing of these beautiful figures has not been always successful. Mr. Bourne's article obviously suffers from delayed publication, and consequently much important work dealing with the formation and nature of the coral-skeleton has to be briefly referred to in an appendix. Mr. Bourne has done considerable work on the relation of the hard and soft parts in the corals, but we cannot help asking for his authority in his representation of the epitheca in fig. 28 as a saucer-like structure surrounding the theca but separated by a distinct interval into which a hollow reduplication of the body-wall extends.

The present volume contains six chapters, which, with the exception of chapters iv and v, are separately paginated, and the contained figures are separately numbered; each, further, is provided with an index: these indices are sometimes difficult to find, and we personally should have preferred a continuous pagination and a general index at the end of the volume.

CORRESPONDENCE.

GEOLOGICAL HYPOTHESIS.

Sir,—In the July number of your Magazine, just received, there is an article called "A Word on Geological Hypothesis," by Professor H. Macaulay Posnett.[1] After some admirable platitudes on the subject of scientific dogmatism, he proceeds to explain why he has been forced to tender this kindly advice by the following illustrations.

"Shortly after the Tarawera eruption of June, 1886, some professors of science proceeded to the Rotorua district and there held a Maori meeting. The Maoris were told that, the lines of volcanic energy having such and such directions, they need entertain no fears of the recurrence of the late disaster—'they might plant their kumeras in peace.' Hereupon an old Maori chief, with the usual sagacity of his race, rose and remarked, 'If the volcano-doctors know so much about what is to be, what a pity it was they did not come and forewarn us of the eruption.' Needless to say, the 'volcano-doctors' had no reply; and in our civilized views of volcanic forces it would be far better to own ignorance than to even hint a claim to foresight where it does not as yet exist."

Now as I am one of the 'volcano-doctors' referred to, and Professor Posnett was at the time in Auckland, 170 miles away, I suppose I know more about what took place than he does. The following is a plain statement of the facts. Professors Thomas and Douglas-Brown, of the Auckland University College, and myself were commissioned by the N.Z. Government to report upon the eruption. The Maoris, naturally, were in a great state of alarm. Many had left and quartered themselves on neighbouring tribes; and the remainder wanted to leave, but had no land to go to. Under these circumstances the Resident Magistrate at Rotorua asked us whether we could help in dissipating these fears. We consented to try. He called a meeting, and I, as senior, was deputed to make the speech. I pointed out that as the eruption had only lasted for a few hours and had been over for more than a week, it was not likely that it would recur in the near future, as time must be allowed for the subterranean forces to again accumulate. Even, I said, if a second eruption should take place it would probably not be a severe one, like the first, for an opening had been made through which the steam could now escape. I said nothing about lines of volcanic energy. The Maoris saw the common-sense of these reasons; their fears ceased, the runaways returned, and crops for the coming season were planted. I do not remember being asked why we had not forewarned the Maoris of the eruption—it sounds like a newspaper yarn—but if I was so asked, no doubt I made it clear to my audience that the two things were very different; a point which Professor Posnett appears not to see.

[1] Geol. Mag., 1900, pp. 298–302.

He then goes on to say: "It is worth adding that, not very far from the Rotorua district, in the now famous gold-fields of the Thames, an eminent but dogmatic and hasty geologist many years ago prophesied that no gold could there ever be found." As the Thames gold-fields were well established fifteen years or more before Professor Posnett came to Auckland, this charge must rest on second- or third-hand evidence; for, to the best of my knowledge, the prophecy was never published. As I was living in Auckland at the time of the discovery of the fields (1867), I should certainly have heard of it if any scientific man had said publicly that no gold would be found at the Thames. When Professor Posnett was in Auckland he could easily have investigated the truth of club gossip, and he should have done so before repeating it as a well-attested fact. I therefore call upon him either to produce his evidence or to acknowledge that he has done the very thing he is blaming geologists for doing, namely, made dogmatic statements without giving any hint that they may not be true. F. W. Hutton.

Christchurch, New Zealand.
31*st August*, 1900.

THE AGE OF THE RAISED BEACH OF SOUTHERN BRITAIN.

Sir,—Mr. Tiddeman's extremely interesting note in the October Number "On the Age of the Raised Beach as seen at Gower" seems to be supported by several facts, which I had observed and already published with regard to the Raised Beach in Sussex. The section to the west of Brighton exhibits, near the top, a distinctly festooned arrangement of the lines of bedding, which can be best explained on the supposition of the occurrence of interbedded ice-masses.[1] Another important point is the discovery of two species of Ostracoda of northern habit in the Sussex Raised Beach.[2] And further, the Rubble-Drift immediately above the Raised Beach at Aldrington shows decided evidence of a continuation of a rigorous climate, for here there are some blocks of almost pure foraminiferal sand, very friable, but with their own wavy bedding preserved, which leads one to conclude that these fragments were transported in a frozen condition.[3] I may also, perhaps, be allowed to draw attention to the excellent sections of the Raised Beach and Rubble-Drift which can now be visited at Copperas Gap, near Portslade-by-Sea, but which is being rapidly cut away by the work of sand excavation.

Frederick Chapman, A.L.S.

111, Oakhill Road,
Putney, S.W.

[1] Transactions of the Union of South-Eastern Scientific Societies, 1900, p. 58.
[2] Proc. Geol. Assoc., vol. xvi, pt. 6, p. 263.
[3] Ibid., pp. 267, 268.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. VII.

No. XII.—DECEMBER, 1900.

ORIGINAL ARTICLES.

I.—On *Hyperodapedon Gordoni.*

By Prof. Rudolf Burckhardt, Ph.D., of the University of Basel, Switzerland.

(*Continued from the November Number, p.* 492.)

In the foregoing description I have confined my remarks to the right side of the skull. The observer will not fail to notice from the figures the disparities existing in the two sides. This asymmetry is particularly conspicuous ventrally, the region from which Huxley principally deduced the arguments in support of his more important speculations. The area of dislocation, the centre of which apparently lies in the crater-like opening of the left præsplenial, extends from the left præmaxillary to the pterygoid in the skull, and as far as the splenial on the lower jaw. Its place of greatest intensity has been marked by a + on the figure, where not only the surface of the bones is most damaged, but where the mandible has been so much compressed that a crest has actually been formed below the row of teeth on its outer wall.

The splenial too has been displaced; the pterygoid is broken across; a deep fissure separates the three inner rows from the regularly placed outer rows of teeth on the palate-bone.

This dislocation is partly responsible for the deception it caused in the location of the posterior nares, and for the supposed boundary of the palate-bone and the maxillary. Huxley himself, in his first paper, inaugurates the description of the dentition by stating his inability to find any suture in the roof of the mouth, but he supposed such to exist somewhere in the groove of the hard gum, into which the lower jaw is received when at rest.

In his second paper he lays particular stress on the fact of there being only a single row of teeth tending in a forward direction on either the palatine or the maxillary. Certainly some of the smaller fragments show no suture within the denticulated space, but there is one which runs parallel with and is situated laterally to the outermost row of teeth, which can be traced without cutting a cross section through it.

This leads us to a consideration of the dentition itself. Lydekker was the first to make known the existence of one to two rows of detached teeth on the posterior margin of the oral surface in the lower jaw of the Indian species, next to the palisade-like row of teeth. Huxley considered that the Indian specimens probably did not differ specifically from the English specimens, but merely exceeded them in point of size.

As the two fragmentary specimens of undoubtedly British origin show exactly the same arrangement in the dentition of the lower jaw, Lydekker's contention as to the specific value of the character of his Indian specimens therefore breaks down.

The study of the lower jaw of *Hyperodapedon minor* is particularly instructive in this respect, as the principal row of mandibular teeth extends backward considerably further than in *H. Gordoni.*

The dentition of the palate-bones has been accurately described by Huxley, except in the case of the anterior portion of the right side, which he states has three rows, of which the middle one is decayed away, being indicated only by the empty sockets of the teeth. The regularity in distribution of the teeth is somewhat indistinct on the left side of the fore-part of the palate-bone, and it appears to me to depart from the normal plan, a circumstance which I am inclined to attribute to the local displacement already mentioned. In size the teeth increase consecutively from the front backwards. Neither from this fact alone, nor from sections made at a right angle to their longitudinal line of distribution, is information available as regards a succession of teeth. But judging from a fragment of *H. minor*, containing the germs of the teeth, which have as yet not cut through the bone, I should infer that this does not point to a real change of the teeth, but that it rather suggests the mode of a successive supply of them from the rear, which would continue during the whole of the animal's lifetime.

Now, therefore, that the purely palatine nature of the dentition has been proved, there is no further occasion for assuming a change of teeth to apply to it in the same manner as that in which it is accomplished in the maxillaries. Whether or not such a change of teeth, in its actual sense, takes place in other palatal bones, is a matter for further examination. Whatever its outcome, it is not likely to furnish direct counter-evidence against *Hyperodapedon*, the apparatus for prehension in which is so markedly different.

The peculiar anatomical structure of this apparatus implies a number of physiological derivations capable of throwing light into the vast abyss which divides its dental arrangement from that of *Sphenodon.* It would be wrong to imagine the cutting edge of the lower jaw to move backward and forward in the masticating furrows opposing it. This would be an utter impossibility on account of the two furrows converging towards the front. It is more likely that during the process of attrition, they moved obliquely across the upper part of the apparatus, and that the furrows received the lower jaws when at rest, for which purpose they seem to be provided. This is probably the reason too why the tooth-rows which flank them are ground down. In further support of this view of a gradual expansion of the attritive surface in the posterior portion of the lower jaw, is the fact that it was achieved by an increase of the tooth-rows. Another reason why this expansion has been confined to this particular place is, that the mandibular teeth are in correlation with the presence of a true horned beak, which would have been a natural obstacle to any development of teeth. In this way, and further too by the continuous renewal of teeth, another useful means has been contrived for the process of mastication.

By way of compensation, during the individual development the dentulous surface was so modified that no disadvantage would accrue to the animal through the incapacity of the mucous membrane to remove the worn-down acrodont teeth.

To look for a physiological parallel of this peculiar kind of dentition it is necessary to go to the Placodontia. Of these latter, however, the material at my disposal did not permit of a detailed comparison, but it should be mentioned here that in the Placodonts the maxillary appears to me to bear no teeth, and to be divided from the tooth-row by a suture.

Referring specially to the tendency to expansion, within the dentigerous portion of the posterior part of the lower jaw, by the introduction of new elements, I remember a parallel case, having noticed on the vomer-plate of a species of *Pycnodon*, which is in the Museum at Basle, that the otherwise regular quinto-serial arrangement was augmented by an additional tooth in its widest posterior part.

From the character of the teeth in *Hyperodapedon*, the question arises once more as to the natural haunts of the animal. What is the kind of food required in the case of a placodont animal? Generally this consists of Crustacea, Molluscs, Echinoderms, and other hard-shelled animals. If we take into consideration the dentition alone, coupled with the extraordinary position of the eyes, to which may be added the reduction in size of the posterior extremities, one feels inclined to attribute to it a marine existence; more particularly would this be the case if Huxley's supposition as regards the length of its tail were confirmed. On the other hand, the structure of the manus, in which no tendency to a lengthening of the phalanges can be perceived, is in direct contradiction to this interpretation.

Hyperodapedon, therefore, and probably also *Rhynchosaurus*, will have to be regarded as inhabitants of the littoral. What other terrestrial animal is equipped with a similar dental structure? Or what else could have induced *Hyperodapedon* to frequent the sandy Triassic shores, from whose strata up to the present no signs of petrefactions have been procured, except fossil reptiles.[1]

[1] The writer desires to refer to the remarkable discoveries made prior to 1892 in the Elgin Sandstone, Morayshire, which were described by Mr. E. T. Newton, F.R.S. (Proc. Roy. Soc., Dec. 15, 1892, vol. lii, pp. 389–391; Phil. Trans., vol. clxxxiv), in which he enumerates *Gordonia Traquairi*, *G. Huxleyiana*, *G. Duffiana*, *G. Juddiana*, *Geikia Elginensis*, and *Elginia mirabilis*. Reference was also made to a form resembling *Ætosaurus* (Geol. Mag., 1893, p. 557) named *Ornithosuchus Woodwardi*, and to *Erpetosuchus Granti* (see Proc. Roy. Soc., Dec. 7, 1893, vol. liv, pp. 437, 438; Phil. Trans., 1894, vol. clxxxv B, p. 573, pls. liii–lvi). There were probably also two species of *Thecodontosaurus* from the Trias of Bristol, and perhaps a third from Leamington.

I carefully sought for any evidence of dermal ossification, and detected a few vague signs here and there: for instance, on the eighth rib of the left side, and on the opposed surface, in the vicinity of the ends of the eleventh and the twelfth ribs; also, some small plates of an oval shape on the humeri. Under favourable light the contours of the body, too, seemed to be indicated, notably in the interspaces between the ends of the ribs. Finally, as may be seen from our figure of the counterpart of the right side, a heart-like projection can be observed in the blank space near the fourth rib, differentiating it from other parts, through absence of matrix in that place, from which a fibre of the thickness of a finger starts, tending towards the neck in a decided manner, where it disappears again in the slab. I suspect it to have been a visceral organ, probably the stomach, to judge from its position.

It may be mentioned that there are two specimens of *Rhynchosaurus* in the British Museum in which indications of the skin can also be traced. Lortet has also already described such structures in *Sauranodon.* In one of the *Rhynchosauri,* viz. the type from which Huxley figured its hind-foot (pl. xxvii, fig. 5), the skin is so unmistakable that I have reproduced it here.

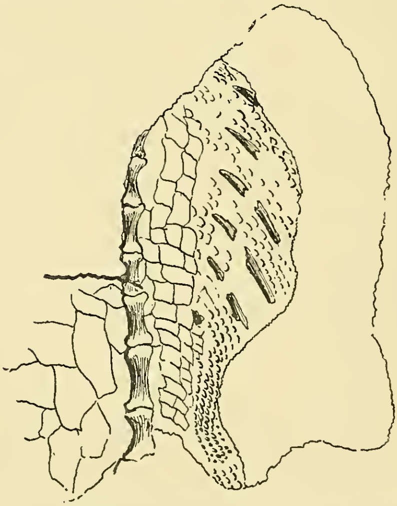


Fig. 3.—Skin from the posterior abdominal region of *Rhynchosaurus articeps.* Two-thirds nat. size. From the specimen preserved in the British Museum (Natural History).

It belongs to the abdominal region, and vividly recalls a fragment from the skin of a Lepidosaurian. But on this head I will not venture upon any evidence of a closer relationship with either the latter or any of the Rhynchocephalians, since we are yet quite ignorant as to the skin structures of the Theromorphæ. A more intimate knowledge of the Lepidosauria from this point of view may even necessitate a change of the name.

The second specimen, disclosing impressions of the skin, is that which supplied Huxley with the type for tab. xxvii, fig. 2. I have been able to detect some smaller scales on this near the remains of the caudal vertebræ, but not so clearly to be seen as in the other example.

I cannot conclude my account of *Hyperodapedon* without making a few remarks on the systematic position of the Rhynchosaurians. Although in the beginning of Huxley's second treatise he strongly supports the theory of an intimate relationship existing between this extinct group and the living *Sphenodon*, his conclusions, however, are that they have only the following characters in common with each other:—

1. A præmaxillary rostrum.
2. A longitudinal series of palatine and maxillary teeth, of which the posterior ones receive between them the mandibular row.
3. An abdominal sternum.
4. Absence of procœlous vertebræ in the præsacral portion.

Of the foregoing characters, number 1 breaks down at once, being based upon a supposed identity of origin in two totally distinct structures; and the second no less so, as will have been seen in our previous discussion. There remain only the third and the fourth points, upon which it would be futile to base characters for the establishment of a closer relationship between them.

Von Zittel, too, ascribes to the Rhynchosaurians affinities with *Sphenodon*, and places them nearer the latter than to the remaining groups of Rhynchocephalians, as does also Smith Woodward.

Boulenger unites the Proterosauridæ with the Palæohatteridæ to form his Proterosauria. Some of the characters which he assigns to this group are shared also by the Rhynchosaurians, such as the flattened bone composing the pelvis, and especially the opisthocœlous vertebræ of the Proterosauridæ. The Rhynchosaurians and the Champsosaurians are brought under one heading too, with the latter of which, except through convergence of similarities, they have really nothing in common. For the reasons mentioned, then, the classification as proposed cannot be said to be wholly satisfactory.

Recently Fürbringer brought to a conclusion his comprehensive systematic treatise on Reptiles, wherein, following Baur, he separates *Hyperodapedon* from *Rhynchosaurus*, and places the family Hyperodapedontidæ near that of Proterosauria, and the Rhynchosauridæ with the Rhynchocephalia *vera*. I can only follow the views of these authors in so far as they are restricted to the closer relationship existing between *Hyperodapedon* and the Proterosauridæ, and on account of its being already connected with the latter by the possession of opisthocœlous vertebræ. Otherwise I consider a separation of *Hyperodapedon* from *Rhynchosaurus* entirely erroneous, and I can find no apology for it on the part of these authors, except in the insufficiency of the published materials on which they based their conclusions.

After what has been stated as to the dentition and the characters of the skull of *Hyperodapedon*, there exists no further ground for trying to effect a closer union of the Rhynchosaurians with Rhynchocephalia vera. We ought rather to regard the former family as a branch, in a wider sense, of the Rhynchocephalian stem, totally independent of the true Rhynchocephalians, and linked in all probability in a more direct manner to the lowest organized Proterosauridæ. So long, therefore, as the inferior zygomatic arch is held to be a differentiating character for the Rhynchocephalians, the Rhynchosaurians will have to be attached to them and not to the Theromorpha. At the same time it should be borne in mind that latterly Baur and Case have excluded *Dimetrodon* from the Theromorpha, and have subsequently included it with the Rhynchocephalians, chiefly on account of this character, and it is possible also that a similar transfer awaits the Endothiodontidæ under similar circumstances. It is to the latter that the Rhynchosaurians appear to bear the greatest resemblance, but in this case also the resemblance may be based upon analogy alone.

The principal conclusions I have arrived at are as follows:—

1. All the bones in the skull of *Hyperodapedon Gordoni*, as seen in the specimen in the British Museum (apart from the occipital region), can be identified, except such as may be still embedded in the matrix.

2. The upper side of the skull agrees with the one known for Rhynchocephalians, with this difference, that the postorbital is rather large and removed in position from the orbital.

3. In the lower jaw five bones can be clearly distinguished, to which an angular should be added, analogous to *Rhynchosaurus*.

4. The maxillaries are edentulous; the palatines possess numerous rows of teeth in serial arrangement, which increase in size from the front to the back. They are not changed, but their number is augmented in their hinder margins; their complete wear is prevented by alteration in the position of the attritive surfaces. The suture between the palate-bone and the maxillary lies to the outside of the dentigerous portion, and is probably the same in the Placodontia.

5. *Hyperodapedon*, together with *Rhynchosaurus*, forms a separate group of the Rhynchocephalians, viz. the Rhynchosaurians, which are connected in a direct line with the lowest forms. This group has no affinity with the Rhynchocephalians in a stricter sense; its analogies with the Chelonians, the Endothiodontidæ, and the Champsosauridæ are physiological ones.

Literature.

1. Owen, R.—"Description of an Extinct Lacertian Reptile, *Rhynchosaurus articeps*": Trans. Cambridge Phil. Soc., vol. vii (1842).

2. Huxley, T.—I. Postscriptum to Sir Rod. Murchison, "On the Sandstones of Morayshire (Elgin, etc.) containing Reptilian Remains": Quart. Journ. Geol. Soc., vol. xv (1859), p. 435. II. "On *Hyperodapedon*": ibid., vol. xxv (1869), p. 138. III. "Further Observations upon *Hyperodapedon Gordoni*": vol. xliii (1887), p. 675.

3. Günther, A.—"Contributions to the Anatomy of *Hatteria*": Phil. Trans., vol. clvii (1867).

4. Woodward, A. Smith.—Discussion on A. Irving, "The Red Rock Series, etc." : Quart. Journ. Geol. Soc., vol. xliv (1888), p. 163.
5. Lydekker, R.—I. "Note on some Gondwana Vertebrates" : Rec. Geol. Surv. India, vol. xiv (1881), p. 177. II. "Indian Pretertiary Vertebrata" : Palæontologia Indica, ser. iv, vol. i (1885). III. "Catalogue of the Fossil Reptilia and Amphibia in the British Museum" ; London, 1888.
6. Zittel.—"Palaeozoologie," iii (1890).
7. Boulenger, G. A.—"On British Remains of *Homœosaurus*, with Remarks on the Classification of the Rhynchocephalia" : Proc. Zool. Soc., 1891, p. 167.
8. Newton, E. T.—"On some new Reptiles from the Elgin Sandstones" : Phil. Trans., vol. clxxxiv (1893) and vol. clxxxv (1894).
9. Woodward, A. Smith.—"Outlines of Vertebrate Palæontology," pp. 186–189 ; Cambridge, 1898.
10. Newton, E. T.—"On a remarkable Bone from the Chalk of Cuxton" : Proc. Geol. Assoc., vol. xvi (1900).
11. Fürbringer.—Tenaische Zeitschr. für Naturw., 1900.

II.—Notes on some Remains of *Cryptocleidus* from the Kellaways Rock of East Yorkshire.

By Thomas Sheppard, F.G.S.

On visiting Brough a short time ago I noticed a small section had been made on the western slope of Mill Hill, about twenty or thirty feet below the top. The excavation is made in soft white sand, which is very ferruginous in places. Beds of hard sandstone, varying in thickness from one to three inches, traverse it in the upper part of the section. These beds of sandstone are practically horizontal, and contain casts of *Belemnites Owenii*, *Gryphœa bilobata*, *Trigonia*, and other characteristic Kellaways Rock fossils. In not a single instance was a portion of a shell remaining, the whole of the calcite having been dissolved away. There is only a thin covering of soil ; and this contains numerous pebbles of doubtful origin, and some pieces of Roman pottery.

The excavated material is sent to Leeds, where it is used by an engineering firm for moulding.

On examining the pit I noticed a piece of very ferruginous material. It was of rather peculiar shape, however, and on picking up further pieces it became evident that they were small fragments of bone. They had been thrown on a heap on one side, and such bones as were found had to be picked from this heap ; consequently their exact horizon could not be determined. Subsequent visits were the means of finding still further specimens, chiefly whole and broken vertebræ, pieces of ribs, etc. On one of these occasions a vertebra was noticed protruding from the quarry face, at a depth of about seven feet; this was in close proximity to the heap from which the other remains had been obtained. This vertebra was extracted, and several others were found on the same level, fitting close together. These vertebræ were nearly circular, and were without the prominent processes which occurred on some of the earlier specimens found on the refuse heap. Evidently, therefore, this was the tail end of the animal, and unfortunately the most important remains had already been excavated and were not preserved. However, the find in the quarry face enables the exact horizon of the animal to be fixed, and there can be little doubt that the almost complete skeleton of a huge saurian had been buried, where it had rested undisturbed from the day it was deposited in Jurassic times. The disposition of the remains suggests quiet waters, and subsequent undisturbed conditions.

Below the remains the sand is much whiter and finer, and more resembles the pure white sand exposed in a section near Sancton church, a few miles away.

Having been informed that some time previously, when the bones were first excavated, a few of the larger specimens had been sent to Mr. W. Richardson, of South Cave, I called upon that gentleman and found that he possessed three very large paddle-bones, obviously from the same skeleton as my specimens; these he has been good to hand over to me.

A selection from the collection of bones has been sent to Mr. E. T. Newton, F.R.S., of H.M. Geological Survey, and he has kindly examined the specimens for me. Mr. Newton reports that they "belong to some animal allied to the *Plesiosaurus*, and probably to the one which has been named *Cryptocleidus*, but the broken condition of the specimens prevents a certain determination." Mr. Newton adds, "such reptiles are known from the Oxford Clay, but not from the Kellaways Rock," and in this opinion Mr. C. Fox-Strangways, who has recently completed a volume on the Jurassic Rocks of Yorkshire, concurs.

Twenty-five specimens were sent to Mr. Newton, and he has determined them as under:—

Nos. 1 & 2.	Parts of one paddle-bone, femur or humerus.
,, 3.	Part of another.
,, 4–10.	Pieces of above.
,, 11.	Piece of a jaw.
,, 12.	Paddle ossicles.
,, 13–21.	Portions of vertebræ.
,, 22–25.	Ribs.

No. 11 is very interesting, but unfortunately it is only the anterior half of the lower jaw, and does not contain any teeth.

In addition to the above there are some dozens of pieces of bone, principally vertebræ and ribs.

The condition of the remains is interesting. Being found in a soft sandy deposit they were easily extracted, a chisel not being required. There has been little labour, therefore, in freeing the bones from the matrix, an operation that would have been exceedingly difficult had they been in hard rock. It is no doubt due to the fact that the specimens are very ferruginous (some being almost like cast iron) that they are in such a good state of preservation.

Seeing that remains of *Cryptocleidus* have not previously been recorded from the Kellaways Rock, it would perhaps be as well if a word or two were said on the stratigraphical position of these particular specimens. The geology of Mill Hill is simple, and may be briefly stated as follows :—

FORMATIONS.	DESCRIPTION.	WHERE EXPOSED.
1. Superficial Gravels.	Loose waterworn gravel and sand.	In a quarry on the top of the hill.
2. Kellaways Rock.	Hard sandstone with fossils	In the quarry where the Saurian bones occurred.
3. Kellaways Sand.	Ferruginous sands.	
4. Great Oolite Clay or Sandy Oolite.	Sand and clay.	In a well-section lower down the hill.
5. Millepore Oolite.	Hard limestone with fossils.	At the base of the hill.

The fact that thin beds of sandstone, with well-known Kellaways Rock fossils, occur some six feet above the bed containing the remains, clearly indicates that the bones were found in what is known as the Kellaways Sands. These beds are well exposed in the railway cutting at South Cave, a short distance away, though of this section Mr. Fox-Strangways says,[1] "the beds [of the Great Oolite Clay] are so similar to the sands of the Kellaways Rock above that it is difficult to fix an exact horizon between them."

The question arises, does the lower part of the section on Mill Hill, in which the *Cryptocleidus* remains were found, belong to the Kellaways Sands or the Great Oolite Clay series? The beds of the Great Oolite Clay (sometimes called the 'Sandy Oolite') consist mostly of sands, clayey in parts.[2] This rock, however, occurs further down the hill. In a previous paper[3] I have described a well section that was being made in 1895, which was sunk in the Great Oolite Clay. It showed six feet of stiff blue clay, greatly mottled and stained with yellow, containing no fossils or stones. Below this was about three feet of yellow clay; the standing water prevented me from seeing further, but at one end of the heap of excavated material at the top of the well was a quantity of fine yellow sand, which had no doubt been taken from below the yellow clay. This section was some distance down the hill.

At the bottom of Mill Hill are some small exposures in the Millepore Oolite, whilst at the top I have frequently observed slabs of Kellaways Rock in the floor of the gravel-pit, hard masses of this rock evidently occurring in a few places towards the top of the hill. Taking all into consideration, therefore, there can be little doubt that the Saurian occurred in the Kellaways Sand, and the discovery of these relics of *Cryptocleidus* give that animal a much earlier and longer period of sojourn upon this earth than previous records, from the Oxford Clay, have warranted.

In searching for records of similar finds previously obtained from

[1] "The Geology of the Country between York and Hull": Geol. Survey Mem., 1886, p. 22.

[2] Loc. cit., p. 22.

[3] "Notes on *Elephas antiquus* and other remains from the Gravels at Elloughton, near Brough, East Yorkshire": Proc. Yorks. Geol. and Polyt. Soc., 1897, p. 222.

the Kellaways series, I noticed that Phillips, in his "Geology of Yorkshire,"[1] in a list of "Fossils from the Kellaways Rock," refers to a "coracoid bone? of a saurian animal," and this is the only record of any kind that I have been able to find. I thought it possible that the specimen referred to by Phillips might be in the York Museum. On communicating with Mr. Platnauer, the Curator, however, on the matter, he states—"Phillips' 'Undetermined Coracoid' from the Kellaways is not in our Museum. Indeed, our collections have no vertebrate remains from the Kellaways Rock at all."

It should be mentioned that whilst at Scarborough recently I noticed two lumps of hard ferruginous rock in the Museum grounds, the matrix and general appearance of which very much resembled that of the Kellaways Rock, which is exposed in several places in the neighbourhood. Each piece on its broken face exhibited the section of a huge bone, somewhat resembling the paddle-bones from Mill Hill, just described. A portion of an articular surface also protruded from one of the pieces. Of course it is possible that these two Scarborough blocks were found together in the Kellaways Rock, and it is not even improbable that they represent the specimens referred to by Phillips. In the absence of labels or other information, however, we are left in the dark on these points, but it seems desirable that the specimens should be recorded.

III.—Coal Plants. Incontrovertible Evidence of Growth *in situ.*

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

THE fossils to which this communication relates were described and the deductions drawn from their mode of occurrence in a paper I submitted to the Geological Society of London in 1896, but as that paper was not printed *in extenso* (see Q.J.G.S., vol. liii, p. 245), with the Editor's kind permission the gist of it appears as follows.

I am not aware that entirely satisfactory evidence showing that any of the coal-forming plants[2] grew exactly where they occur to-day as fossils, has as yet been produced. What authenticated cases of demonstrated growth-in-place coal-forming plants have been admitted by reliable or competent workers and teachers in this connection? While many instances of tree stumps with root-processes and other forms of vegetation more or less in contact with beds of coal have been cited in many countries, in no case do they seem to have contributed coal to the seam, or been found to be composed of but little else than material foreign to coal (stone, pyrites, clay, shale, etc.). Many trustworthy observers have pointed out the danger in taking it for granted that erect fossil stumps met

[1] 1829 edition, p. 142.

[2] The term 'coal-forming' used in this paper means entering more or less extensively into, or contributing, material of a coal-like aspect and chemical composition, practically the same as the coal-bed in which occurring, with which to help to pile up or add thickness to the seam.

with in or upon (very rarely *in*) a coal-bed grew where they now are; but if a case of growth in place in coal has been or can be established, notwithstanding the substance of the fossil is rock or shale, nobody will dispute that the tree or the plant, whatever it was, did contribute some coaly material to the coal-bed in which it flourished. Be this as it may, the object of this paper is to record the occurrence of forms or fossils composed of coal in actual contact with beds of coal, that unquestionably were plants that grew absolutely *in sitû*, and thus to establish the fact that some coal-seams, and typical ones too, are partly, at any rate, composed of vegetal remains that have lived and died exactly on the spots now occupied by them. I also want to make it quite evident that the forms to which special reference is here made grew under water.

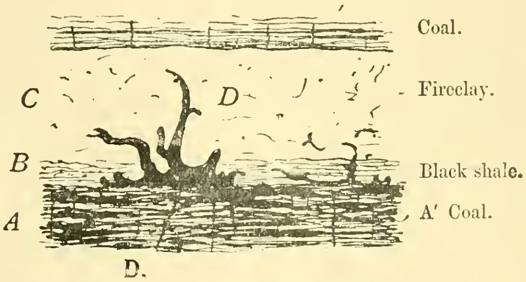


Fig. 1.—Section of Coal and Clay-slate.

The coal-seam A, Fig. 1 (the uppermost few inches of which appear), is about 6 feet thick: it is overlain by a layer of black, tough shale (called 'bone'), B, which is about 2 inches thick. Over this 'bone' comes 10 to 11 inches of mottled fireclay, C, and the clay is followed by strata of coal and shale for several feet. These alternations of Coal-measures (Carboniferous), with trifling local differences, obtain for a very large portion of the area of the seam, which is the 'Pittsburg' bed in S.W. Pennsylvania.

An examination of the horizon A–A′—the top of the seam of coal proper—reveals the phenomenon of the bright, brittle, pitch-like coal laminæ, sending out, or more properly, having developed, upward swellings, expansions, and horn-like processes D, not only into the black shale B, but also into the clay C, and in those two strata dividing, branching, curving, and expanding in a peculiar but uniformly characteristic manner. This phenomenon is a very common one; and since these coaly forms extend very much farther horizontally than vertically, and possess their limbs, lobes, expansions, branches, leaves, or whatever their parts or processes should be called, in ever varying shape, position, and trend, any section or exposure of them shows change and difference in form. In some places they appear in great profusion, in others are scattered or of less development and therefore less conspicuous. As to chemical composition and physical aspect, these strange meandering forms in the top of the coal-seam differ but little, if at all, from the black brittle laminæ lower down in the seam, where the forking and curving phenomena are very much less in evidence. Occasionally one notices suggestions of a core or centre in these fossils—a little clay or pyrites, for instance—but the majority of them are composed of compact, bright, brittle, apparently structureless coal. The exteriors, when the fossils enter the clay, are always filmed with clay, but seem quite devoid of markings—are very smooth. A noticeable feature of the terminals or extremities of the leaves or processes is a tendency to thicken or become slightly bulbous there. Complete pockets of clay are sometimes seen in them. When embedded in the coal-seam they cannot be separated from the matrix. The longest individual measured over 12 feet; the thickest part of any one, about 4 inches,—and all compact coal. Rarely one reaches to the base of the coal above the fireclay C; and here and there specimens seem wholly in the latter stratum. From an examination of a very large number of these forms, extending over many years of my professional work (that of a mining engineer), underground in coal-mines and in clay-mines, as well as in open-cast workings in coal and fireclay districts, my conclusion is that in *form* or *shape* these fossils resemble, more than anything else I know of, the fronds of the Elk-horn fern. Fish teeth, scales, etc., have been found in contact with these coaly forms.

Viewed or regarded as veins, or in a purely stratigraphical and physical light, wholly apart from botanical considerations, these forms or shapes of coaly material, since they intersect the beds B and C, would be regarded as having been formed there or placed there *since* those beds were deposited. But as those forms are presumed to be of vegetable origin, fossil plants or parts of plants which evidently contributed coal to the seams A–A′, two explanations of their origin are possible, viz.: (1) That they are the drifted and buried remnants of shrunk-up parts of trees, etc.; and (2) that they are plants which grew and died where they now are. If the former,

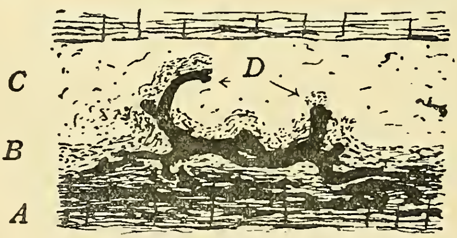


Fig. 2.

then they became buried before the coal A was fully accumulated, and therefore before B and before C were deposited; if the latter, then we ought to find some tangible proof of the fact in connection with them. That there is this proof is the burden of this paper—of my argument. When these forms or fossils are strongly in evidence and protrude stout processes up into the clay C, two things are noticeable: one is that the black shale or 'bone' bed is, as it were, ploughed up and overturned along the sides of the coaly intruders (see Fig. 2); and the other is that ruptured masses of the 'bone' are seen to lie upon the backs and tops of the more prominent expansions (see D, Fig. 2), making it perfectly plain that these plants, in pushing their way upwards, carried patches or strips of the layer B with them in the water (they must have been under water) or slime in which they were growing. I fail to see how one could wish for a more striking demonstration of expansive or upward growth of plants *absolutely in place of growth* than such as this figure is typical of. What other explanation, I ask, will be satisfactory?

But if we would attempt to account for this phenomenon by supposing the forms were in place before the bone layer was deposited, its deposition would have been a horizontal, even, or unbroken one, and the projecting (? woody) processes, such as D, Fig. 2, would have stood up through or been left bare of it, as suggested in Fig. 1. But we are not left to conjecture upon this point. Look at the conditions or the phenomenon sketched in Fig. 3,

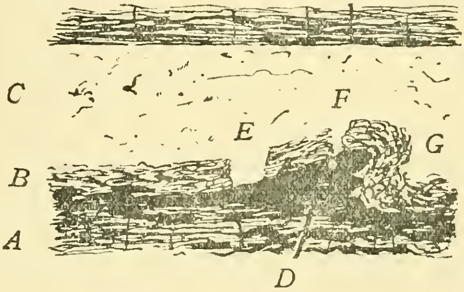


Fig. 3.

for clearly here we have one of these forms, D, actually arrested as it were in the act of rupturing the bone layer B. That that stratum was undergoing lateral stretching, amounting to tearing it asunder at E and F, as well as crumpling or thrusting it aside at G, when overwhelmed or when solidification took place, and that the cause of the rending and twisting was the lateral thrust from the extension towards G of the form, or coal-plant growth, D, is to my mind perfectly clear, admitting of no other explanation when taken in conjunction with the phenomena illustrated in Figs. 1 and 2, besides other facts to be noted.

Having these forms of coaly material interlaminated or interstratified with the body of the coal-seam in a descending direction, and inseparably connected stratigraphically and physically in the opposite direction with the beds immediately overlying the coal-seam, to draw a hard and fast line between the coal-bed and the clay above it is impossible. The conclusion, then, is, that growth *in sitû*, for *a part* at least, of the seam of coal, must be granted, even by those who would prefer what we call the 'drift theory.' Another point that seems to admit of no question is this: that since these coaly forms grew in place, that 'place' cannot have been other than under water, for the reason that the black slime, the stratum B, must have been an aquatic deposit: so that our 'coaly forms' were denizens of mud and presumably of water too.

Other facts may be cited in this connection. The underclay or 'seat earth' of the No. 2 coal-bed in Illinois—a seam far-reaching in extent and of wonderfully uniform thickness and character as regards floor, coal, and roof—in very many places is penetrated by 'coaly forms' possessing the same facies and characteristics as those we have been considering in the 'Pittsburg' seam. If the reader will look at Figs. 1, 2, and 3 upside down, and disregard the bed B, the general aspect of these forms, in vertical sections, will appear. In other words, they are *grown* to the coal-bed, and protrude twisty and horny sheets of compact bright coal in every variety of shape and direction into the underclay; thus making it evident that they were formed exactly where they are now, and that some of the laminations of the coal-bed also, as plants or parts of plants, lived and died in place of growth. The characteristic markings of *Stigmaria* have also been observed in this underclay, but so totally different are the two fossils or objects and their state of preservation, that to get confused in tracing them is impossible. Here, then, also we cannot escape the inference that these coaly forms were plants of aquatic habitat; and although admitting some shrinkage or reduction in bulk to have taken place during conversion from vegetal matter into brittle material resembling coal, it is evident that comparatively little shrinkage did obtain.

Besides the above localities that have produced this kind of coal-bed formation phenomena, the author has discovered very similar fossils in contact with three or four coal-beds in the Leicestershire and South Derbyshire Coalfield; in fact, it was in the mines in this district that they first attracted his attention.

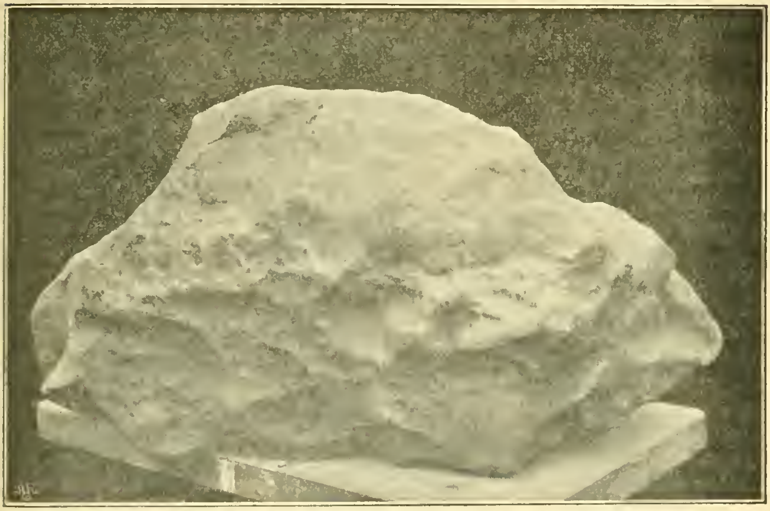
Doubtless similar forms exist in other regions, and the discovery and study of them will yet furnish valuable facts in this line. I am fully aware that if the palæobotanist and microscopist were to pass judgment on my observations and conclusions, they would say the case was 'not proven'; but my contention or claim is this: that no matter what the anatomy and internal organization of these forms was and may yet be found to show, the stratigraphical evidence is clearly pronounced, unmistakable, and altogether in favour of my contention. Further, I hold this: that *science* does not demand a demonstration—a knowledge—of the anatomical structure of an extinct plant or animal to prove or claim the existence or discovery of a new species or genus when *the shape or form* (cast or mould, etc.) of such make it evident that something new has turned up. But *time* will show whether or not I have come upon something new or important in this interesting question of coal-bed formation. If I have made my claim good, it is for those who may refuse to accept it to show that these fossils did not have the attributes and environment herein described or suggested.

IV.—A Greywether at South Kensington.

By H. B. Woodward, F.R.S.

In the Geological Magazine for March, 1891, p. 119, I drew attention to the occurrence of a large Greywether in Moscow Street, Bayswater. Another and smaller example has lately been discovered in the foundations for the new buildings of the Victoria and Albert Museum, South Kensington. The excavations show:

Made ground and soil, about 5 feet.
Gravel, full thickness about 20 feet.
London Clay with cement stones.



Greywether or Sarsen-stone from the Gravel. Victoria and Albert Museum, South Kensington. (One-twelfth natural size.)

The Greywether was found at the south-western part of the site, ten feet from the surface, and at a depth of five feet below the top of the undisturbed gravel. In size it is 3 ft. 10 in. by 3 ft. 3 in. and 2 ft., according to the greatest measurements, but the stone is somewhat irregular in shape and the bulk is less than these full measurements would indicate.[1] The stone is a somewhat coarse sandstone, with the grains more distinct than in many examples of Greywether or Sarsen-stone. One side is much smoothed and almost polished, as if by wind-drifted sand. The block may have been formed in the Bagshot Sand, and may have long remained on the surface of the land in Pre-Glacial times, a relic of Eocene strata the denudation of which took place partly during the Miocene and

[1] Mr. C. Barlow, Mason-Formatore in the Geological Department, estimates the cubic contents of the 'Sarsen-stone' at from 10 to 11 feet, and its weight from 13 cwt. to 14 cwt.

Pliocene periods. It may have been shifted and incorporated in glacial drift, and afterwards dislodged and transported by river-ice, and thus transferred to the wide-spreading gravels of the Thames Valley. It is, however, impossible to speak precisely of its past history. The fact of its occurrence is interesting, as Mr. Whitaker has remarked that such blocks "occur somewhat rarely in our River Gravel." An example fully three feet across was, however, noticed by Mr. J. Allen Brown at Alperton, in the Brent Valley, and other records have been published.[1]

The specimen to which attention is now directed was observed by Colonel C. K. Bushe, F.G.S., and he lost no time in securing it and in presenting it to the British Museum of Natural History, Cromwell Road, where it will be preserved and placed in the Garden on the eastern side near the Fossil Tree from Craigleith, Edinburgh, and not very far from the spot where it was discovered in the Gravel.

V.—Pleistocene Shells from the Raised Beach Deposits of the Red Sea.

By R. Bullen Newton, F.G.S., of the British Museum (Natural History).

(*Concluded from the November Number, p.* 514.)

(PLATES XX–XXII.)

Family CONIDÆ.

Conus flavidus, Lamarck.

Conus flavidus, Lamarck: Hist. Nat. Anim. sans Vert., vol. vii (1822), p. 468.

Distribution.—Red Sea, East Africa, Ceylon, Java, etc. (Tryon); Red Sea, Persian Gulf, East Africa, Polynesia, Fiji Islands, etc. (E. A. Smith). Coll. Geol. Surv. Egypt: raised beach 80 feet above sea, Camp 6, north of Wadi Gueh, west of Kosseir (Nos. 1,651, 1652, Box No. 79*j*).

Conus miliaris, Hwass.

Conus miliaris, Hwass.: Encyclop. Méthodique, 1792, vol. i (vers), p. 629.

Distribution.—Red Sea to Sandwich Islands (Tryon). Coll. Geol. Surv. Egypt: beach east of Gharib (Nos. 2,227–2,254, Box No. 17*j*).

Conus monachus, Linnæus.

Conus monachus, Linnæus: Systema Naturæ, 10th ed. (1758), p. 714.

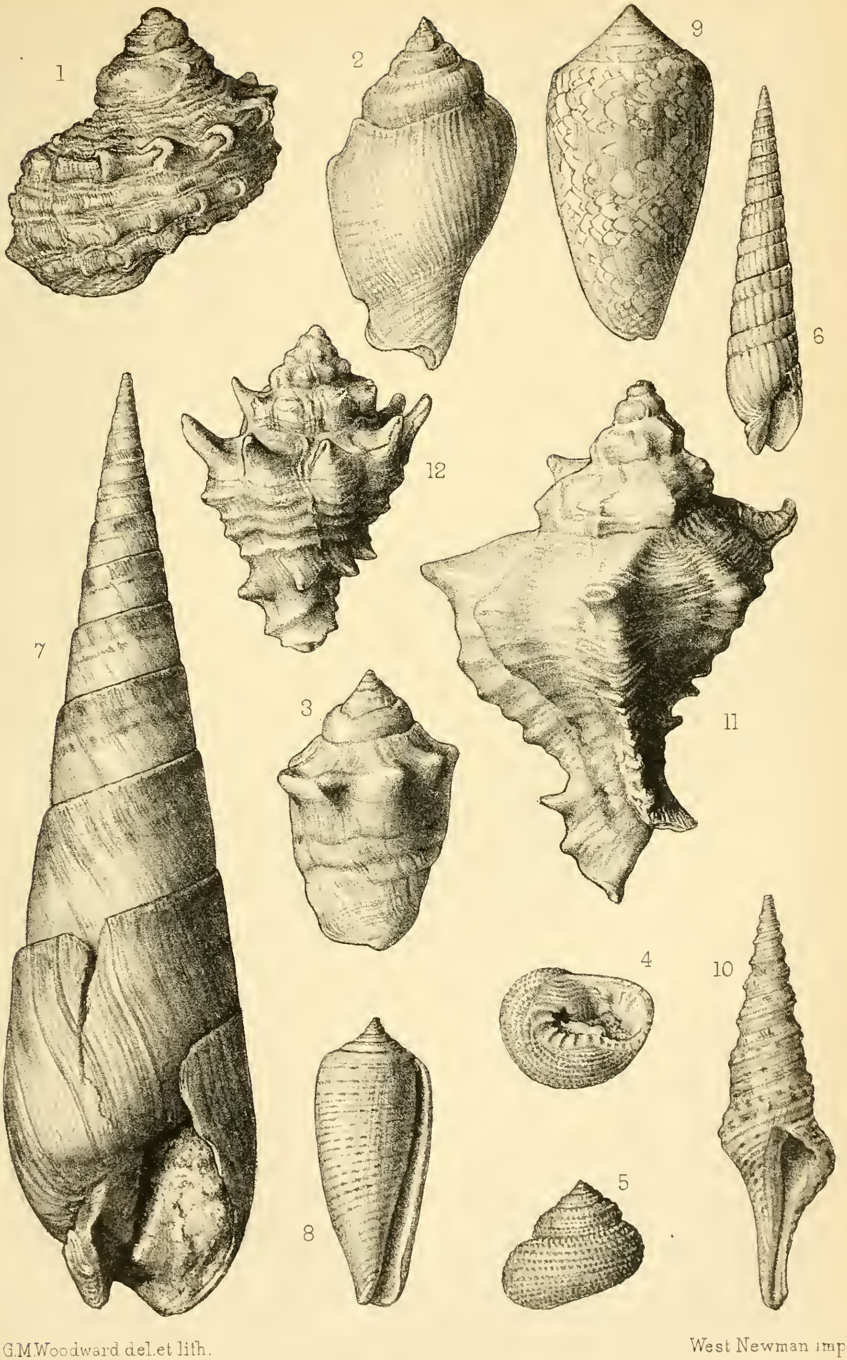
Distribution.—Philippines and New Caledonia (Tryon). Coll. Geol. Surv. Egypt: raised beach 80 feet above sea, Camp 6, north of Wadi Gueh, west of Kosseir (Nos. 1,651, 1,652, Box No. 79*j*); raised beach, Camp 6, Wadi Gueh (Nos. 1,591 and 1,567, Box No. 30*k*).

Conus nussatella, Linnæus. (Pl. XX, Fig. 8.)

Conus nussatella, Linnæus: Systema Naturæ, 10th ed. (1758), p. 716.

Distribution.—Beach deposits of Red Sea (Gray & Frembley, Issel); Red Sea to Polynesia (Tryon); Aden, Red Sea, East Africa, Ceylon, Java, Philippines, North Australia, Polynesia (E. A. Smith). Coll. Geol. Surv. Egypt: beach east of Gharib (Nos. 2,227–2,254,

[1] See Whitaker: "Geology of London," vol. i, pp. 330, 362, 449, etc.



G. M. Woodward del. et lith. West Newman imp.

Modern Shells from Red Sea Beach deposits.

Box No. 17*j*); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*); raised beach 80 feet above sea, Camp 6, north of Wadi Gueh, west of Kosseir (Nos. 1,653, 1,654, Box No. 80*j*); raised beach, Wadi Gueh, Camp 6 (Nos. 1,591 and 1,567, Box No. 30*k*).

Conus omaria, Hwass. (Pl. XX, Fig. 9.)

Conus omaria, Hwass.: Encyclop. Méthodique, 1792, vol. i (vers), p. 743 (= *pennaceus*, Born, *vide* Tryon).

Distribution.—Red Sea, Philippines (Tryon). Coll. Geol. Surv. Egypt: 50 foot beach, Gemsah (Nos. 2,031–2,057, Box No. 58*j*); raised beach, Camp 6, Wadi Gueh (Nos. 1,591 and 1,567, Box No. 30*k*).

Conus generalis, Linnæus.

Conus generalis, Linnæus: Systema Naturæ, 12th ed. (1767), vol. i, pt. 2, p. 1,166.

Distribution.—Beach deposits of the western shore of Red Sea (Gray & Frembley); Red Sea, Ceylon, East Africa, Philippines, New Caledonia (Tryon); Aden, Red Sea, Ceylon, East Africa, Philippines, etc. (E. A. Smith). Coll. Geol. Surv. Egypt: Ras Gharib (Barron).

Conus textile, Linnæus.

Conus textile, Linnæus: Systema Naturæ, 10th ed. (1758), p. 717.

Distribution.—Red Sea, Indian Ocean, Philippines, Polynesia, Aden (E. A. Smith); beach deposits, western borders of Red Sea (Gray & Frembley); Red Sea, Mauritius, Philippines, etc. (Tryon). Coll. Geol. Surv. Egypt: raised beach 80 feet above sea, Camp 5, Wadi Gueh (No. 1,608, Box No. 54*k*).

Conus tessellatus, Bruguière.

Conus tessellatus, Bruguière: Encyclop. Méthodique, 1792, pl. cccxxvi, fig. 7.

Distribution.—Beach deposits, western shores of Red Sea (Gray and Frembley); Gulf of Akaba and Red Sea beach deposits (Issel); Aden, Pidang, Sumatra (E. A. Smith); Red Sea (B.M.); Red Sea, Mauritius, Ceylon, Philippines, etc. (Tryon). Coll. Geol. Surv. Egypt: raised beach 80 feet above sea, Camp 5, Wadi Gueh (No. 1,608, Box No. 54*k*).

Conus virgo, var. emaciatus, Reeve.

Conus virgo, Linnæus: Systema Naturæ, 10th ed. (1758), p. 713.
Conus emaciatus, Reeve: Conchologia Iconica, 1849, Suppl., pl. v, fig. 248.

Distribution.—Philippines (B.M.); Java, Philippines, Australia, Polynesia (Tryon). Coll. Geol. Surv. Egypt: raised beach, Wadi Gueh, Camp 6 (Nos. 1,591 and 1,567, Box No. 30*k*).

Family BULLIDÆ.

Bulla ampulla, Linnæus.

Bulla ampulla, Linnæus: Systema Naturæ, 10th ed. (1758), p. 727.

Distribution.—Beach deposits western borders of Red Sea (Gray and Frembley); desert of Attaka, near Suez (Issel); Aden, Indian and Pacific Oceans (E. A. Smith). Coll. Geol. Surv. Egypt: Jebel Zeit (Barron); raised beach 20 feet above sea at Gharib lighthouse

(Nos. 2,058–2,098, Box No. 18*j*); beach against old island west of Camp 51, south of Gharib lighthouse (Nos. 2,021–2,030, Box No. 57*j*); raised beach 80 feet above sea, Camp 6, north of Wadi Gueh, west of Kosseir (Nos. 1,651, 1,652, Box No. 79*j*).

Class SCAPHOPODA.

Family DENTALIIDÆ.

Dentalium octogonum, Lamarck.

Dentalium octogonum, Lamarck: Hist. Nat. Anim. sans Vert., vol. v (1818), p. 344.

Distribution.—Red Sea and Persian Gulf, and Red Sea beach deposits (Issel). Coll. Geol. Surv. Egypt: Ras Gharib (Barron); raised beach 20 feet above sea, Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

Class LAMELLIBRANCHIATA.

Family ARCIDÆ.

Arca imbricata, Bruguière.

Arca imbricata, Bruguière: Encyclop. Méthodique, 1789, vol. i (vers), p. 98.

Distribution.—West Indies, Fernando Noronha, South Africa, Indian Ocean, Australia, Aden (E. A. Smith); Philippines, Zanzibar, etc. (B.M.). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*); 50 foot beach, Gemsah (Nos. 2,031–2,057, Box No. 58*j*); raised beach, Camp 6, Wadi Gueh (Nos. 1,562 and 1,564, Box No. 61*k*).

Arca rotundicostata, Reeve.

Arca rotundicostata, Reeve: Conchologia Iconica, vol. ii (1844), pl. vii, fig. 46.

Distribution. — Locality unknown (B.M.). Coll. Geol. Surv. Egypt: plain between Ras Gemsah and Jebel Zeit (No. 2,224, Box No. 12*j*).

Arca squamosa, Lamarck.

Arca squamosa, Lamarck: Hist. Nat. Anim. sans Vert., 1819, p. 45, vol. vi, pt. 1.

Distribution.—Suez, Australia (Issel). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

Anadara antiquata, Linnæus. (Pl. XXI, Fig. 6.)

Arca antiquata, Linnæus: Systema Naturæ, 10th ed. (1758), p. 694.

Distribution.—Beach deposits, western shore of Red Sea (Gray and Frembley); Australia, Indian Ocean, Mozambique (E. A. Smith). Coll. Geol. Surv. Egypt: Recent beach south of Gharib lighthouse (Nos. 2,198–2,216, Box No. 53*j*); raised beach 80 feet above sea, Camp 6, north of Wadi Gueh, west of Kosseir (No. 1,644, Box No. 74*j*); raised beach, Camp 6, Wadi Gueh (No. 1,601, Box No. 56*k*; Nos. 1,562 and 1,564, Box No. 61*k*).

Anadara radiata, Reeve.

Arca radiata, Reeve: Conchologia Iconica, vol. ii (1844), pl. vi, fig. 40 (=*scapha*, Issel, *non* Chemnitz).

Distribution.—Gulf of Akaba, Suez (Issel). Coll. Geol. Surv. Egypt: plain between Ras Gemsah and Jebel Zeit (No. 2,223, Box

No. 9*j*); young forms from raised beach east of Jebel Esh (Nos. 2,172–2,190, Box No. 64*j*); 50 foot beach, Gemsah (Nos. 2,031–2,057, Box No. 58*j*); beach No. 2, north-west of Camp 40, plain east of Jebel Mellaha, east of Red Sea Hills (No. 2,256, Box No. 26*h*); Ras Shokair, west coast of the Gulf of Suez, north-east of Camp 50 (No. 2,267, Box No. 37*h*).

Barbatia lima, Reeve.

Arca lima, Reeve: Conchologia Iconica, vol. ii (1844), pl. xv, fig. 101.

Distribution.—Philippine Islands, Cape York, Aden (E. A. Smith). Coll. Geol. Surv. Egypt: beach east of Gharib (Nos. 2,227–2,254, Box No. 17*j*); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*; Nos. 2,090–2,105, Box No. 20*j*); raised beach, Camp 6, Wadi Gueh (No. 1,601, Box No. 56*k*; Nos. 1,562 and 1,564, Box No. 61*k*).

Glycymeris[1] **pectunculus**, Linnæus. (Pl. XXI, Fig. 7.)

Arca pectunculus, Linnæus: Systema Naturæ, 10th ed. (1758), p. 695 (=*pectiniformis*, Lamarck).

Distribution.—Bengal, Suez Bay, Gulf of Akaba, Persian Gulf, Madagascar (E. A. Smith); beach deposits, western shore of Red Sea (Gray & Frembley, Issel); Gulf of Akaba, Suez Bay, Philippines (Issel). Coll. Geol. Surv. Egypt: beach east of Gharib (Nos. 2,227–2,254, Box No. 17*j*); Recent beach south of Gharib lighthouse (Nos. 2,198–2,216, Box No. 53*j*); 50 foot beach, Gemsah (No. 2,043, Box No. 63*j*); big bay south of Sherm, Sinai (No. 3.527, Box No. 44*l*); a young form from raised beach east of Jebel Esh (Nos. 2,172–2,190, Box No. 64*j*).

Family MYTILIDÆ.

Septifer bilocularis, Linnæus.

Mytilus bilocularis, Linnæus: Systema Naturæ, 10th ed. (1758), p. 705.

Distribution.—Africa, etc. (B.M.). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

Septifer excisus, Wiegmann.

Tichogonia excisa, Wiegmann: Archiv Naturgeschichte (Wiegmann), 1837, p. 49.

Distribution.—Beach deposits of the Red Sea (Issel); Aden, Madagascar, Mauritius, Mozambique, etc. (E. A. Smith). Coll. Geol. Surv. Egypt: beach east of Gharib (Nos. 2,227–2,254, Box No. 17*j*).

Volsella[2] **auriculata**, Krauss.

Modiola auriculata, Krauss: Die Südafrikanischen Mollusken, 1848, p. 20, pl. ii, fig. 4.

Distribution.—Aden, South and East Africa, Gulf of Suez (E. A. Smith); Red Sea (B.M.). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea, Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

[1] *Glycymeris*, Da Costa, 1778 = *Pectunculus*, Lamarck, 1799, and *Axinæa*, Poli, 1795.

[2] *Volsella*, Scopoli, 1777 = *Modiolus*, Lamarck, 1799.

Lithophaga Avitensis, Mayer-Eymar.

Lithodomus Avitensis, Mayer-Eymar, in Hörnes' "Foss. Moll. Tert.-Beck. Wien.": Abhandl. k.k. geol. Reichs., 1867, p. 354, pl. xlv, fig. 12.

This species is represented by some excellent casts showing ornamentation and form.

Distribution.—Miocene of Germany (Mayer-Eymar); Pliocene of Italy (Pantanelli, etc.). Coll. Geol. Surv. Egypt: Ras Shokhair, west coast of the Gulf of Suez, north-east of Camp 50 (No. 2,265, Box No. 35*h*); raised beach 380 feet above sea, near Camp 7, Wadi Shigeleh (No. 1,662, Box No. 64*k*).

Lithophaga Lessepsianus? Vaillant.

Savigny's Desc. de l'Egypte, 1817, pl. xi, fig. 3.
Lithophagus Lessepsianus, Vaillant: Journ. Conchyliologie, 1865, p. 115.

Represented by a cluster of young forms in coral crypts, resting on matrix, probably belonging to this species.

Distribution. — Gulf of Suez (Vaillant). Coll. Geol. Surv. Egypt: raised beach north of Kosseir (No. 2,111, Box No. 46*j*).

Lithophaga Lyellanus, Mayer-Eymar.

Lithodomus Lyellanus, Mayer-Eymar: in Hartung's "Geol. Beschr. Madeira," 1864, p. 218, pl. iv, fig. 23.

A species of less cylindrical shape than *L. Avitensis*, otherwise closely related; represented by casts only.

Distribution.—Tertiary: Madeira (Mayer-Eymar). Coll. Geol. Surv. Egypt: raised beach north of Kosseir (Nos. 2,121–2,138, Box No. 50*j*).

Family OSTREIDÆ.

Alectryonia cucullata? Born.

Ostrea cucullata, Born: Testacea Mus. Cæsarei Vindobonensis, 1780, p. 114, pl. vi, figs. 11, 12.

Represented by some young examples of a plicated oyster, which may probably belong to this species.

Distribution.—Red Sea, etc.; and in the later Tertiary formations of Italy, Algeria, Egypt, etc. Coll. Geol. Surv. Egypt: raised beach 20 feet above sea, Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*; Nos. 2,090–2,105, Box No. 20*j*).

Alectryonia crenulifera, G. B. Sowerby.

Ostrea crenulifera, G. B. Sowerby: Conchologia Iconica, vol. xviii (1871), pl. xxvii, fig. 67.

An example consisting of a single valve externally covered with several small Balani.

Distribution.—Red Sea (B.M. and G. B. Sowerby). Coll. Geol. Surv. Egypt: raised beach north of Kosseir (Nos. 2,121–2,138, Box No. 50*j*).

Alectryonia plicatula, Gmelin.

Ostrea plicatula, Gmelin: Systema Naturæ, 13th ed. (1790), p. 3,336.

Distribution. — Mediterranean, Atlantic and Indian Ocean; Miocene to Saharian of Italy, Egypt, etc. (Mayer-Eymar). Coll. Geol. Surv. Egypt: raised beach north of Kosseir; an adult specimen and some young forms (No. 2,109, Box No. 32*j*; Nos. 2,121–2,138, Box No. 50*j*).

Alectryonia, allied to crista-galli, Linnæus. (Pl. XXII, Figs. 5, 6.)

Mytilus crista-galli, Linnæus: Systema Naturæ, 10th ed. (1758), p. 704.

A short, deeply plicated form, ornamented with wide transverse lamellæ. Cardinal line horizontal, with a small central triangular ligamental area. There is only one specimen of this shell in the collection, both valves being in contact, one being rather fragmentary. It is, however, particularly well marked, and appears to be intermediate between *A. crista-galli* and *A. turbinata*, Lamarck (Hist. Nat. Anim. sans Vert., 1819, vol. vi, pt. 1, p. 212), both of which are Indian Ocean species and prominently plicated. This example is probably an extinct form.

Dimensions.—Height 45 mm., width about 40 mm.

Coll. Geol. Surv. Egypt: raised beach north of Kosseir (Nos. 2,121–2,138, Box No. 50*j*).

Alectryonia Virleti, Deshayes.

Ostrea Virleti, Deshayes: Expéd. Sci. Morée, vol. iii (1833), pt. 1 (Mollusques), pp. 122–124, pl. xxi, figs. 1–6.

This species is accompanied by casts of *Anadara radiata*, *Dosinia radiata*, *Lævicardium* like *oblongum*, etc.

Distribution.—Miocene of Morea (Deshayes); Armenia (Abich); Persia (Fuchs); Egypt (Fuchs, etc.); Pliocene of Italy (Gregorio, etc.). Coll. Geol. Surv. Egypt: plain east of Jebel Mellaha, low range east of Red Sea Hills (No. 2,255, Box No. 33*h*); beach No. 2, north-west of Camp 40, plain east of Jebel Mellaha, east of Red Sea Hills (No. 2,193, Box No. 30*h*); foothills of Jebel Dara, Wadi Dara (No. 2,261, Box No. 3*h*). The specimen from the last-mentioned locality consists of a fragmentary valve, and is therefore of doubtful determination.

Family PECTINIDÆ.

Pecten lividus, Lamarck.

Pecten lividus, Lamarck: Hist. Nat. Anim. sans Vert., vol. vi (1819), pt. 1, p. 178.

A fragment of this species partly encrusted with a small form of *Balanus*.

Distribution.—Red Sea, Mauritius, Aden (E. A. Smith); Red Sea (Issel). Coll. Geol. Surv. Egypt: raised beach north of Kosseir (Nos. 2,121–2,138, Box No. 50*j*).

Pecten Vasseli, Fuchs. (Pl. XXII, Figs. 7–9.)

Pecten Vasseli, Fuchs: Denksch. Math. nat. Cl. k. Ak. Wiss., vol. xxxviii (1877), p. 40, pl. ii, fig. 3.

Syn. *Pecten radula*, var. *subfossilis*, Fraas: Aus dem Orient, 1867, p. 189.

This species is distinct from all others, and is not known in existing seas. It is a rounded, shallow shell, characterized by possessing dichotomizing ribs, which, together with the intermediate grooves, are finely sculptured with almost microscopic, closely-set, transverse striations. In worn examples the striæ are scarcely evident on the ribs themselves. Dimensions of an adult lower valve: height 57, width 63, depth 15 mm.

Distribution. — Pleistocene deposits from near Kosseir (Fraas) and the Bitter Lakes (Fuchs). Coll. Geol. Surv. Egypt: raised beach north of Kosseir (Nos. 2,121–2,138, Box No. 50*j*); raised beach, Northern Wadi Gueh, Camp 6, 240 feet above sea (No. 1,636, Box No. 22*k*); upper coral terrace (*Pecten*-bed) between Nebk and Sherm, South-East Sinai (No. 3,540, Box No. 40*l*).

Chlamys Reissi, Bronn. (Pl. XXII, Fig. 10.)

Hinnites Reissi, Bronn: Reiss' "Santa Maria," in Neues Jahrb., 1862, p. 44, pl. i, fig. 18.

Pecten Reissi, Mayer-Eymar: in Hartung's "Geol. Besch. Madeira," etc., 1864, p. 227, pl. v, fig. 32.

Testa subæquivalvi rotundato-oblonga, compressa, costis radiantibus circiter 30, *inæqualibus, irregularibusque, rotundatis; squamulosis, sæpe binis; auriculis inæqualibus radiatis, antica majori, obliqua.* (Mayer-Eymar.)

The numerous elevated, rounded costæ, covered with close squamulose ornamentation, appear to be the distinguishing features of this shell. The structural characters are well displayed in the specimen figured, although the marginal line has been fractured in places, and a central breakage rather spoils its otherwise elegant appearance.

Dimensions.—Height 46, width 42 mm.

Distribution. — Modern limestone of the Azores and Madeira (Bronn, Mayer-Eymar, etc.) and near Kosseir (Fraas). Coll. Geol. Surv. Egypt: raised beach north of Kosseir (Nos. 2,121–2,138, Box No. 50*j*); raised beach east of Jebel Esh (Nos. 2,172–2,190, Box No. 64

Chlamys varia, Linnæus.

Ostrea varia, Linnæus: Systema Naturæ, 10th ed. (1758), p. 698.

Distribution.—Recent in the Mediterranean, etc.; Tertiary of Italy and other parts of Europe. Coll. Geol. Surv. Egypt: raised beach north of Kosseir (No. 2,111, Box No. 46*j*).

Chlamys (Gigantopecten) latissima, Brocchi.

Ostrea latissima, Brocchi: Conch. Foss. Subapennina, vol. ii (1814), p. 581.

The specimens are small and apparently very young forms.

Distribution. — Species extinct, and ranging from Miocene (Helvetian) to Pleistocene times (Mayer-Eymar, etc.). Coll. Geol. Surv. Egypt: raised beach east of Jebel Esh (Nos. 2,172–2,190, Box No. 64*j*); *Pecten*-bed, upper coral terrace between Nebk and Sherm, south-east of Sinai (No. 3,540, Box No. 40*l*).

Chlamys (Æquipecten) opercularis, Linnæus.

Ostrea opercularis, Linnæus: Systema Naturæ, 10th ed. (1758), p. 698.

A fragmentary specimen, exhibiting the usual structure of this species, associated with *Pecten Vasseli* of Fuchs.

Distribution.—Recent in the Mediterranean and other European seas, and ranging from Miocene (Helvetian) to Pleistocene times (Mayer-Eymar, etc.). Coll. Geol. Surv. Egypt: raised beach, Northern Wadi Gueh, Camp 6, 240 feet above sea (No. 1,636, Box No. 22*k*).

Family SPONDYLIDÆ.

Spondylus aculeatus, Chemnitz.

Spondylus aculeatus, Chemnitz: Conchylien-Cabinet, vol. vii (1784), p. 74, pl. xliv, fig. 460.

Distribution.—Beach deposits, Red Sea (Issel); Suez Bay, Gulf of Akaba (Issel). Coll. Geol. Surv. Egypt: 50 foot beach at Gemsah (Nos. 2,034–2,036, Box No. 61*j*); Recent beach west of Jebel Zeit (No. 2,157, Box No. 72*j*).

Spondylus, sp. indet. (A fragmentary valve.)

Distribution.—Coll. Geol. Surv. Egypt: 50 foot beach at Gemsah (No. 2,038, Box No. 62*j*).

Plicatula ramosa, Lamarck.

Plicatula ramosa, Lamarck: Hist. Nat. Anim. sans Vert., vol. vi (1819), pt. 1, p. 184.

Distribution. — Beach deposits of the Red Sea (Issel); Enruk Katah el Kebir and desert of Attaka, etc. (Issel). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*; Nos. 2,090–2,105, Box No. 20*j*); Recent beach south of Gharib lighthouse (Nos. 2,198–2,216, Box No. 53*j*); beach against old island west of Camp 51, south of Gharib lighthouse (Nos. 2,021–2,030, Box No. 57*j*).

Mantellum (allied to) inflatum, Chemnitz. (Impression of valve in matrix.)

Lima inflata, Chemnitz: Conchylien-Cabinet, vol. vii (1784), pl. lxviii, fig. 649.

Distribution.—Coll. Geol. Surv. Egypt: raised beach north of Kosseir (No. 2,151, Box No. 33*j*).

Family CARDITIDÆ.

Cardita calyculata, Linnæus.

Chama calyculata, Linnæus: Systema Naturæ, 10th ed. (1758), p. 692.

Distribution.—Beach deposits western border of Red Sea (Gray and Frembley). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

Cardita (Beguina) gubernaculum, Reeve.

Cardita gubernaculum, Reeve: Conchologia Iconica, vol. i (1843), pl. ii, fig. 9.

Distribution. — Beach deposits of Red Sea (Issel, Gray & Frembley); Red Sea (Issel); Aden, Zanzibar, and Madagascar (E. A. Smith). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*; Nos. 2,090–2,105, Box No. 20*j*); 50 foot beach at Gemsah (Nos. 2,031–2,057, Box No. 58*j*); young form from raised beach east of Jebel Esh (Nos. 2,172–2,190, Box No. 64*j*).

Venericardia Cumingi, Deshayes.

Cardita Cumingi, Deshayes: Proc. Zool. Soc. London, 1852, p. 102, pl. xvii, fig. 15.

Distribution.—Aden (B.M.); Aden and Borneo (E. A. Smith). Coll. Geol. Surv. Egypt: 50 foot beach at Gemsah (Nos. 2,031–2,057, Box No. 58*j*).

Family ARCTICIDÆ (=CYPRINIDÆ).

Libitina oblonga, Linnæus.

Chama oblonga, Linnæus: Systema Naturæ, 10th ed. (1758), p. 692 (=*Guinaica*, Lamarck).

Distribution.—Beach deposits of the Red Sea (Issel); Andaman Islands and Polynesia (B.M.). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,090–2,105, Box No. 20*j*); raised beach 80 feet above sea, Camp 6, north of Wadi Gueh, west of Kosseir (Nos. 1,646, 1,647, Box No. 76*j*).

Family LUCINIDÆ.

Loripes globosa, Forskal.

Venus globosa, Forskal: Desc. Animalium, 1775, No. 53, p. 122.

Distribution.—Beach deposits western border of Red Sea (Gray and Frembley); Gulfs of Akaba and Suez (Issel); Red Sea (B.M.). Coll. Geol. Surv. Egypt: beach east of Gharib (Nos. 2,227–2,254, Box No. 17*j*).

Codakia exasperata, Reeve. (Pl. XXI, Fig. 4.)

Lucina exasperata, Reeve: Conchologia Iconica, vol. vi (1850), pl. i, fig. 4.

Distribution.—Honduras (Reeve—this locality is doubted by Mr. E. A. Smith); North Australia, Aden, Red Sea, etc. (E. A. Smith). Coll. Geol. Surv. Egypt: beach east of Gharib (Nos. 2,227–2,254, Box No. 17*j*); raised beach 80 feet above sea, Camp 6, Wadi Gueh (No. 1,645, Box No. 57*h*; No. 1,584, Box No. 23*k*; No. 1,557, Box No. 25*k*); raised beach, Camp 6, Wadi Gueh (No. 1,574, etc., Box No. 62*k*); raised beach north of Kosseir (No. 2,130, Box No. 45*j*; No. 2,111, Box No. 46*j*; Nos. 2,121–2138, Box No. 50*j*); raised beach 300 feet above sea, Camp 5, Wadi Hamrawen (No. 1,553, Box No. 18*k*).

Codakia fibula, Reeve.

Lucina fibula, Reeve: Conchologia Iconica, vol. vi (1850), pl. vii, fig. 33.

Distribution. — Red Sea (B.M.). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea, Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*); raised beach 80 feet above sea, Camp 6, Wadi Gueh (No. 1,557, Box No. 25*k*).

Family TELLINIDÆ.

Tellina remies, Linnæus.

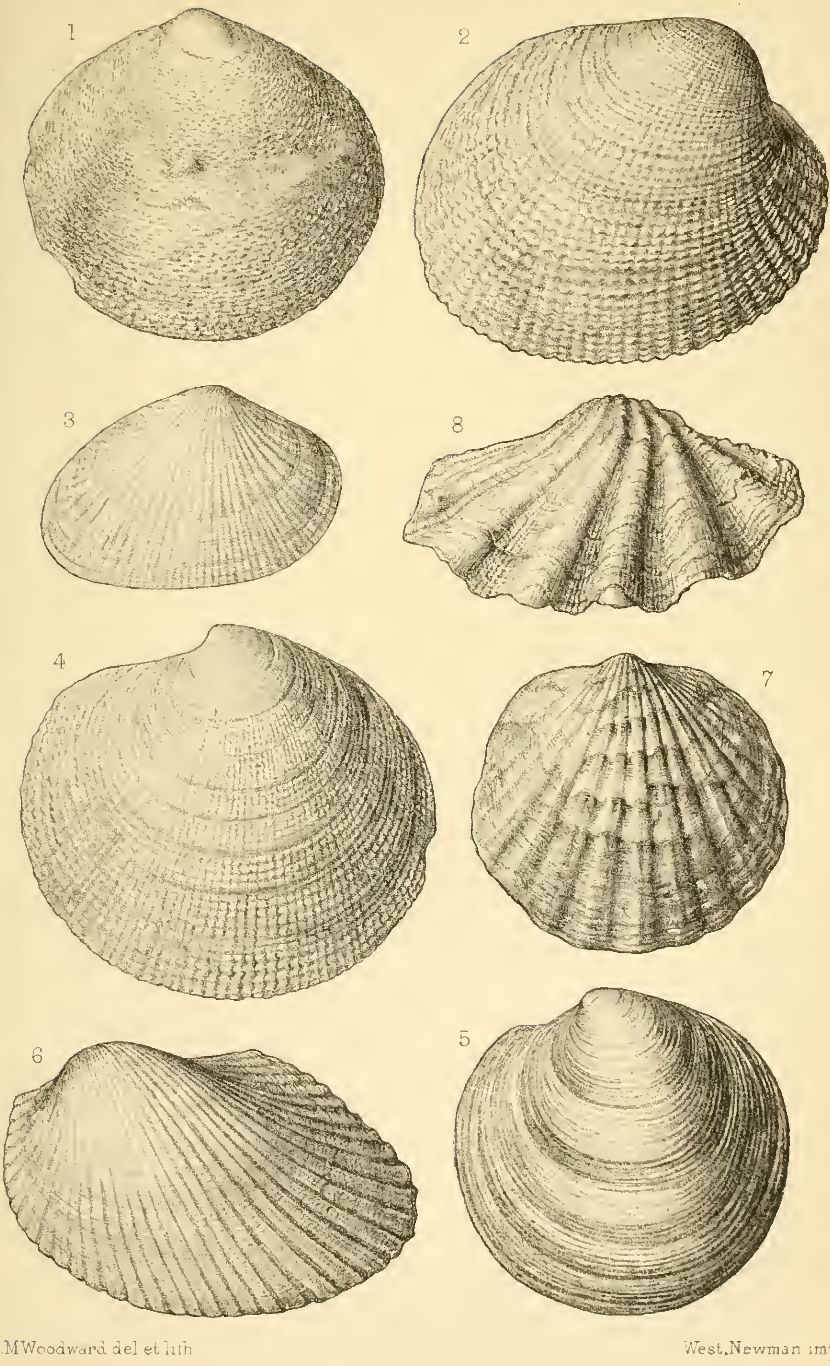
Tellina remies, Linnæus: Systema Naturæ, 10th ed. (1758), p. 676.

Distribution. — Australia (B.M.). Coll. Geol. Surv. Egypt: raised beach 80 feet above sea, Camp 6, north of Wadi Gueh, west of Kosseir (No. 1,645, Box No. 75*j*).

Tellina rugosa, Born.

Tellina rugosa, Born: Testacea Mus. Cæsarei Vindobonensis, 1780, pl. ii, figs. 3, 4.

Distribution.—Beach deposits on the western shore of Red Sea (Gray & Frembley); New Caledonia, etc. (B.M.). Coll. Geol. Surv. Egypt: raised beach 80 feet above sea, Camp 6, north of Wadi Gueh, west of Kosseir (Nos. 1,646, 1,647, Box No. 76*j*); raised



G.M Woodward del et lith West, Newman imp

Modern Shells from Red Sea Beach deposits.

beach, Camp 6, Wadi Gueh (No. 1,600, Box No. 57*k*; Nos. 1,574, etc., Box No. 62*k*).

Tellina (Tellinella) sulcata, Wood.

Tellina sulcata, W. Wood: General Conchology, 1815, p. 178, pl. xlvii, fig. 1.

Distribution.—Red Sea, Aden, Philippines (E. A. Smith). Coll. Geol. Surv. Egypt: raised beach, Camp 6, Wadi Gueh (Nos. 1,574, etc., Box No. 62*k*).

Eutellina (Peronea = Psammotella) rosea, Gmelin.

Tellina rosea, Gmelin: Systema Naturæ, 13th ed. (1790), p. 3,238.

Distribution. — Red Sea (B.M.). Coll. Geol. Surv. Egypt: Recent beach south of Gharib lighthouse (Nos. 2,198–2,216, Box No. 53*j*); 50 foot beach at Gemsah (Nos. 2,031–2,057, Box No. 58*j*); an abnormal form from beach east of Gharib (Nos. 2,227–2,254, Box No. 17*j*).

Arcopagia scobinata, Linnæus. (Pl. XXI, Fig. 1.)

Tellina scobinata, Linnæus: Systema Naturæ, 10th ed. (1758), p. 678.

Distribution.—Isle of Réunion; Gulf of Akaba (Issel). Coll. Geol. Surv. Egypt: raised beach 80 feet above sea, Camp 6, Wadi Gueh (No. 1,584, Box No. 23*k*).

Family DONACIDÆ.

Donax trifasciatus, Reeve.

Donax trifasciatus, Reeve: Conchologia Iconica, vol. viii (1854), pl. ii, fig. 7.

Distribution.—Philippines (B.M.). Coll. Geol. Surv. Egypt: beach against old island west of Camp 51, south of Gharib lighthouse (Nos. 2,021–2,030, Box No. 57*j*).

Family MACTRIDÆ.

Mactra olorina, Philippi.

Mactra olorina, Philippi: Abbild. und Besch. Conchylien, vol. ii (1847), p. 72, pl. ii, fig. 2.

Distribution.—Gulf of Suez and in the Red Sea beach deposits (Issel). Coll. Geol. Surv. Egypt: Recent beach south of Gharib lighthouse (Nos. 2,198–2,216, Box No. 53*j*).

Family VENERIDÆ.

Venus reticulata, Linnæus. (Pl. XXI, Fig. 2.)

Venus reticulata, Linnæus: Systema Naturæ, 10th ed. (1758), p. 687.

Distribution. — Red Sea beach deposits (Gray & Frembley); Gulf of Akaba, Madagascar, Philippines, Society Islands, and the Red Sea beach deposits (Issel); Red Sea, Aden, Persian Gulf, Indian Ocean, etc. (E. A. Smith). Coll. Geol. Surv. Egypt: raised beach 80 feet above sea, Camp 6, north of Wadi Gueh (No. 1,648, Box Nos. 3*j* and 77*j*; No. 1,563, Box No. 26*k*); Recent beach between Jebel Mellaha and Jebel Zeit (No. 2,168, Box No. 6*j*); raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,090–2,105, Box No. 20*j*); raised beach No. 2, west of Kosseir, 520 feet above sea (No. 1,579, Box No. 13*k*); raised beach 300 feet above sea, Camp 5, Wadi Hamrawen (No. 1,553, Box No. 18*k*); raised beach, hill north-west of Camp 7, Wadi Abu Shigeleh, 560 feet above sea (No. 1,627, Box No. 19*k*).

Chione costellifera, Adams & Reeve.

Venus costellifera, Adams & Reeve: Zool. Voy. "Samarang," 1848, p. 79, pl. xxi, fig. 18.

Distribution—Philippines (B.M.). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

Callista florida, Lamarck.

Venus florida, Lamarck: Hist. Nat. Anim. sans Vert., vol. v (1818), p. 602.

Distribution. — Suez, Madagascar, Mozambique, Pacific Ocean, New Holland, and Red Sea beach deposits (Issel); Red Sea, Aden, Persian Gulf, Mozambique, Madagascar, Seychelles (E. A. Smith). Coll. Geol. Surv. Egypt: Recent beach south of Gharib lighthouse (Nos. 2,198–2,216, Box No. 53*j*).

Callista (like) **costata**, Chemnitz.

Venus costata, Chemnitz: Conchylien-Cabinet, vol. xi (1795), p. 226, pl. ccii, fig. 1,975.

Distribution. — Philippines (B.M.). Coll. Geol. Surv. Egypt: raised beach north of Kosseir (No. 2,111, Box No. 46*j*); beach No. 2, north-west of Camp 40, plain east of Jebel Mellaha, east of Red Sea Hills (No. 2,258, Box No. 29*h*).

Circe æquivoca, Chemnitz.

Venus æquivoca, Chemnitz: Conchylien-Cabinet, vol. xi (1795), p. 229, pl. ccii, fig. 1,980.

Distribution.—Philippines (B.M.). Coll. Geol. Surv. Egypt: raised beach 80 feet above sea, Camp 6, Wadi Gueh (No. 1,557, Box No. 25*k*).

Circe corrugata, Chemnitz.

Venus corrugata plana, Chemnitz: Conchylien-Cabinet, vol. vii (1784), p. 25, pl. xxxix, figs. 410, 411.

Distribution.—Suez (Issel); Red Sea, Persian Gulf, Aden, Madagascar, New Holland (E. A. Smith). Coll. Geol. Surv. Egypt: raised beach 80 feet above sea, Camp 6, Wadi Gueh (No. 1,557, Box No. 25*k*).

Circe callipygia, Born.

Venus callipygia, Born: Testacea Mus. Cæsarei Vindobonensis, 1780, p. 68, pl. v, fig. 1.

Distribution.—Gulf of Akaba, Red Sea, and beach deposits of Red Sea (Issel); Red Sea and Aden (E. A. Smith). Coll. Geol. Surv. Egypt: raised beach east of Jebel Esh (Nos. 2,172–2,190, Box No. 64*j*).

Circe (Lioconcha) lentiginosa, Chemnitz.

Venus lentiginosa, Chemnitz: Conchylien-Cabinet, vol. xi (1795), p. 223, pl. cci, figs. 1,963, 1,964.

Distribution.—Red Sea and beach deposits of Red Sea (Issel); Red Sea and Madagascar (B.M.). Coll. Geol. Surv. Egypt: Recent beach south of Gharib lighthouse (Nos. 2,198–2,216, Box No. 53*j*); beach against old island west of Camp 51, south of Gharib lighthouse

(Nos. 2,021–2,030, Box No. 57*j*); raised beach 80 feet above sea, Camp 6, Wadi Gueh (No. 1,610, Box No. 27*k*).

Circe (Crista) pectinata, Linnæus. (Pl. XXI, Fig. 3.)

Venus pectinata, Linnæus: Systema Naturæ, 10th ed. (1758), p. 689 (= *Cytherea Savignyi*, Jonas).

Distribution.—Suez and Red Sea beach deposits (Issel); Red Sea, Indian Ocean, Aden, Moluccas, etc. (E. A. Smith). Coll. Geol. Surv. Egypt: plain between Ras Gemsah and Jebel Zeit (No. 2,224, Box No. 12*j*); beach east of Gharib (Nos. 2,227–2,254, Box No. 17*j*); Recent beach between Jebel Mellaha and Jebel Zeit (Nos. 2,162–2,167, Box No. 21*j*); Recent beach south of Gharib lighthouse (Nos. 2,198–2,216, Box No. 53*j*); beach against old island west of Camp 51, south of Gharib lighthouse (Nos. 2,021–2,030, Box No. 57*j*); raised beach east of Jebel Esh (Nos. 2,172–2,190, Box No. 64*j*).

Tapes virgineus, Linnæus.

Venus virginea, Linnæus: Systema Naturæ, 12th ed. (1767), vol. i, pt. 2, p. 1,136.

Distribution.—Aden, New Holland, China Sea (E. A. Smith). Coll. Geol. Surv. Egypt: Recent beach south of Gharib lighthouse (Nos. 2,198–2,216, Box No. 53*j*).

Sunetta effossus, Hanley.

Cytherea effossa, Hanley: Proc. Zool. Soc. London, 1842, p. 123.

Distribution.—Philippines (B.M.). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

Dosinia laminata, Reeve.

Artemis laminata, Reeve: Conchologia Iconica, vol. vi (1850), pl. vii, fig. 41.

Distribution.—Philippines (B.M.). Coll. Geol. Surv. Egypt: 50 foot beach at Gemsah (Nos. 2,031–2,057, Box No. 58*j*); raised beach east of Jebel Esh (Nos. 2,172–2,194, Box No. 64*j*).

Dosinia radiata, Reeve. (Pl. XXI, Fig. 5.)

Artemis radiata, Reeve: Conchologia Iconica, vol. vi (1850), pl. vii, fig. 37.

Distribution.—Bay of Suez (Issel). Coll. Geol. Surv. Egypt: plain between Ras Gemsah and Jebel Zeit (No. 2,222, Box No. 8*j*); Recent beach south of Gharib lighthouse (Nos. 2,198–2,216, Box No. 53*j*); raised beach east of Jebel Esh (Nos. 2,172–2,190, Box No. 64*j*); raised beach 300 feet above sea, Camp 5, Wadi Hamrawen (No. 1,553, Box No. 18*k*); beach No. 2, north-west of Camp 40, plain east of Jebel Mellaha, east of Red Sea Hills (No. 2,257, Box No. 29*h*).

Family CARDIIDÆ.

Cardium leucostoma, Born.

Cardium leucostoma, Born: Testacea Mus. Cæsarei Vindobonensis, 1780, pl. iii, figs. 6, 7.

Distribution.—Indian Ocean (B.M.). Coll. Geol. Surv. Egypt: Recent beach south of Gharib lighthouse (No. 2,198–2,216, Box No. 53*j*); a cast allied to this species from beach No. 2, north-west of Camp 40, plain east of Jebel Mellaha, east of Red Sea Hills

(No. 2,257, Box No. 27*h*); cast of probably this species from raised beach, hill north-west of Camp 7, Wadi Abu Shigeleh, 560 feet above sea (No. 1,627, Box No. 19*k*).

Cardium rubicundum, Reeve.

Cardium rubicundum, Reeve: Conchologia Iconica, vol. ii (1844), pl. ix, fig. 44 (= *C. magnum*, Chemnitz, *vide* Issel).

Distribution. — Gulf of Suez (Issel); Aden, Zanzibar (E. A. Smith). Coll. Geol. Surv. Egypt: raised beach east of Jebel Esh (Nos. 2,172–2,190, Box No. 64*j*).

Lævicardium (like) **oblongum**, Gmelin.

Cardium oblongum, Gmelin: Systema Naturæ, vol. i (1790), pt. 6, p. 3,254.

Distribution. — Mediterranean (Gmelin). Coll. Geol. Surv. Egypt: beach No. 2, north-west of Camp 40, plain east of Jebel Mellaha, east of Red Sea Hills (No. 2,258, Box No. 29*h*).

Hemicardium (Opisocardium) auriculum, Forskal.

Cardium auriculum, Forskal: Desc. Animalium, 1775, No. 52, p. 122.

Distribution.—Gulf of Akaba, Bay of Suez, and beach deposits of the Red Sea (Issel). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,090–2,105, Box No. 20*j*); Recent beach west of Jebel Zeit (No. 2,157, Box No. 72*j*).

Family TRIDACNIDÆ.

Tridacna gigas, Linnæus. (Young forms.) (Pl. XXI, Fig. 8.)

Tridacna gigas, Linnæus: Systema Naturæ, 10th ed. (1758), p. 691.

Distribution.—Beach deposits near Kosseir (Fraas, B.M.). Coll. Geol. Surv. Egypt: Recent beach between Jebel Mellaha and Jebel Zeit (No. 2,161, Box No. 7*j*); Recent beach south of Gharib lighthouse (Nos. 2,198–2,216, Box No. 53*j*).

Family CHAMIDÆ.

Chama cornucopiæ, Reeve.

Chama cornucopia, Reeve: Conchologia Iconica, vol. iv (1846), pl. iv, fig. 22 (= *C. Corbierei*, Jonas, *vide* Issel).

Distribution.—Beach deposits of the Red Sea (Issel); Gulf of Akaba and Suez (Issel); Red Sea (B.M.). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,090–2,105, Box No. 20*j*); Recent beach south of Gharib lighthouse (Nos. 2,198–2,216, Box No. 53*j*).

Chama Jukesi, Reeve.

Chama Jukesi, Reeve: Conchologia Iconica, vol. iv (1847), pl. vii, fig. 39.

Distribution.—Isle of Luzon, Philippines (B.M.). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,058–2,098, Box No. 18*j*).

Chama nivalis, Reeve.

Chama nivalis, Reeve: Conchologia Iconica, vol. iv (1846), pl. iv, fig. 17.

Distribution. — Australia (B.M.). Coll. Geol. Surv. Egypt: beach east of Gharib (Nos. 2,227–2,254, Box No. 17*j*); Recent beach south of Gharib lighthouse (Nos. 2,198–2,216, Box No. 53*j*); 50 foot beach at Gemsah (No. 2,038, Box No. 62*j*); raised beach east of Jebel Esh (Nos. 2,172–2,190, Box No. 64*j*; No. 2,179, Box No. 66*j*); raised beach 80 feet above sea, Camp 6, north of Wadi Gueh, west of Kosseir (Nos. 1,655–1,657, Box No. 81*j*); raised beach No. 2, west of Kosseir, 520 feet above sea (No. 1,581, Box No. 16*k*).

Family GARIDÆ (=PSAMMOBIIDÆ).

Asaphis deflorata, Linnæus.

Venus deflorata, Linnæus: Systema Naturæ, 10th ed. (1758), p. 687.

Distribution. — Red Sea, Indian and Pacific Oceans, Aden (E. A. Smith). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,090–2,105, Box No. 20*j*).

Family MYIDÆ.

Lutraria intermedia (Deshayes MS.), Reeve.

Mesodesma intermedia, Reeve: Conchologia Iconica, vol. viii (1854), pl. iii, fig. 17.

Distribution. — Zanzibar (B.M.). Coll. Geol. Surv. Egypt: Recent beach south of Gharib lighthouse (Nos. 2,198–2,216, Box No. 53*j*); 50 foot beach at Gemsah (No. 2,031, Box No. 59*j*).

Corbula cuneata, Hinds.

Corbula cuneata, Hinds: Proc. Zool. Soc. London, 1843, p. 55.

Distribution.—Philippines (B.M.). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,090–2,105, Box No. 20*j*).

Corbula Taheitensis, Lamarck.

Corbula Taheitensis, Lamarck: Hist. Nat. Anim. sans Vert., vol. v (1818), p. 496.

Distribution.—Tahiti, New Guinea, Philippines, Aden (E. A. Smith). Coll. Geol. Surv. Egypt: raised beach 20 feet above sea at Gharib lighthouse (Nos. 2,090–2,105, Box No. 20*j*); Ras Shokhair, west coast of the Gulf of Suez, north-east of Camp 50 (No. 2,267, Box No. 37*h*).

Family PHOLADIDÆ.

Martesia, sp.

Distribution.—Coll. Geol. Surv. Egypt: Ras Shokhair, west coast of the Gulf of Suez, north-east of Camp 50 (No. 2,269, Box No. 39*h*).

LITERATURE.

Several papers have been written on the conchological fauna of the beach deposits of the Red Sea and other parts of Egypt, but as the subject is so interwoven with the history of the actual living forms of the Red Sea, the following list of titles is compiled so as to include the more important contributions dealing with both aspects of the subject.

Beyrich, E.—"Ueber geognostische Beobachtungen G. Schweinfurth's in der Wüste zwischen Cairo und Sueš": Sitz. Akad. Wiss. Berlin, 1882, pp. 163–178.

Brocchi, G. B.—"Catalogo di una serie di conchiglie raccolte presso la costa Africana del Golfo Arabico dal signor G. Forni": Mem. inserita nella Biblioteca Italiano [about] 1820. (A rare work not seen by present writer; it is reviewed and abstracted in Issel's "Malacologia del Mar Rosso.")

Caramagna, G.—"Catalogo delle Conchiglie Assabesi" (=Southern Red Sea): Bull. Soc. Mal. Italiana, vol. xiii (1888), pp. 131–141, pl. viii.

Caramagna, G.—"Conchiglie raccolte in Aden Berbera e Zeila": Bull. Soc. Mal. Italiana, vol. xiii (1888), pp. 142–148.

Cooke, A. H.—"On the Molluscan Fauna of the Gulf of Suez in its relation to that of other seas": Ann. Mag. Nat. Hist., ser. v, vol. xviii (1886), pp. 380–397.

Fischer, P.—"Note sur les Faunes Conchyliologiques des deux rivages de l'Isthme de Suez": Journ. Conchyliologie, 1865, pp. 241–248.

——— "Sur la Faune Conchyliologique marine des Baies de Suez et de l'Akabah": Journ. Conchyliologie, 1870, pp. 161–179. (This paper includes a list of the species found in the Quaternary deposits surrounding the Bitter Lakes.)

——— "Sur la Faune Conchyliologique marine de la Baie de Suez": Journ. Conchyliologie, 1871, pp. 209–218.

Fraas, Oscar.—"Aus dem Orient. Geologische Beobachtungen am Nil, auf der Sinai-Halbinsel, und in Syrien," 1867, pp. 174–195. (Gives a list of species found in the raised beaches near Kosseir and Sinai.)

Fuchs, Theodor.—"Die Geologische Beschaffenheit der Landenge von Suez": Denksch. k. Akad. Wiss. (Wien), vol. xxxviii (1877), pt. 2, pp. 25–42, pls. i–iii (figures of Pleistocene shells and geological map of district).

Gray, J. E., & Frembley.—"Fossil Shells from the Western Borders of the Red Sea": in Lyell's "Principles of Geology," 1st ed., vol. iii (1833), appendix 2, p. 57. (This appears to be the earliest published list of molluscan remains from the Red Sea deposits.)

Issel, A.—"Considerazioni generali sulla Fauna Malacologia del Mar Rosso e suoi rapporti colle Faune limitrose": in Issel's "Malacologia del Mar Rosso," 1869, pp. 3–45.

——— "Conchiglie fossili delle spiagge emerse": in Issel's "Malacologia del Mar Rosso," 1869, pp. 17–28.

——— "Catalogo dei Molluschi raccolti nel Mar Rosso": in Issel's "Malacologia del Mar Rosso," 1869, pp. 49–242, 379–387.

——— "Spiegazione delle Tavole di Molluschi e di Conchiglie eseguite sotto la direzione di G. C. Savigny, comprese nell' opera intituolata 'Description de l'Egypte'": in Issel's "Malacologia del Mar Rosso," 1869, pp. 309–375.

——— "Catalogo delle Conchiglie fossili raccolte sulle spiagge emerse del Mar Rosso": in Issel's "Malacologia del Mar Rosso," 1869, pp. 245–303, pls. iii–v. (Contains figures of new species and map showing Quaternary deposits of district.)

——— "Essai sur l'Origine et la Formation de la Mer Rouge": Bull. Soc. Belge Géol., vol. xiii (1900), pp. 65–84.

Jonas, J. H.—"Unbeschriebene Konchylien des Rothen Meeres": Zeitsch. Malakozoologie (Menke & Pfeiffer), 1846, pp. 65–67.

——— "Beitrag zur Erklärung der in der 'Description de l'Egypte' abgebildeten, nebst Beschreibung einiger anderer im rothen Meere und den angrenzenden Ländern lebender Mollusken": Zeitsch. Malakozoologie (Menke & Pfeiffer), 1846, pp. 59–64, 120–127.

Jousseaume, F.—"Description des Mollusques recueillis par M. le Dr. Faurot dans la Mer Rouge et le Golfe d'Aden": Mém. Soc. Zool. France, vol. i (1888), pp. 165–223.

MacAndrew, R.—"Report on the Testaceous Mollusca obtained during a Dredging Excursion in the Gulf of Suez in the months of February and March, 1869": Ann. Mag. Nat. Hist., ser. IV, vol. vi (1870), pp. 429–450. (This author supports Issel's theory that the Mediterranean and Red Sea were united during Eocene and Miocene times.)

Martens, E. von.—"Verzeichniss der von Dr. E. Schweinfurth im Sommer 1864 auf seiner Reise am rothen Meere gesammelten und nach Berlin eingesendeten zoologischen gegenstände": Verhandl. k.k. Zool. Bot. Ges. Wien, vol. xvi (1866), p. 381.

Mayer-Eymar, K.—"Systematisches Verzeichniss der Fauna des unteren Saharianum (Marines Quartaer) der Umgegend von Kairo, nebst Beschreibung der neuen Arten": Palæontographica, vol. xxx (1898), pt. 2, pp. 60–90, pl. xii.

Neumayr, M.—"Pliocäne Meereskonchylien aus Aegypten": Verhandl. k.k. geol. Reichs, 1887, p. 350. (Gives lists of shells from deposits at Wadi Mellaha.)

Savigny, J. C.—Plates to Audoun's "Description de l'Egypte," 1817 (Hist. Nat., vol. ii).

Smith, E. A.—"Shells from the raised Sea-bed at Moses' Wells" ("Ayun Musa," at the head of the Gulf of Suez): in Hull's "Memoir on Arabia Petræa, Palestine, etc.," 1886, p. 72.

——— "On a collection of Marine Shells from Aden, with some remarks upon the Relationship of the Molluscan Fauna of the Red Sea and the Mediterranean": Proc. Zool. Soc. London, 1891, pp. 390–436, pl. xxxiii.

Tristram, H. B.—"Report on the Terrestrial and Fluviatile Mollusca of Palestine": Proc. Zool. Soc. London, 1865, pp. 530–545.

Tryon, E. W.—"Manual of Conchology," 1880–1891, vols. ii–xiii.

Vaillant, L.—"Recherches sur la Faune Malacologique de la Baie de Suez": Journ. Conchyliologie, 1865, pp. 97–127, pl. vi (*pars*).

Woodward, S. P.—"Geographical Distribution of the Mollusca," Indo-Pacific Province (Red Sea and Persian Gulf): in "A Manual of the Mollusca," 1880, 4th ed., pp. 71–74.

EXPLANATION OF PLATE XX.

FIG. 1.—*Turbo radiatus*, Gmelin. 20 feet above sea, Gharib lighthouse. Back view of medium-sized specimen.

FIG. 2.—*Canarium gibberulum*, Linnæus. Jebel Zeit. Back view of specimen with varicosed spire.

FIG. 3.—*Strombus fasciatus*, Born. Between Jebel Mellaha and Jebel Zeit. Specimen showing colour-markings and characteristic tuberculations at the shoulder.

FIG. 4.—*Clanculus Pharaonius*, Linnæus. 20 feet above sea, Gharib lighthouse. Specimen exhibiting the typical granulate ornamentation.

FIG. 5.—Basal view of same, with umbilicus surrounded by radial plicæ.

FIG. 6.—*Terebra duplicata*, Linnæus. Jebel Zeit. Front view of shell, showing the smooth, depressed ribbing of this species.

FIG. 7.—*Terebra maculata*, Linnæus. North of Ras Mohamed or Ghazlandi Bay. Front aspect of specimen, with original colour-bands.

FIG. 8.—*Conus nussatella*, Linnæus. East of Gharib. Specimen showing the closely-set, granulated striations of this species.

FIG. 9.—*Conus omaria*, Hwass. Wadi Gueh, Camp 6. A well-marked specimen, bearing the triangular white spots peculiar to this shell.

FIG. 10.—*Pleurotoma Garnonsi*, Reeve. 50 foot beach at Gemsah. Shell showing small brown spots on the raised spiral ribs.

FIG. 11.—*Chicoreus anguliferus*, Lamarck. South of Gharib lighthouse. Specimen exhibiting a prominent node between each of the varices.

FIG. 12.—*Vasum cornigerum*, Lamarck. 80 feet above sea, Camp 6, north of Wadi Gueh. A medium-sized specimen, showing the typical sculpture of this species.

EXPLANATION OF PLATE XXI.

FIG. 1.—*Arcopagia scobinata*, Linnæus. Northern Wadi Gueh, Camp 6, 80 feet above sea. Exterior of right valve, showing the rasp-like character of the ornamentation.

FIG. 2.—*Venus reticulata*, Linnæus. 80 feet above sea, Camp 6, north of Wadi Gueh. Exterior of a right valve.

FIG. 3.—*Circe pectinata*, Linnæus. South of Gharib lighthouse. Medium-sized example, showing characteristic sculpture.

FIG. 4.—*Codakia exasperata*, Reeve. 80 feet above sea, Camp 6, north of Wadi Gueh. External view of a left valve.

FIG. 5.—*Dosinia radiata*, Reeve. South of Gharib lighthouse. External view of a left valve, showing strong concentric striations and the growth periods of the shell.

FIG. 6.—*Anadara antiquata*, Linnæus. Camp 6, Wadi Gueh. External surface of left valve.

FIG. 7.—*Glycymeris pectunculus*, Linnæus. Big Bay, south of Sherm, Sinai. Exterior of valve, showing striped colouring.

FIG. 8.—*Tridacna gigas*, Linnæus. Between Jebel Mellaha and Jebel Zeit. External view of a left valve belonging to a small example of this species.

EXPLANATION OF PLATE XXII.

FIG. 1.—*Capiluna Ruppelli*, var. *Barroni* (var. nov.). Ras Gharib. Front view of specimen, showing the elongate perforation.
FIG. 2.—Lateral aspect of same specimen.
FIG. 3.—Internal view of same shell, showing a nearly circular basal margin.
FIG. 4.—Details of external sculpture, magnified.
FIG. 5.—*Alectryonia*, allied to *crista-galli*, Linnæus. North of Kosseir. Fractured view of specimen, with parts of both valves attached, exposing the ligamental area.
FIG. 6.—Another aspect of the same shell.
FIG. 7.—*Pecten Vasseli*, Fuchs. Northern Wadi Gueh, Camp 6, 240 feet above sea. External view of a lower valve.
FIG. 8.—*Pecten Vasseli*, Fuchs. Upper coral terrace between Nebk and Sherm, S.E. Sinai. External view of an upper valve belonging to another specimen.
FIG. 9.—*Pecten Vasseli*, Fuchs. Magnification of external sculpture.
FIG. 10.—*Chlamys Reissi*, Bronn. North of Kosseir. External view of a left valve with numerous ribs ornamented by thin, transverse, elevated striæ.

(Except where otherwise mentioned, the figures on all the Plates are drawn natural size.)

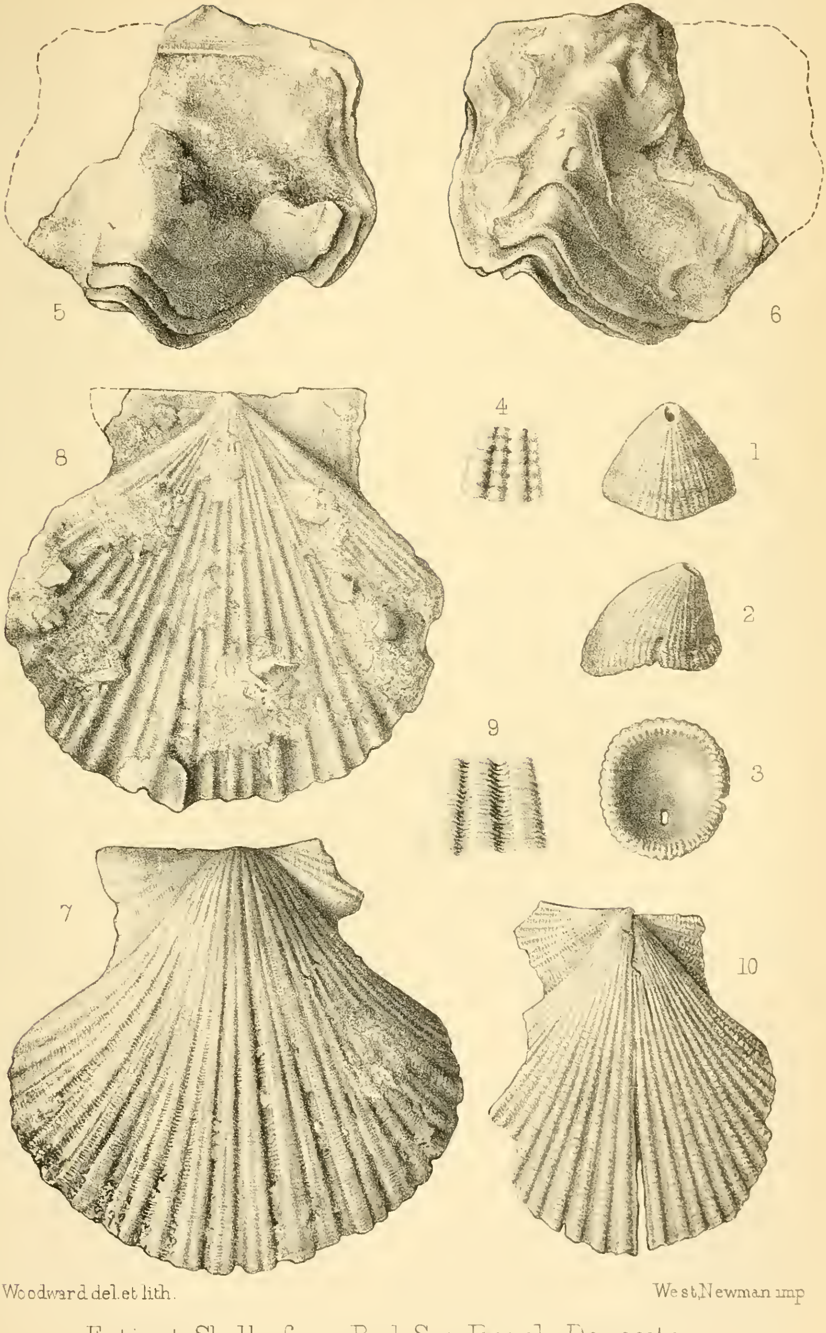
VI.—NOTE ON *EPHIPPIOCERAS CLITELLARIUM*, J. DE C. SOWERBY, SP., AND *E. COSTATUM*, A. H. FOORD.

By G. C. CRICK, F.G.S., of the British Museum (Natural History).

THE name *Nautilus clitellarius* was given by J. de C. Sowerby[1] to a Nautiloid from the Coal-measures, Coalbrookdale, Shropshire, and the description was accompanied by three figures, each representing a different specimen. In 1884[2] the species was included by Professor Hyatt in his new genus *Ephippioceras*. In 1891 Dr. A. H. Foord[3] found a new species, *Ephippioceras costatum*, which was said to be "distinguished from *E. clitellarium* (to which it is, however, very closely related) by the character of the septa and by the surface ornaments. The septa in *E. costatum* do not form such an acute lobe upon the periphery as do those of *E. clitellarium*, and they are also a little wider apart in the former species than they are in the latter. Moreover, *E. costatum* is provided with prominent transverse costæ, which are strongest upon the sides of the shell where they swell out into heavy folds. These costæ are directed obliquely backwards, and cross the septa at an acute angle, passing across the periphery and forming a shallow sinus in the middle. None of the specimens in the British Museum have the test preserved, so that the ribbing has only been observed upon casts. The costæ are equally well developed upon the body-chamber and upon the septate part of the shell in the adult, but they were either very feeble or altogether absent in the young." A re-examination of the specimens in the Museum collection shows that the separation of the two forms is quite justifiable.

Since Dr. Foord's species was instituted the British Museum collection has been enriched by the addition of two of Sowerby's figured specimens, viz., the originals of his figs. 5*a* and 5*b*.

[1] Trans. Geol. Soc., vol. v, pt. 3 (1840), expl. of plates, etc., pl. xl, figs. 5, 5*a*, *b*.
[2] Proc. Boston Soc. Nat. Hist., vol. xxii (1884), p. 290.
[3] Cat. Foss. Ceph. Brit. Mus., vol. ii (1891), p. 103.



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

Extinct Shells from Red Sea Beach Deposits

Sowerby's description of his species is as follows :—

"Globose, umbilicated, septa numerous, much bent in the middle, truncated and not recurved at the ends; siphuncle central; umbilicus small; aperture above twice as wide as long.

"The length of the aperture is $1\frac{1}{2}$ inch, the width $2\frac{3}{4}$ inches."

In regard to the angle of the septa on the ventral or peripheral area, the presence of obscure coarse costæ, and the general form of the shell, the original of Sowerby's fig. *5a* agrees exactly with the type of Foord's *E. costatum*; the costæ appear to be almost wanting on the earlier portion of the outer whorl, but the fossil is here somewhat imperfectly preserved.

The specimen represented in Sowerby's fig. *5b* is a fragment of an apparently smooth shell, the septa of which form an angle on the ventral or peripheral area corresponding almost exactly to that in the specimen figured by Dr. Foord as *E. clitellarium.* It appears, however, to have belonged to a rather more rapidly expanding shell with slightly more depressed whorls than the fossil which Dr. Foord has figured and referred to that species; in fact, in these respects it agrees better with the earlier portion of the outer whorl of the original of Sowerby's fig. *5a*. Still, the form of the septa and the apparent smoothness of the shell lead us to regard the specimen as specifically identical with the example figured by Dr. Foord as *E. clitellarium,* J. de C. Sowerby, sp.

As we have not seen the original of Sowerby's fig. 5, we can make no observations on that specimen.

From the foregoing remarks it will be seen that the specimens figured by Sowerby probably belong to at least two distinct species; the original of his fig. *5b* agreeing with Foord's interpretation of *E. clitellarium,* whilst the specimen represented in his fig. *5a* is specifically identical with Foord's *E. costatum.* It would then be of great interest to know where the fossil represented in Sowerby's fig. 5 is, and to learn whether its characters correspond to those of the original of that author's fig. *5b*, or to those of the example depicted in his fig. *5a*, for if it be specifically distinct from the fossil represented in his fig. *5a* (= *E. costatum*, Foord), we think it should, owing to the fragmentary nature of the original of his fig. *5b*, be regarded as the type of Sowerby's species (*E. clitellarium*).

VII.—Note on Zieten's Type-Specimens of *Ammonites polygonius* and *Ammonites discoides.*

By G. C. Crick, F.G.S., of the British Museum (Natural History).

THE presence of Zieten's type-specimen of *Ammonites calcar*[1] in the British Museum (Natural History) among some fossils which were bought of Dr. Bruckmann naturally suggested an examination of the other fossil Cephalopoda obtained from the same source, in the hope of finding other type-specimens. Thus far, the result of this examination has been the discovery of two more

[1] See Geol. Mag., December, 1899, p. 554.

of Zieten's types; these are the type-specimens of (i) *Ammonites polygonius* and (ii) *Ammonites discoides.*[1]

(i) *Ammonites polygonius*, C. H. v. Zieten, Verstein. Württembergs, Heft iii (1831), p. 21, pl. xv, figs. 6*a*, *b*, *c*. This specimen [register number 39,699] is labelled in Dr. Bruckmann's handwriting as follows: "*Ammonites pustulatus Suevicus*, Quenst. (*Amm. polygonius*, Ziet.) Selten. Brauner Jura ζ (Ornatenthon), Gammelshausen"; and on the label there has been written in pencil the letters "[Dr. O.]," signifying "Dr. Oppel," as I have been able to ascertain from other labels in this Museum that are also in Dr. Bruckmann's handwriting. The specimen agrees so well in size, form, and colour with Zieten's figure (except that the latter is reversed), that there cannot be any doubt whatever about its being the type-specimen, the imperfection of the anterior part of the fossil being accurately represented in Zieten's fig. 6*a*. The periphery, however, is not so sharp as Zieten's fig. 6*b* indicates, but is slightly truncated[2] owing to the absence of the keel. The specimen is entirely septate, but the suture-line is only imperfectly displayed; its complete course cannot be traced.

Zieten described the species as follows:—"Rücken scharf, die sehr dicken, der Länge nach feingestreiften Windungen bilden einen tiefen Nabel, welcher mit spitzigen Knötchen umgeben ist. Rippen theils einfach, theils gegabelt. Nach dem vieleckigen Durchschnitt seiner Windungen benannt. Verkiest im Lias-Schiefer von Zell, unweit Boll."

["Back (periphery) sharp; the very thick longitudinally finely-striated whorls form a deep umbilicus, which is surrounded by pointed tubercles. Ribs sometimes simple, sometimes bifurcated. Named after the polygonal shape of the cross-section of its whorls. Pyritized in the Lias shales of Zell, not far from Boll."]

From the above remarks it will be seen that Zieten's statement as to the horizon and locality does not agree with the label which now accompanies the specimen, for the fossil is labelled "Brauner Jura ζ (Ornatenthon), Gammelshausen," which is a short distance south-east of Boll, in Württemberg, whilst Zieten states that the species occurred in the "Lias-Schiefer von Zell," i.e., a little to the north-east of Boll. According to Oppel ("Juraformation," p. 560), the species occurs pyritized in the "Zone of *Ammonites anceps*" [=the Brauner Jura ζ in part] at Oberlenningen and Gammelshausen, near Boll; and Quenstedt, in his work on "Die Ammoniten des schwäbischen Jura" (Bd. ii, Heft 14–15, 1887, p. 755, tab. lxxxvi, fig. 10), describes and figures the species, under the name *Ammonites pustulatus suevicus*, from the Brauner Jura ζ of Gammelshausen. It is most probable, then, that the specimen is accurately labelled; for it is quite evident that some other species which Zieten attributed to the Lias are certainly not of Liassic age.

It may be mentioned that this species has been referred[3] to Denys

[1] Briefly alluded to in GEOL. MAG., December, 1899, p. 556, note 1.

[2] See F. A. Quenstedt's "Die Ammoniten des schwäbischen Jura," Bd. ii, Heft 14–15 (1887), tab. lxxxvi, fig. 10.

[3] See Waagen's "Jurassic Fauna of Kutch," vol. i (Cephalopoda), 1873, p. 41.

de Montfort's genus *Amaltheus*, but Parona and Bonarelli[1] include it in the genus *Lophoceras* instituted by them in 1897.

(ii) *Ammonites discoides*, C. H. v. Zieten, Verstein. Württembergs, Heft iii (1831), p. 21, pl. xvi, figs. 1*a*, *b*, *c*. This specimen [register number 62,568] is accompanied by a label in Dr. Bruckmann's handwriting to the following effect: "From Zieten's collection. *Ammonites capellinus jurensis*, Quenst. (*Amm. discoides*, Ziet., T. 16, F. 1). Selten. Jurensismergel. Heiningen in Württemberg"; and on the label there has been written in pencil the letters "[Dr. O.]," signifying "Dr. Oppel." Its size, general form, and colour agree so well with Zieten's figure (except that the latter is reversed), that there can be no doubt whatever as to its identity. At about the commencement of the last third of the outer whorl a small piece is broken away at the periphery, and although this imperfection is not figured, yet the shape of the anterior portion of the specimen is so accurately represented in Zieten's figure that there cannot possibly be any doubt as to the identification of the specimen.

Zieten's description is as follows:—"Rücken sehr scharf, die inneren Windungen stark bedeckt, Rippen sichelförmig, welche auf der scharfen Rückenkante in spitzigen Winkeln zusammenlaufen. In der Hauptform dem *Ammonites discus* (Sow.), ähnlich. Aus dem Lias-Sandstein von Reichenbach im Thal."

["Back (periphery) very sharp, the inner whorls strongly ornamented, ribs falciform and meeting on the sharp periphery in acute angles. In general form similar to *Ammonites discus*, Sowerby. From the Lias sandstone of Reichenbach in the Valley."]

In this case also there seems to be a discrepancy between the label and Zieten's statement as to the locality of the fossil; Heiningen, the locality given on the label, being about three miles south of Göppingen, whilst "Reichenbach im Thal," the locality given by Zieten, is north of Donzdorf and almost due east of Göppingen. Quenstedt, in his work on "Die Ammoniten des schwäbischen Jura" (Bd. i, Heft 8–9, 1885, pp. 416–7, tab. liii, figs. 1 and 3), records the species from the *Jurensis*-beds at both places.

It may be remarked that this species was placed by Hyatt[2] in his

[1] Mém. Acad. Sci., etc., Savoie, sér. iv, vol. vi (1897), p. 122.

[2] A. Hyatt: Bull. Mus. Comp. Zoöl., vol. i, No. 5, p. 102. The whole volume, consisting of Nos. 1–13, is dated 1863–9; No. 4 was published in June, 1865, and No. 6 is dated December 26, 1867, but the copies of No. 5 that I have seen are not dated. This number, however, was published towards the end of December, 1867. For this date I am indebted to Mr. S. S. Buckman, who tells me that he has a copy of Prof. Hyatt's paper bearing a date-slip, of which the following is an exact copy:—

Boston Society of Natural History.
March 23, 1868.

[Extract from Records of Jan. 3, 1868.]

"Mr. A. Hyatt laid upon the table No. 5 of the Bulletin of the Museum of Comparative Zoölogy, published about a week since, but accidentally bearing no date of publication," etc.

S. H. Scudder,
Sec. Boston Soc. Nat. Hist.

Please attach this to the copy of the Bulletin sent to you.
A. Hyatt.

genus *Lioceras*,[1] but Buckman[2] has made it the type of a new genus, *Polyplectus*. The Museum, then, is fortunate in possessing this type-specimen, for it is not only the type of Zieten's species *Amm. discoides*, but also the type of Buckman's genus *Polyplectus*.

NOTICES OF MEMOIRS.

I.—The Basal (Carboniferous) Conglomerate of Ullswater and its Mode of Origin. By R. D. Oldham, Geological Survey of India.[3]

On the western shore of Ullswater, near its lower end, a good section has recently been exposed of the basal conglomerates variously ascribed to Old Red or lowermost Carboniferous age. This conglomerate has been considered as glacial in its origin, but does not appear to the author to present any true glacial characteristics. It contains angular and subangular blocks of all sizes, which are not scattered indiscriminately, but are arranged with a distinct, though obscure, banding. In the admixture of blocks of all sizes and the absence of rounded boulders, it differs from the known river deposits of temperate climes, and more closely resembles the accumulations of débris which result from cloud-bursts than any other form of deposit which can be observed in the British Isles at the present day. The conglomerate cannot, however, be reasonably attributed to any such local deposits; its true analogue must be looked for in the dry regions of Western and Central Asia, where all rainfall rushes off the bare hills, producing an effect very like that of a cloud-burst in our own climate, and causing a mixed mass of water, silt, and stones to rush down the river channels, which are dry or carrying only a feeble stream in ordinary times. This mass of material is carried out from the hills, and forms a deposit with a gently sloping surface extending for miles into the open country. Carried along in this manner the rock-fragments do not undergo the rounding which they suffer in a more permanent torrent, and are deposited, on the sudden subsidence of the flood, in a mixed mass of fragments of all sizes. The sections exposed along the roadside near the foot of Ullswater not only exhibit a rude trending, due to the action of successive floods, but also show patches of current-bedded, fine-grained, gravelly material, representing the action of the feebler stream which continued after the passage of the flood.

The conclusion drawn is that the conglomerate is a torrential deposit, formed on dry land, near the foot of a range of hills, in a generally dry climate, varied by seasonal or periodical bursts of rain. The red colour of the fine-grained material suggests tropical or sub-tropical conditions, as the formation of red soils is at the present day so much more common in tropical than in temperate regions that it may almost be regarded as a characteristic of a hot climate.

[1] Originally spelt *Leioceras*.

[2] S. S. Buckman: Inf. Oo. Amm. (Mon. Pal. Soc.), pt. iv (1890), p. 214.

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

II.—The Influence of the Winds upon Climate during Past Epochs: a Meteorological Explanation of some Geological Problems. By F. W. Harmer, F.G.S.[1] (Abstract.)

THIS paper is a summary of a communication the author hopes to make to the Geological Society of London during the present winter, and is in continuation of one read at Dover in 1899, on "The Meteorological Conditions of North-Western Europe during the Pliocene and Glacial Periods."

The irregular distribution of the isotherms in the northern hemisphere is largely due to the direction of the prevalent winds. In regions where these are constantly varying, as, for example, in Great Britain, the climate varies diurnally, one day being often dry or cold and the next rainy or warm. In others, where the wind changes seasonally, one part of the year is rainless and another pluvial. Permanent alterations in climate would equally result were the course of the prevalent winds permanently changed.

The direction of the winds, which must always be more or less parallel to the isobars, depends on the relative position, and on the form and alignment of areas of high and low barometric pressure. The movements of the latter being largely interdependent, any important meteorological disturbance, however caused, may make its influence felt at a considerable distance from the focus of its origin.

The winds blow round areas of high and low pressure; outwards, from the former, and to the north of the Equator, from left to right; and inwards, towards the latter, from right to left. Hence, in the northern hemisphere, southerly winds prevail to the east of a cyclonic centre, and northerly winds to the west of it, the contrast between the temperature of the two areas being usually in proportion to the distance the aerial currents may have travelled from the south and the north respectively. Warm and cold winds must therefore necessarily coexist, causing differences in climate in countries having the same latitude. The winter temperature of Hudson's Bay is, for example, 60° F. colder than that of Great Britain. Similar climatal conditions must have also existed during the Pleistocene epoch.

The continental regions of the northern hemisphere, being at present warmer during summer than the ocean, are cyclonic; in winter they are colder, and consequently anticyclonic. Over the great ice-sheets of the Glacial Period, however, high pressure must have prevailed, more or less, at all seasons, and, generally, the meteorological conditions, including the direction of the prevalent winds, and local variations in climate must then have been widely different from those of our own times. Oceanic winds, with copious rainfall, may have prevailed in regions now arid, and mild winters where they are now excessively severe. Such cases of anomalous climate as those of the pluvial conditions of the Sahara, and of Arabia and Persia, during the Pleistocene era, may be satisfactorily explained by the changes in the relative positions of cyclonic and anticyclonic systems which were caused by the gradual growth and

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

disappearance of the great ice-sheets, as may be the alternate humidity and desiccation of the great basin of Nevada, the former existence of the mammoth on the shores of the Polar Sea, etc.

It is difficult, however, to restore hypothetically the meteorological conditions of the Pleistocene epoch, on the theory that the maximum glaciation of the eastern and western continents was contemporaneous. At present the influence of the Gulf Stream, and the south-west winds caused by the Icelandic cyclone, carries in winter a comparatively warm climate, and low pressures, northwards into the Arctic Circle, but no permanent ice-sheet could have existed in Great Britain under such circumstances. Cyclones and anticyclones in regions more or less contiguous are, however, necessarily complementary, in order that the vertical circulation of the atmosphere may be maintained. The existence of an enormous polar anticyclone, extending southwards over a great portion of Europe and North America, would have involved also that of a cyclonic system of corresponding importance in the North Atlantic, a region which must have been at all seasons warmer than those covered with ice; but this would have caused south-west winds over Great Britain, and have prevented the permanent existence of an ice-sheet in these islands. If Europe and North America had been glaciated at the same time, which for the reasons given, however, seems improbable, the Icelandic cyclone, which now lies (statistically) in winter near to the south-east coast of Greenland, would have been forced to the south; but the further south it went the warmer would have been the southerly winds which blew east of its centre towards Great Britain and Western Europe. Conditions similar to those which may have prevailed during the maximum glaciation of North America occurred during the early part of 1899—for information as to which the author desires to acknowledge his indebtedness to Mr. W. N. Shaw, F.R.S., of the Meteorological Office. At that time a great low-pressure system, which sometimes extended from Europe to America, and from Iceland to the Canary Islands, occupied the North Atlantic. Vast volumes of cold air from the Arctic regions were consequently poured over North America, while Western Europe was flooded by warm aerial currents from the sub-tropical zone. At the beginning of February temperatures of from $-40°$ F. to $-60°$ F. were commonly registered in different parts of North America; at the same time the thermometer rose in London to 66° F., in Liége to 70° F., and in Davos, more than 5,000 feet above the sea, to 62° F., the average maximum for that month at the latter place being 38° F. For some weeks storms of exceptional violence occurred almost daily in the Atlantic. These coincident phenomena are directly traceable to the same cause.

No meteorological difficulties arise if we adopt the hypothesis that glacial and interglacial periods alternated in the eastern and western continents. If the ice-cap extended from Greenland to Scandinavia, the North Atlantic cyclone would have been forced to the south-west, towards the American coast, producing warm south-east winds over Labrador; if, on the contrary, it stretched from Greenland to North

America, the cyclone would have been driven in the direction of Europe, causing mild weather in the latter, as in the case just given.

Such a view affords a simpler explanation of the geological facts than those usually adopted. Instead of supposing that the climatic changes of the Great Ice Age, several times recurrent at intervals of a few thousand years only, were due to astronomical causes, it is here suggested that the climate of the Pleistocene epoch being uniformly colder than that of our own era, conditions of comparative warmth or cold may have been local, as they now are, affecting the great continental areas at different periods.

REVIEWS.

I.—Studies in Fossil Botany. By Dukinfield Henry Scott, M.A., Ph.D., F.R.S., F.G.S., Honorary Keeper of the Jodrell Laboratory, Royal Gardens, Kew. pp. xiii, 553, with 151 illustrations. (London: A. & C. Black, 1900.)

As the title of Dr. Scott's work implies, "Studies in Fossil Botany" is not a 'textbook' in the ordinary acceptation of the term, giving a systematic course of the entire range of fossil plants, but contains thirteen lectures devoted to the microscopical structure, morphology, and affinities of Carboniferous plants, and one on the Mesozoic Gymnosperms. The groups studied are not chosen at random, but follow each other in natural sequence.

Lectures i–iii are devoted to the Equisetales. The *Calamites* are first described, and here, as in the subsequent groups, a description of the external characters of the group is given. These descriptions, however, take a subordinate place to the description of the internal organization of the plants, which forms the main subject of the lectures. The development of the young Calamite is traced through its early stages, and the different structures which go to make up the complete plant are described in detail. One of the important results of Dr. Scott's examination of the *Calamites* is to prove that the carinal canals of *Equisetum* and *Calamites* are homologous, both resulting from the rupture of the primary wood. After the description of *Arthropitys*, the common English form of Calamite, the two other types of Calamite stem structure, *Arthrodendron* and *Calamodendron*, are considered. The Calamite fructifications, *Calamostachys*, *Palæostachya*, and *Cingularia*, are then dealt with and their morphology discussed; then follow notes on *Archæocalamites* and *Macrostachya*.

In Lecture iv the *Sphenophyllales* are considered. In this group are placed the two genera *Sphenophyllum* and *Cheirostrobus*. This is a specially interesting chapter, dealing with types of plant structure which disappeared with Carboniferous times. Fortunately, the structure of stems, roots, leaves, and fructification of *Sphenophyllum* is known. The two British species showing structure—*S. plurifoliatum*, from the Lower Coal-measures, and *S. insigne*, from the Calciferous Sandstone series—are fully described. *Sphenophyllum*

Dawsoni is taken as the type of *Sphenophyllum* fructification, and is fully described. It might be remarked here, that *S. Dawsoni* is almost certainly the fruit of *S. cuneifolium*, Sternb., sp., of which probably *S. plurifoliatum* is the stem. The fructifications of other species of *Sphenophyllum* are described or referred to, and though the vegetative organs of all the species of *Sphenophyllum* have a great similarity, the arrangement of the sporangia in some of the species varies considerably: so much is this the case, that the genus as presently employed must be regarded more in the light of a group than a genus; but in vegetable palæontology the imperfect knowledge of many critical characters makes it most unwise to treat fossil genera in the restricted manner in which one would proceed in dealing with existing plants. Although *Cheirostrobus* is here placed in the *Sphenophyllales*, its connection with *Sphenophyllum* does not appear to be very close.

The *Lycopodiales* occupy Lectures v–vii, and contain descriptions of *Lepidodendron*, *Lepidophloios*, *Sigillaria*, and *Stigmaria*. We cannot agree with Dr. Scott's treatment of *Halonia* and *Ulodendron*. *Halonia* is correctly referred to *Lepidophloios* as its fruiting branch (p. 156), and *Ulodendron* in part to *Lepidodendron* and *Sigillaria* (p. 152); but, again, it is said: "What, then, was the nature of the Halonial branches, which were evidently not characteristic of a separate genus, but occurred as terminal ramifications on ordinary Lepidodendroid stems?" (p. 158). Again, "Williamson, however, described a specimen with multiseriate, quincuncially arranged scars of the *Ulodendron* character, and also a *Halonia* with the tubercles in two series, so this distinction loses its value" (pp. 158–159). As references for this statement Dr. Scott mentions Williamson's figures given in Mem. xix, pl. vi, figs. 22 and 25*a*. Now the "cortex of *Lepidophloios*, with rows of Ulodendroid fructiferous scars, arranged as in *Halonia regularis*" (Williamson, l.c., p. 33), shows a typical specimen of a fruiting branch of *Lepidophloios* with leaf and cone scars, and does not possess a single Ulodendroid character; whereas Williamson's fig. 22, "a young fructiferous Halonial branch, with its tubercles in two lateral series" (l.c., p. 33), is *decorticated*, and does not exhibit any characters by which it can be referred with certainty to either *Lepidophloios*, *Lepidodendron*, or *Sigillaria*; and as *all the specimens with two rows of large scars which have shown the leaf-scars, have invariably belonged to Lepidodendron, Sigillaria, or Bothrodendron*, there seems little warrant for referring this specimen to *Lepidophloios*, especially when *no* specimen has ever been described or figured wherein a distichous arrangement of the fructiferous scars has been found associated with the *Lepidophloios* leaf-scar. We also know the specimen referred to on p. 160, and here, also, there is absolutely no evidence for including it in *Lepidophloios* rather than referring it to *Sigillaria discophora*, where the fructiferous scars were in two rows, and the other characters of this specimen would seem to refer it to this species. We would naturally expect to find that the internal organization of two such closely allied genera as *Lepidodendron* and *Lepidophloios* possessed an almost identical structure. We believe it is now recognized that isolated vascular axes of *Sigillaria* and *Lepidodendra* cannot be distinguished apart from the structure of the cortex and its leaf cushions.

The internal structure of the Lycopodiales is admirably described. The material for the study of the *Lepidodendra*, being plentiful and exceptionally well preserved in the Yorkshire and Lancashire Coal-field and a few other localities, has given exceptional facilities for a description, which could be little more perfect had it been drawn up from the living plant. The description of the internal organization of *Sigillaria* is also good, although specimens of undoubted Sigillarian stems showing structure preserved are very rarely found. "The two lateral points on the surface of the leaf cushion below the leaf-scar" of *Lepidodendron* are supposed to have some connection with the parichnos. This conclusion may possibly be correct, but as the point is said to have been investigated by Potonié in a *Lepidophloios*, where the curious structures known as the parichnos do not occur on the cushion, it is probable that the specimen investigated was a *Lepidodendron*.

It might, perhaps, have been better if Dr. Scott had substituted the name of *Lepidodendron Veltheimianum* for that of *L. brevifolium*, given under the figure on p. 133, as the plant there shown really belongs to that species, and especially as the cones of the same stem are named *Lepidostrobus Veltheimianus* in figs. 67, 68, 69, and 70*c–d*. Professor Williamson subsequently corrected his error in identifying the Pettycur plant with Ettingshausen's *Lepidodendron brevifolium*, which latter is a *Lepidophloios* (=*Lepidophloios acerosus*, L. & H., sp.). In the same lecture *Lepidostrobus* and *Spencerites* find a place; the latter, known only from its cones with curious winged spores, is a most peculiar and interesting genus.

The Ferns occupy Lectures viii and ix, and are admirably treated. Here, we believe, is given the best and most concise account of the structure of Palæozoic ferns with which we are acquainted, for though the space devoted to their consideration is not large, their characteristics and structure are most clearly described.

Lecture viii serves somewhat as an introduction to the study of the chief fern genera and their fructifications, and concludes with a description of the anatomy of *Psaronius*. Lecture ix is reserved for the consideration of the Botryopteridæ, the two forms described being *Zygopteris Grayi* and *Botryopteris hirsuta*, which belong to the herbaceous monostelic type of fern structure. The petioles of *Z. Lacattii* and *Z. bibractensis* have long been known as common fossils in the Yorkshire and Lancashire Coal-balls. Thanks to the labours of M. Renault, in some respects *Zygopteris* is one of our most completely known fossils, but its affinities are difficult to determine, the annulate sporangia of *Zygopteris* and *Botryopteris* being very different from any fructification known to occur amongst recent ferns.

The Cycadofilices occupy Lectures x and xi, and comprise one of the most interesting groups of Palæozoic plants with which the palæontologist has to deal. The group contains ferns belonging to several 'genera' as determined by the impressions of their fronds, for we find members of the Brongniartian genera *Sphenopteris*, *Alethopteris*, and *Neuropteris* among the Cycadofilices. *Sphenopteris Höninghausi* is the frond of *Lyginodendron Oldhamium*, and M. Renault has shown that the petioles of certain *Alethopteris* and *Neuropteris* have the structure of *Myeloxylon*, which in turn has been found attached to the stem of *Medullosa*, one of the Cycadofilices.

In dealing with these interesting plants, *Lyginodendron Oldhamium*, one of the monostelic forms, is first described. It is treated very fully, the stems, branches, roots, and foliage being very common in the 'Coal-balls.' The only point of interest unknown is its fructification, which, however, Dr. Scott presumes may have been Calymmatothecous, as shown in his restoration in the frontispiece. The evidence on which Dr. Scott arrives at this conclusion is derived from the reference to *Sphenopteris* (*Calymmatotheca* ?) *Stangeri*, Stur, of a Calymmatothecous fructification, and his belief that this fern is specifically identical with *Sphenopteris Höninghausi*—a view we are unable to share, as we regard these two species as essentially distinct.

Lyginodendron—or perhaps better, *Lyginopteris Oldhamia*, as renamed by Potonié—is followed by a description of *Heterangium*, another monostelic form with Sphenopteroid foliage, at least in the case of *H. Grievi*. *Calamopitys Saturni*, whose generic name gives a very false idea of its true position, the *Cycadoxyleæ*, and *Protopityeæ*, are next considered, and these lead us up to the genus *Medullosa*, the type taken for description being the *Medullosa anglica*, Scott, the oldest known member of the genus, and one possessing a less complex structure than those occurring in later Carboniferous rocks. *Medullosa* exhibits a polystelic type of structure. All the Cycadofilices show the remarkable character of a normal development of secondary bast and xylem. The fern petioles originally named *Myeloxylon* are now known to belong to *Medullosa*. The complex organization of these ferns has been worked out in admirable detail, and the occurrence of cycadaceous characters in association with the fern type of structure is fully dwelt on.

The *Poroxylon* and *Cordaiteæ* fall to be considered in Lecture xii. The *Cordaiteæ* are only now beginning to be understood. Some species of so-called *Araucarioxylon*, which must be referred to the *Cordaiteæ*, have been shown to possess a primary wood arranged in a circle round the periphery of the pith. For our knowledge of the structure of the flowers of *Cordaites* we are indebted to M. Renault, who has worked them out in great detail. The anatomy of the leaves and roots is also known and described. The position of *Cordaites* seems to lie between Cycads and Conifers, though at the same time it holds individual characters which prevent it being united with either.

Lecture xiii gives an account of the Mesozoic Gymnosperms, and Lecture xiv is devoted to the "General Results" derived from the foregoing course of study. The last lecture is therefore in some respects the most important of all, for it gives us the conclusions arrived at regarding the affinities of the various groups described, and contains the views of one than whom there is none more competent to express an opinion on the subject under discussion.

The results attained from the study of the Palæozoic flora lead to most interesting conclusions as to the antecedents of our existing flora, and certain points are prominently brought out. The first of these that strikes one is the entire disappearance of the traditional simple type of structure which was supposed to characterize the Carboniferous flora, the truth being that the Palæozoic plant type (at least as far back as the basement beds of the Carboniferous formation) is of a much more complex nature than is found to occur in the representatives of the similar groups at present existing; it is also further seen that it is quite possible that the recent *Equisetaceæ* are not derived from the *Calamites*, but are descendants of a simpler type which was contemporary with them, and there seems to be even less room for doubt that our *Lycopodium* and *Selaginella* have descended from a group of herbaceous Lycopods which existed side by side with the *Lepidodendra*, of which we have clear evidence as far back as the basement beds of the Carboniferous formation. The *Lepidodendra* appear to have entirely disappeared with Palæozoic times and to have transmitted no descendants to later formations.

"Studies in Fossil Botany" is one of the most valuable additions to the literature of Palæozoic botany which has appeared for many years, and shows the advance made during the last decade in the knowledge of the structure and classification of fossil plants. The student of recent botany also profits from such a volume as that issued by Dr. Scott, for it is impossible to fully understand the existing vegetation without a knowledge of the source from which it has been derived.

Dr. Scott possesses the great faculty of clear description and ability to grasp the salient structural features of the plants about which he writes, and this, coupled with his great knowledge of Palæozoic plant structures, makes his "Studies" indispensable to all students of botany; and we can only congratulate the author on the issue of a work the appearance of which has been looked for with so much interest.

The illustrations, 151 in number, are well chosen and excellent in every respect, and many of them have been specially prepared for the author. The Index, a most important adjunct, is also very complete. R. K.

II.—The Calabro-Sicilian Earthquake of November 16, 1894.

(1) G. Mercalli, "I terremoti della Calabria meridionale e del Messinese": Memorie della Soc. Ital. delle Scienze, vol. xi (1897), pp. 1–154.

(2) A. Riccò, "Riassunto della sismografia del terremoto calabro-siculo del 16 novembre, 1894": Rend. della R. Accad. dei Lincei, vol. viii (1899), pp. 3–12, 35–45.

(3) P. Tacchini, "Terremoto calabro-messinese del 16 novembre, 1894": ibid., vol. iii (1894), pp. 275–277.

(4) P. Tacchini, "Sulla registrazione a Roma del terremoto calabro-messinese del 16 novembre, 1894": ibid., vol. iii (1894), pp. 365–367.

(5) Boll. Meteor. dell' Uff. Centr. di Meteorologia e Geodinamica, Supplemento 113.

Shortly after its occurrence, a Government Commission was appointed to study the disastrous earthquake of November 16, 1894, in Sicily and Southern Italy. The work was divided into sections, the seismological part being undertaken by Prof. A. Riccò, the director of the observatory of Catania. Prof. G. Mercalli has also completed a valuable memoir on the seismic history of the district, the final chapter being devoted to the earthquake series of 1894.

Both the writers mentioned furnish maps of the isoseismal lines, Prof. Riccò making use of the Rossi-Forel scale of intensity and Prof. Mercalli of that which bears his name. In the central portion of the disturbed area, the two series of lines agree fairly closely, but they differ somewhat as regards those of lower intensity. Discrepancies in the latter are, however, to be expected on account of the small number of observations collected and the large portion of the area occupied by the sea.

The epicentral district, which overlaps that of the great Calabrian earthquake of February 5–6, 1783, lies about twenty miles north-east of Reggio Calabria. To the west and north-west, there is a notable expansion of the isoseismal lines; but in the opposite direction they are closely grouped, showing that the intensity of the shock died out rapidly in crossing the crystalline masses of Aspromonte and towards the Ionian Sea. The outermost isoseismal, according to Prof. Riccò, includes an area of 43,890 square miles.

The damage to property was confined to an area of 3,540 square miles in the provinces of Reggio Calabria and Messina; more than three-fourths occurring in the former province, where it was estimated to amount to about a million pounds. It was due chiefly to the very poor materials employed, the insufficient foundations, the imperfect connection between the different parts of the building, and the exceedingly heavy roofs. Altogether, 922 houses were completely ruined, and 44,493 more or less seriously injured; about a hundred people were killed and nearly one thousand wounded.

In nearly all parts of the disturbed area, the shock consisted of two distinct series of vibrations; the first and weaker series being separated from the other by an interval of rest lasting two or three seconds. Within and near the epicentral district, the concluding vibrations were vorticose, being subject to rapid changes of direction. Both Etna and Stromboli were strongly shaken, but neither showed any sign of increased volcanic action. A puteometer at Catania (70 miles from the epicentre) indicated an abrupt rise in the water of 17 mm., followed by a fall of 14 mm., after which it returned nearly to its original level. The shock was also recorded by seismographs at Catania, Portici, Ischia, Rocca di Papa, Rome, Siena, Pavia, and Nicolaiew (1,009 miles from the epicentre); and the diagrams given by several of these instruments show two or more groups of oscillations.

Prof. Riccò has made some attempts to determine the depth of the seismic focus, but the results do little more than illustrate the imperfection of the methods employed. From the recorded times at Catania, Ischia, and Rome, he estimates it at 99 miles; and from the time-curve corresponding to eight good observations, at 107 miles. Mallet's method was inapplicable, and Dutton's gave values ranging from 13 to 100 miles.

Prof. Mercalli's numerous observations on the direction of the shock have an important bearing on the origin of the earthquake. He shows that there are two small areas in which the directions intersect, one on the north-west slope of Montalto d'Aspromonte, between Plati and Delianova; the other in the sea, a few miles from the coast, between Palmi and Cape Peloro. Recalling the double character of the shock, he concludes that the earthquake originated in two foci, the one beneath the sea being the last in action and giving rise to the strongest part of the shock. C. Davison.

III.—On Metamorphic Rocks in Eastern Tyrone and Southern Donegal. By G. A. J. Cole. Trans. Roy. Irish Acad., 1900, vol. xxxi, pp. 431–472.

On certain Rocks styled 'Felstones' occurring as Dykes in the County of Donegal. By G. A. J. Cole and J. A. Cunningham. Scientific Proc. Roy. Dublin Soc., 1900, vol. ix (n.s.), pp. 314–324.

THE problems presented for investigation in the complex regions of crystalline rocks near Pomeroy in Tyrone, and Pettigo in Donegal, are stated, in the first paper, as a series of questions—

(i) Is the intrusive granite distinct from the gneiss, or is the former merely an offshoot from the latter?

(ii) Is the gneiss itself an igneous rock, and if so, has it assumed its local richness in ferromagnesian minerals by absorption of basic and other rocks adjoining it?

(iii) If the gneiss is distinct from and older than the granite, what claim has it to be regarded as Archæan and fundamental?

The author favours the view that the gneiss has been produced by the intricate intrusion of a granitic magma into ancient schists, which may originally have been of sedimentary origin. The gneisses thus produced, as well as the less altered schists, are traversed by and included in the granite of the Slieve Gallion type, which also cuts an overlying basic igneous series, the latter giving rise to 'eyes' of amphibolite. The paper is illustrated by two plates, one of them coloured.

Three series of igneous dykes occur in the schists and quartzites of the north-west of Ireland; those belonging to the series intermediate in age are described in the Survey publications as 'felstones,' but they have since been shown by Hyland and others to include various rocks of the lamprophyre group (camptonite, vogesite, minette, kersantite). In the second paper quoted above these determinations are confirmed, and a glassy olivine-basalt belonging to the same series is also described.

IV.—Some Recent Papers by Professor W. M. Davis.

WHEN ascending the valley of the Ticino on the way to St. Gothard, Professor W. M. Davis observed that the side valleys opened into the main valley several hundred feet up, and streams cascaded down in sharp-cut shallow clefts. Such discordance between main and lateral valleys appears to be the rule in Alpine regions, and in all valleys which have been strongly glaciated; and the attention which Professor Davis has given to the subject dispelled the doubts which he had long felt as to the ability of ice to erode deep valleys and basins. It is not surprising to learn that the features are, in his opinion, of so much importance that a special name, that of 'hanging valleys,' suggested by Professor Gilbert, is employed to designate these side valleys. The peculiar features to which he draws attention are ascribed to the action of the heavy ice-stream that once filled the valley to a great depth: this trunk glacier at times rose so high that the small lateral glaciers were held back and prevented from deepening their channels, while the main valley was continuously subject to erosion. ("Appalachia," vol. ix, March, 1900.)

The recognition of the competence of glaciers thus to deepen and widen their valleys is regarded by Professor Davis as an important supplement to the belief that they can excavate lake basins. He therefore pursues the subject of "overdeepened main valleys and hanging lateral valleys," in an article on Glacial Erosion in France, Switzerland, and Norway (Proc. Boston Soc. Nat. Hist., vol. xxix, July, 1900). He points out that if the existing breadth of the glaciated valleys, which are broad-floored, had been acquired in the ordinary manner by the lateral swinging of the main stream and by the weathering of the walls, the long time required for such a change would have amply sufficed for the side streams to cut down their valleys to grade with the main valley. He concludes that the troughs were deepened and widened by ice-action. Similar features occur on the borders of Lake Lugano and other Alpine lakes, in our own Lake District, and in Norway. Irregularities along the main valleys eroded by glaciers may have arisen through the greater destruction of softer or more jointed rocks; and if the glacier should vanish by climatic change while in this condition a lake would occupy the deepened reach, and its outlet would flow forward over rocky ledges to the next lower reach or lake. As the energy of a glacier is declining, it becomes in its lower course only a transporting, not an eroding agent, and this would facilitate for a time irregular erosion. Professor Davis discusses the origin of Corrie Basins, and concludes with a review of previous writings on the subject of glacial erosion. This and the previously mentioned paper are illustrated by excellent photographic plates.

Professor Davis gives a graphic account of a fault scarp in the Lepini Mountains of Italy (Bull. Geol. Soc. Amer., vol. xi, April, 1900). The region, as described by Signor Viola, consists of Cretaceous limestone, capped here and there with Eocene beds, uplifted and separated from the Eocene of the Sacco Valley by a fault of considerable magnitude. Extinct Quaternary volcanoes occur on the southern part of the fault line. The fault scarp may be seen from Morolo station to occur along the mountain base. If the original uplift of the mountain mass ever produced a great fault cliff all traces of it are now destroyed, for the front is carved into a succession of buttressing-spurs and ravines. 'Rock-fans' or débris due to the retrogression of the escarpment are described. The fault scarp, in Professor Davis' opinion, is much more recent than the great dislocation which upraised the mass of the mountain front, and was probably due rather to an irregular depression of the Piedmont Eocene mass than to a further elevation of the Cretaceous mountain block.

In an article on the Fresh-water Tertiary Formations of the Rocky Mountain Region (Proc. Amer. Acad., vol. xxxv, March, 1900), Professor Davis maintains that sufficient attention has not been given to the fact that rivers deposit as well as erode, and that in consequence the probable fluviatile origin of most Piedmont plains has not been generally realized. He gives reasons for believing that mere continuity of even-bedded deposits, such as occur in the Tertiary formations of Western America, even if occupying many square miles, should not alone be taken as conclusive evidence of lacustrine origin. The object of his paper is to promote consideration of the subject.

CORRESPONDENCE.

A FELSTONE DYKE ON LLECHOG.

Sir,—In my paper published in the Geological Magazine under the title "Firstfruits of a Geological Examination of Snowdon,"[1] I said that the Felstone Dyke on Llechog might possibly be the same as are seen in Cwm Clogwyn at the foot of Llechog. I have now satisfied myself that such is the case, and I give a diagram (not drawn to scale) showing how the dyke rises through the cleaved felsitic rocks of the mountain, and a sketch-map of the area where it occurs. The dyke is from 15 to 20 yards wide where

[1] Geol. Mag., 1900, June, p. 267.

the section is drawn, but on the top of the cliff it rapidly thins away towards the south-east. In the cwm below it can be traced for about two hundred yards till it is lost to sight under débris.

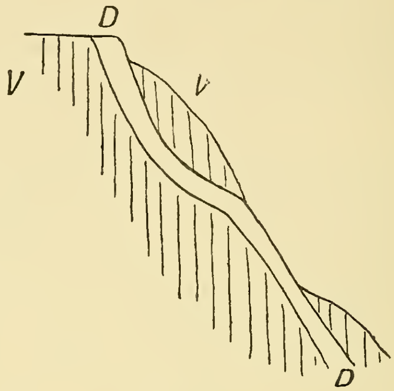
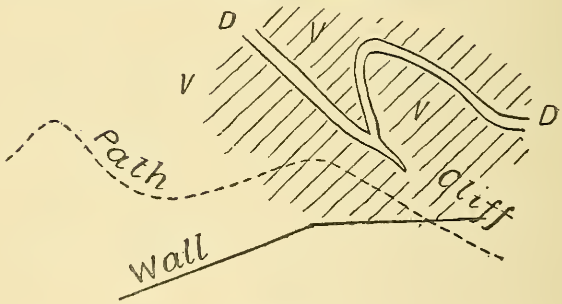


DIAGRAM.
D, dyke; V, cleaved volcanic rocks.



SKETCH-MAP.
D, dyke; V ////, cleaved volcanic rocks. Strike of cleavage, N.E.

This arm of Snowdon called Llechog must not be confused with that overlooking the Pass of Llanberis. The word Llechog means a 'slaty place,' and is applied to more than one such place.

J. R. DAKYNS.

RHYD-DDU, CARNARVON.

MISCELLANEOUS.

VICTORIA INSTITUTE.—At a special general meeting of the Victoria Institute held at Adelphi Terrace on Monday, 5th November, Sir G. Gabriel Stokes, President, in the chair, Professor Edward Hull, F.R.S., was unanimously elected Secretary to the Institute, in the room of the late Captain Francis Petrie.

INDEX.

STEPHEN AUSTIN AND SONS, PRINTERS, HERTFORD.

No. 427. New Series.—Decade IV.—Vol. VII.—No. I. Price 1s. 6d. nett.

THE

GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., &c.,

WILFRID H. HUDLESTON, M.A., F.R.S., F.L.S., F.G.S., &c.,

GEORGE J. HINDE, Ph.D., F.R.S., F.G.S., &c., AND

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

JANUARY, 1900.

CONTENTS.

LONDON: DULAU & CO., 37, SOHO SQUARE.

No. 428. New Series.—Decade IV.—Vol. VII.—No. II. Price 1s. 6d. nett.

THE GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., &c.,

WILFRID H. HUDLESTON, M.A., F.R.S., F.L.S., F.G.S., &c.,

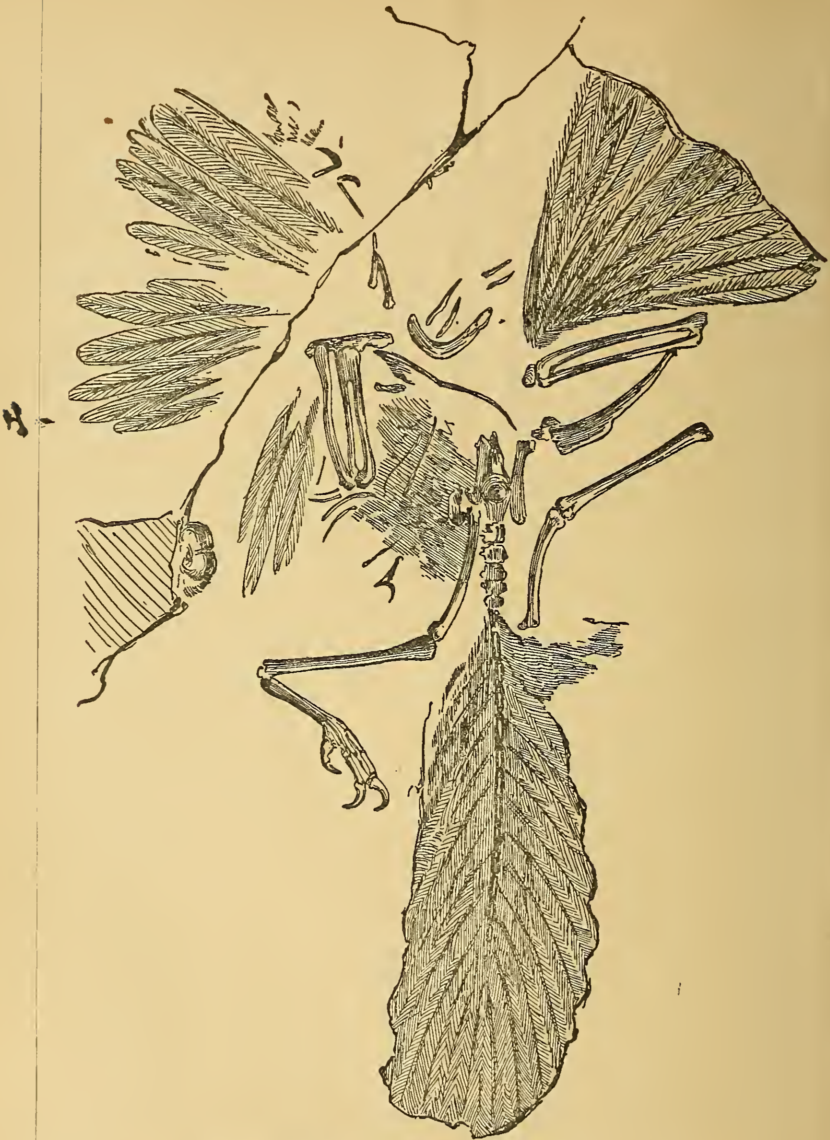
GEORGE J. HINDE, PH.D., F.R.S., F.G.S., &c., AND

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

FEBRUARY, 1900.

CONTENTS.

LONDON: DULAU & CO., 37, SOHO SQUARE.



No. 429. New Series.—Decade IV.—Vol. VII.—No. III. Price 1s. 6d. nett.

THE GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., &c.,

WILFRID H. HUDLESTON, M.A., F.R.S., F.L.S., F.G.S., &c.,

GEORGE J. HINDE, Ph.D., F.R.S., F.G.S., &c., AND

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

MARCH, 1900.

CONTENTS.

LONDON: DULAU & CO., 37, SOHO SQUARE.

No. 430. New Series.—Decade IV.—Vol. VII.—No. IV. Price 1s. 6d. nett.

THE

GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., &c.,

WILFRID H. HUDLESTON, M.A., F.R.S., F.L.S., F.G.S., &c.,

GEORGE J. HINDE, PH.D., F.R.S., F.G.S., &c., AND

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

APRIL, 1900.

CONTENTS.

LONDON: DULAU & CO., 37, SOHO SQUARE.

No. 431. New Series.—Decade IV.—Vol. VII.—No. V. Price 1s. 6d. nett.

THE

GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., &c.,

WILFRID H. HUDLESTON, M.A., F.R.S., F.L.S., F.G.S., &c.,

GEORGE J. HINDE, Ph.D., F.R.S., F.G.S., &c., AND

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

MAY, 1900.

CONTENTS.

LONDON: DULAU & CO., 37, SOHO SQUARE.

No. 432. New Series.—Decade IV.—Vol. VII.—No. VI. Price 1s. 6d. nett.

THE

GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., &c.,
WILFRID H. HUDLESTON, M.A., F.R.S., F.L.S., F.G.S., &c.,
GEORGE J. HINDE, Ph.D., F.R.S., F.G.S., &c., AND
HORACE BOLINGBROKE WOODWARD, F.R.S., F.G.S.

JUNE, 1900.

CONTENTS.

LONDON: DULAU & CO., 37, SOHO SQUARE.

No. 433. New Series.—Decade IV.—Vol. VII.—No. VII. Price 1s. 6d. nett.

THE

GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., &c.,

WILFRID H. HUDLESTON, M.A., F.R.S., F.L.S., F.G.S., &c.,

GEORGE J. HINDE, Ph.D., F.R.S., F.G.S., &c., AND

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

JULY, 1900.

CONTENTS.

LONDON: DULAU & CO., 37, SOHO SQUARE.

No. 434. New Series.—Decade IV.—Vol. VII.—No. VIII. Price 1s. 6d. nett

THE

GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., &c.,

WILFRID H. HUDLESTON, M.A., F.R.S., F.L.S., F.G.S., &c.,

GEORGE J. HINDE, PH.D., F.R.S., F.G.S., &c., AND

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

AUGUST, 1900.

CONTENTS.

LONDON: DULAU & CO., 37, SOHO SQUARE.

No. 435. New Series.—Decade IV.—Vol. VII.—No. IX. Price 1s. 6d. nett.

THE

GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., &c.,

WILFRID H. HUDLESTON, M.A., F.R.S., F.L.S., F.G.S., &c.,

GEORGE J. HINDE, Ph.D., F.R.S., F.G.S., &c., AND

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

SEPTEMBER, 1900.

CONTENTS.

LONDON: DULAU & CO., 37, SOHO SQUARE.

No. 436. New Series.—Decade IV.—Vol. VII.—No. X. Price 1s. 6d. nett.

THE

GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., &c.,
WILFRID H. HUDLESTON, M.A., F.R.S., F.L.S., F.G.S., &c.,
GEORGE J. HINDE, Ph.D., F.R.S., F.G.S., &c., AND
HORACE BOLINGBROKE WOODWARD, F.R.S., F.G.S.

OCTOBER, 1900.

CONTENTS.

LONDON: DULAU & CO., 37, SOHO SQUARE.

No. 437. New Series.—Decade IV.—Vol. VII.—No. XI. Price 1s. 6d. nett.

THE

GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., &c.,

WILFRID H. HUDLESTON, M.A., F.R.S., F.L.S., F.G.S., &c.,

GEORGE J. HINDE, Ph.D., F.R.S., F.G.S., &c., AND

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

NOVEMBER, 1900.

CONTENTS.

LONDON: DULAU & CO., 37, SOHO SQUARE.

No. 438. New Series.—Decade IV.—Vol. VII.—No. XII. Price 1s. 6d. nett.

THE

GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology.

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

EDITED BY

HENRY WOODWARD, LL.D., F.R.S., F.G.S., &c.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., &c.,

WILFRID H. HUDLESTON, M.A., F.R.S., F.L.S., F.G.S., &c.,

GEORGE J. HINDE, Ph.D., F.R.S., F.G.S., &c., AND

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

DECEMBER, 1900.

CONTENTS.

With this Number is presented an Extra Sheet, containing Index and Title for Decade IV, Vol. VII, 1900.

LONDON: DULAU & CO., 37, SOHO SQUARE.