THE

GEOLOGICAL MAGAZINE.

NEW SERIES.

DECADE IV.   VOL. V.

JANUARY—DECEMBER, 1898.

THE

GEOLOGICAL MAGAZINE

OR,

Monthly Journal of Geology:

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

NOS. CCCCIII TO CCCCXIV.

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NEW SERIES. DECADE IV. VOL. V.
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LIST OF PLATES.

LIST OF ILLUSTRATIONS IN THE TEXT.

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

Figs.1-5,Avalonia Sanfordi.   Figs.6-9,Picrodon Herveyi.
              (Seeley.)   (Seeley.)
          Rhætic Beds, Wedmore Hill.

ORIGINAL ARTICLES.

I.—On large Terrestrial Saurians from the Rhætic Beds
of Wedmore Hill, described as *Avalonia Sanfordi* and
Picrodon Herveyi.

By H. G. Seeley, F.R.S., Professor of Geology in King's College, London.

(PLATE I.)

IN 1894 Mr. W. A. Sanford described, in the Proceedings of the
Somerset Archæological Society (vol. xl, 1894, p. 234), the
geological circumstances of the discovery of a large fossil reptile.
The fossil bones were found by the Rev. Sydenham H. A. Hervey
and himself in the Rhætic beds in the parish of Wedmore, in the
Vale of Glastonbury; and compared to *Megalosaurus* in its large
size and carnivorous character. The remains were generously
presented to the British Museum (Natural History) at South
Kensington. I have now to redeem a promise made by Mr. Sanford
in his paper that I would name and describe the specimens.

The fossils comprise teeth, bones of the hind limb, dorsal and
caudal vertebræ, and ribs. The discoverer remarks upon the way
in which the bones appear to have been broken, crushed out of form,
and scattered in the deposit. These results are partly due to
transport of the specimens at the time of deposition; and partly,
apparently, to movements of the strata associated with the uplifting
of the rocks in that part of England.

Only two teeth were saved; they indicate two distinct genera. One
tooth (p. 2, Fig. 1) is of a generalized Megalosaurian type, and has
the summit of the crown greatly worn with use, and rounded. The
crown is broad and thick, 12 mm. wide and 7 mm. in thickness;
but towards the base of the crown, the width from front to back
increases faster than its thickness. The anterior margin is rounded
from side to side, as well as convex from above downward. If any
serrations were ever developed, they were in the proximal part, which
is worn away. In type the tooth resembles *Zanclodon* and *Euskele-
saurus*. Those types agree with *Megalosaurus* in the limitation of
the anterior serrations to the upper margin of the tooth in the lower
jaw. Mr. Sanford states that the root of the tooth crumbled, and
that portions of the lower jaw were found. Taken by itself the

crown suggests affinity rather with *Zanclodon* than *Megalosaurus.*
The serrations on the hinder border are at right angles to the margin.
I refer this tooth to *Avalonia*, the fossil being found in Avalon, the
district associated with King Arthur and his Knights of the Round
Table.

FIG. 1.   FIG. 2.
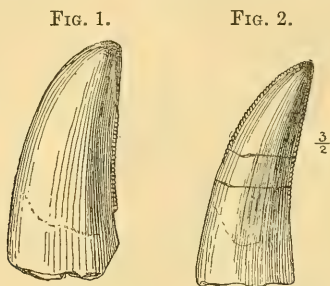
FIG. 1.—Tooth of *Avalonia Sanfordi*, Seeley.
FIG. 2.—Tooth of *Picrodon Herveyi*, Seeley.
Rhætic Beds: Wedmore (Vale of Glastonbury).

The second tooth (Fig. 2) is also represented by an imperfect
crown. It is from the lower jaw, but of a very different type. It is
$\frac{4}{5}$ inch long and $\frac{3}{10}$ inch wide at the base. It is sharp-pointed and
slender, and the only tooth which at all resembles it in form is one
from the collection of the late Rev. P. B. Brodie, found near Warwick,
now in the British Museum (Natural History), which I refer to the
same genus. This acuminate tooth, manifestly smaller than the
tooth of *Avalonia*, and imperfectly preserved, is flattened externally
and rather convex on the inner side, where there are three or four
short slight ribs towards the lower half of the crown, which some-
what recall the ribs in the teeth of *Suchosaurus*, which the type
resembles in form ; but the crown differs from that genus in being
more pointed, and especially in having the anterior and posterior
margins serrated. The anterior serrations are limited to the summit
of the crown. Their general direction is at right angles to the
curved surface, but they have a perceptibly greater upward tendency.
The posterior serrations are also directed upward. This constitutes
a distinct resemblance to *Thecodontosaurus* and a difference from
Megalosaurus, in which the serrations are at right angles to the
cutting margins of the tooth, as they are in the short crown of
Palœosaurus. The nearest approximation to this kind of serration
is made perhaps by the French genus *Dimodosaurus.* But the
serrations, except for their direction, are similar to those of *Megalo-
saurus*, and there is no median ridge running down the length of the
tooth such as is figured by M. Gaudry. The tooth indicates the
genus *Picrodon.* I have therefore no doubt that the remains of the
skeleton preserved belong to two distinct though closely allied
animals, of which the second was the smaller.

The true nature of the larger animal, *Avalonia Sanfordi*, is indicated
by the remains of the femur and other parts of the hind limb. The

femur (Pl. I, Fig. 1) is about 38 inches long.   It is a moderately strong bone, compressed from front to back, with the proximal and distal ends in the same plane.   There is no trace of a sigmoid curve such as is seen in *Palæosaurus,* and to some extent in *Megalosaurus* and *Dimodosaurus.*   The least transverse width of the proximal end is $9\frac{1}{2}$ inches and the greatest width $10\frac{1}{2}$ inches.   Of this width, at least $2\frac{1}{2}$ inches is due to the inward direction of the convex articular surface, which measures 6 inches from front to back in the middle of the articulation, is flattened above, and is round from above downward as it extends inward.   Below the proximal articulation towards the outer border, the front of the bone is impressed for a width of about 3 inches.   This condition somewhat approximates to that seen in the corresponding part of the femur of *Euskelesaurus Browni*; only in that type the transverse expansion of the head of the bone is much less, and the shaft of the bone is nearly cylindrical, shorter, and relatively stouter.   The lower border of this impression is an oblique ridge, which passes downward and outward, but is not appreciably elevated; it is 4 or 5 inches long, and is the only representative of the proximal trochanter of *Megalosaurus,* which is scarcely developed in *Euskelesaurus* and *Palæosaurus,* is almost lost in *Massospondylus* and *Dimodosaurus,* and passes away in some Zan-clodonts.   This is one of the most distinctive characters of the bone. Below the termination of the ridge the external lateral contour of the bone is concave in length, and this causes the shaft to narrow from a width of 7 inches to $5\frac{1}{2}$ inches in its middle length, below which it widens again to $11\frac{1}{2}$ inches towards the distal end.   The middle length of the inner lateral border is occupied by a trochanter, which is now broken away but had the backward direction seen in carnivorous genera of Saurischia.   Its broken base is a foot long, is perfectly straight, and occupies the middle third of the length of the bone.   Above the trochanter the concave inner border is approximately parallel to the convex external border.   The widening of the distal end of the bone is similarly due to an inward extension of the bone below the trochanter in a concave contour. This inner side is flattened and inclines slightly forward, being supported by the large inner distal condyle.   The length and position of the lateral trochanter are distinctive; in *Euskelesaurus* it occupies the middle of the bone, and in *Massospondylus* it is towards the middle, but in both the African genera it is relatively shorter, while in *Palæosaurus* and *Megalosaurus* the proximal position of the trochanter is as pronounced as in *Zanclodon*; so that this also is a distinctive feature of the bone.

   The distal end is about $11\frac{1}{2}$ inches wide.   In front there is a slight concave longitudinal channel, slightly external to the middle width. The distal extremity is truncated.   The larger inner condyle seen behind is 7 inches from front to back, and separated from the outer condyle by a moderately deep concave channel about 2 inches wide. The back-to-front measurement between the two channels exceeds 4 inches.   The outer posterior surface external to the lesser condyle is oblique, and has the usual compressed aspect.

The bone is manifestly that of a new Zanclodont Saurian, and the pelvis and other parts of the skeleton may be expected to conform to the types at Stuttgart and Tübingen. The shaft of the femur is much straighter than in *Megalosaurus*, and the other characters all tend to remove the genus *Avalonia* from the types in which the pubic bones are slender and rod-like, and refer it to types in which those bones are flattened plates.

Only 16 inches of the proximal end of the left tibia is preserved. The proximal end is greatly expanded, especially towards the anterior crest of the bone. The proximal surface is truncated in the usual way, and is triangular. It measures 12 inches from front to back, and 9 inches from side to side behind, indicating, as the femur is nearly a foot wide, that the fibula had the usual slender form. The inner side of the bone is smooth and convex from front to back; the fibular side has a shallow channel for the fibula. The posterior side is concave in the middle width at the proximal end. These characters are too few to greatly elucidate the characters of the animal, but they are in harmony with the proximal end of the tibia in the genera which have resemblances to the femoral bone.

The hind foot is evidenced by digital and terminal claw phalanges. In all characters these bones are so remarkably like those which I have figured in *Euskelesaurus* (Annals Nat. Hist., ser. vi, vol. xiv, p. 332, 1894) that I can point to no differences between them. The transverse width of the claw phalange removes the animal from all allies of *Megalosaurus*. It is not quite so wide as the same bone in *Cetiosaurus*, and conforms to the type of *Zanclodon* preserved at Tübingen. The digital phalanges are $2\frac{2}{10}$ inches long, as wide behind, narrower in front; $1\frac{8}{10}$ inch deep behind, depressed in front. The bone narrows superiorly, and has the trochlear extremities completely ossified. The claw phalange exceeds 4 inches in length, being more than one-tenth of the length of the femur, and nearly twice the length of a penultimate phalange. Its articular end is trapezoidal, fully 2 inches deep, and as wide below the middle. The usual vascular grooves extend in arched curves along the sides of the bone, and are continued transversely beneath the articular end. The limb bones probably indicate an animal less than six feet high.

The vertebræ preserved appear to indicate two animals. The dorsal vertebræ all agree in the anterior face being flattened and relatively small, while the posterior face is concave and much larger. In this they resemble the vertebræ of *Avalonia*. But since one type has the centrum 5 to $5\frac{1}{2}$ inches long, with the anterior face 6 inches deep, while the posterior face is 8 inches deep, I conclude that it indicates a distinct animal from the second type, in which the centrum is $5\frac{1}{2}$ to 6 inches long, with the articular faces vertically ovate instead of circular, $4\frac{1}{2}$ inches deep in front, and 5 inches deep behind. After making all allowances for the effects of compression and distortion, I am compelled to refer the larger vertebra to the animal with the larger tooth, and suppose that the animal with the smaller tooth was represented by the smaller dorsal vertebra. The large size of the centrum exceeds

anything seen in British carnivorous saurians, and is especially large as compared with the dorsal vertebræ of *Megalosaurus*, in which the vertebræ are as unlike the fossil as are the limb-bones.

The large dorsal vertebra of *Avalonia Sanfordi* is somewhat crushed, and has the body of the centrum unusually constricted, both at the sides and the base. Above the middle of the side, and a little behind the middle length, is a concave impression, pinching the sides till they are about 3 inches apart. The flattened anterior face is not well preserved, and the margin of the deeply concave posterior face is rounded. The measurements indicate a moderate arching of the back. The neural canal is $2\frac{6}{10}$ inches high in front and 2 inches wide; behind it is wider than high.

The neural arch has a strong elevated capitular facet 2 inches deep and $1\frac{1}{2}$ inch wide, vertical and flat, with the anterior border straight and the posterior border convex. It is an elevation upon and expansion of the anterior buttress of the arch, just as the tubercular facet (which is lost with the transverse process) is supported by the posterior buttress, which is a narrow oblique ridge. Hence there is a concavity between the facet and the ridge, which extends under the transverse process. The large posterior zygapophyses extend back beyond the neural spine; and the buttresses below them, which face obliquely outward and backward, are excavated for the reception of the pre-zygapophyses. The neural spine is compressed and vertical, about 3 inches from back to front and half an inch thick, though there is no certain indication of its height. The transverse width over the neural arch as indicated was ten inches. The height of the vertebræ up to the summit of the neural spine may have been 20 inches. The transverse elevation of the capitular facet an inch above the base of the neural arch is a remarkable and distinctive character. The large size of the vertebra is somewhat Cetiosaurian.

The ribs were strong: one fragment, more than 15 inches long, is 3 inches deep at the fracture towards the proximal end, where the external surface is reflected somewhat backward, and as the rib extends outward its plane becomes twisted, so as to present a wider and oblique lateral superior surface, the measurement being about $1\frac{1}{2}$ inch at the fracture at the distal end.

The remainder of the vertebræ are referred to *Picrodon Herveyi*. They comprise dorsal vertebræ, with the body of the vertebræ compressed from side to side, and relatively more elongated, but with the front of the centrum narrower than the back. There is a distinct suture between the neural arch and the centrum. And the neural arch has strong upwardly converging buttresses, supporting the transverse processes. The articular faces are deeper than wide; the width does not exceed $4\frac{1}{2}$ inches.

A caudal vertebra, showing the base of the transverse process, has the centrum about 5 inches long, and the base of the transverse process $2\frac{1}{2}$ inches from front to back, by $1\frac{1}{4}$ inch deep. The articular face is about 5 inches deep, by less than 4 inches wide, but the preservation does not show whether chevron bones were developed at the hinder border. A later caudal, with the articular surface

fully $2\frac{1}{2}$ inches deep and the centrum 4 inches long, has no transverse process, and shows no indication of a chevron facet, though the base of the articulation is somewhat thickened behind. A still later vertebra has the centrum 3 inches long, and the articular face $1\frac{1}{2}$ inch deep by $1\frac{1}{10}$ inch wide. The caudal vertebræ continue to diminish in length, and the neural arch becomes compressed from side to side, but remains well developed, and nearly an inch longer than the centrum. The pre-zygapophyses look obliquely upward and forward, and receive the wedge of the posterior zygapophyses between them. There appear to be faint indications of very small chevron bones in these latest vertebræ. It is possible that the smaller caudal vertebræ belong to *Avalonia*.

These vertebral characters indicate an animal closely allied to *Avalonia*, but well distinguished by the lateral compression of the centrum, supported by the singular form of the tooth crown, obliquely serrated at the margin, and ribbed on the inner side.

EXPLANATION OF PLATE I.

Avalonia Sanfordi, Seeley.

Fig. 1.—Anterior aspect of left femur. *a*, articular head ; *b*, ridge representing the trochanter major ; *c*, broken base of the inner lateral trochanter ; *d*, inner of the larger distal condyle.

Fig. 2.—Posterior aspect of a dorsal vertebra.

Fig. 3.—Right side of a dorsal vertebra, showing (*f*) the capitular and (*t*) tubercular facets, and the xygapophyses.

Fig. 4.—Side view of claw phalange and penultimate phalange of hind foot.

Fig. 5.—Articular end of claw phalange.

Picrodon Herveyi, Seeley.

Fig. 6.—Dorsal vertebra, posterior aspect.

Fig. 7.—Same vertebra, lateral aspect.

Fig. 8.—Early caudal vertebra, lateral aspect.

Fig. 9.—Late caudal vertebra.

Rhætic Beds : Wedmore Hill (Vale of Glastonbury), Somerset.

See also note on some Rhætic Foraminifera from Wedmore, by F. Chapman, 1895, Ann. and Mag. Nat. Hist., vol. xvi, p. 305.

II.—RECENT OBSERVATIONS ON EUROPEAN DINOSAURS.

By Professor O. C. MARSH, M.A., Ph.D., LL.D., F.G.S. ; of Yale College, New Haven, U.S.A.

DURING the past summer, it was my privilege to attend the International Congress of Geologists at St. Petersburg, as an official delegate from the United States, and this gave me an opportunity to see a number of museums and collections in Europe which I had not before visited. I thus had the privilege of inspecting personally many interesting reptilian remains that I had not previously known, and of examining others which were more or less familiar to me from figures and descriptions.

In the present paper, I have only time to speak of the Dinosaurs, in which I have long taken a special interest, and have endeavoured to study all the known specimens of importance, both in this country and in Europe, having in view the preparation of a series

of memoirs on the different groups of this subclass of extinct Reptilia.

London.—I began my investigations in the British Museum in London, a great treasure-house for fossil reptiles, to which I have long made frequent pilgrimages. This time the Dinosaurs were seen to better advantage than ever before, but of new or unknown forms I found that few had been added to the collection since my visit two years ago; and I consoled myself with the other extinct Reptilia, and especially with the new fossil birds and mammals from South America.

St. Petersburg.—In St. Petersburg I hoped to find many Dinosaurian remains, as here had been brought together an abundance of fossil treasures from various parts of the Russian Empire, which I knew must contain many forms of this group. In the four principal museums of the city, however, I could find no bones of Dinosaurs on exhibition, nor could I learn from any of the museum authorities that such remains had been recognized among the specimens received, neither could I find any such fossils myself among the débris of the collections, so often a rich repository for new or inconspicuous specimens. This was true also of the smaller collections visited, and I was at last forced to admit that here, at least, the Dinosaurs of Russia, like the snakes of Ireland, were conspicuous only by their absence.

Moscow.—This opinion was not changed by a visit to the rich geological collections of Moscow, which I examined with care; although other fossil vertebrates, including many reptiles, were abundantly represented. I was assured, moreover, by various Russian palæontologists, that in other museums of the empire or in the known localities they had seen no Dinosaurian remains. This vain quest, however, only proves that the discoveries are yet to be made, and I confidently expect them at no distant day, since in almost every other part of the world Dinosauria have already been brought to light. In Northern Europe west of Russia, and in North America to the east, these reptiles were especially abundant, and the vast territory intervening must contain numerous Dinosaurs, including many new forms of the group.

Vienna.—In Vienna I knew that my friend Professor Suess had a large collection of Dinosaurs in his museum to show me, and I spent several days there in their investigation. This collection was of special interest to me, as it was from the Gosau freshwater deposits, which, as a student, years ago, I explored mainly in the expectation of finding Cretaceous mammals; and I was not without hope of still detecting such remains during my present visit, as here were the localities where they were, in my judgment, most likely to be found in Europe. The Dinosaurs I examined were from Neue Welt in this formation, and were of great interest. They had all been studied by Bunzel, Seeley, and others, who had recognized ten or twelve distinct genera and many species among them. I could find, however, not more than a quarter of this number, and among these I found no indications of the *Ceratopsia*, which from

the published figures and descriptions I supposed to be represented in this collection. The Dinosaurs with dermal armour which I saw all pertained to the Stegosauria, and two distinct genera among them were more nearly like *Scelidosaurus* of the English Jura and *Nodosaurus* of the American Cretaceous than any others with which I am familiar. This collection contained the only Dinosaurian remains I could find in Vienna.

Munich.—I next went to Munich, which, under Professor von Zittel, has become a great centre for palæontology. I found that the gem of the collection is still the unique *Compsognathus*, which in several previous visits I had studied with care. A re-examination impressed me even more with the fact, that this is one of the most perfect and interesting vertebrate fossils yet discovered, and no other example of the genus is known. It was in this unique specimen that years before I had detected the embryo, and this fossil still affords the only known evidence that Dinosaurs were viviparous. I could find no other Dinosaurian bones of interest in the Munich collection, the new features being mainly numerous fine specimens of Mosasauria from America, and some interesting remains of *Hesperornis* and *Baptornis* from the same horizon in Kansas.

I was much pleased to see here the new Jurassic fossils collected by Nansen in 1896, at Cape Flora, in Franz Josef Land. These interesting remains are now under investigation by Dr. J. F. Pompeckj, assistant in the Munich Museum. I could detect no vertebrate fossils among them, although various indications favour their presence in this fauna.

Paris.—My limited sojourn in Paris gave me no opportunity for a careful examination of the museums there, but I could learn of no recent additions of Dinosaurian remains since my last visit.

Caen.—I next went to Caen, in Normandy, to see the famous Dinosaur *Poikilopleuron,* so well described by Deslongchamps many years ago. Through the kindness of my friend Professor A. Bigot, I had a good opportunity to study this unique specimen, which of late has been regarded as identical with the *Megalosaurus* of Buckland, the first genus of Dinosaurs described, and one about which little is yet known.

Among the undetermined material of this museum, I was greatly pleased to find the genus *Pleurocœlus* well represented by characteristic fossils, and from a well-defined Jurassic horizon in the vicinity of Havre. The species appears to be a new one, somewhat smaller than *Pleurocœlus suffosus* from the Kimmeridge of Swindon, England.[1] It resembled still more closely *Pleurocœlus nanus,* which I have described from the Potomac formation of Maryland.

Pleurocœlus is one of the most characteristic genera of the Sauropodous Dinosauria, and its value in marking a geological horizon should therefore have considerable weight. It is now known from the two European localities mentioned above, both in strata of undoubted Jurassic age. The same genus is well represented in

[1] Lydekker records a Wealden species, *Pleurocœlus valdensis,* in Quart. Journ. Geol. Soc., 1890, vol. xlvi, p. 182, pl. ix.

the Potomac deposits of Maryland, and has been found also in the *Atlantosaurus* beds of Wyoming, thus offering, with the associated fossils, strong testimony that the American and European localities are in the same general horizon of the Upper Jurassic.

Havre.—The last day at my disposal before sailing for America, I spent in Havre, in the Muséum d'Histoire Naturelle, where the director, M. Lennier, showed me many vertebrate fossils of interest, from the well-known localities near the city. Here, again, among the fragmentary specimens not yet investigated, I found the bones of another Dinosaur, also one of the Sauropoda, but considerably larger than the *Pleurocœlus* at Caen. The remains were very similar to those of *Morosaurus*, and the horizon was in the Kimmeridge, which is here well defined.

From Havre, I crossed the Channel to Southampton, and with a parting look at the Wealden cliffs of the Isle of Wight, which have furnished the remains of so many interesting Dinosaurs, I sailed for home.

III.—Narrative of a Geological Journey through Russia.

1. Finland.

By Geo. F. Harris, F.G.S., M.S.G.F., etc.

THE meeting of the International Geological Congress at St. Petersburg towards the end of August last year was about as successful in promoting the main objects the Congress has in view as any of its predecessors. There was a marked absence of anything like a serious radical programme, and in that sense the meeting may be said to have been progressive. The majority of the papers read were commonplace, the few exceptions being mostly in the domain of petrology. Every geologist who attended the meeting was grateful to the Organizing Committee for getting together such a nice little exhibition of specimens, maps, and models for the occasion. It was full of interest.

The official Russian geologists did everything in their power to assist their visitors. They caused certain scientific institutions in St. Petersburg to remain open longer than usual, and were never tired of explaining the rich collections stored in the geological and mineralogical museums in the Imperial University, and in kindred museums. During the week of meeting they organized a day's excursion to the Czar's palace at Peterhof, and another to the renowned falls of Imatra—a long distance off, in Finland, but distance counts as nothing in the Russian Empire. Then there were the inevitable receptions, though, fortunately, these were not carried out to the same extent as at the Washington Meeting.

But it was not of the actual Congress meetings, nor of the papers read or mumbled before them, nor of the wonderfully preserved mammalian remains in the temporary museum, nor of the unvarying courtesy of the Russian officials, that I desire to write in these articles. Neither may I say anything in the Geological Magazine concerning the social aspects of our visit to the other side of Europe

—of the many banquets held in our honour, of the terrible number of speeches, mostly by self-elected "representative" spokesmen, which frequently commenced shortly after the soup was placed upon the table (so keen was the competition to do justice to our hosts!) : these and many minor incidents, some of a distinctly sensational character, would more fittingly be recorded in the pages of a three-volume novel.

The Committee of Organization had arranged that four excursions should take place in connection with the Congress meeting. Of these, three were to be held before the meeting, viz. :—(1) to the Urals, (2) to Esthonia, (3) to Finland ; and one after, namely (4) to South Russia, by the Volga or alternative routes, over the Caucasus through Tiflis to Baku (variations), thence to Batoum and across the Black Sea, through part of the Crimea to Sebastopol, and on to Odessa. I had the good fortune to be included amongst the participants of journeys 3 and 4—to Finland and Transcaucasia ; and the aim of these articles is to give some account of the geology along the lines of route pursued by those two parties. To begin with the Finland journey ; and I prefer to write in narrative style.

Starting from St. Petersburg at night-time for Helsingfors, we had no opportunity, then, of learning the character of the scenery through which we passed. The next morning broke dull and grey, and through the rain we could see that although the country was flat it was extremely well wooded, and that the fields adjacent to the railway track were strewn with enormous boulders. The country was saturated with water, and the bracken fern and undergrowth generally were doing their best to hand plenty of peat down to posterity. Here and there was evidence of disastrous forest fires, whilst numerous blackened stumps stood out of the peaty soil and could be counted by hundreds in the clearings. Vegetation was not only abundant, but luxuriant, and this in what is usually called cold, icy Finland ! And so we continued to Helsingfors, meeting with but little else by the way except an occasional outcrop of granite.

At Helsingfors, Wilhelm Ramsay, of the University of that city, met us. This indefatigable geologist has done much for the geology of the country adopted by his ancestors. His work in the Isle of Hogland [1] and on the Quaternary deposits of Finland [2] may be cited as examples, whilst he has written joint memoirs with H. Berghell [3] and E. T. Nyholm [4] on the petrography and stratigraphy of the older rocks of Finland.

Helsingfors stands at the extremity of a small promontory, which is composed of a heterogeneous mass of what, for want of a better

[1] " Om Hoglands geologiska byggnad " : Geol. Fören. Förh. Stockholm, Bd. xii, 1890. " Beskrifning till kartbladen, No. 19 och 20, Hogland och Tytärsaari " : Finl. Geol. Und. 1891.

[2] " Ueber den Salpausselkä im östlichen Finnland," Fennia 4, No. 2 ; Helsingfors, 1891.

[3] " Das Gestein von Iiwaara in Finnland " : Geol. Fören. Förh. Stockholm, Bd. xiii, 1891, p. 300.

[4] " Cancrinitsyenit und einige verwandte Gesteine aus Kuolajärvi " : Bull. Comm. Géol. de la Finlande, No. 1, 1895.

name, is called gneiss or "granitic schist," and the same class of rock extends for many a square mile around, relieved only by considerable extensions of overlying Glacial and Post-Glacial clays, and sands. The gneiss is believed to be of Archæan age. It is an indescribable mixture, the so-called foliations resembling flow-structure, leading one to the belief that the whole was due to contact metamorphism. In certain cases, where schistose fragments appear to have been more or less absorbed, such an explanation is highly probable ; but, except the " Rapakivi," practically all the granite of South Finland, for at least 200 square miles, is foliated or " gneissose," or " schistose." Over large tracts appearances are certainly in favour of differential movements in the magma. But I will not say much about the rock, for our opportunities of examining it in the field were very small. The islets which add so much to the beauty of the environs of the Finnish capital are constituted either of this gneiss or the " gneissose granite."

The courteous Director of the Geological Commission of Finland, Mr. J. J. Sederholm, invited us all to the offices of the Survey, where he had prepared a representative collection of rocks and minerals, and examples of such fossils (all Quaternary) as have been found in the country. Sederholm's contributions to geology are already important. Amongst other things he has prepared a small geological map of Finland in two editions—solid and drift. He has especially studied the " Rapakivi "[1] and Archæan[2] rocks of South Finland. During the past year or two he has been engaged on the detailed mapping of the extremely interesting country in the neighbourhood of Tammerfors.[3] In conjunction with W. Ramsay, he prepared the useful guide[4] for the use of members attending the Finland excursion.

The collection of specimens at the office of the Geological Commission proved very interesting, and, in a measure, served as an illustrated guide to the class of rocks which we were to study in the field during the following week. Many types, however, did not lie along our track ; amongst these latter were marvellous examples of " rapakivi " and some " globular " granites, and a word or two respecting them may not be out of place.

The peculiar kind of " granite " known as rapakivi has, typically, a number of large phenocrysts, commonly rounded or ovoid, composed of a kernel of orthoclase enclosed within an envelope of oligoclase (Fig. 1). The rock between these phenocrysts is fine-grained and frequently micropegmatitic. The formation of the acid

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[1] "Ueber die finnländischen Rapakiwigesteine " : Tscherm. Min. und Petrogr. Mitth. Wien, Bd. xii, 1891.

[2] "Archäische Eruptivgesteine a. d. südwestlichen Finnland " : id., Bd. xii, 1891. "Ueber einen metamorph. präcamb. Quarzporphyr von Karvia, Provinz Åbo " : Bull. Comm. Géol. Finlande, No. 2, 1896 ; etc.

[3] "Archäische Sedimentformation im südwest. Finnland " : Bull. Comm. Géol. Finlande, No. 6, 1897.

[4] "Guide des excursions VII Congrès Géol. Internat. : XIII, Les Excursions en Finlande " ; St. Pétersbourg, 1897.

before the more basic felspar in the phenocrysts, and the detailed structure accompanying that phenomenon, form a very instructive study.

At the same time, the term rapakivi is largely applied by the geologists of Finland to holocrystalline rocks of granitic type
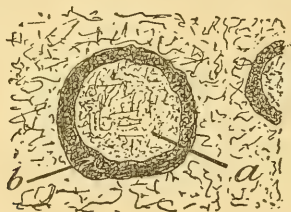
Fig. 1.—"Rapakivi granite" ($\frac{1}{3}$ nat. size). a = orthoclase ; b = plagioclase.

which contain large, rounded, and even irregularly - shaped phenocrysts of orthoclase, and which may not have the triclinic felspar wrapping round them, except in very rare instances in any one *massif*. It is used, in fact, as a general field term for granites of that description of Pre-Cambrian age. As thus defined, "rapakivi granite" extends over enormous areas in Southern Finland, on the north-eastern shore of Lake Ladoga, in the little island of Hogland in the Gulf of Finland, and in the Åland archipelago. It is one of the youngest of the Pre-Cambrian eruptives in the country, and has been classified by Sederholm [1] in his Jotnian formation—the younger subdivision of the Algonkian (or Archæozoic) group.

The "globular granites" exhibited at the offices of the Geological Commission (some of which were subsequently shown in the temporary museum formed in connection with the Congress meeting at St. Petersburg) have been described in some detail by Benjamin Frosterus.[2] The accompanying diagram (Fig. 2) represents one of these rounded or ovoid bodies. Mr. Frosterus tells me that the kernel is frequently formed of a fragment of biotite schist. Following his observations in the work just quoted, it will be seen that, normally, there is a kernel or nucleus, outside of which are four successive zones. In the diagram (Fig. 2) a represents the nucleus, which, in the specimen analyzed by Frosterus, contained 63·64 per cent. plagioclase ($Ab_2 An_1$) with 18·92 of biotite and 19·60 of quartz. Then followed the first coating or andesine zone (b), in which the plagioclase ($Ab_4 An_3$) amounted to 73·22, biotite 8·00, and quartz 16·50. The next coating, the oligoclase-andesine zone (c), yielded plagioclase ($Ab_1 An_1$) 56·07, biotite 5·60, and quartz 39·72. This is succeeded by a microcline zone (d), in which we have plagioclase ($Ab_3 An_2$) 16·52, alkali-felspar 57·44, and

[1] "Guide des Excursions," etc. (op. cit.), p. 18.
[2] "Kugelgranit von Kangasniemi in Finland" : Bull. Comm. Géol. Finlande, No. 4, 1896.

quartz 26·74. The outermost zone (*e*) has plagioclase (Ab$_2$ An$_1$) 44·28, alkali-felspar 6·79, biotite 4·00, quartz 42·82. The mineral composition of the stone between the globular bodies is plagioclase (Ab$_2$ An$_1$) 35·49, alkali-felspar 16·88, biotite 12·27, quartz 32·53. From this and from the chemical composition of the different zones and the "muttergestein," it is evident that the general tendency of the ordinary separation of the crystals from the original magma was normal—that the zones, on the whole, become more acid as they recede from the nucleus. The proportion of Si O$_2$, for example, in zone *b* is 61·64, *c* 72·92, *d* 74·80, and *e* 75·67, whilst the rock between the globular bodies has 70·46. Not the least interesting feature in these remarkable bodies is the mechanical deformation to which they have occasionally been subjected, and which has had the effect of breaking through the zones and squeezing out some of the substance of the interior. In certain of these Finnish "globular granites" shown at Helsingfors the spheroidal and ovoid bodies have been partially absorbed by the matrix in which they occur. The concentric zoning is clearly marked, and in most cases the minute crystals are so arranged as to produce a radiating effect.
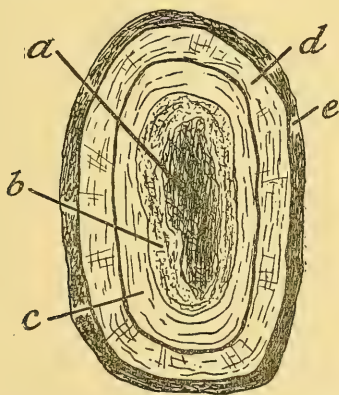
Fig. 2.—"Globular granite." Diagram showing disposition of zones in one of the typical ovoid bodies (about ¼ nat. size). The distinguishing italics are explained in the text.

The structure of these bodies differs somewhat from that of the well-known spheroids in the granite of Mullaghderg, County Donegal, described by Dr. Hatch,[1] though the Finnish rock agrees better with the Irish than with certain Continental rocks adverted to by the last-mentioned author.

At length, after a stay of three days, it was time to leave Helsingfors, and Mr. Sederholm took charge of the party. A long railway ride north, to Tammerfors, and an enthusiastic welcome from

[1] Quart. Journ. Geol. Soc., vol. xliv, 1888, p. 548 et sqq.

the inhabitants of that manufacturing town were the first items on the programme. The country seen on the way was flat or but slightly undulating, with low hills occasionally; the whole well wooded and watered. The Glacial clays passed through shortly after starting were here and there covered by Post-Glacial clays and littoral deposits containing *Litorina, Cardium, Mytilus, Tellina,* etc. A ridge of considerable size was traversed by the railway at Hyvinkää, which proves to be a large terminal moraine. To the north of that place moraine gravels predominate, and there are several åsar, a phenomenon which I intend to describe more particularly at another stage of our journey. Then several lakes come into view, and Tammerfors with its hilly scenery is reached.

Tammerfors is situated on a narrow neck of land formed by an " ås," which separates the lakes of Näsijärvi and Pyhäjärvi. The former lake is about 58 feet above the latter, and the two are connected by rapids, which in parts are very beautiful. The journeys for the next two or three days were from that place as a centre, a special train being always at our disposal.

The neighbourhood of Tammerfors is excellent for studying the Archæan rocks of Finland. The following divisions are recognized by Mr. Sederholm [1] :—

        1. Post-Bothnian granite.
        2. Bothnian schists.
        3. Pre-Bothnian gneiss.

In the last division, granites (essentially metamorphic), porphyroides, and closely foliated gneiss predominate. These latter, according to Sederholm, are granitized mica-schists. All these rocks crop out to the south of the town.

We examined the foliated granite and mica-schist (on the afternoon of our arrival) in a railway cutting at Siuro, about twenty miles west of Tammerfors; and in a railway cutting to the west of Suoniemi we had an opportunity of examining the mica-schist highly plicated. The micro-structure of these and some other Finnish rocks will presently be described.

We will turn now to the second division—the Bothnian schists, which, as will be seen as this narrative proceeds, we examined at many points. The local development of these is known as the Tammerfors schists. They crop out in bands running east and west, the whole being highly inclined and limited by the Pre-Bothnian gneiss on the one hand and the enormous outcrops of the Post-Bothnian granite on the other. These schists are often represented by phyllades,[2] which occasionally approach true argillites and sometimes pass gradually into fine-grained mica-schists. The foliated arkose, which Mr. Sederholm calls " leptite " (to be more particularly referred to hereafter), occurs in this subdivision. So also do certain hornblende (mostly uralite) schists (called porphyritoides), which were originally volcanic tuffs, and sometimes have altered lavas intercalated between them.

[1] " Excursions en Finlande " (op. cit. supra), p. 2.
[2] This term is here used in its broad sense.

But one of the most remarkable features of the " Bothnian schists" in the neighbourhood of Tammerfors is the presence of conglomerates on several horizons. These, in many instances, are so fresh that one finds some difficulty at first in believing that they are really Archæan. The waves of Lake Näsijärvi, in the lovely bay of Hormistonlahti, where these conglomerates are well exposed, have assisted the atmosphere in picking out the more or less crystalline cement between the pebbles. In other situations these Finnish rocks reminded me strongly of certain Cambrian conglomerates in North Wales; but I do not desire to draw the comparison any closer, for the Cambrian of the neighbouring parts of Russia, as everyone knows, is peculiar. as being so little affected by the ravages of time.

Mr. Sederholm places[1] the thickness of the Tammerfors schists at from 4,000 to 5,000 mètres—2,000 mètres for the phyllades, 1,500 for the lower tuffs and conglomerates, and the remainder for the upper tuffs with their intercalations of phyllade and conglomerate.

The Post-Bothnian granite, which crops out to the north of the schists in the Tammerfors area, is shown by Sederholm to traverse the latter, veins being thrown out at certain places, and large pieces of the schists being caught up at frequent points along the junction between the two rocks. And these pieces of included rock, in addition to possessing the structure and mineral composition of the Tammerfors schists, have occasionally been discovered to contain typical pebbles as found in the last-mentioned formation.

As I proceed with the narrative, I propose to give field notes and some account of the micro-structure of examples of these Archæan rocks which I collected, and to deal with the Glacial deposits, in the next article.

(*To be continued.*)

IV.—NOTES ON SOME SMALL LAKE-BASINS IN THE LEPONTINE ALPS.
By Prof. T. G. BONNEY, D.Sc., LL.D., F.R.S., V.P.G.S.

ROCK-BASINS have been getting out of favour of late. The "heckling" which they have suffered from my friend Mr. Marr tempts one to echo Betsy Prig's classic remark about Mrs. Harris. Mr. Brend, however, though " dealing faithfully " with them in the September number of the GEOLOGICAL MAGAZINE, does permit one or two to exist on sufferance. so that I feel minded, were it only as an act of charity to these depreciated securities, to describe two or three examples in the Alps which I think must be true rock-basins.

The first is called the Lago Tremorgio.[2] It lies, at a height of 5,997 feet above the sea, on the southern flank of the Val Bedretto, at the top of a long and steep ascent from Fiesso. It is slightly irregular in outline, but circular in form, with a diameter between

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[1] Op. cit. supra, p. 4.
[2] I examined it in 1893.

seven and eight hundred yards. It is almost enclosed by steep slopes and crags, and is entered through a narrow V-shaped gully, with a rapidly rising ridge on either side. Through this gully runs the stream which carries off the water of the lake. I followed a track which mounts gradually up the right bank, and no blocked outlet exists on that side ; I had an excellent view of the other bank, and feel certain there could not be one there. In fact, the rapid rise of the rocky ridge on either side and its outline are almost conclusive to an eye accustomed to mountain forms against there

South.
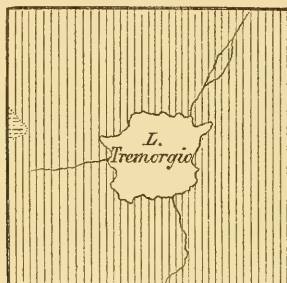
North.

Fig. 1.—Broken horizontal lines : Gneiss.
Vertical lines : Schists, micaceous, etc.
White : Water.
(Scale as below, Fig. 2, on p. 17.)

being any outlet to the cirque but the present one. At this the live rock can be seen not only on either side but also in the bed of the stream. Of that I could be sure, because the channel had been deepened, apparently in order to add slightly to the pasture-land by lowering the level of the lake, and had been cut down for about four feet into the solid rock. Above the cliffs is an undulating tract of pasture, forming a kind of step, on which is a small shallow tarn, and from this rocky slopes lead to the crest of the range, the lowest part of which, at the Passo Campolungo, is 7,595 feet above the sea. Thus the Lago Tremorgio is enclosed between two lofty spurs from the range, somewhat in the position of the seat of an armchair.

The next rock-basin, the Lago Ritom [1] in the Val Piora, is on the opposite side of the Val Bedretto, at almost exactly the same elevation above sea-level.[2] Its position is remarkable. A mass of crystalline schists, calcareous, quartzose, and micaceous, with some overlying rauchwacke, are apparently infolded between two masses of gneiss, of which the southern forms a high spur separating the Val Piora from the Val Bedretto, and the northern belongs to the watershed of the Lepontine Alps. Thus the Val Piora occupies a kind of trough between these two masses of gneiss, which runs

[1] I was there for some time last summer, and had already paid four short visits.
[2] It is a few inches over 6,000 feet.

almost from east to west, and its upper end descends from a bold craggy peak, which is called the Pizzo Columbe, and is formed of dolomitic limestone (a variety of the rauchwacke). On either side of this peak gaps, about 7,800 feet in height, lead to the upper part of the Lukmanier Road. After the first descent from these passes, the bed of the valley falls rather gradually and is fairly open, the mountains rising with moderate steepness on the southern side and precipitously on the northern. Sheltered in a recess in the latter side, just before we reach a break in the level of the valley, we find the Lago Cadagno (6,303 feet). It occupies a kind of cirque or gigantic corrie. Steep crags of gneiss sweep round about one half of it;

North.

1 Kilometer
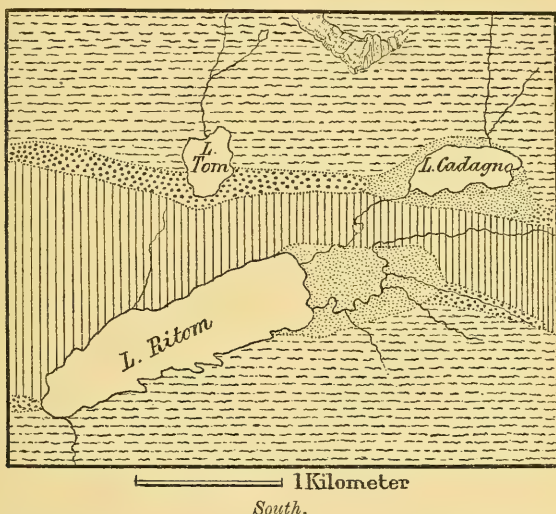
South.

Fig. 2.—Broken horizontal lines : Gneiss, with garnet and actinolitic schists (in northern part).
Vertical lines : Schists, micaceous, quartzose, and calcitic.
Coarse dotted : Rauchwacke.
Fine dotted : Alluvial.
White : Water.

the western end is barred by a spur, formed of an infold of rauchwacke, followed by a mass of dark micaceous schist ; the former corresponding with a slight depression, the latter with a hill. The lake is nearly 900 yards from east to west, but a small marshy plain shows that it has once extended rather farther in the latter direction ; it is about 275 yards across. The stream draining it flows from the south-west end. The character of the ground makes it difficult to speak positively, and one or two low mounds near the stream may be morainic, but the minor ridges in the neighbourhood of the more open side are clearly live rock, and the stream itself passes over the same at a level a very few feet indeed

below that of the lake. Hence, even if the latter to some extent is retained by drift, it may nevertheless, since it is not very shallow, be claimed as a rock-basin.

A short distance from the Lago Cadagno, the level of the valley, as already stated, is interrupted by cliffs and craggy steep slopes, at the bottom of which lies the basin of the Lago Ritom, in shape something like a shortish straight sausage. The part occupied by water is rather more than two thousand yards in length, and on an average about a quarter of the width;[1] the upper end, now a grassy meadow traversed by streams, is rather less than a thousand yards long. The basin is bounded on the southern side by a range of gneiss—forming here the northern boundary of the Val Bedretto—which descends with moderate steepness to the lake, and slightly indents the margin of the latter with the openings of its shallow valleys. Steep grass slopes and crags of micaceous schist, becoming more precipitous towards the north, form the head of the basin, and a line of crags, at about the same elevation, extends nearly to the lower end of the delta, where they are merged in the steep slope. The basin, indeed, is bounded on all the northern side by steep grass slopes and high cliffs, outposts of the central range of the Lepontine Alps. The part visible from below consists of the dark micaceous schists,[2] already mentioned. The lake-basin, in fact, lies obliquely across the zone of these rocks; its upper end being not far from their northern boundary, its lower just at the southern limit. As this is approached, the slopes continue steep; the schists pass away across a range towards the lower end of the Val Canaria; the lowest part of the crest, where also some rauchwacke occurs, lying between the Pian Alto (7,428 feet) and Fongio (7,257 feet), perhaps four or five hundred feet below the latter. This mountain is chiefly composed of gneiss, and is in reality a prolongation of the gneissic range which, as already mentioned, forms the southern bank of the Lago Ritom. There the valley in which that lake lies makes at this point a sharp turn to the south, and the water is discharged through a very narrow glen —a mere gateway in the mountains; for within a few yards of the foot of the lake the stream leaps down towards the Val Bedretto in a grand series of cascades. This is practically unbroken for some hundreds of feet, since the craggy slope is extremely steep to below the hamlet of La Valle. At the above-named gateway, close to the Hotel Piora, rock can be seen on either side of the stream, obviously forming its bed. A glance at the mountains on either side shows the existence of any other outlet to be impossible. So the Lago Ritom must occupy a true lake-basin, and that a fairly deep one.

[1] Professor Forel has kindly informed me that it is 2,000 mètres long, 500 mètres wide, and 60 mètres in greatest depth. I am indebted to him for the measurements of Lago Cadagno and Tom.

[2] They belong to the group which for purposes of reference I have called the Upper Schist. They are described, as well as the geology of the Val Piora, in the Quart. Journ. Geol. Soc., xlvi (1890), p. 199, etc.

Putting aside for the moment some questions which arise from the physiography of its borders, I pass on now to a fourth lake situated on the northern flank of the Lago Ritom, at a considerably higher level. This flank, as I said, rises in cliffs and steep grass slopes. A path up the latter, near the side of a cascading stream, brings us into a small upland valley, and we presently reach a lake at its head called the Lago Tom (6,637 feet). Like the Lago Cadagno, it occupies a kind of cirque,[1] and lies in the strike of the same rocks, for the enclosing crags consist of similar amphibolitic and granatiferous gneiss, and at the lower end is rauchwacke, which can be traced from the southern side of the basin of the Lago Cadagno across the intermediate spur. But the Lago Tom is not only on a rock-basin but also on a very remarkable one. The lower end is dammed by a mass of rauchwacke, in shape something like a rude causeway. Its top, as a rule, is not less than 12 to 15 feet above the water, but in one place it is cut by a dry gully two to three yards wide. Still, the bottom of this cannot be less than six feet above the level of the water. Rather to the east of this gap a curving channel or inlet from the lake pierces into the barrier for some distance. Its sides are cliffs, which at its head are three or four yards high. Just on the other side of the barrier, a fairly copious stream breaks out in a shallow glen which continues the line of the dry gully already mentioned. This unquestionably drains the lake, but where it starts is not easily ascertained.[2] There is no distinct flow up the inlet already mentioned,[3] and yet the stream, within a few feet of its issuing from the rock (a bank of old snow concealed the actual outlet), is a yard or more wide and a few inches deep, running with a brisk current. I suppose, therefore, that the rocky bed of this inlet is traversed by a number of small fissures,[4] through which the water percolates, to be collected and carried off by the stream. The rauchwacke (the usual cream-coloured, rather soft, and broken-looking limestone) is exposed in so many parts of the barrier that the existence of a drift-blocked channel seems to me an impossibility, and the Lago Tom must occupy a true rock-basin.

Three out of these four lakes are situated within cirques or very precipitous corries, and if we suppose the main outlines of these to be anterior to the Glacial Age, the ice, as it descended from the ranges above, would impinge on the level floor, on which under these circumstances it might have some erosive force. The origin of the largest lake (Ritom) is less easily explained, unless we suppose that in all other respects the physical features of the neighbourhood remain practically as they were when it began to

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[1] Its area is given as 1,000 square mètres, and it is said to be shallow. But I should think it would not be less than some 20 feet deep, and might be more.

[2] The only sign of disturbance in the lake itself, several yards away from the shore, was clearly an upward flow, i.e. was produced by a strong spring in the bed of the lake.

[3] I twice examined the surface of the water; on the second occasion (a very still day) I thought I detected a slight movement in some scum on the water.

[4] Rauchwacke often has a shattered, almost rubbly aspect.

be formed. The Val Piora, as I have said, consists of a lower step (the Lago Ritom) and an upper step, with which the Lago Cadagno is connected. These are separated by a rocky slope, precipitous in places, nearly 300 feet high. Supposing a glacier to be descending the Piora valley, we must assume this wall to be already in existence, or it could not acquire any plunging force, and even then the fall seems hardly adequate to produce the erosion of a basin like that of Lake Ritom. Possibly, however, the ice, just at this part, may have been "jammed"; for the main glacier was probably augmented by another ice-stream, which descended a shallow, but fairly well-marked valley, leading from a gneissic peak lying south-east down to the corresponding corner at the head of the Ritom basin; while the narrow "gate" by which the water is now discharged towards the Val Bedretto would block the mass of ice above it, and this would produce more than usual friction on the bed of the valley now occupied by the lake and its delta. This basin, then, the part which lies below the present contour-line of 6,000 feet (in round numbers), is the utmost that, in my opinion, can possibly be attributed to the erosive action of ice. Of this action, all the other dominant features in the surrounding scenery exhibit nothing more than superficial traces, and they appear to be due to the usual meteoric agencies.

The broad outlines of the Val Piora must have been determined at an early date. It lies, as I have said, in an infold of schists, belonging to the upper part of the crystalline series, and of some rauchwacke of Triassic age, which, after crossing the lower end of the Val Canaria, reaches the floor of the Val Bedretto at and near Airolo. Regarding this simply as a fold (it is really a complicated and faulted one), the natural line for the discharge of its drainage would be towards the Val Bedretto, in the direction of Airolo, passing over the col mentioned above as lying to the north of Fongio. The top of this col is probably about 6,800 feet above the sea. Fongio itself is clearly a prolongation of the gneissic range between the Val Piora and the Val Bedretto. Hence, at some very early date, differential movements in the mountain mass must have diverted the drainage of the Val Piora from a western direction to its present outlet on the east side of Fongio, through some chance dip already existing in the range. Owing to the rapid descent to the north a groove would soon be formed, and the direction of discharge finally determined. Since then, as I suppose, all of the lower half of the Val Piora that lies below the contour-line of 6,800 feet (in round numbers), with some of the upper, must have been excavated. Somewhat beneath this level, perhaps at about 6,500 feet, a rather marked increase of steepness is often perceptible in the slopes on the northern side of the lower part of the Piora valley. Besides this, a structure which is conspicuous in the Val Bedretto itself may not be without significance. Looking up that valley from such a point as the top of Fongio, one perceives that the slopes become near a certain part very much steeper, and begin to descend from that level rather abruptly towards the bed of

the valley. On the right bank of the Val Bedretto we can trace this terrace-like configuration for a long way below the opening of the Val Piora, and opposite to that gap I estimated its height as much the same as that of the pass north of Fongio, i.e. not far from 6,700 feet.[1] On the left bank, it will be remembered that, at the opening of the Val Tremola, the slope markedly changes, perhaps a thousand feet lower down.[2] I have observed this structure in many of the uppermost portions of the Alpine valleys, often some couple of thousand feet, perhaps occasionally rather more, above the present floor. It must indicate some very marked change in the erosive agents, probably an increase in the velocity of the torrents, since the valley becomes much more steep-sided. Can it possibly indicate the results of the Pre-Pliocene set of disturbances? But this is venturing into the realm of speculation; my present purpose is to show that, although doubtless many tarns and lakelets have no real claim to be called occupants of rock-basins, a few such do really exist.[3]

V. — On the Cretaceous Fossils found at Moreseat, Aberdeenshire.[4]

By A. J. Jukes-Browne and John Milne.

1. General Report by Mr. John Milne.

MORESEAT is in the parish of Cruden, in the east of Aberdeenshire. It lies at an elevation of 300 feet above sea-level, and the surface of the ground slopes to the sea at Cruden Bay, distant five miles to the south. On the north the ground rises gradually, reaching the height of 450 feet above sea in Torhendry Ridge, which is strewn with chalk-flints in great abundance.

Previous Investigations.—Geologists are indebted to Dr. William Ferguson, of Kinmundy, for the earliest notices of Greensand at Moreseat. In 1839 an excavation 14 feet deep was made for the water-wheel of a mill, and a drain away from it, on the south side of the farm steading, a little below the 300-feet level. The excavation was made in clay, and in it were found layers of sandstone containing many fossils. The Rev. J. Johnstone, Belhelvie, who lived at Moreseat at the time, says that the discovery excited great interest, and that Moreseat was visited by scientific men, amongst others by Professor Knight, of Marischal College and University, Aberdeen, who communicated with Dr. Thomson, of Glasgow University, on the subject, and informed his class

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[1] The slope, above Fiesso, begins of course just below the Lago Tremorgio, or nearly at 6,000 feet.
[2] No doubt this has been subsequently cut down below the original level, the valley being a large one; the Val Canaria has been cut yet lower.
[3] I believe I know of others than those mentioned in this paper, but, as I have not examined them since Mr. Marr's paper was published, will not refer to them.
[4] Report of the Committee, consisting of T. F. Jamieson (Chairman), A. J. Jukes-Browne, and John Milne (Secretary), appointed to ascertain the Age and Relation of the Rocks in which Secondary Fossils have been found near Moreseat, Aberdeenshire.

of 1839–40 that Greensand had been discovered at Moreseat. Dr. Ferguson was a student in this class, and thus had his attention directed to the Moreseat fossils from the first. Hundreds of loads of clay were removed from the excavation, and many fossils were collected; but when the wheel was put in and built up, and the drain was covered up, there remained no trace of the interesting discovery.

In 1849, on making a deep ditch alongside a road to the north of the farm steading, and a little above the 300-feet level, the same clay, sandstone, and fossils were met with. Dr. Ferguson sent a notice to the Philosophical Society of Glasgow.[1] Next year he visited the newly-made ditch, and sent an account of the original discovery and a description of what he saw to the *Philosophical Magazine*.[2] Dr. Ferguson's description of what he saw is quoted here, because it exactly coincides with what was seen in subsequent excavations. " An excavation about 7 feet in depth was made, and the section presented irregular layers of unctuous clay, of a dark-brown colour and soapy feel, and so tough and adhesive as to render it a work of considerable labour to dig it out. Interstratified with this clay were thin layers of a compact sandstone. These layers of sandstone were not continuous; they graduated into each other, thinned out, disappeared, and reappeared most confusedly. They were very much inclined, dipping towards the south. The whole mass had much the appearance of having been drifted; although from the nature of the matrix, and the state of preservation in which the shells are found, it does not appear as if it could have been drifted far. The sandstone is tough and soft when newly dug, but hardens on exposure to the air and becomes light-coloured in drying. When wet, it presents a mottled appearance, the colour being greenish; when dry, this almost disappears."

In 1856 a collection of fossils from Moreseat made by Dr. Ferguson was examined by Mr. J. W. Salter and Mr. W. H. Baily. An account of them was published next year in the Quarterly Journal of the Society, along with a note by Dr. Ferguson. Mr. Salter regarded the Moreseat fossils as an indication, in the near neighbourhood, of Upper Greensand *in situ*. Types of these fossils are preserved in the Museum of Practical Geology, Jermyn Street, London.

In the memoir descriptive of the sheet of the Geological Survey containing Moreseat, notice is taken of the Greensand fossils found there, and of the Chalk-flint fossils found at Bogingarrie, a few miles to the south-west, also described by Mr. Salter; but the surveyor does not say that he saw at Moreseat any fossils or fragments of Greensand sandstone.

In 1894 the Secretary of the Committee was lecturing at Cruden on Geology and Agriculture for the Aberdeen County Council, and was induced by the mention of Greensand in the memoir to visit

[1] See Proceedings of the Society, vol. iii, 1849.
[2] See vol. xxxvii, 1850.

Moreseat and make inquiries; but he could learn nothing further than that fossils had been found in the excavation made for the mill-wheel, and as it was enclosed with masonry nothing could be seen.   He visited the place repeatedly and examined all the ditches and watercourses on the farm, but found no fossils.   The reason of this was seen afterwards.   When pieces of the sandstone were exposed to frost they became a soft paste on thawing, and all trace of the fossils they contained disappeared.

He afterwards met with Mr. Alexander Insch, Peterhead, who had heard that fossils had been found north of the farm steading. Accompanied by him and Mr. D. J. Mitchell, Blackhills, Peterhead, he again visited Moreseat.   An excavation was made to the north of the ditch seen by Dr. Ferguson, and after passing through a foot or eighteen inches of sandy clay, thin layers of sandstone with fossils were found.   The appearance of the layers of sandstone was peculiar.   They conveyed the idea that they were cakes of some plastic material spread out in a soft state, yet not wet enough to bear great lateral extension without cracking.   The layers were full of vertical cracks, which broke them up into small fragments. These might have been caused by shrinking on drying, as the excavation was made where the ground would be dry in summer. The method of occurrence was the same as that described by Dr. Ferguson already quoted.   The fossils found were chiefly casts of shells.

Specimens were forwarded to the British Association with an application for a grant of money to ascertain by deeper excavation whether the bed from which the sandstone had come could be found there.   Though the application was unsuccessful, digging was continued by Messrs. Mitchell and Insch, who collected a large quantity of fossils in various places over an area a quarter of a mile broad in the neighbourhood of Moreseat.

In 1895 specimens were sent to Dr. H. Woodward, of the British Museum (Natural History), London, with another application for a grant from the British Association.   A grant of £10 was given, and the Committee already named was appointed.

Professor J. W. Judd, of the Royal College of Science, South Kensington, was consulted about the specimens already collected by Messrs. Mitchell and Insch, and by his advice they were sent to the Geological Survey Office, where they were examined and compared with Dr. Ferguson's typical specimens by Mr. G. Sharman and Mr. E. T. Newton.   They published a statement of the result in the GEOLOGICAL MAGAZINE, Dec. IV, Vol. III, 1896, p. 247. They came to the conclusion that the specimens had " been derived from beds where a large part of the Cretaceous series of strata occurs; not only Upper and Lower Chalk and Upper Greensand, as pointed out by Salter, but also beds of Lower Greensand or Speeton Clay age."   In making this statement they seem to have referred not only to the specimens collected by Messrs. Mitchell and Insch, but also to the Chalk-flint specimens in the Ferguson collection.   It may therefore be noted that though flints are found

in great abundance on the ridge above Moreseat, they become fewer in going down the hillside, and are comparatively scarce at Moreseat, and it may be assumed that none of the flint-fossils in the Ferguson collection were found in the immediate neighbourhood of the Greensand fossils.

Work of the Committee.—On being made aware of their appointment the Chairman and the Secretary met on the ground, accompanied by Messrs. Mitchell and Insch. Mr. Johnstone, the proprietor of the farm, kindly consented to allow an excavation to be made. All the places where fossils had been found were examined, and it was resolved to sink a shaft at the highest place where they were certainly known to be, in the belief that the fragments of sandstone had been moved from a higher to a lower level. The place selected is on a knoll north of Moreseat, about 330 feet above the sea-level, and about a quarter of a mile from the place where fossils were found in 1839. The ground to the north is covered with peat-moss overgrown with heather, and nothing can be seen of its character. Half a mile to the north-east there is some cultivated land, and a pit had been sunk by a crofter for a pump in white unstratified siliceous matter, apparently detritus of chalk-flints. To the north-west another pit had been dug. At first glacial drift clay was met with, then fine stratified sand, unsuitable for a pump well, and the excavation was stopped at 14 feet deep. This hole was 50 feet above the site selected for the shaft. It was thought best to defer the sinking of the shaft till the following summer to avoid risk of obstruction from water.

Mr. J. T. Tocher, the Secretary of the Buchan Field Club, which is affiliated to the British Association, undertook to contract for the work, and along with Mr. Mitchell to visit it while in progress, and to examine the material excavated.

The shaft was dug in the summer of 1896, and a depth of 30 feet was attained. The first foot consisted of ordinary soil. Below it was found a yellowish-brown sandy clay mixed with small fragments of sandstone and pebbles of quartzite and flint. The sandstone was afterwards found to contain Glauconite, and may be termed Glauconitic Sandstone. Almost every fragment yielded fossils, mostly casts of small shells. At 3 feet the clay became finer and the sandstone fragments more abundant. At 4 feet they were in layers among the clay, gradually thinning out and disappearing, as described by Dr. Ferguson. At 5 feet, on the south side of the shaft, a deposit of fine white sand was found, in which were pebbles of granite, quartzite, and flint. In the other part of the shaft the clay continued, with numerous bits of the grey glauconitic sandstone in a layer, much broken, dipping to the south, which is the direction of the slope of the surface of the ground at Moreseat. The mass of sand increased down to 8 feet, where it ended. At the bottom of the sand there was a block of granite a foot in diameter, and under it a large flint pebble. At 10 feet there was, on one side, a mass of black clay

with a soapy feel, in which sandstone fragments, much worn, were found. This black clay stopped at 11 feet. At 14 feet it began to appear again, and to take the place of the yellowish-brown clay, which ended at 16 feet. The lower part of it contained many stones. From this level the black clay continued all the way down to 30 feet, where it was succeeded by red laminated clay, without stones of any kind. The black clay contained large stones of granite and quartzite and small fragments of the glauconitic sandstone all the way, but the stones grew fewer in number the deeper the shaft was sunk, and the sandstone fragments had almost ceased at 27 feet. The excavation could not be carried farther than 30 feet, because, on reaching the red laminated clay, water began to come in and the funds were exhausted.

The Committee regret that they were unable to ascertain the nature of the solid rock under the shaft. Most likely it would have been found to be granite, the rock seen at the sea-coast from Cruden Bay to Peterhead. The shaft was evidently in glacial drift clay all the way, and therefore the sandstone fragments were not *in situ*, but had been transported, apparently from the north. By a series of pits a few feet deep made in this direction it might be possible to follow the sandstone farther up the hill, and a shaft sunk at the uppermost place where they could be found might discover the bed from which they came; yet the Committee cannot venture to express a confident opinion that another excavation would be more successful than the last in finding the origin of the Glauconitic Sandstone. Many appearances indicate that the latest changes on the surface of the ground in the district in which Moreseat is situated were caused by local glacial sheets, perhaps not on a great scale, yet capable of moving great quantities of loose and soft matter. The white sand in the shaft seemed to have been moved bodily from a bed seen to the north-west at a higher level. The original seat of the Glauconitic Sandstone may have been to the north of the shaft, a little farther up the hill, and yet the bed may have been entirely removed by ice descending the hill. If, however, the British Association renew the grant, the Committee will be happy to make another attempt to find the origin of the Moreseat fossils.

Mr. Tocher, F.I.C., analyzed the clays found in the shaft, and ascertained that the reddish colour of the one was due to ferric oxide of iron, and the black colour of the other to ferrous oxide.

Mr. Insch collected a large quantity of sandstone fragments containing fossils. These were examined by Mr. A. J. Jukes-Browne, and will ultimately be deposited either in the Aberdeen University Museum or in that at Peterhead.

2. Report on the Fossils by A. J. Jukes-Browne, B.A., F.G.S.

The existence of Cretaceous fossils, embedded in a kind of " Greensand," and found at Moreseat, near Aberdeen, has been known to geologists for nearly fifty years. Mr. W. Ferguson

discussed them in a paper read before the Philosophical Society of Glasgow in 1849, and subsequently communicated to the *Philosophical Magazine.*[1] In this he observes that most of the remains are casts, and he mentions the occurrence of several species of *Ammonites* and *Belemnites,* as also of *Cardium, Terebratula, Trochus, Solarium, Cerithium,* and *Spatangus.*

Some of Mr. Ferguson's fossils were examined and named by Mr. J. W. Salter in 1857,[2] who gave a list of fourteen species, two of them being Ammonites doubtfully referred to—*Am. Selliguinus,* Brong., and *Am. Pailletianus,* D'Orb. Four of the others he describes as new species, and from the remaining six he comes to the conclusion that the fauna is of Upper Greensand age.

From 1857 to 1896 no further light was thrown on the subject, but in the latter year some of the fossils collected by Messrs. Mitchell and Insch were submitted to Messrs. Sharman and Newton, who made a careful examination of them, and communicated the results to the GEOLOGICAL MAGAZINE.[3] They compared these fossils with the specimens described by Salter, which are preserved in the Museum of Practical Geology, and found the matrix to be the same. They also state that though slight differences are noticeable in different pieces of the rock, yet all the samples are " so similar that one can scarcely question their having been originally derived from the same bed."

They found, however, that many of the fossils could not be identified with any Upper Greensand species, but were Lower Cretaceous forms, many of them identical with those occurring in the Speeton Clay. They admitted, however, a few species which occur in the Upper Cretaceous series only, and have not been found in any British Lower Cretaceous deposit. Hence they conclude " that the faunas which in the south mark the distinct horizons of Lower Greensand, Gault, and Upper Greensand are here in Aberdeenshire included in one bed of nearly uniform character throughout." This conclusion certainly invested the Moreseat fossils with still greater interest than they possessed before.

A collection of the fossils was sent to me by the Rev. John Milne in September, 1896, but it was impossible for me to examine them in time to report on them before the meeting of the British Association in that year. I have since, however, given them careful attention, and have received much assistance from Messrs. Sharman and Newton, whose previous acquaintance with many of the species has saved me much time and labour.

It is not an easy task to identify these Moreseat fossils, for they are all in the state of casts and impressions. In no case does any actual shell or test remain, but the firmness of the rock has in most cases prevented the enveloping matrix from being pressed down on to the internal cast, so that the external cover generally retains the shape and impression of the original shell, and a mould

[1] Phil. Mag., vol. xxxvii, p. 430 (1850).
[2] Quart. Journ. Geol. Soc., vol. xiii, 1857, p. 83.
[3] GEOL. MAG., Dec. IV, Vol. III, 1896, p. 247.

can, if necessary, be taken from it.   The fossils had been carefully collected, and as both casts and covers had been transmitted, it has been possible to determine many of the species.

Before discussing the species, however, the rock itself merits description, for its peculiar characters seem to have escaped previous observers.   To the eye it presents itself as a very fine-grained siliceous rock, resembling malmstone, dark grey when damp and freshly broken, drying to a lighter grey.   Fractured surfaces often show spots and patches of darker material than the rest of the mass. Under the lens it showed a finely granular matrix, containing many small grains of glauconite and numerous flakes of mica, with small patches of a yellowish-green mineral which is apparently a decomposition product.

The general aspect and light specific gravity of the rock led me to suspect the presence of colloid silica, and accordingly I sent specimens to Mr. W. Hill, F.G.S., for microscopical examination. Mr. Hill cut slices from two of these, and furnishes me with the following account of the structure exhibited by them : — " The material of both slides is alike, and compares most nearly with the micaceous sandstone of Devizes (Upper Greensand).   The ground-mass consists of amorphous and semi-granular silica, neutral to polarized light, with little or no calcite.   There are many sponge spicules, the walls of which have mostly disappeared, but which are outlined in the matrix.   The space once occupied by the spicule is often partly filled with globules of colloid silica, like those in malmstone described by Dr. Hinde,[1] and similar globules are dispersed through the mass of rock.   There is much quartz sand in small, angular, even-sized grains, but not so much as in Devizes sandstone.   Glauconite grains are also abundant, but the quantity varies much in different parts of the rock ; the grains seem to be breaking up, and are often seamed with vein-like markings. There are also larger patches of dirty-green material, which has a somewhat indefinite outline, and may be of secondary formation. Small flakes of mica are scattered through the slides, but it is only when these are cut transversely that the mineral can be easily identified."

From the above description it will be seen that the rock may be termed a *gaize*—that is, a fine-grained sandstone, in which colloid silica is an important ingredient ; this is not a common rock, and in England it is only known as occurring in the Upper Greensand in association with malmstone.   In France a gaize of Lower Gault age, containing *Ammonites mammillatus* and *Am. interruptus*, occurs in the Ardennes (Draize), but I can find no record of the rock occurring in the Lower Cretaceous series either in France or Germany.

The formation of gaize and malmstone probably took place in clear water of a moderate depth ; it is not a shallow-water deposit, and yet it was deposited within the range of a current which carried

[1] Phil. Trans. Roy. Soc. 1885, pt. ii, p. 403.

fine sand.   The abundance of sponge spicules shows that the con-
ditions were such as to favour the growth of siliceous sponges.

Remarks on some of the Fossils.

The collection sent to me includes some species which have not
yet been recorded from the Moreseat rock, and as these are all
Lower Cretaceous forms, the Vectian element in the fauna is clearly
very strong—so strong indeed that I am led to doubt the existence
of some of the Upper Cretaceous species which have been supposed
to occur.   I shall therefore offer some remarks on certain species,
and give a complete revised list of the Moreseat fauna, so far as
it is at present known.

Micrabacia coronula, Goldf.—This identification requires confirma-
tion.   It depends solely on Salter's authority, for the specimen
he saw is not in the Jermyn Street Museum, and no other
specimen has been detected in the collections recently made.   The
species is not known to occur below the Upper Greensand zone of
Pecten asper, and would be difficult to recognize from a cast only.

Echinoconus castanea, Brong.—This also requires confirmation, for
the specimen so named by Mr. Salter has not been found at Jermyn
Street, and no other example has been seen.   In England its
earliest appearance is near the top of the Upper Greensand, but
in Switzerland it ranges down to the base of the Gault (see De
Loriol in "Echinologie Helvétique"), so that it may in some localities
range even lower.   No species of *Echinoconus*, however, has yet
been recorded from rocks of Lower Cretaceous age.

Discoidea decorata (?), Desor.—This specimen was among those
sent by Mr. Milne.   It consists of a nearly perfect external mould
in two parts.   It differs from *D. subucula* in having close-set
rows of nearly even-sized tubercles, eight rows on the inter-
ambulacral areas, four on each set of plates, and four rows on
the ambulacral areas; but the two inner ambulacral rows do not
reach either to the apex or to the peristome.   The mouth and vent
are both rather large.   In these respects it agrees with *D. decorata*.

Mr. C. J. A. Meyer having informed me that he possessed
specimens of a *Discoidea* from the Vectian of Hythe, the Moreseat
specimen was sent to him for comparison.   He reports that it agrees
with those from Hythe, but he is doubtful whether they are
referable to *D. decorata*, Desor, or *D. macropyga*, Ag.   Both are
Lower Cretaceous species.

Rhynchonella compressa.—The specimen so named by Salter is at
Jermyn Street, and has been examined again by Messrs. Sharman
and Newton, with the result that they think it is only a compressed
variety of *Rh. sulcata*, Park.   As specimens of *Rh. sulcata* are not
uncommon at Moreseat, and as it is a very variable form, *Rh.
compressa* may safely be excluded from the list.

Waldheimia faba, D'Orb. (*non* Sow.).— One specimen apparently
referable to this species is among those sent to me.   As it is only

a cast and as the shell is smooth, one cannot be quite sure of the species, but the shape is well preserved, and I am indebted to Mr. Meyer for pointing out that it has the squareness towards the front which is characteristic of the species in question. This is well shown in the example figured by Davidson (" Cret. Brach.," vol. iv, pl. vi, figs. 12–14), which came from the Speeton Clay of Knapton in Yorkshire.

Lima semisulcata, Sow.—This species has appeared in previous lists on the authority of Mr. Salter, but the specimen is in the Jermyn Street Museum, and Mr. Newton informs me that it is only an internal cast, and may, with equal probability, be referred to *L. Dupiniana.* As specimens of the latter do occur, and none referable to *L. semisulcata* have since been found, I think this Upper Cretaceous species may be omitted from the list.

Arca securis, D'Orb.—I have ventured to enter the common *Arca* of the Moreseat sandstone under the name of *securis* instead of under *carinata*, because the specimens I have examined seem to me to come nearer to *securis*, and Mr. Meyer, to whom a specimen was sent, is of the same opinion. The two species are so closely allied that some palæontologists regard them as identical; but there are slight differences, and Messrs. Sharman and Newton agree with me in considering the Moreseat specimens to be smaller and shallower in the valve than the ordinary *A. carinata* of the Upper Greensand; and in these respects they resemble *A. securis*. In some of them, moreover, the ribs on the posterior area are like those in D'Orbigny's figure of *securis*; so that, if the forms are separable, I think these should be listed as *securis*.

Leda scapha (?), D'Orb.—I have seen two casts which probably belong to this species, though they equally resemble *L. Mariæ* of the Gault, for, as Mr. Gardner has remarked, there is very little difference between these species.

Pectunculus umbonatus, Sow.—This is another of Mr. Salter's identifications, and unfortunately it also is only an internal cast. There are several species of *Petunculus* to which such a cast might belong, but the probabilities are against its being *P. umbonatus*. As no other specimen has occurred among the fossils recently collected, it will be best to leave it without a specific name for the present.

Turbo Triboleti (?), Pict. and Camp.—There is one specimen, a portion of the external impression of the shell, showing an ornamentation closely resembling that of *Turbo Triboleti*, which is a species from the Upper Gault of Ste. Croix. This specimen was sent to Mr. Meyer, who informs me that he has an imperfect specimen from the Vectian of the Isle of Wight which it equally resembles.

Ammonites flexisulcatus (?), D'Orb.—A small Ammonite was found in breaking up a lump of the material sent to me, and was

forwarded, with other specimens, to Messrs. Sharman and Newton. They reported that it most resembles *A. flexisulcatus*, though the portion preserved is smooth and without sulcations.

Nautilus sp., Sow.—Among the fossils sent to me by Mr. Milne is the cast of a Nautilus, badly preserved, but showing strong transverse rugations or ribs like those of *N. radiatus*, but its condition is such as to prevent any certainty of identification. Mr. A. H. Foord has kindly examined the specimen, but could not venture to name it.

In previous Collections.	In Mr. Milne's Collection.	Moreseat Fossils.	Speeton Clay and Lower Greensand.	Lower Gault.	Upper Gault and Malmstone Group.	Greensand of *Pecten asper* Zone.
		Actinozoa.				
		Coral (like Micrabacia)				
		Echinoderms.				
p.		Ananchytes (? Cardiaster)				
p.	M.	Discoidea decorata, Desor (?)	*			
p.		Echinocyphus difficilis, Ag.				*
p.	M.	Enallaster Scoticus, Salter				
p.		Echinoconus castanea (?)		*	*	*
		Annelida.				
p.		Serpula, sp.				
		Polyzoa.				
p.		Entalophora (?)				
		Brachiopoda.				
p.	M.	Rhynchonella sulcata, Park.	*	*	*	
p.		Terebratula, sp.				
	M.	Terebratella (cast only)				
	M.	Waldheimia faba, D'Orb. (non Sow.)	*			
p.		,, hippopus var. Tilbyensis, Dav.	*			
		Lamellibranchiata.				
	M.	Anatina, sp.				
p.	M.	Arca securis, D'Orb.	*			
p.		,, Raulini (?), D'Orb.	*	?		
p.	M.	Astarte striato-costata, Forbes	*			
p.	M.	Avicula simulata, Baily				
p.	M. ?	Cardium Raulinianum, D'Orb.	*	*		
	M.	Cardium, sp. (cast only)				
p.		Corbula, sp.				
p.	M.	Cyprina Fergusoni, Salter				
p.	M.	Exogyra (small species)				
p.		Gervillia solenoides, Defr.	*	*	*	
p.		,, near to rostrata				
p.		Goniomya, sp.				
p.		Inoceramus, sp.				
	M.	Leda scapha, D'Orb.	*			
p.		Lima Dupiniana, D'Orb.	*			
	M.	,, longa (?), Röm.	*			
p.		,, near to abrupta, D'Orb.				
p.	M.	Limopsis texturata, Salter				
p.	M.	Lucina, sp.				
	M.	Ostrea frons (?), Park. (carinata, Sow.)	*	*	*	*
p.		Panopea, sp.				
p.	M.	Pecten orbicularis, Sow.	*	*	*	*
p.		Pectunculus, sp.				

In previous Collections.	In Mr. Milne's Collection.	Moreseat Fossils.	Speeton Clay and Lower Greensand.	Lower Gault.	Upper Gault and Malmstone Group.	Greensand of *Pecten asper* Zone.
p.	M.	Pinna tetragona, Sow.	*	*	*	
p.	M.	Plicatula placunea, Lam.	*	?		
p.		Spondylus, sp.				
	M.	Tellina, sp.				
	M.	Thetis (?)				
p.		Trigonia Vectiana, Lyc.	*			
	M.	,, sp. nov.				
	M.	Venus Brongniartina (?), Leym.	*			
		Gastropoda.				
p.		Acteon, sp.				
p.	M.	Cerithium aculeatum, Forbes MS.	*			
p.	M.	Dentalium cœlulatum, Baily				
p.		Phasianella (like ervyna, D'Orb.)				
	M.	Solarium, sp.				
p.	M.	Trochus pulcherrimus	*			
p.		,, sp.				
	M.	Turbo Triboleti (?), P. & C.	*		*	
		Cephalopoda.				
	M.	Ammonites flexisulcatus (?), D'Orb.	*			
p.	M.	,, Mortilleti, P. & Lor.	*			
p.	M.	,, Speetonensis (var.)	*			
p.		,, Selliguinus (?), Brong.		*		
p.		Belemnites, sp.				
p.		Crioceras Duvallii, Lév.	*			
	M.	Nautilus, like radiatus, Sow.	?			

It only remains to indicate the conclusion to which the study of the Moreseat fossils has led me.

Of the species enumerated by Mr. Salter in 1857 four have been omitted from the preceding list, being regarded as doubtful identifications which have not been confirmed by subsequent discoveries. Of the three genera of Echinoderms mentioned by him the *Discoidea* was probably the species which resembles *D. decorata,* and the two named respectively *Diadema* and *Ananchytes* may have been Lower Greensand forms for anything that we know to the contrary.

The number of named species available for comparison with other faunas is now 33. Out of this total no fewer than 25 are species of Lower Cretaceous age, and only 7 of these range into the Gault ; 5 are species which have not been found elsewhere, 2 are Upper Greensand species, but one of these is a doubtful determination, and 2 are Ammonites, of which the identification is also doubtful. There is therefore an overwhelming proportion of exclusively Lower Cretaceous species, namely 18 to 2, while out of the 6 Cephalopods 5 are exclusively Lower Cretaceous forms, the only one which is not being the very doubtful *Am. Selliguinus.*

The occurrence of one Upper Greensand Echinoderm (*Echino-cyphus difficilis*), and the possible occurrence of another ranging

from Lower Gault to Chalk (*Echinoconus castanea?*), is hardly
sufficient evidence to warrant the conclusion that a part of the
rock-mass was of Upper Greensand age. There is nothing except
the *Am. Selliguinus* that is specially characteristic of the Gault,
and the question is this: What is the evidential value of the
occurrence of *Echinocyphus difficilis*, and possibly also of *Echinoconus
castanea* (?)? I think it may be answered in this way : it is more
reasonable to suppose that these two species, or forms very closely
allied to them, date really from Lower Cretaceous times, than it is to
suppose the deposition of exactly the same kind of rock material
should have continued at any one place from the time of the
Lower Greensand to that of the Upper Greensand.   In other
words, I believe that the rock-mass from which the Moreseat fossils
have been derived was entirely a Lower Cretaceous rock, but high
in that series, and corresponding approximately to the Aptien stage
of France, and to the Lower Greensand or Vectian of the Isle of
Wight.

VI.—On the Continental Elevation of the Glacial Period.

By Prof. J. W. Spencer, M.A., Ph.D., B.Sc., F.G.S.

Contents :

Introduction.

BEFORE the last meeting of the British Association, held in
Liverpool, Professor Edward Hull presented a paper upon
"Another Possible Cause of the Glacial Epoch."   In that paper,
Professor Hull applied the writer's work on the "Reconstruction
of the Antillean Continent," [1] which brought together evidence of
great continental elevation.   This elevation and its effects upon the
ocean-currents, in diverting them from the West Indian regions,
with the consequent reduction of their temperature as they reach
the northern latitudes in conjunction with the elevation of the land,
were thought by Professor Hull to be sufficient causes for the
production of the glacial climate over temperate regions in late
geological times.   The writer has hitherto never applied his
observations on high continental elevation to climatic changes ;
but in this paper he proposes to extend briefly his researches
from the Antillean region to the higher latitudes of America
and the North Atlantic regions.   Something has also been learned
of the date of the great elevation ; consequently inferences may be
drawn as to climatic changes.

Character of the Submarine Antillean Valleys.

The feature of the paper on the "Reconstruction of the Antillean
Continents," and subsequent observations of the region, show that

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[1] J. W. Spencer, "Reconstruction of the Antillean Continent" : Bull. Geol. Soc.
Amer., vol. vi, pp. 103–140, 1894.

there are deep valleys, often of great length, extending from the
mouths of the existing rivers, and crossing the American coastal
plains, over deeply-buried channels. These are plainly recognizable
in soundings upon the submarine coastal plateaux, and amongst the
banks and islands of the neighbouring West Indian seas, to depths
of 12,000 feet or more, before reaching the oceanic floors. The
drowned valleys radiate from the continental margins and extend in
a direction across that of the coast, and the mountain ranges to the
back of it. Their courses do not usually coincide with those of the
mountain folds. These submarine valleys are often recognizable for
hundreds of miles in descending to the floors of the ocean-basins, as
may be seen amongst the Bahamas. Frequently the divides between
different systems are themselves submerged, as in the Straits of
Florida. The submerged valleys are no broader than those of
existing rivers, such as those of the Amazon and the St. Lawrence,
nor indeed are they usually as wide. The Colorado cañon, from five
to twelve miles across, between walls of 2,000 feet in height, is wider
than some of the drowned valleys, which in part are cañon-like.
Both the submarine plateaux and the floors of the valleys are like
comparatively level plains or base-levels of erosion, which represent
pauses when the streams and atmospheric agents could not further
deepen their valleys, but only broaden them out into plains, until
a subsequent elevation of the region permitted the streams once
again to deepen their channels.

Gradients of Submarine Valleys.

The gradients of the submerged valleys (except along the reaches
crossing extensive plains, now below sea-level) can only be com-
pared with those of plateau regions, and not with the slopes of such
a river as the Mississippi, which flows over great plains at low
elevation. The manner in which the valleys descend from one
platform to another is illustrated in the plateau region of Mexico
and the West. An example of the declivity of such valleys may
be seen along the Mexican Railway, back of Vera Cruz, and another
above Monterey. The land valleys are made up of a series of steps
with greater declivities between them than occur between those
submerged. The various platforms represent the rise of the land
during the excavation of the valleys. The gradients of the sub-
merged plateaux are frequently as small as, or smaller than, those of
such plains as the Mississippi, while the declivities at their margins
are less abrupt than those of the land valleys descending from
tablelands, as may be seen by comparing them with the Mexican
valley sections. The gradient of the Colorado river, in its cañon
3,000 feet deep, is greater than that of the submerged platforms.
Besides the greater valleys, descending from the high plateaux,
there are many short tributaries, heading in amphitheatres, where
the slopes may be from 200 to 600 feet per mile; the whole
resembling gigantic "wash-outs." So also similar short drowned
valleys occur on the edges of the submarine plateaux. The data
concerning these comparative declivities were not obtained when the

original paper upon the submarine river-like valleys was prepared, but they now greatly strengthen the inferences that the drowned plateaux may be used as " yardsticks " for measuring the amount of late continental elevation.

In his paper referred to, Professor Hull endorses the correctness of the interpretation that the submerged valleys were formed by atmospheric agents. Such inferences being correct, the West Indies formed a high continental plateau, while the Gulf of Mexico and the Caribbean Sea were plains or inland lakes draining into the Pacific Ocean across what are now low passes of Mexico and Central America.

Date of the Continental Elevation.

Elsewhere the writer has shown [1] that the old Mio-Pliocene surfaces extended much beyond their present limits, and were subjected to long-continued reduction to base - levels of erosion. Upon the undulations of the country then produced, the Lafayette deposits of the continent form an extensive mantle, which has been provisionally considered as belonging to the late Pliocene epoch. The surfaces are enormously denuded. Following this formation northward, although there are but few exposures of contact, the writer has observed near Somerville, N.J., the Lafayette overlain by a few feet of glacial drift, which has been extensively denuded, as it is locally wanting. Resting upon the boulder drift, and where this has been removed, upon the underlying Lafayette loams and gravels, the Columbia formation may be seen. This feature shows that the epoch of glacial deposits occurred between the Lafayette and Columbia periods. Consequently, the epoch of great elevation, which favoured the excavation of the valleys, coincided with that of the glacial deposits of the early Pleistocene days.

Migration of Mammals.

The Antillean Continent formed a bridge connecting North and South America, over which only a few mammalian remains have been found, as the greater portion of it is now beneath the sea. At Port Kennedy, Pennsylvania, an extensive fauna has been discovered in fissures, and upon it Professor Edward D. Cope was engaged at the time of his recent death, but some results he had made known. Of 38 species of mammals, so far determined, a large percentage are extinct, and among these occur *Equus* and *Megalonyx*. There is also an abundance of remains of an old form of South American bear, which are not known to have crossed the plains of the West. The occurrence of these types at Port Kennedy, Professor Cope regarded as strongly supporting the theory of the Antillean bridge in the early Pleistocene epoch. There is also a newer cave-fauna in Eastern North America, which belonged to a later period, separated from the first by a partial submergence, according to the conclusions of that distinguished author. *Elephas* has recently been found in Guadeloupe.

[1] " Reconstruction of the Antillean Continent," cited before.

Submarine Channels off the Eastern Coast of America.

The submerged valleys, which are best developed among the Bahamas and off the adjacent portions of the continent, provide the key for interpreting the submarine features of other regions. The broad subcoastal plain off the south-eastern States becomes narrowed to a few miles east of Cape Hatteras ; but northward it broadens again, and eventually reaches a width of nearly 300 miles south-east of New England, and more than that across the submarine plateau which forms the Newfoundland banks. East of Labrador it has a considerable breadth, but the soundings there are too scanty for its delineation. In drawing the contours at a considerable distance apart, the same forms of indentation are repeated in the borders of the plateau as those observed farther south ; but where the contours are drawn close together (even where the soundings are not as numerous as is desirable), the deep valleys are found to be continuations of existing rivers. Thus, Lindenkohl[1] traces the Hudson River channel to a depth of 2,832 feet, and the Great Egg Harbour channel to 2,334 feet, where the plateau is submerged only 600 feet. The Delaware and the Susquehanna valleys are also recognizable on the subcoastal plain to depths of about 3,000 feet.

In 1889, the writer showed how the Laurentian valley was submerged for a distance of 800 miles, beneath the waters of the Gulf of St. Lawrence, with the channel from 1,200 to 1,800 feet below the surface of the sea ; but near the edge of the drowned plateau it descends abruptly to a depth of 3,666 feet.[2] The same is true of the valleys crossing the New England, Nova Scotia, and the Newfoundland banks. From the edge of the continental shelf, the Susquehanna valley descends precipitously to a depth of more than 9,000 feet, with its valley recognizable to 12,000 feet. The Delaware descends abruptly to 6,066 feet, and is plainly traceable to 11,256 feet, and to greater depths beyond. The same is true of the Hudson and its tributaries from Connecticut, being recognizable to depths of more than 12,000 feet. From the borders of Massachusetts, Nova Scotia, and the Newfoundland banks the valleys descend precipitously into amphitheatres 6,000 or 7,000 feet below the surface, and continue to depths of 12,000 feet, and in some cases to even 15,000 feet.

While to an unknown extent the drowned plateaux are covered with Tertiary formations, still the submerged valleys must, to a considerable extent, have been excavated out of hard Palæozoic and older strata, thus producing variations in the lengths of the deeper channels, and forming a contrast with some of those of the Antillean region.

From analogy with land valleys, the channels crossing the submarine coastal plains of a few hundred feet, afterwards of perhaps 3,000 feet, represent a long period of elevation. Then followed the

[1] American Journal of Science, vol. xli, p. 490, 1891.
[2] J. W. Spencer, " High Continental Elevation preceding the Pleistocene Period " : Bull. Geol. Soc. Amer., vol. i, p. 65, 1889.

great elevation of perhaps two miles or more in height, continuing only long enough to allow the streams to dissect the margins of the tablelands, and form amphitheatres belonging to the new base-level of erosion. While the great depressions shown in the soundings may have in part been occasioned by an exaggerated oceanic subsidence along the line of the continental margin, yet amongst the West Indies it has been found that the actual depression has exceeded two miles. Although the deeper valleys of the north may be less than a hundred miles in length, their slopes are no greater than those of the valleys descending from the Mexican plateaux.

From the generalization of facts just given, the conclusion is, that the high continental elevation of the Antillean region extended northward in Eastern America, of which supporting data have been collected as far as Labrador.

Submerged Plateau of the North Atlantic.

If the analytical methods which have revealed the drowned valleys of the American coast be applied to the well-known North Atlantic plateau, similar valley-like phenomena will be discovered. While there are numerous soundings across the Atlantic, in the region of latitude 52°, the lines of soundings to the north are too far apart to everywhere afford detailed study of the submarine features ; except that they show an extensive submerged plateau (from 7,000 to 9,000 feet) rising northward to the Iceland ridge, beyond which it again descends rapidly to depths of 12,000 feet, and west of Spitzbergen, 15,900 feet. The summit of the plateau, between Greenland and Norway, is submerged scarcely more than 1,200 feet. However, across the summit there are deeper channels, from the *cols* of which, valleys trend in opposite directions, like those amongst the West Indies or in the Straits of Florida. These *cols* are now submerged : that between Greenland and Iceland, to 1,974 feet ; between Iceland and Faroe, 1,814 feet ; between Faroe and Shetland, somewhat more than 3,000 feet ; and between Shetland and Norway, about 1,000 feet. The southern margin of this plateau (in the region of latitude 52° N.) is indented by embayments and amphitheatres, similar to those of the border of the American plateau. From the comparatively numerous soundings upon the summit of the divide, and in the adjacent Arctic sea, the valleys from the *cols* just mentioned, and many others, can be traced to abyssmal depths. Thus, that between Greenland and Iceland descends rapidly from a depth of 2,000 feet to 6,642 feet, and may be followed to a depth of 9,000 feet. The valley in the opposite direction from the same *col*, extends northward, and receives the tributary from the Scoresby Sound (which is 1,800 feet deep far within the Greenland mass). In latitude 74°, there is a remarkable amphitheatre of 5,520 feet in depth ; and just south-west of Spitzbergen, a similar amphitheatre of 8,100 feet in depth is found where the plateau is submerged only a few hundred feet. Spitzbergen and Norway are connected by a plateau which is generally depressed to less than 1,200 feet. From it valleys descend to the Greenland sea.

The Baltic valley hugs the coast of Norway, and beyond that it extends to the same sea. From the *col* of the channel between Faroe and Shetland, at a depth of somewhat more than 3,000 feet, a great valley extends southward. North-west of Ireland, this valley reaches a depth of 9,980 feet, upon the north-westward side of which the plateau is characterized by shallow banks; and it continues to a depth of 12,000 feet at the margin of the plateau. Tributary amphitheatres to this great valley may be seen westward of Ireland. One of these is 8,160 feet deep, where the platform has been depressed 5,040 feet; and two others have a depth of 10,500 feet, where the plateau is submerged only 4,000 feet. Further southward, extending from the oceanic basin, a large embayment indents and extends far into the platform south-west of Ireland, having still a depth of 10,500 feet, where the shelf is covered by only about 2,500 feet of water. The Bay of Biscay is a remarkable embayment of great depth, with tributary amphitheatres like those just mentioned. The amphitheatres mentioned have no extraordinary widths. Their land equivalents are characterized by inconsiderable streams descending precipitously over steps from plateaux of great altitude.

It is manifest, that Europe and Greenland form one continental mass, while the latter country is separated by a much deeper sea from the American continent. Accordingly, the search for these drowned valleys should be made by means of numerous soundings along lines parallel to the Iceland ridge, rather than off the coast of Ireland. From the fragmentary knowledge already acquired, it would be reasonable to expect the discovery of as complete systems of river-valleys as those found off the American coast and in the Antillean regions; indicating a late continental elevation of 12,000 feet or more.

Continental Elevation a Cause for Glacial Climate.

As has already been stated, the great continental elevation of Eastern America occurred during the early Pleistocene period, and was characterized by a stupendous amount of erosion, with the production of cañons and amphitheatres (at the heads of the valleys). Such an elevation of two miles or more, as measured by the depths of the valleys, must have produced a glacial climate in the more northern regions of America and of the North Atlantic. Thus we find a cause for the Glacial epoch; but many of the phenomena cannot be considered here. Whether the elevations of the North Atlantic and the American regions were absolutely simultaneous, or compensated each other with alternations, like the Antillean and Mexican undulations, is not known. Such alternations, with their diversions of the oceanic and atmospheric currents, together with the more recent partial submergence of the northern lands, would produce variations of the glacial phenomena, and would bring into close proximity those of high elevation and submergence, and of warmer and colder climates.

From as yet unpublished data, it appears that the late Pleistocene

depression of base-level in New England reached 2,700 feet at least. As there was a Mid-Pliocene (our separation of Pliocene and Pleistocene formations being largely arbitrary) elevation of undetermined amount, and as there have been several minor oscillations of level of land and sea, there is great latitude in the application of the phenomena to the Glacial epoch not yet determined—only that great elevation of measurable amount did obtain in Pleistocene days.   With alternations of elevation between the North Atlantic and American plateaux, the changes of currents would further modify the climatic conditions of the period, so that this paper only suggests one phase of physical changes—tending to produce the phenomena of the Glacial period.

NOTICES OF MEMOIRS.

I.—THE AFFINITIES OF *HESPERORNIS*.[1] By O. C. MARSH.

IN the autumn of 1870, I discovered in the Cretaceous of Western Kansas the remains of a very large swimming bird, which in many respects is the most interesting member of the class hitherto found, living or extinct. During the following year, other specimens were obtained in the same region, and one of them, a nearly perfect skeleton, I named *Hesperornis regalis*.[2]   In subsequent careful researches, extending over several years, I secured various other specimens in fine preservation, from the same horizon and the same general region, and thus was enabled to make a systematic investigation of the structure and affinities of the remarkable group of birds of which *Hesperornis* is the type. The results of this and other researches were brought together in 1880, in an illustrated monograph.[3]

In the concluding chapter on *Hesperornis*, I discussed the affinities of this genus, based upon a careful study of all the known remains. Especial attention was devoted to the skull and scapular arch, which showed struthious features, and these were duly weighed against the more apparent characters of the hind limbs, that strongly resembled those of modern diving birds, thus suggesting a near relationship to this group, of which *Colymbus* is a type. In summing up the case, I decided in favour of the ostrich features, and recorded this opinion as follows:—

"The struthious characters seen in *Hesperornis* should probably be regarded as evidence of real affinity, and in this case *Hesperornis* would be essentially a carnivorous, swimming ostrich." ("Odontornithes," p. 114.)

This conclusion, a result of nearly ten years' exploration and study, based upon a large number of very perfect specimens and a comparison with many recent and extinct birds, did not meet with

[1] From the American Journal of Science, vol. iii, 1897.

[2] Silliman's Journal, vol. iii, p 56, January ; and p. 360, May, 1872.

[3] "Odontornithes : a Monograph on the Extinct Toothed Birds of North America."   4to, 34 plates ; Washington, 1880.

general acceptance. Various authors who had not seen the original specimens, or made a special study of any allied forms, seem to have accepted without hesitation the striking adaptive characters of the posterior limbs as the key to real affinities, and likewise put this opinion on record. The compilers of such knowledge followed suit, and before long the Ratite affinities of *Hesperornis* were seldom alluded to in scientific literature.

Several times I was much tempted to set the matter right as far as possible by reminding the critics that they had overlooked important points in the argument, and that new evidence brought to light, although not conclusive, tended to support my original conclusion that *Hesperornis* was essentially a swimming ostrich, while its resemblance to modern diving birds was based upon adaptive characters. On reflection, however, I concluded that such a statement would doubtless lead to useless discussion, especially on the part of those who had no new facts to offer, and, having myself more important work on hand, I remained silent, leaving to future discoveries the final decision of the question at issue.

It is an interesting fact that this decision is now on record. A quarter of a century after the discovery of *Hesperornis,* and a decade and a half after its biography was written in the "Odontornithes," its true affinities, as recorded in that volume, are now confirmed beyond dispute. In the same region where the type-specimen was discovered, a remarkably perfect *Hesperornis,* with feathers in place, has been found, and these feathers correspond with the typical plumage of an ostrich.[1]

II.— ON THE RELATIONS AND STRUCTURE OF CERTAIN GRANITES AND ASSOCIATED ARKOSES ON LAKE TEMISCAMING, CANADA.[2] By A. E. BARLOW, M.A., and W. F. FERRIER, B.Sc., Geological Survey of Canada.

THE rocks to which the following facts relate outcrop on both the eastern and western shores of Lake Temiscaming immediately north of the "Old Fort" Narrows on the upper Ottawa river, the deep channel of which forms the boundary-line between the Provinces of Ontario and Quebec.

On the eastern side of the lake the granite forms a strip along the shore half a mile wide, extending from a point three-quarters of a mile north of "The Narrows" on which is situated the now abandoned Fort Temiscaming, a fur-trading post belonging to the Hudson Bay Company, to the steamboat wharf near the village of Baie des Pères. It also constitutes the rocky promontory known as Wine Point to the west of Baie des Pères, extending inland in a north-easterly direction for about one mile and a quarter. On the western side of the lake the first outcrop is noticed about half a mile west of "The Narrows," continuing along the shore for about four miles as far as

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[1] Williston, Kansas University Quarterly, vol. v, p. 53, July, 1896.
[2] Abstract read before the British Association, Section C (Geology), Toronto, 1897.

Paradis Point, and varying in breadth from half a mile to one mile. The whole area thus underlain by the granite is approximately about six square miles.

Macroscopically the fresh rock is a rather coarse, though very uniformly even-grained aggregate of felspar, quartz, and a dark-coloured mica, probably biotite. Felspar is by far the most abundant constituent, and the abundance of red oxide of iron disseminated through all the cracks and fissures of this mineral gives to the rock its beautiful deep flesh-red colour. The quartz is, as usual, allotriomorphic, but a decided tendency is noticed to segregate in more or less rounded areas or individuals which, especially on surfaces worn and polished as a result of glacial action, gives to the rock a porphyritic or pseudo-conglomeratic appearance ; a fact first made note of by Sir William Logan in 1844 on his manuscript map of this portion of the Ottawa river.

The microscope shows the rock to be composed essentially of orthoclase, microcline, plagioclase (oligoclase ?), quartz, and biotite almost completely altered to chlorite. The microcline has evidently been derived from orthoclase as a result of pressure, and all the gradations of this change may be noted, from the " moire structure " characteristic of the imperfectly or only partially developed mineral, to the fine and typical " cross-hatched structure " peculiar to this mineral. The felspar shows only incipient alteration to sericite, and scales and flakes of this mineral are developed especially abundantly in the central portion of the individuals, leaving a comparatively fresh periphery almost altogether free from such decomposition products.

The arkose with which this granite is associated and surrounded is a beautiful pale or sea-green quartzite or grit, passing occasionally into a conglomerate, the pebbles of which are chiefly grey and red quartz with occasional intermixed fragments of a hälleflinta-like rock.

Under the microscope the finer-grained matrix appears to be almost wholly composed of pale yellowish-green sericite in the form of minute scales and flakes, although occasional individuals are macroscopically apparent. Most of this sericite has originated from the decomposition *in situ* of felspar originally present, and irregular portions or areas of the unaltered felspar may be occasionally detected.

The line of junction between this granite and arkose shows a gradual and distinct passage outward or upward from the granite mass. The series of thin sections examined, as well as the hand-specimens themselves, show every stage in the process, which has been carefully studied.

In the first place, as a result of dynamic action, the orthoclase is converted into microcline with the incipient development of sericite, which gradually increases in those specimens where the greatest perfection of the " cross-hatched " microcline structure is reached. In these the individuals of quartz and felspar have undergone rather extensive fracturing, but with little or no movement apart of the fragments. This breaking up of the original larger individuals is,

as usual, much more apparent in the quartz than in the felspar, and beautiful examples of " strain-shadows " may frequently be seen in those quartz areas which have not yielded altogether to the pressure. A further stage in the process is reached when the sericitization of the felspar has proceeded so far as to permit of the " shoving apart " of the fragments by the various forces which have acted in bringing about the degradation of the whole rock mass. This gradual decomposition of the felspar and movement of the rock constituents can be perfectly traced in the series of thin sections examined until the rock cannot be distinguished from an ordinary arkose, while the arrangement on the large scale, and the more or less parallel alignment of rounded and waterworn quartzose fragments, amply testify to the final assortment and rearrangement of the disintegrated material as a result of ordinary sedimentation.

The relations between this granite and arkose are of rather unusual scientific interest, showing, as they do, the Pre-Huronian existence of a basement or floor upon which these sediments were laid down, and which in this portion at least has escaped the movements to which the Laurentian gneisses have been subjected. The granite is also somewhat different, both in composition and appearance, from the granites and gneisses classified as Laurentian, and which are so frequently referred to as the Fundamental Gneiss or Basement Complex, although during recent years the assumption implied in these terms has been considerably weakened by the fact that the contact between such rocks and the associated clastics is, wherever examined, one of intrusion. On the other hand, the composition of the Huronian strata furnishes indubitable evidence of a pre-existing basement or floor essentially granitic in composition, while the abundance of red granite pebbles and fragments, which are so pre-eminently abundant in the breccia-conglomerate lying at the base of the Huronian system, are very similar in composition and appearance to the granite described above. This granite is, therefore, regarded by the authors as the only instance at present known in which the material composing the Huronian clastics can be clearly and directly traced, both macroscopically and microscopically, to the original source from which it has been derived.

III.—THE FOSSIL PHYLLOPODA OF THE PALÆOZOIC ROCKS. Thirteenth Report of the Committee, consisting of Professor T. WILTSHIRE (Chairman), Dr. H. WOODWARD, and Professor T. RUPERT JONES (Secretary). (Drawn up by Professor T. RUPERT JONES.)[1]

§ I. 1889–1892. Anomalous Silurian Phyllopods (?) from Germany and America.—In the *Sitz.-Ber. Gesell. naturf. Freunde zu Berlin,* 1890, p. 28, Dr. A. Krause described a small fossil carapace of doubtful alliance, but possibly related to the Phyllopods, from the North-German gravel of Scandinavian *Beyrichia*-limestone (Upper Silurian). In the *Zeitsch. Deutsch. Geol. Gesell.,* vol. xliv, 1892, p. 397, pl. xxii, figs. 19 *a–c,* Dr. A. Krause redescribed and figured this anomalous little fossil.

[1] Read before the British Association, Section C (Geology), Toronto, 1897.

Its lateral moieties are not free, separate valves, but united by an
antero-dorsal suture for a third of its length, and by an antero-
ventral suture for half of its length, the posterior region remaining
open at the edges. It also shows in front a round aperture, with
a sulcus formed by the somewhat inverted edges below it. The
test is nearly oval and compressed ; thickest and subacute in front ;
bearing a small, low, subcentral swelling. The surface has some
reticulate ornament along the margins for the most part, succeeded
by linear, radiating, and concentric sculpture towards the more
convex area, which is finely punctate. It is 6 mm. long, 4 mm. high,
and 1·5 mm. thick.

In S. A. Miller's "North-American Geology and Palæontology,"
2nd edition, 1889, p. 549, fig. 1,009, an allied form is described and
figured as *Faberia anomala*, n. sp. et gen., from the Hudson-River
group, Ohio (Lower Silurian). This has evidently some analogy to
the foregoing Upper Silurian form. It has a compressed, ovoidal,
smooth shell, consisting of two moieties, partially sutured above and
below, and is rather smaller than the German specimen.

§ II. 1885–1894. Cambrian Phyllopoda (?).—Dr. G. F. Matthew,
of St. John, New Brunswick, has discovered several very small
organisms in the Cambrian rocks of North-Eastern America, some
of which he regards, with doubt, as having been carapace-valves of
Phyllopodous Crustaceans. He has described and figured them in
the Transactions of the Royal Society of Canada.

To this group of small subtriangular valve-like bodies, obliquely
semicircular or semi-elliptical, with straight hinge-line and more or
less definite umbo, belong (1) *Lepiditta alata*, M., Trans. Roy.
Soc. Canada, vol. iii, 1885, sect. 4, p. 61, pl. vi, figs. 16, 16*a* ;
(2) *L. curta*, M., p. 62. pl. vi, fig. 17 ; (3) *Lepidilla* [1] *anomala*, M.,
p. 62, pl. vi, figs. 18, 18*a, b, c* ; (4) *Lepiditta sigillata*, M., xi, 1894,
sect. 4, p. 99, pl. xvii, fig. 1 ; (5) *L. auriculata*, M., p. 99, pl. xvii,
figs. 2, 2*a, b*. Some of these were referred to by us in the Sixth
Report (for 1888), p. 174.

§ III. 1889. *Rhachura venosa*, Scudder, 1878, Proc. Boston Soc.
Nat. Hist., vol. xix, p. 296, pl. ix, figs. 3, 3*a* (referred to in our
Report for 1883, p. 216). Dr. A. S. Packard, having received from
M. Gurley some imperfect specimens found in the Middle Coal-
measures, Danville, Illinois, describes them as being parts of
a carapace, probably a little over three inches long, and three
caudal spines, also rather obscure (Proc. Boston Soc. Nat. Hist.,
vol. xxiv, 1889, pp. 212, 213).

§ IV. 1893. *Rhinocaris columbina.*—Mr. J. M. Clarke has con-
tributed a paper " On the Structure of the Carapace in the Devonian
Crustacean *Rhinocaris*, and the relation of the Genus to *Mesothyra*
and the Phyllocarida," with illustrative cuts, published in the
American Naturalist, Sept. 1, 1893, pp. 793–801. The carapace-
valves of *Rhinocaris columbina* (J. M. C., "Palæont. New York,"

[1] Dr. G. F. Matthew, in a letter of November 5, 1897, expresses a " wish to
withdraw *Lepidilla*, as not being a Crustacean ; more perfect specimens seem
to show a fan-like structure of internal tubes."

vol. vii, 1888, pp. lviii and 195–7) are described from better speci-
mens, which show it to be a bivalved (not univalved) form, and as
having a narrow, median plate, of which there is evidence in
Mesothyra, making a double dorsal suture. There is also a long,
narrow, leaf-like rostrum inserted between the valves in front. The
relationship of this form with *Mesothyra* and *Tropidocaris* is dwelt
upon.   The author thinks that *Dithyrocaris* and *Emmelezoe* have
some affinity with it. *Rhinocaris* and *Mesothyra* are regarded as
typical members of the family Rhinocaridæ. We may mention that
Dr. Matthew regards his *Ceratiocaris pusilla* from the Silurian of
New Brunswick (see Trans. Roy. Soc. Canada, vol. vi, 1888, sect. 4,
p. 56, pl. iv, fig. 2 ; and our Seventh Report, for 1889, p. 64) as
Rhinocaris.

§ V. 1895. *Emmelezoe Lindstroemi.*—Since our Twelfth Report,
presented to the British Association at Ipswich in 1895, the Swedish
Phyllocarids mentioned in that Report as having been found by
Dr. Gustav Lindström in the Upper Silurian beds at Lau, Gothland,
have been duly described and figured in the GEOLOGICAL MAGAZINE,
Decade IV, Vol. II, No. 378, December, 1895, pp. 540, 541, Pl. XV,
Figs. 2*a*–2*d*, as *Emmelezoe Lindstroemi*, J. and W. The fish-remains
(*Cyathaspis*) and other fossils associated with it are mentioned in
detail by G. Lindström in the *Bihang till K. Svensk. Vet.-Akad.
Handl.*, vol. xxi, part 4, No. 3, 1895, pp. 11, 12.

Mr. J. M. Clarke has suggested at p. 801 of his memoir, mentioned
in § IV, that the oculate genus *Emmelezoe* may have some relation-
ship to the group to which *Rhinocaris* belongs.

§ VI. 1895. *Pinnocaris Lapworthi.*—This genus, represented by
its only known species, *P. Lapworthi*, has been carefully examined
by Woodward and Jones, and several specimens described, selected
from a large number in Mrs. Robert Gray's collection at Edinburgh.
This memoir appeared in the GEOLOGICAL MAGAZINE, Decade IV,
Vol. II, 1895, pp. 542–5, Pl. XV, Figs. 5–10.   Excepting one
specimen from the Upper Silurian of Kendal, Westmoreland, all
the known specimens are from the Lower Silurian of Girvan,
Ayrshire, where Mrs. Gray has made a large collection.

The peculiar " corded " dorsal margin of the valves may have
reference to some longitudinal, narrow, intermediate ligament or
plate as in *Rhinocaris* and *Mesothyra*.

§ VII. 1895.   A new species of *Ceratiocaris* (*C. reticosa*, J. and
W.), preserved in the Museum of the Geological Survey, was de-
scribed in the GEOLOGICAL MAGAZINE, Decade IV, Vol. II, 1895,
pp. 539, 540, Pl. XV, Figs. 1*a*, 1*b*. It is from the Silurian beds of
Ludlow, Shropshire, and is allied to *C. cassioides*, from that locality.
Traces of a peculiar reticulate sculpture constitute its distinguishing
feature.

§ VIII. 1895. *Lingulocaris.*—In the same number (378) of the
GEOLOGICAL MAGAZINE, 1895, at pp. 541, 542, a specimen *Lingulo-
caris lingulæcomes*, Salter, belonging to the Rev. G. C. H. Pollen,
S.J., F.G.S., was figured and described. It came from Capel Arthog,
North Wales, probably from the Ffestiniog or middle division of the

Lingula-flags. Hence we may add "*Lingulocaris*" to "*Hymenocaris*" for that formation at p. 425 of our Twelfth Report (fifth line from the bottom).

§ IX. 1896.　Devonian species of *Ceratiocaris* (?). — In the "Monograph of the Devonian Fauna of the South of England," Palæont. Soc., vol. iii, part 1, 1896, the Rev. G. F. Whidborne describes and figures three obscure casts of *Ceratiocaris*, one *C.* (?) *subquadrata*, sp. nov., p. 7, pl. i, fig. 5, from East Anstey ; another, *Ceratiocaris* (?) sp., p. 8, pl. i, fig. 6, from Sloly ; and the third, somewhat indistinct specimen, namely *Ceratiocaris* (?) sp., p. 8, pl. ii, fig. 12, from Croyde.

§ X. 1896.　*Entomocaris* and *Ceratiocaris.* — A collection of *Ceratiocaris*-like Crustaceans from the Lower Helderberg Formation (Upper Silurian), near Waubeka, Wisconsin, has afforded Mr. R. P. Whitfield, of the American Natural History Museum, New York, the opportunity of determining two new species of *Ceratiocaris*, and a new genus (*Entomocaris*), allied to *Ceratiocaris*, but differing from it by the carapace-valves being "strongly curved in front and behind on the dorsal margin," and by the posterior margin not being truncate, as in *Ceratiocaris*, but obtusely rounded. *Entomocaris Telleri*, Whitfield (p. 300), is figured in pl. xii, of full size, but slightly distorted by pressure.　Including the four exposed body-segments and the trifid appendage, it is about 21 centimetres (about 8 inches) long ; and the valves are about $13\frac{1}{2}$ centimetres long by about $6\frac{1}{2}$ high.　Some indications of the swimming-feet attached to the body are visible where one valve has been partially broken away from the internal cast.　Some mandibles, supposed to belong to this species, are shown in pl. xiv, figs. 1, 2 ; and the caudal appendages in fig. 9.

Ceratiocaris Monroei, Whitfield (p. 301, pl. xiii, figs. 1–5, and pl. xiv, figs. 3–8), is carefully described from one nearly perfect and an imperfect specimen, together with body-segments, caudal appendages, and some mandibles.　The carapace-valves seem to have been about $7\frac{1}{2}$ centimetres long and 4 high.

Ceratiocaris poduriformis, Whitfield (p. 302, pl. xiv, fig. 10), is represented by a small specimen of abdominal segments and caudal spines.

§ XI. 1896.　*Echinocaris Whidbornei*, J. and W., noticed in our Seventh Report (for 1889), p. 63, has been redescribed and refigured by the Rev. G. F. Whidborne in the "Monogr. Devonian Fauna, S. England," Pal. Soc., vol. iii, part 1, 1896, p. 6, pl. i, fig. 3.

Within the last few months Ananda K. Coomáry-Swámy, Esq., of Warplesdon, has fortunately obtained a very interesting specimen of this *Echinocaris* from the Sloly mudstone, showing on the two counterparts of the little split slab, two individuals, each having the same characters as the specimen first described in the GEOLOGICAL MAGAZINE, Decade III, Vol. VI, 1889, p. 385, Pl. XI, Fig. 1. Though rather narrowed by oblique pressure, the valves are equal in breadth to those of the first specimen.　An additional feature of interest is seen in some body-segments, five in one individual and

three in the other. In each case, though the series of segments is not complete either at beginning or end, they are characteristically like those of *Echinocaris*, the distal edges bearing tubercles, the equivalents of spinules.

§ XII. 1896. *Caryocaris.*—In the Journal of Geology, Chicago, vol. iv, 1896, p. 85, Dr. R. R. Gurley has described *Caryocaris* as the "lateral appendages" of the "polypary" of a Graptolite! *Caryocaris* was referred to by us in the First and Seventh Reports (for 1883 and 1891), and was described in detail and figured in the "Monogr. Brit. Palæoz. Phyllocarida," Pal. Soc. 1892, p. 89 et seq., pl. xiv, figs. 11–18.

§ XIII. 1897. A new locality in Nova Scotia has been determined by Sir William Dawson for *Estheria Dawsoni*, namely, East Branch, East River, Pictou County, Lower Carboniferous. Several casts and impressions of small valves, not more than two millimetres long, occur on the bed-planes of a dark-red Lower Carboniferous shale. Former occurrences of this species were noticed in our Report (Eleventh) for 1894.

REVIEWS.

PETROLOGY FOR STUDENTS : AN INTRODUCTION TO THE STUDY OF ROCKS UNDER THE MICROSCOPE. By ALFRED HARKER, M.A., F.G.S. Second edition, revised. 334 pp., 75 figs. (Cambridge : Messrs. C. J. Clay & Sons, 1897. Price 7s. 6d.)

THE appearance within two years of a second edition of so excellent a textbook as Harker's "Petrology for Students" is not a subject for surprise. In this revised edition the author states that he has endeavoured to profit by the criticisms of reviewers and private friends. The slight alteration, however, which the book has undergone shows how little cause for adverse criticism there was in the first edition. In general plan and scope the book remains precisely the same. Only about thirty pages have been added, and these are mainly due to the introduction of descriptions of American examples among the igneous rocks, one result of which is, that the reader makes the acquaintance of a number of those new names (Absarokite, Banakite, Carmeloite, Shonkinite, etc.) to the invention of which American geologists have of late been perhaps a little too prone.

The method of classification of the igneous rocks remains practically the same, but Brögger's name "hypabyssal" is substituted for "intrusive." As the author remarks, "petrology has not yet arrived at any philosophical classification," and certainly the attempt to pigeonhole the igneous rocks, both basic and acid, into the three groups, plutonic, hypabyssal, and volcanic, involves inconsistencies which are evident in the text. Thus three chapters intervene between the descriptions of such similar rocks as the pitchstones of Arran and the "pitchstones" (or, as the author prefers to call them, the Permian rhyolites) of Meissen ; while the

treatment of the Derbyshire "toadstones" rather leaves the impression that they would have been described in connection with the Shropshire "diabases" but for the fact that "Mr. Arnold Bemrose regards them as contemporaneous lavas." That there should be any difficulty in naming a rock before its mode of occurrence, either as an intrusive mass or as a lava-flow, has been determined, may present no terrors to the field-geologist; but to the Museum-Curator it is hardly less appalling than the idea that before giving a rock a name it is necessary to determine its geological age. The author, it is true, is faithful to the British School in rejecting any distinction between rocks drawn from geological age; but the simplification in classification which should follow the removal of this incubus is partly discounted in this, as in many other English textbooks, by the fact that the hypabyssal groups are to a large extent recruited from rocks which are so mildly intrusive as to be included by Continental writers in their palæovolcanic groups (Ergussgesteine).

The book has been brought up to date by references to recent work, and still remains, what it was recognized to be on its first appearance, one of the most trustworthy guides for the student who wishes to take up the microscopic study of rocks.   G. T. P.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—November 17, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair.   The following communications were read:—

1. "The Geology of Rotuma." By J. Stanley Gardiner, Esq., B.A.   (Communicated by J. E. Marr, Esq., M.A., F.R.S.)

The author describes the relationship of the island of Rotuma (situated in lat. 12° 30′ S., long. 177° 1′ E.) to the adjoining isles. It is almost separated into two parts, which are united by a narrow neck of sand.   The interior is composed of volcanoes, which have emitted lavas and fragmental rocks.   Around the volcanic rocks are stratified deposits composed of sea-sand with volcanic fragments. These are partly denuded, and are mantled round by coral-reef and beach sand-flats.   A remarkable cavern in the lava of Sol Mapii, with lava-stalactites, is described; there is a similar cavern in Au Huf Huf.

An account of the prevalent meteorological conditions is also given.

In an Appendix by Mr. H. Woods, M.A., some of the rocks are described.   They consist of olivine-dolerites and basalts and associated fragmental rocks.

2. "A Geological Survey of the Witwatersrand and other Districts in the Southern Transvaal." By Frederick H. Hatch, Ph.D., F.G.S.

After giving an account of the physical characters of the area, the author proceeds to describe the various rocks referred to

(1) The Karoo System,
(2) The Cape System,
(3) The Primary or Archæan System.

The Archæan rocks protrude in a few places through the sedimentary beds, which form the greater part of the area, and consist of an igneous complex of rocks of varied composition.

The Cape System is capable of division into five distinct series :—

UPPER
BEDS.
{ Magaliesberg and Gatsrand series; alternating quartzites, shales, and lava-flows. 16,000 to 20,000 feet.
Dolomite and cherts, thickly bedded. 6,000 to 8,000 feet.
Black Reef; a bed of quartzite and conglomerate, 20 to 50 feet, and Klipriversberg amygdaloid; a basic volcanic rock, 5,000 to 6,000 feet.

LOWER
BEDS.
{ Witwatersrand Beds; sandstones and conglomerate (in part auriferous). 11,000 to 15,000 feet.
Hospital Hill series; quartzites and ferruginous shales. 8,000 to 10,000 feet.

A full description of each of the series, and the associated volcanic and igneous rocks, is given in the paper.

The Karoo formation is represented by the Coal-measures of Vereeniging and the district south of Heidelberg, and by the measures of other coal-areas. They have furnished plants which Mr. Seward refers to in a note as being of Permo-Carboniferous age.

The age of the Cape System is doubtful. The Upper beds rest unconformably on the Lower ones, and if the latter be of Devonian age, as has been inferred, the former may represent the Lower Carboniferous rocks.

In conclusion the author makes some observations upon the geotectonic relations of the area.

3. " Observations on the Genus *Aclisina*, De Koninck, with Descriptions of British Species, and of some other Carboniferous Gastropoda." By Miss J. Donald, of Carlisle. (Communicated by J. G. Goodchild, Esq., F.G.S.)

The author makes some preliminary observations on the genus *Aclisina*, and considers it advisable to regard *A. pulchra* as the type of the genus, while the so-called *A. striatula* must be placed among the *Murchisoniæ*, and *A. nana* is placed in a new genus. The author gives a diagnosis of *Aclisina*, De Kon., belonging to the family Turritellidæ, and describes the British species, twelve of which are new, including two new forms placed in a subgenus.

Of the family Murchisonidæ, and in the section *Aclisoides* of the genus *Murchisonia*, the form of *A. striatula*, De Kon., and a variety are described; and a diagnosis of the new genus, in which *A. nana* of De Koninck is placed, is given, followed by a description of the species.

II.—December 1, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read :—

1. " A Revindication of the Llanberis Unconformity." By the Rev. J. F. Blake, M.A., F.G.S.

In a paper published in the Quarterly Journal of the Society for 1893, the author of the present paper maintained that certain conglomerates and associated rocks occurring for some distance north-east and south-west of Llanberis, which had hitherto been

considered to lie below the workable slates of the Cambrian rocks of that area, were in reality unconformable deposits of later date than those slates. In 1894 (Quart. Journ. Geol. Soc., vol. L, p. 578), Professor Bonney and Miss C. A. Raisin maintained that in no case which they had examined could any valid evidence be found in favour of the alleged unconformity, and that in one (on the north-east side of Llyn Padarn) which they supposed to afford the most satisfactory proof of it, the facts were wholly opposed to the notion.

The present paper is a reply to these authors, in which their objections, founded on general considerations, on field observations, and on microscopic examination of rock-specimens, are discussed, and the author gives the results of further observations on the rocks of the district. The Moel Tryfaen sections and those on each side of Llyn Padarn in the Llanberis district are considered, and he maintains that the post-Llanberis (using this term in the sense of being after the deposition of the main workable slates) age of the conglomerates which are under discussion is established; though the more he considers the correlation of these conglomerates with the Bronllwyd Grits the less he likes it, and as far as the stratigraphy is concerned, they may be much newer—their age is at present an open question; but of their unconformable position he has no doubt.

2. "The Geology of Lambay Island, Co. Dublin." By Messrs. C. I. Gardiner, M.A., F.G.S., and S. H. Reynolds, M.A., F.G.S.

The authors, who have previously described the neighbouring district of Portraine (Quart. Journ. Geol. Soc., Dec. 1897), undertook an examination of this island, with the intention of comparing the rocks with those of Portraine, and of investigating the nature of the rock familiar to geologists under the name of "Lambay porphyry." The sedimentary rocks are similar to some of those of Portraine, and are of Middle or Upper Bala age. Associated with them are pyroclastic rocks and andesitic lava-flows, some of the lavas having flowed beneath the sea. The sediments and volcanic rocks were exposed to denudation, and a conglomerate composed of their fragments was accumulated round the volcano. The "Lambay porphyry," which has been determined as a diabase-porphyry by Dr. von Lasaulx, is partly intrusive in the other rocks, but has in places come to the surface as a lava-flow.

Petrographical descriptions of the various rocks are given by the authors.

MISCELLANEOUS.

New Geological Survey Maps. — Since our notice in the Geological Magazine for 1897, p. 192, several other of the Sheets of the General Map of England and Wales (scale one-inch to four miles) have been issued, *printed in colours* and priced 2s. 6d. each. These include Sheets 2, Northumberland, etc.; 3, Index of Colours; 4, Isle of Man; 7, North-West Wales; 10, Parts of South Wales and North Devon; and 13, Cornwall and the Scilly Isles with part of Devon.

Antlers of the great Red-Deer, *Cervus elaphus*, Linn.

Alport, Youlgreave, Bakewell, Derbyshire.

[Described in Phil. Trans., 1785, vol. lxxv, p. 353.]

Reduced to $\frac{1}{11}$ natural size.

ORIGINAL ARTICLES.

I.—Note on the Antlers of a Red-Deer (*Cervus elaphus*, Linn.)
from Alport, Youlgreave, near Bakewell, Derbyshire
—now in the British Museum (Natural History), Cromwell
Road, London.

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

(PLATE II.)

IN 1891, Frank S. Goodwin, Esq., of Bakewell, Derbyshire,
presented to the British Museum (Natural History) a pair of
antlers of red-deer, with fragments of the calvarium attached, which
had been obtained, with other cervine remains, from a tufaceous
deposit of comparatively modern date near Bakewell, Derbyshire.

Owing to the loss of all animal matter the antlers were in a very
friable condition and fell in pieces on being handled, although at
some distant time they had been repaired partially with long strips
of calico.

Two causes rendered them of interest: firstly, they were of
unusually large size, resembling the great American Wapiti (*Cervus
Canadensis*) in stoutness and length of beam; secondly, they proved
to have been described in a letter from the Rev. Robert Barber, B.D.,
to John Jebb, Esq., M.D., F.R.S., which was published in the Phil.
Trans. Royal Society for 1785 (vol. lxxv, p. 353).

Notwithstanding their almost hopeless state of dilapidation, they
attracted the attention of Sir Edmund Giles Loder, Bart., and
Mr. J. G. Millais (the latter of whom examined and made drawings
of them about a year ago). An attempt was made to bring
the broken antlers together again; and after much time and labour
expended by Mr. C. Barlow, the Formatore, they have at length
been successfully rehabilitated, and are now exhibited on the top of
pier-case No. 16, in the Geological Gallery devoted to fossil Mam-
malia, where they form, from their size and whiteness, one of the
most striking objects in the series of cervine remains.

The following is the account printed in the Phil. Trans. R.S. for
1785 (vol. lxxv, p. 353), read April 14th, 1785 :—

"About five years ago, some men working in a quarry of that kind of stone which in this part of the country we call ' tuft ' [tufa],[1] at about five or six feet below the surface, in a very solid part of the rock, met with several fragments of the horns [antlers] and bones of one or different animals.

"Amongst the rest, out of a large piece of the rock which they got entire, there appeared the tips of three or four horns [antlers] pro- jecting a few inches from it, and the *scapula* of some animal adhering to the outside of it. A friend of mine, to whom the quarry belongs, sent the piece of the rock to me, in the state they got it, in which I let it remain for some time.

"But suspecting that they might be tips of the horns [antlers] of some head enclosed in the lump, I determined to gratify my curiosity by clearing away the stone from the horns [antlers]. On doing which, I found that the lump contained a very large stag's head, with two antlers upon each horn, in very perfect preservation, inclosed in it.

"Though the horns [antlers] are so much larger than those of any stag I have ever seen, yet, from the sutures in the skull appearing very distinct in it, one would suppose that it was not the head of a very old animal.

"I have one of the horns nearly entire, and the greatest part of the other, but so broken in the getting out of the rock, that one part will not join to the other, as the parts of the other horn [antler] do.

"The horns [antlers] are of that species which park-keepers in this part of the country call ' throstle-nest horns,' from the peculiar formation of the upper part of them, which is branched out into a number of short [tines or] antlers which form a hollow about large enough to contain a thrush's nest.

"I send you the dimensions of the different parts of them, com- pared with the horns [antlers] of the same species of a large stag which have probably hung in the place from whence I procured them, two or three or perhaps more centuries ; and with another pair of horns [antlers] of a different kind which are terminated by one single pointed antler and which were the horns [antlers] of a seven-year-old stag [*Cervus elaphus*].

"The river Larkell runs down the valley, and part of it falls into the quarry where these horns [antlers] were found, the water of which has not the property of incrusting any bodies it passes through.

"It is therefore probable that the animal to which these horns [antlers] belonged was washed into the place where they were found, at the time of some of those convulsions which contributed to raise this part of the Island out of the sea.

"Besides this complete head, I have several pieces of horns, bones (particularly the scapula I mentioned above), and several vertebræ of the back found in the same quarry ; some, if not all, of them probably belonging to the animal whose head is in my possession.

[1] Tuft (*tufa*) is a stone formed by the (calcareous) deposit left by water passing through beds of sticks, roots, vegetables, etc., of which there is a large stratum at Matlock Bath, in this county.

DIMENSIONS OF THE HORNS [ANTLERS] FOUND AT ALPORT.

				ft.	ins.
Circumference at their insertion into the corona ...	...	...			$9\frac{7}{8}$
a. Length of the lowest antler [brow-tine]	...	...	...	1	2
b. Length of the second antler [bez-tine]	...	...	...		$11\frac{1}{2}$
c. Length of the third antler [trez-tine] ...	...	...	...	1	$1\frac{1}{2}$
Length of horn antler [in the beam] ...	...	...	...	3	$3\frac{1}{2}$

DIMENSIONS OF LARGE PAIR OF 'THROSTLE-NEST HORNS'
(ORDINARY RED-DEER ANTLERS).

				ft.	ins.
Circumference at their insertion into the corona ...	...	...			7
a. Length of the lowest antler [brow-tine]	...	...	...	1	0
b. Length of the second antler [bez-tine] ...	...	...	...		$10\frac{1}{8}$
c. Length of the third antler [trez-tine] ...	...	...	...		$11\frac{1}{2}$
Length of horn antler [in the beam] ...	...	...	...	2	$7\frac{1}{2}$

DIMENSIONS OF THE HORNS OF A STAG SEVEN YEARS OLD.

				ft.	ins.
Circumference at their insertion into the corona ...	...	...			$5\frac{1}{2}$
a. Length of the lowest antler [brow-tine]	...	...	...		9
b. Length of the second antler [bez-tine] ...	...	...	...		10
c. Length of the third antler [trez-tine] ...	...	...	...		10
Length of horn antler [in the beam] ...	...	...	...	2	$8\frac{3}{4}$

" *Youlgreave, January 23rd,* 1785."

P.S.—The following measurements have been taken since the antlers have been repaired and mounted in the Gallery.[1]

MEASUREMENT OF ANTLERS OF *Cervus elaphus* FROM ALPORT, YOULGREAVE.

					ft.	ins.
Width at the " nests "	...	...	...	...	3	9
Length of right antler	...	...	...	...	4	0
,, ,, left ,,	...	...	...	...	3	8
,, ,, brow-tine	...	...	...	...		11
,, ,, 2nd ,,	...	...	...	...	1	0
,, ,, 3rd ,,	...	...	...	...	1	1
Girth of pedicle ...	...	...	...	...		$7\frac{1}{2}$
,, above the burr	...	...	...	...		$9\frac{3}{4}$
,, ,, 1st tine	...	...	...	...		$9\frac{1}{4}$
,, ,, 2nd ,,	...	...	...	...		$6\frac{1}{2}$
,, ,, 3rd ,,	...	...	...	...		$6\frac{1}{4}$

II.—THE LAKES OF SNOWDON.

By J. E. MARR, M.A., F.R.S., and R. H. ADIE, M.A., F.C.S., Lecturers of St. John's College, Cambridge.

THE waterways of Wales owe their directions to a complex series of events which it is not our province to discuss in this place, but the minor features of Snowdonia are largely determined by planes of weakness which were produced in the rocks of the region during the occurrence of the marked earth-movements at the close of Silurian and Carboniferous times. The Post-Silurian earth-movements gave rise to planes of weakness running in a general north-east and south-west direction, and in a direction at right angles

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[1] See also " British Deer and their Horns," by J. G. Millais, p. 96, fig. 2, and p. 105. (Roy. 4to; Sotheran & Co., 1897.)

to this. Amongst other features parts of the coastlines of Anglesey are determined by these planes of weakness. The Post-Carboniferous planes run approximately north-and-south and east-and-west. The Glaslyn below Beddgelert runs generally along a north-and-south plane and the Capel Curig Valley along one extending in an east-and-west direction.

The Snowdon mass, with its northern prolongation forming the Moel Eilio range, is of a rectangular shape. It is about ten miles long, and has an average width of about four miles. The ridge runs in a general north-west and south-east direction, whilst the ends are at right angles to this, for the Snowdon mass is bordered by depressions coinciding with planes of weakness produced during the Post-Silurian period of earth-movement. On the north-east side the mass is bounded by the upper portion of the Seiont Valley, containing the two lakes of Llanberis ; on the south-west side by the upper part of the Gwrfai Valley, holding the lakes of Cwellyn and Llyn-y-gader, and the head of Nant Colwyn ; the south-eastern boundary is formed by the Vale of Gwynant, with Llyn Gwynant and Llyn-y-ddinas ; and on the north-west is a portion of the Seiont, east of Carnarvon, which has worn its bed along the soft Arenig shales. Of ridges determined by the Post-Silurian changes, the prevailing one is that which runs north-west and south-east from Moel Eilio, through Moel Goch and Moel Cynghorion, over the summit of Snowdon, and is continued to the south-west as the buttress of Lliwedd. At right angles to this is the ridge of Crib-y-ddysgl, and also the ridge running from Snowdon on the Beddgelert side known as Llechog, part of which, however, runs parallel to the north-west and south-east system, as does also the ridge which culminates in the peak of Yr Aran. Of the ridges determined by the north-and-south and the east-and-west planes of weakness, the most important are that of Crib Goch, which runs east and west, and that extending between Snowdon and Y Geuallt, which is at right angles to this. Bounded by these ridges and others having the same general directions, lie the six beautiful cwms of Snowdon, four of which contain one or more lakelets. We have laid stress upon the planes of weakness, because they contribute some information concerning the origin of the lakelets. The south-eastern and south-western shores of Llyn Llydaw are defined by two Post-Silurian planes of weakness. In the cwm on the west side of Snowdon, the three upper tarns, Llyn Glas, Llyn Coch, and Llyn-y-nadroedd, occur on a north-east and south-west line ; the stream from the central one, Llyn Coch, runs at first along a north-west and south-east line, and this, if continued, runs along the long axis of Llyn Ffynnon-y-gwas.

The principal precipices of Snowdon occur on the north-east side, and the same feature is seen in the case of the Glyder range ; and in the Lake District the east side of the Helvellyn and High Street ranges is the precipitous one. Minor examples may readily be called to mind showing a precipitous eastern slope and gentle western one, and the cases are too frequent to be merely accidental. It is possibly due to the rainfall from the south-west, and the south-

westerly aspect of the slopes causing much vegetation to grow on the south-west faces of the hills and giving rise to peat-mosses, thereby allowing the waters to discharge gently instead of running off at once. In connection with this, we may notice that the streams on the north-east side of the Snowdon range are gradually cutting their way back into the hills, thus shifting the watershed to the south-west of its general trend where these notches are formed. This is specially well seen in the case of the passes of Maes Cwm and Cwm Brwynog between Snowdon and Moel Eilio.

The literature dealing with the Snowdonian Lakes is not extensive. No doubt all geologists have read the masterly account of " The Old Glaciers of Switzerland and North Wales," by Professor Ramsay, which originally appeared in the series of " Peaks, Passes, and Glaciers," and was afterwards published separately in 1860. Recently Mr. W. W. Watts contributed " Notes on some Tarns near Snowdon," which will be found in the Report of the British Association for 1895 (p. 683) and also in this Magazine (Dec. IV, 1895, Vol. II, p. 565). During last Easter Vacation we paid some attention to the lakes and tarns of Snowdon, and believe that our observations may be of some use as a small contribution to the subject of the origin of lakes. In the first place we will deal with the lakes of the larger valleys of the Seiont, Gwrfai, and Gwynant, and then notice the lakes and lakelets which lie embosomed in the upland hollows of Snowdon.

The Seiont, rising at the Pass of Llanberis, flows in a north-westerly direction through the two lakes of Llanberis, Llyn Peris and Llyn Padarn. These lakes were once one, and are now separated by the alluvial strip near Dolbadarn Castle. This strip is part of the delta brought down by the stream which descends from the heights of Snowdon and Moel Eilio, and it is of interest to notice that at one time a considerable bay must have extended up the valley occupied by this stream, for alluvium extends some way towards the waterfall Ceunant Mawr. In Llyn Peris there is a bay on the south-west side of the lake, which is continued landward as a valley of some importance, down which a stream of minute proportions runs, and consequently the sediment which it has borne down has been insufficient to fill up the bay. Several similar bays at one time marked the south-west shores of Llyn Padarn, but as the lakes of Llanberis are now used as receptacles for slate-rubbish, the primary features of their shore-lines are almost obliterated. Llyn Peris once extended much further up the valley, as shown by the strip of alluvium extending to Gwastadnant.

The present exit of the river from Llyn Padarn is between two rocky masses, but there is a considerable width of ground, on which the bridge at Cwm-y-glo is built, which shows no rock *in sitú*, though it probably exists at no great depth beneath the surface. A depression occupied by alluvium leaves the lake on its western side, about a quarter of a mile south of the present exit, and curving round a rocky knoll joins the present stream opposite the village of Cwm-y-glo. It is somewhat over 100 yards wide in its narrowest part (where it

leaves the lake at the north end of the railway tunnel), and the alluvium is just above lake-level. There is no stream of any importance in this valley, and it is difficult to account for its existence unless we suppose that the main river ran through it, and that it became filled with drift, causing the formation of the lake, which drained over what was formerly a low col, situated at the present exit. Near the point where this old valley joins the present one, are several large pools in the present valley surrounded by alluvium. They are probably "kettle-holes" in the drift. The floor of the Seiont Valley is occupied by drift all the way from the lake to the sea, so that it is quite possible that the floor of the lake may be below sea-level and yet that the lake may not be in a rock-basin.

We now proceed to consider the two lakes of the Vale of Gwynant. Each is about three-quarters of a mile in length, and has its longer axis running in the direction of the valley. Llyn Gwynant is the higher of the two, and the bottom of the valley is occupied by drift between its foot and the head of Llyn-y-ddinas. At the head of the latter lake, the river has partly cut its valley through this drift, but without reaching the rock. The exit from this lake is apparently over rock, though no actual rock is seen in the stream at the outlet, but the width of the area devoid of rock is here very small. A bold rocky eminence lies between the foot of the lake and the road ; the road is carried along a drift-filled depression west of the present exit for a short distance, and to the north of this the drift-filled depression is seen north of the road, and joins the lake a few hundred yards above the exit. This depression is about thirty yards wide in its narrowest part. To the south-west it joins the drift-covered bottom of the valley, and this valley-bottom is covered with drift to some distance below Beddgelert. It may be noted that Beddgelert stands on an alluvial flat which was once an old lake, and a barrier of rock runs across the stream at the entrance to the Pass of Aberglaslyn, but a drift-filled depression is seen to the west of this, which joins the main valley a short way down the pass.

The lakes in the Gwrfai Valley present points of some interest. Llyn Cwellyn is 464 feet above sea-level. An alluvial flat runs for half a mile from the foot of the lake, and no doubt marks a former portion of the lake filled up by the sediment brought down by the small streams from Moel Eilio and Mynydd Mawr. The water then runs over rock forming the cascade at Nant Mill, and the head of this cascade is only about five feet below the level of Cwellyn. At this point a barrier of rock extends right across the valley in such a way as to forbid the existence of any drift-filled depression, which could account for the lake. We lay special stress upon this point, for it might be urged that a possible drift-filled channel could be indicated in the case of all lakes, owing to the large extent of ground where live rock is not seen as compared with that which shows the rocks *in situ.* One of us has had considerable experience in the examination of the exits of lakes, and has found so many (like Llyn Peris and Llyn-y-ddinas) where there is only one possible exit, that he felt sure that if rock-basins exist with any frequency in

Britain, there must be some where proof is obtainable that there is no possible drift-filled exit. Cwellyn illustrates this : *there is no possible exit at the foot*, and if this lake were backed by high hills towards the head, the existence of a rock-basin could be proved here ; but, as we shall now proceed to point out, the physiographical features at the *head* of the lake are compatible with the existence of a drift-filled depression in this direction ; and, indeed, some of the phenomena exhibited above the head of Cwellyn are extremely difficult to explain, unless such a depression exists there.

An alluvial flat extends above Cwellyn for a quarter of a mile up the Gwrfai. This river runs over solid rock at Rhyd-ddu between Cwellyn and Llyn-y-gader, but a drift-filled depression is traceable from the head of the alluvial flat, firstly up the main stream, then up a tributary joining it a few yards south-east of Cwellyn Slate Quarry ; it crosses a low watershed at a height of 740 feet (i.e., nearly 300 feet above the surface of Cwellyn, and nearly 150 feet higher than that of Llyn-y-gader), just east of Ffridd Slate Quarry, after which it follows another small stream and joins Llyn-y-gader close to the prominent crag, which stands out of the alluvium on the east side of the lake. This is the only possible exit in this direction, and its resemblance to a drift-filled gorge is very striking. The depth of Cwellyn is, so far as we are aware, not known ; but assuming it is nearly 50 feet deep, the gorge, which is about 80 yards wide at the narrowest part, would require to be 350 feet deep at this point, in which case it would be comparable with some of the Alpine gorges. Such gorges might well be cut by the water issuing from a glacier, and highly charged with sediment, and the nature of the ground is favourable for the formation of one at this point, for it is occupied by a well-jointed basic intrusive rock. Furthermore, the rock comes to the surface here so extensively, that there is no approach to any similar drift-filled depression ; in fact, where the depression crosses the col, it is a conspicuous feature owing to the rocky ridge above and below it, and it is difficult to understand why this continuous tract of drift-covered ground occurs here, except on the supposition that a valley lies below. If the possibility of the existence of the gorge be admitted, there is no difficulty connected with the introduction of the drift, for the locality is just beneath the great cwm on the west side of Snowdon, which must have been the gathering-ground of a large glacier, and also lies below the drift-covered tract on the upland plateau on which Maen Bras stands. There is another remarkable feature which requires explanation, but which is readily understood if it be supposed that a drift-filled valley exists here. To the south-east of Llyn-y-gader is a peaty moor, which slopes gently to the watershed separating the Gwrfai from the Colwyn. Viewed from the detached mass known as Pitt's Head, the watershed appears as a level line, and is apparently composed of an alluvial deposit. It strikingly resembles one which one of us has previously described at the head of Wet Sleddale in Westmoreland (Geol. Mag., Dec. IV, Vol. I, p. 539), and as in the case of the Wet Sleddale watershed, may be accounted for on the supposition that

a valley was here stopped up by ice, and partly converted into a lake, which became largely silted up with sublacustrine detritus. The bed of the Colwyn runs over drift until within a short distance of Beddgelert. It will be seen, therefore, that a continuous line of drift-covered tract can be traced from Nant Mill, past Cwellyn and Llyn-y-gader, for a distance of about four miles. If the drainage has been reversed between the present head of the Gwrfai and Nant Mill, the curious course of the stream from Llyn-y-dywarchen will be accounted for. This stream runs a little east of south into Llyn-y-gader, whilst the Gwrfai issues from that lake in a general northerly direction, whereas if the waters of the Cwellyn and Llyn-y-gader depression originally drained southwards, the Llyn-y-dywarchen stream would then have proved a normal tributary to the river once occupying that depression.

We may now pass on to the consideration of the upland tarns and lakes. The four tarns on the west side of Snowdon may be dismissed in a few words. The late Professor Ramsay speaks of them as follows : " The lake called Llyn Ffynnon-y-gwas is possibly dammed up by moraine matter "; and again, " a minor moraine encircles Llyn-y-nadroedd on the north and east, and another beautiful small one made of angular blocks and stones, now covered with vegetation, bounds Llyn-goch on the west and south-west, while a third dams up Llyn-glas." None of these lakes, then, can be claimed as resting in a rock-basin, nor can the drift-stopped tarn below Moel Eilio (Llyn Cwm Dwythwch) be asserted to rest in a basin of that nature. The lakes lying to the north-west of the main Snowdon ridge merit a fuller description. Below the precipice Clogwyn du'r Arddu, lies the little Llyn du'r Arddu at a height of 1,900 feet above the sea. The extensive moraine which blocks it up, and extends far down Cwm Brwynog in a series of concentric semicircles, is admirably described by Professor Ramsay. The exit to the west is between the great drift dam and solid rock ; the latter is well rounded with striæ running parallel to the stream, and the rough sides of the *roches moutonnées* face westward. On them rest *subangular* perched blocks, whilst the innermost crescent of the drift-dam consists of *angular* blocks, as though some at least of this material was rather of the nature of snow-slope detritus than true moraine. It is quite clear that the course of the stream before the lake was formed cannot have been as it is now, otherwise no lake would have been produced ; it must have run in a more northerly direction, but this former valley is now completely buried beneath gigantic moraine-mounds for a long distance. We call attention to this, as we shall have occasion to recur to the point when describing the exit of Llyn Llydaw.

The water of Llyn du'r Arddu is of a deep indigo tint, a colour not represented in Forel's scale of lake-colours. It is popularly asserted that the colour is due to the presence of copper in the water ; but we are not aware that any analysis has been hitherto made to test this. Old copper-mines exist close to the lake, but as one of us has been unable to find any trace of copper in the lake-water, it would

seem that the colouring is not caused by the presence of this sub-
stance. The same may be said concerning the waters of Glaslyn
and Llyn Llydaw, which have also yielded no trace of copper.

Cwm-glas is the next hollow which contains lakelets, and these
have been specially noticed by Mr. Watts. He states that there can
be little doubt that the upper lakelet "is a portion of a bending
valley dammed at both ends by scree- and stream-débris, and thus
compelled to find an escape over the rocky side"; and that in the
rainy season the lakelet finds "a second outlet over the long, low
col to the east, so that in this state it has the two outlets depicted
in the six-inch map." We here find a missing link in the series
of lakes leading up to those whose outlet is permanently over solid
rock. One of us has described Hard Tarn on Helvellyn, a lakelet
which strikingly recalls this tiny lakelet on Snowdon, being, like
it, situated on a shelf formed by a dip slope between two escarpments
(Quart. Journ. Geol. Soc., vol. lii, p. 13). In the Helvellyn pond,
the normal outlet is over drift, whilst the wet-weather outlet is over
solid rock ; in the Cwm-glas pool, the normal outlet is over solid
rock, and the wet-weather one over drift, for the drift has accumu-
lated to a greater extent than that at the end of Hard Tarn. The
next stage in the Cwm-glas pool will be the complete stoppage of the
eastern exit over the drift, when the pool will drain permanently
and in all weathers over the solid rock.

The lower pool of Cwm-glas is stated by Mr. Watts to be
"certainly confined in a rock-basin, as rock occurs at its actual
outlet, and at every point where any former outlet might have
been possible. The lake is, however, so shallow that its occurrence
in a basin of rock is perhaps of little consequence." We had
hoped to obtain soundings of this lake, but owing to the quantity
of floating ice, were unable to do so, although as the bottom
is everywhere visible, there is probably no spot where the depth
reaches six feet. We could not satisfy ourselves that the pool
occupied a true rock-basin. The stream issues from the lake with
a bank of solid rock at each side, but the stream is some feet in
width here, and its floor strewn with boulders, and a former ravine
six or more feet in depth might readily be blocked by detritus
at this point. We do not, however, believe that this is the case, for
just east of the present exit a drift-filled depression is seen, which
runs parallel to the existing stream, and joins it about 150 yards
below the exit, at a level far below that of the lakelet. The col
in this drift-filled depression is about 15 yards north of the exit, and
there we found a width of about five yards across from obviously
live rock on either side. It is true that large blocks of stone here
extend right across, but they do not seem to be *in situ*, for the
cleavage planes run in very different directions in the different
blocks. It was easy to bury a walking-stick up to the handle
at several points along this depression, and in other cases the stick
was prevented from penetrating by coming in contact with obvious
boulders which were movable. This pool, like the upper one, is
situated on a dip slope shelf between two escarpments, and the ice

has merely rounded off the edges of the escarpments without altering their general character. It has acted like sandpaper, and there is no indication of such erosion as would produce a rock-basin,—quite the reverse. The same feature may be noticed in the case of Sprinkling Tarn on Scawfell.

The last cwm which contains lakes is the magnificent one east of the summit of Snowdon. The lowest lake, Llyn Teyrn, is shallow, and the stream from it flows over drift for a long distance below the exit. Near this tarn, and close to the path, a glaciated rock shows intercrossing striæ, one set running east and west and the other about 30° E. of N. and 30° W. of S. A better example of intercrossing is seen by the path bordering the shores of Llyn Llydaw, due west of the causeway. A *roche moutonnée* shows three sets of striations—one trending E. and W., another S.W. and N.E., and the third 35° W. of N. and E. of S. These directions point respectively to the top of Snowdon, the Lliwedd cliffs, and the cliffs immediately above the *roche moutonnée*, and were probably produced by glaciers coming from those directions at different times. We call attention to them to emphasize a difficulty which has often been felt if one assumes that glaciers can carve out rock-basins and yet are unable to obliterate the striæ formed at other times. Mr. Kendall has, however, shown that the same mass of ice produces intercrossing striæ; also, we are aware that glaciers, like rivers, must be under conditions more favourable for erosion at some times than at others; the difficulty is, therefore, by no means insuperable to those who maintain the power of ice to form rock-basins, but still we think it is a difficulty.

Mr. Watts writes :—" Immense quantities of moraine material occur on the south-east side of Llydaw, but a careful examination of the map shows that only two possible outlets exist—that now used for the purpose; and a second which is occupied by bog resting on moraine, and gives rise to a small stream which is joined lower down by the outlet of Llyn Teyrn. The moraine is, however, only a thin skin on the surface of the rock. The present outlet shows live rock forty or fifty feet below the level of the lake, and the second possible exit at a rather less distance below the same level. If the moraine were stripped off, there is little doubt that this lake .   .   .   .   would show a basin of rock which would hold water, unless it is very much shallower than is generally supposed to be the case." It is very desirable that accurate soundings of this lake should be made ; indeed, we wish someone would do for the lakes of North Wales what Dr. Mill has so admirably performed in the case of those of English Lakeland. Mr. Watts' observations would permit the existence of a lake forty feet deep, which is not situated in a rock-basin, and our observations lead us to believe that a very much greater depth of water may be here held up by drift. A great moraine runs right across Llyn Llydaw near the present outlet. It is seen rising into high hillocks on the north side of the lake, projecting as islets from the lake itself, and covering much ground on the south side below the exit. No doubt it is, as Mr. Watts says,

a thin skin on the surface of the rock in many places. Rock, as he states, occurs in the stream which comes from the lake at a distance of forty or fifty feet below the exit, but the left bank of the stream is bounded by drift for a long way beneath this, and the stream is in places obviously cutting between drift and rock ; nevertheless, we do not believe that the old exit was here. Viewed from above, a depression is seen running diagonally across the moraine-covered ground between the two streams mentioned by Mr. Watts, and this depression is marked by some pools, one of which is of sufficient size to be inserted upon the six-inch map. The depression joins the stream south-west of Llyn Teyrn, and the first live rock seen along this line occurs between Clogwyn Aderyn and Clogwyn Pen-llechen, south of Llyn Teyrn, at a vertical distance of nearly 200 feet below the level of Llyn Llydaw. The lesson taught by Llyn du'r Arddu proves that a buried valley need not show any marked traces upon the surface ; and we believe that, even though the greater part of the moraine material forms a thin skin over the rock, a buried channel runs in an easterly direction along the route we have indicated.

The water of Llyn Llydaw is described by Professor Ramsay as being "of a green colour, like some of the lakes of Switzerland," though the difference of colour between the waters of Glaslyn and Llydaw did not appear to us to be very marked when we visited the lakes in the early spring.

Above Llydaw lies Glaslyn, at a height of 1,970 feet above the sea, and immediately below the great precipice surmounted by Y Wyddfa, the highest point of Snowdon. The tarn is very instructive. It is, as Mr. Watts remarks, "bounded on all sides by live rock, except at and near its outlet. This exit is over moraine, which, however, is not very deep, for rock makes its appearance just below, and in such a way as almost to compel belief in a complete rock-bar. Besides the present course of the effluent stream is a parallel strip of moraine running down towards Llyn Llydaw, but living rock soon makes its appearance in this." This parallel slip of moraine looks quite insignificant when viewed from the path ; but when visited is found to be of considerable width. It joins the main stream at a vertical height of at least 50 feet below the exit, and at the junction a small stream is seen cutting its way backwards in the drift. Between the exit and the junction of this drift-filled depression with the present stream is a waterfall, and the water has here cut a *mere groove* in the rock. Moreover, we here meet with a most significant feature : *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. We here find a repetition of what one of us has previously noticed in the case of the tarn Smallwater, near Haweswater in Westmoreland (Quart. Journ. Geol. Soc., vol. xxi, p. 37), and we believe that the explanation given in that case is applicable to Glaslyn also. There is a feature of interest connected with the outline of the tarn. A bay occurs on the north side, whose shore-line forms a curve

parallel with those of the contour-lines above, where they run round a little valley occupied by a small stream. The existence of this bay is, of course, explicable if the lake be drift-dammed, but is difficult to explain if we suppose that it has been excavated by ice.

The colour of the water of Glaslyn is indigo, though the tint is not so deep as that of Llyn du'r Arddu. Here also copper-mines have been worked close to the lake, but, as has been mentioned above, no trace of copper was found in the water.

The samples, of which the analyses are appended in tabular form, were obtained under somewhat different conditions in the case of each lake. That from Llyn du'r Arddu was obtained from fairly deep water, surrounded on the landward side by rock *in situ*, that of Llydaw from the middle of the causeway which has been made across the lake, whilst that of Glaslyn was obtained from shallow water close to an ordinary foreshore, consisting of loose blocks and some vegetation.

					ARDDU.	LLYDAW.	GLASLYN.
					Parts per million.		
Solids { Inorganic	...	...	...	...	22	22	34
{ Organic	...	...	...	...	16	10	12
Hardness (Lime and magnesia salts)			...	...	22	20	22
Chlorine	...	...	...	...	9	9	12
Nitrogen as ammonia	...	...	...	...	·004	·004	·122
,, albuminoid ammonia		...	...	...	·026	·070	·048
Oxygen absorbed in 15 min.		...	...	...	·40	0	·40
,, ,, 4 hrs.		...	...	...	·40	·80	1·20
Nitrogen as nitrates and nitrites		...	...	...	·12	·16	·20

We did not think it necessary to determine the organic carbon and nitrogen, as the above results may be generally used as a substitute for them.

The analyses show that the waters of Arddu and Llydaw are similar in character : they contain about the same amount and variety of inorganic matter (chlorine, lime, etc.), but Llydaw contains rather more than twice the amount of organic matter that Arddu does, as shown by the albuminoid ammonia, and oxygen absorption in four hours. The similarity of the amount of chlorine also suggests that the organic matter is similar in the two cases. This result is what would be expected from the relative position of the lakes.

The results in the case of Glaslyn are very remarkable. The amount of solids (not lime and magnesia salts) and chlorine, also of ammonia (free and albuminoid), oxygen absorbed, and nitrogen as nitrates, would always be held to indicate the presence of much animal organic matter. This hypothesis seems at first ridiculous from the position of the lake, unless the hotel on Snowdon summit drains in any way into it. The only other interpretation is, that the sample obtained from near the bank was not of average quality. No impurity of such character could be introduced in any other way.

The object of these analyses, viz., to put to the proof M. Forel's hypothesis of the cause of coloration of mountain lakes, is unfortunately not attainable from these results, owing to the peculiarity

of Glaslyn, so that we must reserve this point for future work on other lakes, further from possible contamination.

In the meantime, failing an analysis of peat water of the above strength, there is some evidence in favour of the hypothesis from the cases of Arddu and Llydaw, though we were not able to match the indigo colour of these waters by means of his standard solutions. We failed to find any trace of copper. On a future occasion we hope to furnish more analyses.

In an article in *Science Progress*, new series, vol. i, p. 218 (1897), one of us describes some depressions formed on flat surfaces of rock in the Lake District, owing to the more rapid weathering beneath patches of moss, grass, and heather, which, when removed, leave little basins beneath them; and it was suggested that small lakelets might be produced in this way, especially in rocks which contained much soluble material. The depression in question occurred in the volcanic rocks of the Borrowdale Series. To show the effect of the weather upon rocks of this nature, a fragment of rock (possibly hardened mud with volcanic matter) was extracted from a peat-bog near Llyn du'r Arddu, and the analyses of the core and of the weathered crust are given side by side :—

			CORE.	CRUST.
SiO_2	...	...	79·20	72·00
Al_2O_3	...	...	16·74	22·36
FeO	...	...	1·96	2·55
Fe_2O_3	...	...	1·28	0·87
MnO	...	...	0·34	0·41
Alkalies	...	...	0·67	0·51
Loss on ignition		...	1·11	1·41
			101·30	100·11

III.—Note on the Life-Zones of the Carboniferous Deposits of Europe.

By Wheelton Hind, M.D., B.S. Lond., F.R.C.S., F.G.S.

IT has long been a matter of reproach to British geologists that, with such a grand sequence of Carboniferous rocks as occurs in Great Britain and Ireland, many of which are highly fossiliferous, all attempts to establish life-zones in them have hitherto been unsuccessful. As a subcommittee, appointed by the British Association, has been put into existence to endeavour to zone the Carboniferous rocks, it seems to me that a preliminary comparison with each other of the life-zones already established in Russia and Belgium, and as far as is possible to contrast the distribution of the zonal fossils with that which obtains in Great Britain, may to some extent clear the ground, and establish some important palæontological facts as a basis for future work.

Russian geologists are able to state without any hesitation that certain fossil forms are characteristic of certain zones in the Carboniferous rocks of Russia, and that these zones are, with very slight changes, the same for the Carboniferous deposits of Central Russia, the Ourals, and the Donetz basin. Three main stages are recognized

(with subdivisions and some small local variations), which are as follows :—

UPPER ZONE :

> *Spirifer fasiger, Productus cora, Spirifer supramosquensis, Conocardium Uralicum, Schwagerina princeps, Marginifera Uralica,* with coal in the Donetz.

MIDDLE ZONE :

> *Spirifer Mosquensis.*

LOWER ZONE :

> *Productus giganteus, P. striatus, Chonetes papilionacea,* with coal-beds in Central Russia.

It is to be noted that in the Donetz basin the biological division between the upper and lower divisions is not absolute, *Spirifer Mosquensis* passing well up into the beds with *Productus cora* ; but it would appear that *Spirifer fasiger,* Keys, does not trespass into the zone of *S. Mosquensis,* and the two fossils are never found together.

A large number of widely distributed Carboniferous species are common to all three divisions, but are not so frequent in the upper; and this, in addition, contains several forms which have never been noted in Western Europe, but which, on the other hand, are recognized as occurring in beds of the Salt Range period of India, and in the Carboniferous beds of North America.

Passing to the Carboniferous beds of Western Europe, De Koninck and Dupont are able to recognize three subdivisions in the calcareous deposits of Belgium :—

STAGE III.—UPPER—

> VISEAN (detrital): Zone of *Productus giganteus, P. latissimus, P. striatus, P. cora, Chonetes papilionacea.*

STAGE II.—MIDDLE—

> WAULSORTIAN (corallian): *Amplexus coralloides, Syringothyris cuspidatus, Spirifer striatus, Conocardium Hibernicum.*

STAGE I.—LOWER—

> TOURNAISIAN (crinoidal) : *Spirifer Tornacensis, S. cinctus, S. laminosus, Syringothyris distans, Athyris Royssii, A. lamellosa, Conocardium fusiforme,* etc.

This threefold division, however, is not accepted by all Belgian geologists. The Légende de la Carte géologique de la Belgique, dated 1896, shows only two main zones in the Carboniferous Limestone of Belgium—Visean and Tournaisian—the assise de Dinant, with *Chonetes papilionacea,* being considered as a facies of the Visean. The Waulsortian beds are placed as a facies of the Tournaisian, not typified, however, by any fossils ; and the assise of Hastière, with *Spirifer Tornacensis, S. glaber,* and *Spiriferina octoplicata,* is considered to belong also to the lower group.

Gosselet ("Esquisse géol. du Nord de la France," 1880) proposes to divide the Carboniferous Limestone of France and Belgium into ten zones, but, judging from the lists of fossils given, probably not on palæontological grounds. He recognizes *Spirifer Mosquensis* as occurring at horizons below that of *Productus giganteus.*

It will be noted at once that the highest stage of the Carboniferous Limestone of Belgium is characterized by the same zonal form (*P. giganteus*) as that which is so typical of the lowest division in Russia, and that it is accompanied by *P. cora,* one of the zonal forms of the highest Russian division.

Although, some time ago, De Koninck was of opinion that *Spirifer Mosquensis* was found in the lowest Belgian (or Tournaisian) stage, in his paper "Sur le *Spirifer Mosquensis*" (Bull. Mus. Roy. d'Hist. Nat., tom. iii, 1883, p. 373) he showed that he had confounded this species with *Spirifer Tornacensis* and *S. cinctus.* In his remarks on the affinities of the latter shell, he states " qu'elle en diffère essentiellement [from *S. Mosquensis*] par sa grande taille, et, mieux encore, par l'absence dans sa valve ventrale des lamelles dentales divergentes, si fortement développées dans celle de sa congénère Russe."

In a later work, De Koninck figures *Spirifer spissus* from Stage III and *S. suavis* from Stage II, but these, judging from the drawings alone, I should not like to say were not varieties or specimens of *S. Mosquensis* ; certainly they have much fewer ribs than the latter species.

I have lately attempted to solve the question whether *S. Mosquensis* really occurs in Great Britain or not. Originally Davidson figured two specimens in his Monograph on the British Carboniferous Brachiopoda (pl. iv, figs. 13 and 14) which agree very closely with Russian examples. Later on he was led to doubt the correctness of his determination through the influence of De Koninck's work. Unfortunately one of these figured specimens has disappeared, and probably only that one remains which is in the collection of the Royal Society of Dublin, but I have not been able to examine this example.

In the Appendix to the Monograph Davidson figures two shells from Scotland (pl. xxxiv, figs. 3 and 4) which closely resemble *S. Mosquensis* in shape, under the name *S. trigonalis* var. *bisulcata.* Dr. J. Young has kindly compared these shells with a typical Russian example, and says that the Scotch examples have much fewer ribs and that these are thicker.

I have, through the kindness of Professor Lloyd Morgan, examined the shell from the *Oracanthus* bed of the Lower Limestone shales of Clifton named *S. Mosquensis* by Stoddart, but this reference is an error, the shells having nothing in common.

I have also examined a fine series of shells labelled *S. Mosquensis,* from the Carboniferous Limestone of Co. Cork, in the collection of the Geological Survey of Ireland, I recognize amongst them *S. cinctus* and *S. Tornacensis* of De Koninck, but not *S. Mosquensis.* When placed side by side the differences between these three species are

very distinct, much more so than one would judge from the remarks
and descriptions of De Koninck.   Both *S. cinctus* and *S. Tornacensis*
are more transverse, and possess fewer but thicker ribs, than
S. Mosquensis.   The construction of the dorsal mesial fold and
corresponding sinus in the ventral valve is different in each species.
At present, therefore, I am unable to affirm the presence of
S. Mosquensis in Great Britain.

It is an important fact to note, in connection with the absence
of the *Spirifer Mosquensis* zone in Belgium, that *Productus cora* and
P. giganteus, the typical shells of the first and third zones in Russia,
should occur together in Belgium. and that, according to the Belgian
geologists, the beds with *Productus cora* are inferior to those with
P. giganteus.   In the *P. cora* zone of Russia the fauna, taken as
a whole, is remarkably dissimilar to any that occurs in Western
Europe, especially towards the upper portion, most of the species
being entirely different.

The intimate study of De Koninck's later monographs cannot but
convince the reader that with that author the erection of species was
largely secondary to the knowledge of the horizons at which the
various specimens were obtained.   Starting with the preconceived
notion that there were at least three distinct molluscan faunas in the
Carboniferous Limestone of Belgium, he seized on the smallest
differences in detail or growth as a reason to invent a new species,
especially if it had been gathered from a special horizon.   He says
himself (Ann. Mus. Hist. Nat. Belge, sér. Pal., tom. vi, p. 4): "Si aux
caractères différentiels constatés entre des spécimens provenant
d'assises différents quelques faibles, qu'ils soient, vient s'ajouter une
constance bien établie, il me semble loisible d'admettre que ces
spécimens appartiennent à des espèces distinctes, et c'est ainsi que
je les considererai."   A very large number of the species which
De Koninck states are confined to one or other of his three horizons
in Belgium, I have found together in the Carboniferous beds of
Great Britain and Ireland, and am inclined to think that many of
his species will be found to be merely synonyms.

In the volumes on the Lamellibranchs of the Carboniferous Lime-
stone of Belgium, 461 species are described by De Koninck, not one
of which is said to occur except in one stage.   The numbers are as
follows :—

Étage Viséen	.	.	.	222	species
,, Waulsortien	.	.	158	,,
,, Tournaisien	.	.	81	,,
				461	

The species of Brachiopoda also are supposed to have had the same
limited distribution, for not one of the 130 species described is
common to two stages; and out of 499 species of Gasteropoda
described only one species, and that with a query, is supposed to be
present in two horizons.   Thus De Koninck would have it that there
are three absolutely distinct faunas, which never intermingle or

overlap. However correct these facts may ultimately be shown to be in Belgium, there is in the Carboniferous beds of Great Britain and Ireland nothing at all comparable to such exactness in the vertical distribution of the faunas of the Carboniferous period ; and if one fact is emphasized more than another, it is that many species of Brachiopoda and Mollusca reappear again and again at various horizons, and survived throughout the whole of the epoch.

In Great Britain, *Productus giganteus* is a fossil very frequently met with, and of very wide vertical range. In the Pennine area it is met with in all the limestones from the Great Scar to the Crow Limestone, thus passing from the base of the Carboniferous Limestone to the top of the Yoredale Series. In Northumberland, it occurs with *P. cora* throughout the whole of the rocks grouped by the officers of the Geological Survey as the Carbonaceous division ; and in Scotland is characteristic of the limestones of the Carboniferous Limestone Series, both upper, middle, and lower divisions. In North Wales, *P. giganteus* passes from the Middle White Limestone of Mr. Morton to the top of the series, accompanied in the Middle White and Upper Grey Limestones by *P. cora*, which shell is found alone in the lowest member (the Lower Brown Limestone) of the series. In South Wales, Mr. Morton finds *P. giganteus* and *P. cora* in the limestones of Gower, and Mr. Stoddart records both these fossils in the Carboniferous Limestone of the Bristol district. Mr. Stoddart published (Proc. Bristol Nat. Soc., new ser., vol. i, 1874–6, p. 318) a very careful account of the various beds of the Lower Carboniferous Shales and Carboniferous Limestone of the Bristol Coalfield, and the fossils contained in them. The majority of the Mollusca and Brachiopoda are not, however, zonal forms, but are found at various horizons in the Carboniferous series, both there and elsewhere. M. Max Lohest, after going over the ground, published a small pamphlet entitled " Sur le parallélisme entre le Calcaire Carbonifère des environs de Bristol et celui de la Belgique " (Ann. Soc. Géol. Belge, tom. xxii, p. 7), in which he would establish an almost complete identity between the Bristol and Belgian series. This author recognizes zones indicated by A, B, D, E, F.

A. Beds with *Modiola Macadamii* and *Avicula Damnoniensis*, which correspond with those of Comblain au Pont. Mr. Stoddart, however, pointed out the close connection of the fauna of these beds with that contained in the Marwood, Coomhola, and Moyola beds.

B. This bed is a red crinoidal bed, with *Spirifer glaber*, *S. bisulcatus* (?), *S. Tornacensis*, and *Spiriferina octoplicata*, identified with the lower part of the Tournaisian beds of Belgium ; but, with the exception perhaps of *Spirifer Tornacensis*, all the other fossils are found in the zone of *Productus giganteus*, if not near Bristol, in the topmost beds of the Carboniferous Limestone of Derbyshire and Yorkshire. M. Lohest says : " Le base du terme B paraît bien être l'équivalent de notre assise à *Spirifer glaber* ; les schistes du sommet représentant nos schistes à *Spiriferina octoplicata* " ; but in Great Britain both these forms are most abundant in the upper part of the Carboniferous Limestone.

D is a bed of crinoidal limestone.

E is a bed of dolomitic crinoidal limestone.

F is a thick oolitic limestone, which is considered to correspond with the base of the Viséan, with *Productus cora* in the lower part and *P. giganteus* above.

In this succession, Dupont's Waulsortian division of Belgian rocks is entirely absent, and the chief features on which the identification of the two series of beds is based are purely petrological, and not palæontological. There are so many horizons at which beds of crinoids occur, that unless species can be recognized, such statements are utterly valueless for the purposes of identifying horizons.

The Avon section shows the following sequence :—

Zone of *Productus cora* } Mountain Limestone, 2,000 feet.
  and *P. giganteus*

Productus giganteus and } Lower Limestone Shales, 500 feet.
  P. cora absent

In a paper published in the Annales du Soc. géol. de Belge, tom. ix, 1881–2, p. 31, De Koninck, describing some new Cephalopoda from the Carboniferous Limestone of Ireland, gives three lists of fossils which he considers as typical of the three series of beds established in Belgium by Dupont, and states that he is able to make out the same three zones in Ireland from the study of specimens in various museums and collections. He considers that the following parallels occur :—

IRELAND.	BELGIUM.
1. Limestone of Armagh.	Calcaire des Ecaussènes et de Comblain au Pont.
2. Calcareous schist of Hook Point.	Calcaire de Tournai.
3. Limestones of Rathkeale and Co. Limerick.	Calcaire de Waulsort.
4. Limestones of Cork, Dublin, Galway, and Meath.	Calcaire de Visé.

If a comparison be made between the lists of Carboniferous fossils from these districts which were drawn up by the late Mr. Baily for the Memoirs of the Irish Geological Survey, it will be seen at once that no such palæontological divisions can be shown for the Irish Carboniferous beds. Indeed, most of the species on which De Koninck relies for the identification of his three life-zones are not confined to the horizons which he mentions. For example, *Zaphrentis cylindrica, Syringothyris distans, Spirifer laminosus, Athyris Royssii, A. lamellosa,* and *Orthis Michelini* are said to be characteristic of the Tournaisian ; but in Great Britain and Ireland these shells are found to have survived all through the deposition of the limestones, being not at all rare in the upper beds. The fossils of the middle zone are equally associated with those of the upper and lower in British localities, while *Productus giganteus* and *P. cora* are by no means confined to the upper beds. For example, *P. giganteus* occurs at Hook Point in the Lower Limestones with *Syringothyris cuspidatus,*

Spirifer striatus, S. laminosus, Orthis Michelini, Conocardium fusiforme, Athyris Royssii, and *Amplexus corolloides.* At Armagh, *Productus giganteus* occurs at twenty-five different localities, at one of which it is known to occur with *Orthis Michelini, Spirifer laminosus,* and *Zaphrentis cylindrica* ; in fact, unfortunately for De Koninck's rapid generalizations, *Productus giganteus* occurs in all the Carboniferous districts of Ireland, and seems to have survived from the deposition of the Lower to that of the Upper Limestones. Although copious lists of fossils and localities are accurately given in most of the Memoirs of the Geological Survey of Ireland, it is a great pity that those who had to produce them did not see fit to arrange the lists of fossils according to the horizons, instead of only giving localities, and leaving it to the student to identify the horizon of each locality by a reference to the colour which is shown on the map at each place. In the Memoirs of the Scotch Survey, and the later English one, the reader is able to see at a glance not only the locality, but the actual horizon whence each fossil was obtained.

It would therefore appear that in Great Britain the zone of *Productus giganteus* is very largely developed. In the Southern Pennine district this fossil characterizes the beds from the base of the Lower Scar Limestone to the Upper Limestone (the Crow) of the Yoredale group. In Scotland, however, and, to some extent only, in the Pennine and Bristol areas, this extensive zone is preceded by a series of rocks in which this fossil is absolutely wanting—the Calciferous Sandstone Series, which are probably represented only by the basement beds of the Ingleboro area and the Roman Fell beds further north. It is difficult to suggest a zonal form for this series, much of which is non-marine ; but on the Fifeshire coast *Sanguinolites Abdensis,* Etheridge, and *Schizodus Pentlandicus,* Rhind, seem to be confined to the series; and *Modiola Macadamii* is characteristic of the Lower Limestone Shales of Bristol and the Coomhola and Moyola beds of Ireland.

The shales overlying the limestones in Derbyshire and Yorkshire, I have shown to contain a fauna totally distinct from the Carboniferous Limestone and the Yoredale beds of Wensleydale (Geol. Mag., 1897, Dec. IV, Vol. IV, pp. 159–169 and 205–213). This series, mapped by the officers of the Survey as Yoredale beds, may be described as the zone of *Aviculopecten papyraceus, Gastrioceras carbonarium, Posidoniella minor,* and *P. lævis,* and includes the Lower Coal-measures or Ganister Series, Millstone-grits, and shales below them ; while the Coal-measures may well be subdivided into the upper, or zone of *Anthracomya Phillipsii,* and lower, or zone of *Naiadites modiolaris,* with many local horizons at which only certain fossils have as yet been known to occur.

The following table gives the equivalents of these zones in England, Scotland, and Ireland, from above downwards :—

	ENGLAND.	SCOTLAND.	IRELAND.
1. Zone of *Anthracomya Phillipsii.*	Upper Coal-measures of Lancashire, Yorkshire, Staffordshire, Bristol, including the *Spirorbis* Limestones.	The Red Beds of Fifeshire.	? Wanting.
2. Zone of *Naiadites modiolaris* and *Anthracomya modiolaris.*	Middle Coal-measures universally.	The Red Beds of Fifeshire.	Coal-measures.
3. Zone of *Aviculopecten papyraceus, Gastrioceras carbonarium, Posidoniella lævis,* and *P. minor.*	Ganister Series. Millstone Grit. Shales below the Millstone Grit universally.	? Wanting. NOTE.—*Aviculopecten papyraceus* is said to be found some distance above the Ell Coal in the Wishaw district, Lanarkshire; but I have never seen this fossil in any Scotch collection, and the determination is possibly erroneous.	Castlecomer, Leinster Coalfield. Coal - measures of Fynes, co. Limerick.
4. Zone of *Productus giganteus* and *Productus cora.*	The Carboniferous Limestone of Derbyshire. The measures from the Great Scar to the Main Limestone, N. Yorkshire. The Carbonaceous Division of Northumberland. Carboniferous Limestone of Wales and the Mendips.	The Carboniferous Limestone Series of Scotland { Upper, Middle, Lower.	The Upper Limestone. The Calp. The Lower Limestone.
5. Zone of *Modiola Macadamii.*	The Lower Limestone Shales of the Mendips and South Wales, with several fossils common to the Old Red Sandstone Series and the Carboniferous.	The Calciferous Sandstone Series, with *Schizodus Pentlandicus* and *Sanguinolites Abdensis* in Fifeshire, and a fauna very different from the English and Irish equivalents. Mr. Kirkby states that *Productus cora* is contained in the upper 500 feet of these beds.	The Coomhola and Moyola beds, forming a passage from the Old Red to the Carboniferous, and containing certain fossils common to both.

Series 1–3 constitute what I consider to be the " Upper Carboniferous," and series 4 and 5 the " Lower Carboniferous," of my paper on the Yoredale Series (GEOL. MAG., April and May, 1897).

While the zone of *Productus giganteus* corresponds to the Viséen of Belgium, the lower zones of Great Britain do not resemble the

Waulsortian or Tournaisian in their faunas. My own view, from a comparison of the Belgian and British fossils, is that the zone of *P. giganteus* in Great Britain and Ireland corresponds to the whole of the Belgian series; for none of the fossils which are relied upon by MM. De Koninck and Lohest to identify the lower beds in both areas are in Great Britain and Ireland confined to the Lower Limestone Shales, but are found in abundance, and in a full condition of growth, at the top of the zone of *P. giganteus*.

The faunas contained in the beds of shale differ markedly from those contained in limestones, the shales being much richer in Lamellibranchs and Crustaceans, and comparatively poor in Brachiopods and the Actinozoa. Consequently the faunas of the same zone, taken as a whole, vary very much according to locality and the nature of the sediment. Consequently the zone of *P. giganteus* in Scotland, in which the limestones are separated by thick beds of shale, contains a very different fauna from that which obtains in the same zone in Derbyshire, where the shales are practically absent, and the limestone exists in one mass, made up of beds of various lithological characters.

IV.—The Contact-Rocks of the Great Whin Sill.

By W. Maynard Hutchings, F.G.S.

IN what follows, it is proposed to give a general description of the effects of contact-metamorphism, observed in the rocks altered by the intrusion of the Great Whin Sill in Durham and Northumberland.

The work, of which this is the condensed result, has been carried on for the last four years in the microscopical, and to some extent chemical, study of a large series of specimens collected at many points along the course of the Whin Sill exposure by Mr. E. J. Garwood, and also, to a very much smaller extent, by myself. Mr. Garwood has been for a long time engaged in a detailed examination of the geology of the district, and will in due course publish the results of his work, which is not yet complete. It was at his suggestion and request that I undertook the petrological study of the specimens collected.

As is well known, the rocks into which the Whin Sill mass has been intruded consist mainly of limestones, shales, and sandstones of the Lower Carboniferous beds. The special interest and value of the contact-effects here displayed, are enhanced by the fact that the rocks acted upon were all in what may be called a perfectly simple and elementary state. We know exactly what they were like before they were altered by the intrusion, and can study them as fully as we wish, in their original and normal condition, in the same and other districts. Thus, the shales, the metamorphism of which gives us the most interesting portion of the material, with the most important bearings upon the question of contact-action in general, are in all respects counterparts of those from the Coal-measures and the Lower Carboniferous, which I have described in

full detail in previous papers in this Magazine. None of the rocks affected had undergone any sort of "development" previous to the intrusion of the Whin; and as they have not been in any way changed, except by weathering, since the consolidation and cooling of the igneous mass, we are able to see with considerable certainty just what mineralogical and structural changes are to be ascribed to contact-metamorphism.

Such comparatively simple and reliable conditions, in a contact-area of such importance, are so very rare that it is at once apparent how valuable are the indications we may derive from them, and how great is the assistance they may render to us in our endeavours to understand the much more complex cases usually presented to us. I say "in a contact-area of such importance" because, as I shall show, we have here exactly reproduced for us a large portion of the phenomena we are accustomed to see round the intrusions, on a much mightier scale, of granite, etc. It makes no difference that in greater contact-areas the mineralogical and structural details are more striking as to size, so long as on the smaller scale they are equally clear and distinct.

I propose to deal with the altered rocks in the following order: pure or almost pure limestones, argillaceous limestones, shales, calcareous shales, sandstones. These, however, pass over into one another in all degrees, and there is, of course, no sharp division between limestones, argillaceous limestones, calcareous shales, shales, quartzy shales, argillaceous sandstones, and sandstones or grits. It is among some of the intermediate rocks that the most interesting effects are produced.

When a sufficiently large number of specimens had been sliced and examined, it became evident that there was no use in multiplying them beyond a certain point. It was clear that the same results of alteration could be found at intervals all over the long course of the Whin Sill, wherever the chemical nature of the invaded rocks was the same. For this reason, in the following descriptions, particular localities of occurrence will only be mentioned when specially interesting or pronounced developments have taken place, which are qualified to serve as good types of the alterations in general.

Commencing, then, with the limestones, we find that when these are pure, or at all events are non-argillaceous, the action of the Whin Sill upon them has been limited to a recrystallization of them. In some cases this recrystallization is very finely marked, and may stand alongside of the "marmorization" of similarly pure limestones by intrusions of granite.

Whether interfusion has taken place to any extent between the Whin and the purer limestones, at some points, is a question which it is not possible to answer decisively. In many actual contact-slides examined there does not seem to be evidence that any such action has occurred at all; the division line is quite sharp and clear, the Whin is small-grained but quite crystalline right up to the junction, and the recrystallized limestone begins equally sharply on

the other side of it. If there be recrystallized quartz, this also often comes quite sharply up to the contact-line.

In some instances there does appear to be a very narrow streak of more indefinite matter, possibly denoting interfusion; and there are other cases where a very noticeable band is seen of what has clearly been of a tachylitic nature; though whether we ought to regard it as a true tachylite,—i.e. a product simply of rapid cooling of the edge of the molten igneous rock,—or whether it is more a result of interfusion, I think cannot be settled, because chemical analysis would not here give a sufficiently definite answer. So far as microscopical evidence can help us, I rather incline to the view that it points to interfusion having taken place to some extent. Thus, the most striking example is one from Middleton Wood, near Belford. In the hand-specimen the tachylitic material was some two inches thick, and in the slide prepared from it, over the line of contact, there is nearly half an inch of it. The limestone is simply crystallized, as is also silica which it contained. It has not had any new minerals formed in it, but *quite close* to the junction there are a few colourless garnets, just a narrow string of small crystals and grains. Then comes the tachylitic band, mainly a yellow to red-brown glass, with a good deal of indefinite, speckly, felsitic-looking matter, and chloritic decomposition products, but with some felspars and augites of good size dispersed in it, and a few prisms of enstatite. With these is also a good deal of garnet in small grains, and at some parts patches of it of much larger size. As no garnet occurs in the altered limestone except at the actual contact, and as it occurs in the tachylitic band, it seems likely to be a product of the interaction of limestone and Whin. No garnets seem ever to occur in the normal Whin Sill rock.

In some other specimens examined there is, again, a narrow band of what appears to be another product of such interaction. There is a seam of what appears to have been tachylitic, now very much obscured by calcite and chlorite due to decomposition. The lime-stone is perfectly free from any new mineral formation. But on the side towards the Whin comes a zone of close-grained igneous rock, a narrow strip of which is coloured brownish-red of a peculiar shade. Under higher powers it can be made out that this reddish band contains swarms of minute flakes of mica, and that it is from these that it derives its colour. Here and there the compact swarms of this mica open out, and become more scattered and larger in size, some individuals being seen as fairly well-bounded crystals, which can be recognized as a deep brown-red very dichroic biotite, some of the best flakes giving a good optic figure in convergent light with $\frac{1}{12}$ inch objective. None of this mica is ever seen in the normal Whin, and I have not seen any signs of it except at contacts with pure limestones. It certainly appears to be an endomorphic formation in the igneous rock, brought about by interaction with the limestone, though it does not seem easy to explain the chemical re-actions which have been concerned in it. I do not recollect any mention of a similar result on an intruded igneous rock, and have certainly never seen it myself in any other case.

We will now pass on to the altered argillaceous limestones, including under that head all such rocks as are still safely to be recognized, microscopically and chemically, as having been dominantly limestones, but which have contained sufficient shaly material to provide a noticeable amount of silica and alumina, with some alkali and magnesia, which latter will also be present, more or less, in any case, in most of the limestones. Rocks of this class, of varying degrees of admixture, occur at many points along the Whin Sill, and have given rise to very interesting contact-products. The new minerals formed are garnet, augite, idocrase, wollastonite, epidote, hornblende, felspar, chlorite, sphene. The garnet is the most persistent, being seen in all the slides examined from rocks of this class, whereas most of the above minerals may be present in some cases and absent in others.

One or two typical examples will serve to give a general idea of the nature of the alterations produced. Thus, from specimens of not very impure limestones from Burtreeford, sections have been cut which show the actual contact-line. First comes a narrow band (about $\frac{1}{50}$ inch) which seems to mark some sort of interfusion. Though now much obscured by fine-grained secondary calcite, it is distinctly defined both on the side towards the Whin and on that towards the limestone. The Whin is very fine-grained, but contains a good many perfectly fresh and distinct crystals of felspar of larger size. Occasionally one of these crystals projects just into the edge of the interfusion-band, and may be seen to have been melted away in it and left with a rounded end.

Along the edge of the band towards the limestone lie many small but good crystals, and some irregular grains, of idocrase. The largest crystal in these particular slides is a prism $\frac{1}{60}$ inch long by $\frac{1}{150}$ inch wide, very fresh and perfect. A very few lie also a little further in, but none occur at any distance from the contact-line. It is interesting to note the mode of occurrence of these crystals, some of which are completely bedded in quartz, some again in calcite, and others in grains of calcite which are surrounded by quartz.

Then comes another narrow zone, about $\frac{1}{15}$ inch, which consists largely of recrystallized quartz as a sort of ill-defined mosaic, intermixed with varying amounts of calcite. This quartz is all full of inclusions of small garnet grains and indeterminable microlites, and clearly dates from the original metamorphism of the limestone by the intruded Whin, being strongly distinguished from later quartz which has filled in small cracks, etc., and which contains no such enclosures. This quartz band passes abruptly into coarse-grained, highly crystalline, saccharoid limestone, the calcite crystals containing numerous small garnets in rounded grains. A deep-coloured, very dichroic sphene, in good-sized crystals and grains, is also present.

Rather more impure limestones are represented by specimens from Rumbling Churn, near Dunstanburgh. Garnet is again very abundant, mainly in very small crystals and rounded grains

averaging about $\frac{1}{1000}$ inch in diameter, but in some cases reaching $\frac{1}{100}$ inch and a little over.

At some parts of the slides these garnets are packed so close that scarcely anything else is visible. They vary from colourless to yellow and greenish, and some are a rich red-brown. Often the centre is coloured, and the outer rim is colourless. Augite occurs plentifully with the garnet, in good-sized crystals and large irregular complex grains. It is all perfectly fresh, and some of it is of a very decided green colour, and slightly dichroic. Both garnets and augite come right up to the contact-line, and in one slide may be seen lines of very small augite crystals, clearly of contact-origin, growing out from the edge of the Whin, like the teeth of a saw, into the limestone. A very pale hornblende in slender needles is also present at some parts; epidote and sphene are well represented, and there is a good deal of recrystallized quartz, which frequently encloses garnet and augite. The remaining calcite of the limestone is completely recrystallized. There are often large fields of one uniform grain of it, with numerous garnets and augites contained in it.

In the mosaic of recrystallized quartz in these highly calcareous rocks one may often suspect felspar to be present, but without being able to make sure of it, owing to absence of cleavages and the impossibility of making reliable optical tests. In one specimen from near Dunstanburgh, however, an altered limestone shows numerous small crystals, together with more or less irregular grains, of well-cleaved fully-individualized felspar. Some few of the crystals even allow of identification, with much safety, as anorthite or a closely-allied species (sections with parallel cleavage, extinctions $30°–40°$, with emergence of good axial bar inside the field). They lie in amongst very coarse-grained recrystallized calcite, near the junction with the Whin. It will be seen later on that some of the altered shales contain abundant new felspar. The above specimen shows also a few garnets, some epidote, a good amount of recrystallized quartz, together with a considerable amount of wollastonite, mainly in tufts and bunches of often sheaf-like, radiating fibres, with here and there bits of sufficient size for the application of optic tests. This mineral appears to be not of frequent occurrence in these rocks. Indeed, it may be noted that, so far as concerns the limestones which are reasonably free from any admixture except silica, there seems seldom to be any reaction between the lime and the silica. Calcite and quartz recrystallize side by side, and it is rare to see in these particular rocks any formation of wollastonite, or of any calcareous hornfels-like products, such as are more frequently encountered round granite-contacts.

Sometimes there were little bands of sandstone in the pure limestone, quite close to the contact. A specimen from near the Roman station of Borgovicus, close to the Whin, is sliced so as to show both recrystallized limestone, very saccharoidal, and sandstone converted into a well-cemented quartzite, with some new felspar among the interstitial matter. The division-line of the two products is very clear and sharp, and there has not been a trace of action between them.

It is not only close to contact that these limestones have been affected. Complete recrystallization is seen at more than 60 feet away, and small augite crystals are seen in a specimen over 40 feet distant.

We may now turn to the consideration of the alteration-products of the shales. These shales along the contact-area of the Whin Sill have varied in nature in every degree, from argillaceous beds almost quite free from quartz, to others in which that mineral has formed a large proportion. For our present purpose we will call them all shales, speaking of them as more or less sandy, and only draw the line where the quartz has increased so largely that we must recognize them as argillaceous sandstones and classify them accordingly. Of this class of rock a very large number of specimens have been examined, but here again a few examples will suffice to give a clear idea of the general lines on which the metamorphism has proceeded. The intensity, and to some extent also the character, of the alteration varies more or less at different places. This is partly due to different composition, notably the variation in the amounts of quartz and of alkalies contained affecting the susceptibility of the beds to contact-action. Partly it is due also to the varying bulk of the intruded rock at different points, and sometimes we cannot account for the variation except by assuming some difference in the local conditions of the invaded beds, as to temperature, degree of hydration, etc., before the intrusion occurred.

Outwardly the change undergone by the originally soft shales consists in great induration, accompanied by more or less lightening of colour. In the inner zones of action, nearer the igneous rock, (sometimes also at considerable distances), the soft, fissile, dark-coloured shale has been altered into a hard, compact, grey or greenish-grey rock, with often very little fissility remaining, and in many cases completely replaced by a conchoidal or almost flinty fracture.

Inwardly, as revealed in thin sections, the most constant and striking change lies in the production of new mica, with chlorite, with a totally new structure as well as new mineralogical composition. Newly crystallized quartz is also frequently a main feature, in some cases felspar has been abundantly produced, and we have examples of the appearance of special contact-minerals in the form of biotite. andalusite, anthophyllite, etc.

If we take first the purest shales, which have had little, if any, quartz, and which have a chemical composition like that of some of the purest " fireclays," we find that where the contact-action has been most intense we have a complete recrystallization of the entire rock, with formation of a new mass of white mica throughout. Instead of the minute flakes of the indefinite micaceous mineral which has been produced in the fireclay or shale, making its main constituent, and lying nearly all in one plane, we get a network of much larger, well-developed flakes and crystals of white mica, lying criss-cross in all directions. In many cases a good deal of it is grouped together in fans and sheaves, and roughly spherulitic

aggregates giving more or less black-cross figures in polarized light. Intimately mixed and interwoven with this new mica is an abundant chloritic mineral. This chlorite forms part of the sheaves and spherulitic groups, and all over the slides is seen to have been formed flake for flake *with* the mica, as a result of one and the same process. No such chlorite exists in the unaltered beds ; as I have previously pointed out, both it and the white mica are the result of a splitting-up and higher development of the impure and complex micaceous mineral of the clays and shales. In some cases there is a certain amount of biotite formed, with a similar mode of occurrence, but this is not frequent among these rocks. The formation of " spots " may also be seen on a copious scale in some specimens ; and these spots, though small, are exactly analogous to the larger ones seen at some granite contacts, being due to the aggregation of the chloritic material which is separated out during the recrystallization of the rock constituents.

One or two special examples of the alteration of these pure shales may be given in illustration. Thus, a specimen from Rowntree Beck, taken 18 feet below the Whin, is very highly altered but still contains good fossils. An analysis of it gives—

Silica	...	...	...	...	51·40	per cent.	
Alumina ...	...	...	...	...	26·85	,,	
Ferric Oxide [1]	...	...	...	...	6·15	,,	
Lime	...	...	...	...	...	0·56	,,	
Magnesia ...	..	...	...	...	2·38	,,	
Potash	...	...	...	...	5·21	,,	} 6·99
Soda	...	...	...	...	1·78	,,	
Water	...	...	...	...	6·45	,,	

100·78

This composition shows the rock to have been originally of the nature of a fireclay, closely resembling some of the series of which I published analyses in a former paper (GEOL. MAG., 1894, Dec. IV, Vol. I, pp. 36–45 and 64–75). It is now a muscovite-chlorite rock, with abundant " spots " all over it. Into these spots is concentrated nearly all the pigmental matter of the rock, together with chlorite and numerous dark grains and microlites, so that the spots are dark in a light field. Parts of this field are almost clear and colourless. In polarized light they are seen to consist of an interlacing mass of muscovite and pale chlorite. Sheaves and spherulitic bundles of mica and chlorite abound all over the section, and there is no sign of any definite orientation of these minerals in any direction. The entire rock is crowded with small grains and crystals of rutile re-crystallized from the original " needles " of the shale.

Another interesting spot-rock comes from near High Force. In ordinary light a section of it shows a sort of marking off into roughly polygonal, or approximately circular, clear spots, framed in

[1] In this and following analyses *all* the iron is reported as ferric oxide, no special determination having been made of the portion which is always present as ferrous oxide. This often causes more or less excess in the totals, but is not of any importance for the purposes for which these analyses were made.

darker greyish and brownish pigmental matter. The spots are mostly of a very pale greenish colour, and proper illumination enables us to see countless flakes and crystals of a chloritic mineral. With crossed nicols the whole slide is resolved into a network of muscovite flakes, lying again in every possible direction, and amid the brightly polarizing mass of this mica the chloritic spots are more or less dark and isotropic. In some the transition from the bright frame of mica is quite sharp ; in others mica projects more or less into the spot, and only the centre is free. Many spots show a field of quite isotropic, pale-green substance, in among which a dim and speckly fine-grained mosaic polarization is discernible. These spots are again in all respects exact counterparts of what may be seen at some granite-contacts. It is curious to observe that, whereas in the previous example the dark pigmental matter has concentrated inside the chloritic spots, in the present case it has remained completely outside them, and is mixed in with the mica. I have made no analysis of this rock, but it shows only a very small amount of recrystallized quartz, and is no doubt very closely the same in composition as the last. No trace of clastic muscovite remains in either of these, and, indeed, in nearly all the highly altered fine-grained shales examined, it has absolutely disappeared and entered into the same complete recrystallization which has affected the main mass of secondary micaceous and other material of which the shales and clays were composed.

Perhaps among these very fine shales examined, the most interesting case is shown in a specimen from near Winch's Bridge, in Teesdale. It is from a body of rock which has been caught up by the Whin. It contains—

Potash	...	...	...	...	5·71	per cent.	} 7·20
Soda	...	...	...	...	1·49	,,	
Water	...	...	...	...	7·40	,,	

This is very nearly the maximum of alkali which I have found in any of the carboniferous shales and clays. It can have contained but little quartz. When it is examined under the microscope it is seen to consist, to a very large extent, of the peculiar substance which I have previously described in detail as being found in varying quantity in so many altered rocks around granites (GEOL. MAG., January and February, 1894). I traced and described its various modifications and developments, and endeavoured to show the probable nature of its origin and the part it plays in the changes going on during contact-metamorphism. There seems every reason to regard it as a product of the *solution*, or "aqueous fusion," of original materials preliminary to recrystallization. Sometimes we see it in a quite amorphous state. Its first stage of development from this shows a faint minutely-speckly polarization. At very thin edges, with high powers and suitable illumination, it is seen to be very finely granular. We can see it in contact-slates in all stages of evolution, from the first appearance in it of very few and small mica-flakes, up to a full development of new mica out of it.

I alluded, in the paper referred to, to the fact that this substance could be seen in the contact-rocks of basic intrusions, but in less amounts than at granite-contacts. I had not at that time seen the specimen we are now considering, which shows the substance in greater amount than any other I have ever seen, and which strikingly confirms the view at which I had arrived concerning its origin and nature. It here forms a sort of base, or groundmass, all over the slide, and is nearly colourless, there being very little iron present. None of it is quite amorphous, but it has the speckly minutely felsitic polarization. Mica has formed in it throughout, but not regularly diffused, so that whilst at some parts there are patches, large enough to fill the field of a half-inch objective, in which but a few small distinct flakes are to be seen, we have other portions made up so entirely of mica that little of the base-substance can be seen among it. We can trace the growth of the mica in all stages. It is to a large extent in tufts and sheaves and rosettes ; many of these of all sizes, as well as single flakes and crystals, and crossed and interlaced groups of them, may be seen brilliantly polarizing, floating free, as it were, in the nearly amorphous material out of which they have grown.

It is quite clear that what we here see is an intermediate stage,— an interrupted development,—on the road towards some such final product as the two examples we have just been studying. Had the conditions suitable for the crystallization of the mica continued long enough, we should have had a complete and uniform development of that mineral, together with its attendant chlorite, as before. But it is just the fact that the conditions did *not* continue long enough for completion of the process, which gives such particular interest and value to this occurrence. Such interrupted cases, when we can get them, are capable of teaching us more of what actually " goes on " in these contact-metamorphisms than any number of completed examples, where often all trace is lost of the steps by which the final result has been arrived at.

The rutile of the altered shale has crystallized out in much larger and more definite crystals than the original needles, many of them as " hearts " and " kites," and the entire slide, mica as well as base-substance, swarms with them. A good proportion of the mica, in this case, is brown and strongly dichroic, especially some of its larger tufts and sheaves. There is no clastic quartz remaining ; what little there was evidently entered into the general process of solution, and has reappeared as newly-formed mineral. It is also interesting to notice how the numerous small zircons of the original shale have resisted, as they so frequently do, the solution which has destroyed all trace of everything else, and how they remain quite unaltered among the new products.

The greater number of shales affected by the Whin Sill have not, however, been as purely argillaceous as the above examples. They have mainly been more or less sandy. But their alteration has proceeded on much the same lines as those described, and it will not be necessary to consider them in much detail. In some of the more

highly metamorphosed beds all original quartz has disappeared, and has been replaced by newly-formed contact-quartz. Where the amount of it is sufficient, we sometimes get a good "mosaic" of the same nature as what we see so universally at granite-contacts. Where there is less of it, we see it disseminated among the micaceous part of the rock in single grains, and groups of grains. In less intensely affected cases we get more or less clastic quartz remaining; sometimes it does not seem to have been attacked at all, and again, we may be able to see various degrees of its attack and corrosion by the processes of solution which took place. With the more or less regenerated quartz we nearly always see that the argillaceous position of the shale has given rise to just the same products as those we have been considering, the mica and chlorite, the spots, and the residual speckly substance, all appearing in the same relationships as to individual forms and general structures.

Among these altered sandy shales, however, there are some occurrences which are of such special interest that they must be here alluded to, in connection with the review of the whole contact-phenomena of the Whin Sill and their bearings on the general question of contact-metamorphism. In a former paper ("An Interesting Contact-Rock," Geol. Mag., March and April, 1895) I gave minute descriptions of the rocks to which I allude, and I would refer students of the subject to that paper, limiting myself here to a recapitulation of the particular points involved.

The principal rock in question is a bed of shale 8 feet thick, at Falcon Clints. It occurs 75 feet below the Whin, a series of limestones, sandstones, and shales intervening. It contains at some parts large numbers of approximately spherical nodules like peas. Thin sections show, in ordinary light, a grey groundmass in which are bedded grains of clastic quartz. In polarized light it is seen that this groundmass consists largely of an isotropic substance, in which lie numerous grains, rounded, irregular, or more or less definitely-bounded, of newly-formed quartz and some felspar. At parts these grains are so numerous and closely packed that they amount to a true interlocking mosaic, with very little isotropic matter. At other places they are more separated, and we get quite large spaces of the isotropic substance, but containing small flakes of mica and other things. These grains are not yet fully indi-vidualized; they are not water-clear, and have still so much dimness about them that they cannot be properly made out at all except in polarized light. They are absolutely distinguished from the original clastic material; not one of them could ever for a moment be mistaken for anything but a newly-formed secondary product.

The clastic quartz-grains remaining are seen to be all more or less attacked and corroded by the surrounding groundmass; their original angular outlines are in nearly all cases preserved, but the outer portions are no longer quartz, but an altered substance often containing a considerable amount of white mica and sometimes of felspar, whilst in some cases anthophyllite and andalusite are seen.

In the nodules considerable fields of clear, almost colourless, quite isotropic material are seen, in which bundles and sheaves and pseudo-spherulites of felspar, with some quartz, have been formed. Anthophyllite and andalusite are also seen in some of them.

Here, again, we have preserved for us one of those interesting cases of interrupted development. All the finer-grained material of the shale,—the impure micaceous mineral and the minuter quartz, —has been taken up into solution, or aqueous fusion; and out of the substance so formed a mosaic of quartz with some felspar, together with muscovite, has been in process of crystallization. But this process was arrested before it was complete, and so we are again able to see the unfinished stages, to observe the residual indefinite, isotropic, intermediate matter, and to note also the larger quartz-grains which were being attacked and dissolved, and would have all disappeared if the solution stage of the contact-action had been able to continue somewhat longer.

Sections from other parts of this bed show us mainly a fine-grained aggregate of newly-formed quartz and felspar, passing down into a quite cryptocrystalline felsitic-looking mixture (adinole), but opening up, on the other hand, here and there into numerous clear and glassy patches, which in polarized light are seen to consist of groups of well-twinned plagioclase felspar, which can often be identified as albite, whilst the extinctions also point to the presence of a species allied to oligoclase.

From the neighbourhood of Rowntree Beck, again, come specimens of shale altered to adinoles, and showing nodules up to two inches across, with anthophyllite.

We come now to the calcareous shales, and find that among these we have some of the most intensely altered rocks of all. Sometimes they occur as narrow bands in connection with purer limestones, sometimes as patches and lenticular masses in such limestones, and sometimes as thicker independent layers.

The most striking occurrence is at Falcon Clints. The specimens show a compact hornfels-like brown rock, with a jaspery sort of appearance and fracture. It contains many garnets of sufficient size to be easily seen with the naked eye. Thin sections show that these garnets are the most prominent mineral contained. They very much resemble those in the altered impure limestones round the Shap granite, and like them are polysynthetic and show a good deal of birefraction. They are, however, here not so often well-defined crystals, but more irregular grains and patches. They are often very much cracked, the cracks being infilled with chlorite and other substances. They occur irregularly, some parts of the rock being free from them and others containing swarms of small grains and crystals.

In some specimens idocrase occurs with the garnet, some of it as good large, well-defined crystals on which characteristic angles can be determined. It is nearly all quite fresh and good, and in every way of normal character.

Both garnet and idocrase crystals may be seen containing large numbers of small crystals of spinel, the garnet much more so than

the idocrase. No spinels are seen except as enclosures in those two
minerals. The greater portion of them are of a good deep-green
colour, and exactly resemble those seen in altered limestone of
bombs from Somma; there are also colourless and pale reddish-
brown crystals.

If we take several thin sections of specimens from this occurrence
and average, as it were, the results of microscopic examination, we
find that a large proportion of the rock consists again of a base or
groundmass, which varies greatly in its texture and fineness of
grain. Sometimes it is a close-grained, felsitic-looking mass, quite
cryptocrystalline, and nothing definite can be made out as to its
component minerals. At other parts it becomes coarser, and
examination with high powers seems to show that much of it is
quartz and felspar; this conclusion being confirmed when we come
upon good-sized patches, like glassy spots in ordinary light, which
with crossed nicols are seen to consist of well-twinned felspar
with sometimes more or less quartz. This groundmass may be
described as a calcareous adinole. In it are bedded many new
minerals besides garnet and idocrase.

Wollastonite occurs at some parts in considerable abundance,
mainly as radiating sheaves and bunches, with sphene, epidote, and
recrystallized calcite. In some slides are well-developed chloritic
"spots." as well as others of the pale yellow-green, almost quite
isotropic, granular matter; and there are some which appear to
be cordierite in early stages of development, corresponding exactly
with similar spots seen to occur together with undoubted cordierite
in other contact-rocks.

A large hand-specimen of this rock from Falcon Clints I have
analyzed. It contains:—

Silica	...	...	...	...	...	53·80 per cent.
Alumina	...	...	...	...	...	20·25 ,,
Ferric Oxide	...	...	...	...	8·15 ,,
Lime	...	...	...	...	...	3·27 ,,
Magnesia	...	...	...	...	...	3·02 ,,
Potash	...	...	...	...	...	2·32 ,, } 8·86
Soda	...	...	...	...	...	6·54 ,,
Water and Carbonic Acid			...	...	2·90 ,,

100·25

Another occurrence of a similar calcareous adinole is found at
Sneblazes. A thin section shows the same sort of groundmass.
No garnets or idocrase appear in the specimen examined, but there
is a good deal of augite in small crystals, and felspar is again seen
here and there. The analysis of this rock gives:—

Silica	...	...	...	...	...	50·60 per cent.
Alumina	...	...	...	...	...	20·35 ,,
Ferric Oxide	...	...	...	...	8·30 ,,
Lime	...	...	...	...	...	7·75 ,,
Magnesia	...	...	...	...	...	2·58 ,,
Potash	...	...	...	...	...	2·39 ,, } 6·75
Soda	...	...	...	...	...	4·36 ,,
Water and Carbonic Acid			...	...	3·80 ,,

100·13

Another specimen of a like nature, from close to contact, near to Crag Lough, Bardon Mill, has the following composition :—

Silica	...	...	...	...	48·20	per cent.
Alumina	...	...	...	...	17·30	,,
Ferric Oxide	...	...	...	...	12·50	,,
Lime	...	...	...	...	10·08	,,
Magnesia	...	...	...	...	2·17	,,
Potash	...	...	...	...	1·93	,,
Soda	...	...	...	...	4·59	,,
Water and Carbonic Acid			...	...	4·05	,,

Potash and Soda together } 6·52

100·82

It resembles the others in general composition, but shows hornblende among its new minerals.

It now remains to consider the sandstones, of which a large number have been collected from different points. There is not very much to be said about them, because when they are pure, or nearly so, the alteration is limited to a compacting and conversion of them more or less into quartzites; and where they are less pure, the interstitial matter has undergone the same alterations as have been above described. Thus, where there has been any noticeable amount of argillaceous deposit with the quartz-grains, it is now often seen to consist largely of the same mixture of new white mica and chloritic matter; and in this way we pass back again towards altered sandy shales, as the interstitial constituents increase.

It is noticeable, however, that whereas among the altered shales it is but seldom that brown mica is seen as a contact-mineral, and then only to a very subordinate degree, we find it more frequently and much more plentifully among the argillaceous sandstones. In one case from Rumbling Churn, near Dunstanburgh, there is as large a development of this biotite as might occur at any granite-contact, and all the characteristics of the mineral are the same.

In previous allusions to the contact rocks of the Whin Sill (GEOL. MAG., April, 1895) I had occasion to refer to the interesting question of the supposed transfer of soda from the igneous rock to the altered shales, etc., in such cases of *basic* intrusions. I pointed out that observers of the contact-effects of such rocks elsewhere had been forced to come to the conclusion that such a transfer does often take place, a very considerable mass of chemical and other evidence rendering any other verdict difficult, or even impossible. Most of our knowledge on this point comes to us from German petrologists, though instances of altered rocks rich in soda are not lacking in this country.

When I commenced working at the petrology of the Whin Sill contact I naturally gave attention to this very important point, and it so happened that some of my first analyses, and separate determinations of alkalies in altered shales, very strongly confirmed the views expressed by the German authorities. In the course of the work I have made a considerable number of further determinations, the general result being that the answer obtained is not at all uniform in its direction. There are many of the shales in which soda

has increased very considerably; but there are also plenty of others in which this is not the case, even with highly altered rocks close to the contact, the normal excess of potash over soda having remained undisturbed; and the evidence, as will be seen, is rendered all the more contradictory by the fact that in a given vertical section of beds we may have a rock quite near the Whin, showing this chemically unchanged condition, whilst another one, further away from contact, shows a great increase of soda relatively to the potash.

As previously pointed out, the rocks along the Whin Sill are not specially favourable for the study of the chemical aspect of the metamorphism, inasmuch as the igneous mass is intruded parallel to their strike, and we cannot take any one bed at a distance and follow it gradually up to the contact. All we are able to do is to rely on the fact that, apparently without any exception, the normal shales of the Carboniferous show an excess of potash over soda within certain limits. All the trustworthy chemical evidence available shows this to be the case, and I have myself confirmed it by large numbers of careful determinations, published and unpublished, on specimens from various localities; the two latest being a fireclay and a shale which I took from the neighbourhood of Bardon Mill, near to the exposure of the Whin Sill and its contact-rocks, but quite outside the area of its metamorphic action. The alkalies contained are respectively :—

Potash	...	...	...	2·62 per cent. and 2·66 per cent.
Soda	...	...	...	0·98 ,, and 1·24 ,,

The three analyses given above of calcareous adinoles are all striking instances of a large increase in soda. The total alkali-contents are all three high, though not higher than may be seen in some cases of chemically normal shales. But soda far exceeds potash in all of them. No shales of similar composition exist outside the contact-zone, and however we may *explain* the transfer of soda, we cannot very well deny its occurrence. This increase of soda, as a chemical fact, is accompanied by the mineralogical fact of the appearance of albite in the altered rock. Had we these cases only before us, there would not seem to be much difficulty in accepting the statements of previous observers on the subject.

(*To be continued.*)

NOTICES OF MEMOIRS.

I.—Some Characteristic Genera of the Cambrian.[1]   By G. F. Matthew, LL.D., D.Sc., F.R.S.C.

THE paper gives in brief the history and use of several generic names, and the distribution of certain species to which they have been applied. These genera have an important bearing on the antiquity of the *Olenellus* Fauna. *Bathyuriscus*, Meek, known as a Middle Cambrian genus in Montana and Nevada, occurs in the *Olenellus* Fauna of Eastern North America. It is nearly allied

[1] Paper read in Section C (Geology), British Association, Toronto, August, 1897.

to the following genus—*Dolichometopus*, Angelin, of the Upper *Paradoxides* Beds of Sweden, and is found in beds of similar age in Eastern Canada. With it is associated *Dorypyge*, Dames (= *Olenoides* in part of Walcott), which is a Middle Cambrian genus in Montana and is found also in the *Olenellus* Fauna of Eastern North America. *Microdiscus*, a genus of small trilobites, extending in Eastern Canada up to the Upper *Paradoxides* Beds, is found in the *Olenellus* Fauna. *Agnostus* has a peculiar development in the Upper *Paradoxides* Beds in the appearance at that horizon of the section *Lævigati*; the *Brevifrontes* also abound there. These two sections appear to be present in the fauna with *Olenellus*.

If we accept the view that there has been a regular development of the faunas through Cambrian time, it is difficult to understand how *Olenellus* can be at the base of the Cambrian succession and yet found in company with so many genera and subgenera which are known members of the Middle Cambrian fauna, or that of the Upper *Paradoxides* Beds. *Olenellus* has not yet been found below the *Paradoxides* Beds, and the evidence adduced indicates that it extended *above* rather than below this part of the Cambrian system.

II.—PROBLEMS IN QUEBEC GEOLOGY.[1] By R. W. ELLS, LL.D., F.R.S.C., of the Geographical Survey of Canada.

THIS paper is a brief review of the geological work done in the province of Quebec since the appearance of Dr. Bigsby's first paper on the geology of the province in 1827. It contains a short statement of the conclusions arrived at from time to time by the various workers in this field regarding the structure of the rock formations east of the St. Lawrence, as well as of the Laurentian complex to the north of that river. A summary of the latest views reached from the detailed study of these areas during the last fifteen years, which has appeared in the last volume of the Geological Survey's Report, is also presented.

In regard to the structure of the older crystallines north of the St. Lawrence and Ottawa rivers, it may be said that the opinion once held, that these rocks were originally of sedimentary origin, has now been greatly modified. The Laurentian rocks of Logan are now divided into two great groups. Of these, the lower is essentially a gneiss formation, and may be styled, for the sake of distinction, the Fundamental Gneiss. This is clearly older in point of time than the series of crystalline limestones, quartzose grey gneisses, and quartzite with which they are often so intimately associated as to render the determination of their true relations in the field difficult, but which at other points are clearly situated above the lower gneiss formation.

These newer gneisses and limestones, which have been styled by Logan the "Grenville Series," are, without doubt, for the most part of sedimentary origin, though they are invaded in all directions by masses of granite, greenstone, and other forms of igneous rock. As for the Fundamental Gneiss, also once supposed to be largely of

[1] Abstract of paper read in Section C (Geology), British Association, Toronto, 1897.

sedimentary origin, it has been very conclusively demonstrated, chiefly through the agency of the microscope, that this is for the most part at least an altered igneous rock, and that the supposed bedding planes owe their existence to other causes than those of sedimentation.

The original Upper Laurentian division, which included the great area of the Anorthosite rocks, also supposed at one time to represent altered sedimentary deposits, has been removed from the position it once occupied, since it has been proved, both by the evidence in the field and in the laboratory, to be of igneous origin and subsequent to the deposition of the limestone and quartzite series with which it is associated, so that the Grenville Series, according to the earlier view as to the succession of strata, may now be taken to represent the upper portion of the Laurentian system.

It may also be assumed to represent the lowest division of the clastic or sedimentary rocks in Canada. The relations of these to the rocks which have been styled the " Hastings Series " in Ontario are such that they may, in part at least, be regarded as portions of the same series which have been described in different portions of the field under different names ; but whether these be regarded as belonging to the Laurentian or Huronian systems, is of small moment so long as their true relationship to each other and to the underlying Fundamental Gneiss is clearly understood.

To the east of the St. Lawrence the old dispute as to the age of the fossiliferous rocks near the city of Quebec, as well as of their relations to the crystalline schists of the mountain area in the interior of the province, may now be considered as satisfactorily settled. The former hypothesis by which the crystalline schists were regarded as the equivalents, in point of time, of the fossiliferous sediments of the St. Lawrence Valley has been clearly shown to be unfounded, and the schists of the Sutton Mountain area are now assigned to the Huronian system, or are at least beneath the lowest Cambrian of the district. The relative position of the several divisions of the fossiliferous Quebec group has also been ascertained, and it is now established that the Sillery division is situated stratigraphically beneath the Lévis, instead of being, as was at one time supposed, above it. As regards the age of the several divisions of the Quebec group (fossiliferous), it may be said that the Lévis is the apparent equivalent of the Calciferous formation, and that in its upper portion it approaches the Chazy ; while the upper portion of the Sillery is the apparent equivalent of the Potsdam Sandstone formation. Between the upper Sillery and the great mass of the rocks which have been referred to this division, there is a fault of considerable magnitude, so that the lower portion of the Sillery presumably includes rocks which have been elsewhere classed as Cambrian, and these may extend as low as the *Paradoxides* zone or division of that system.

The areas of black slate and limestone, which, in the General Report for 1863, were regarded as beneath the crystalline schists and referable to the Potsdam formation, have been determined, on

the evidence of the contained fossils, to be much newer, and to be in fact the equivalents of the lower portion of the Trenton formation; and to this horizon may also now be assigned the greater portion of the strata in the city of Quebec. Here, however, there are a number of anticlinal folds, and the presence of certain fossils, similar to those obtained from the Lévis beds, indicates that along some of these folds beds of that horizon may be found. The same age may be assigned to the great extension of the black slates and limestones which occur at intervals along the south shore of the St. Lawrence, nearly to the extremity of the Gaspé Peninsula, and which appear to dip beneath the strata of the Sillery formation at many points.

In regard to the use of the term Potsdam a distinction must now be made between the Potsdam formation and the Potsdam Sandstone. The latter has been clearly proved in Canada to be the lower portion of the Calciferous formation, and is not separable from it, while there is a manifest break between this and the lower beds, or the Cambrian proper. The term Potsdam formation in Canadian geology was a comprehensive one like the term Cambrian, and like it included all between the Calciferous formation and the Huronian. The discriminate use of the terms has led to much confusion, and as the divisions of the Cambrian have now been properly determined the expression Potsdam formation has practically no meaning in Canadian geology.

REVIEWS.

MEMOIRS OF THE GEOLOGICAL SURVEY, SCOTLAND: THE GEOLOGY OF COWAL, including the part of Argyllshire between the Clyde and Loch Fine. By W. GUNN, F.G.S., C. T. CLOUGH, M.A., F.G.S., and J. B. HILL, R.N.; with Petrological Notes by J. J. H. TEALL, M.A., F.R.S., Sec. G.S., and Dr. HATCH, Ph.D., F.G.S. 8vo; pp. 333, with index, numerous illustrations in the text, and 10 plates. (Edinburgh: Neill & Co. Price 6s.)

THE Director-General of the Geological Survey observes, in his Preface to this Memoir, that the district known as Cowal "embraces the south-western extension of the various bands of metamorphic rocks which form the southern edge of the Highlands. Bounded on three sides by coast-lines, and penetrated by a number of sea-lochs, it affords better and more continuous sections of these rocks than are generally to be met with in the interior of the country. . . . . From the detailed study of this part of the Highlands much information has been obtained by the Geological Survey regarding the structures of the schists and the successive movements by which these structures have been produced. Originally most of the rocks described in the following chapters formed a thick series of sedimentary deposits, the geological age of which still remains to be determined. These strata have been found to have undergone a remarkable series of repeated movements. After being thrown into folds and having been cleaved so as to acquire a first

system of deformation, they have again suffered a repetition of the process more than once. They consequently represent secondary and tertiary, perhaps even quaternary, structures, probably due to mechanical movements with accompanying recrystallization. The regional metamorphism thus produced is not uniformly distributed, but seems to increase in intensity both from the south-east and north-west towards a nearly central line, ranging about north-east and south-west, which is an anticline of the foliation. It has not been traced to any intrusion of igneous rock, and is so general and diffused that it can hardly be regarded as in any sense a contact phenomenon. Where intrusive masses occur in the district they have given rise to their own accompanying alteration, quite apart from the general metamorphism of the whole area. These interesting and complicated structures, so well displayed in Cowal, are fully discussed in the present Memoir."

The Director-General further observes that "Mr. Clough, having mapped by far the largest part of the whole district, has had general charge of the Memoir, which is mainly written by him."

The extreme length of the district in question, from Ardlamont Point on the south-west to the granite edge in a north-easterly direction, is about 44 miles; with a breadth of about 18 miles from Toward Point on the Firth of Clyde to Otter Beacon on Loch Fine. The country is mountainous, though the elevations nowhere quite attain 3,000 feet, and may be said to decrease rather uniformly towards the south-west. By far the larger portion of the area is occupied by metamorphic rocks. Subjoined is a list of these, not to be regarded as representing a stratigraphical sequence.

SCHISTS PROBABLY OF SEDIMENTARY ORIGIN :—

Phyllites, including the two series of Dunoon and Ardrishaig, which consist of phyllites and thin limestones, mixed in the first series with schistose grits and in the second with quartzite schists.

Schistose grits and greywackes.

Quartzite schist or quartz schist.

Albite schist.

Garnetiferous mica schist.

Graphite schist.

Schistose limestones on various horizons, including the Loch Tay limestone.

Mica schist. Areas coloured thus in the maps may also include unseparated albite schists, sheared grits and greywackes, and phyllites.

Green beds: chlorite-epidote schists. The group lines may include some mica schists and schistose greywackes.

IGNEOUS ROCKS :—

Epidiorites, hornblende and chlorite schists, serpentine.

Besides the above a number of unfoliated igneous rocks occur intrusive in the schists.

The age of the schists, even in relation to each other, is not certainly known, but the different bands are seen to traverse the region in a north-east and south-west direction. The intimate structure of the rocks is described with much detail. Amongst the physical features of the more quartzose beds may be noted the occurrence of pebbles, mainly of quartz, felspar, or clay-slate. These pebbles have been subjected to a stretching action, which is supposed to have

taken place at the time of the production of the streakiness seen on the foliation planes of the adjoining phyllites, and probably both were accompaniments of the production of foliation. The elongation seems comparable to the distortion of fossils on the cleavage planes of slate.

The behaviour of the several groups towards the great central anticline of foliation presents some very interesting features. " In 'the anticline' folds (says Mr. Clough) with axes hading north-west, it is the under limbs of anticlines that have a tendency to be most thinned, whether we are on the south-east or north-west side of the centre of the anticline. Hence, if we regard the early ' pre-anticline' folds as having originally had axes hading north-west, the same law of the greater thinning of under limbs of anticlines prevails in both ; and we may conclude that the source of the pressure which produced them both lay to the north-west of the area being described, and that the pressure was outwards from the Highlands in a south-east direction. The evidence in the north-west of Scotland is now well known to show that there were there, partly at all events in Post-Cambrian times, mountain-making forces pressing outwards from the Highlands in a W.N.W. direction. Hence the central Highlands represent an area from which earth-moving forces have pressed outwards, on the one side in a west-north-westerly and on the other side in a south-easterly direction."

The bulk of the schists are regarded as probably of sedimentary origin. Chapters iii and iv are devoted to a detailed description of them. The albite schists present some curious features. They occur mainly towards the anticline centre, and at Lochgoilhead all the more micaceous schists contain albites. The albite spots are almost confined to the micaceous and chloritic beds, and it is doubtful whether they occur at all in the more quartzose pebbly beds. It is inferred from their never showing any appearance of stretching that the albites are of later age than the mass of the movements affecting the rocks in which they occur.

The " Green Beds " present another curious group of rocks. These are of a mixed and variable character ; for on the north-west side of the anticline about one-half of the group consists of other schists, whilst on the south-east side the different outcrops are comparatively unmixed. They are described for the most part as epidote-chlorite schists, and are often intersected by thin quartzose veins coloured green by epidote [? the " epidosite " of Sterry Hunt].

Of the schistose igneous rocks, the epidiorites, hornblende schists, and related chlorite schists, associated with the presumed sedimentary series, are most abundant towards the side of Loch Fine. They are generally harder than the schists, and thus help in working out the physical structure. It is believed that they represent old intrusions rather than lava-flows. There is a special danger of confusing some of these old igneous rocks with the " green beds." In the area between Stralachlan and Loch Fine, these epidiorites, etc., form huge irregular masses behaving on a large scale like sills with irregular protrusions, the longer axes of which coincide with the strike of the main mass, and of the quartzites in which they are

intruded. Mr. Teall gives the following description of their ap-
pearance under the microscope : "Uralitic hornblende, a saussuritic
aggregate of water-clear felspar and granular epidote, irregular
patches of sphene (leucoxene) and aggregates of chlorite."

In chapter vii the minerals of the schists are enumerated and
partly described, whilst much attention is paid to the direction of
stretching.   Chapter viii is devoted to the general physical structure
of the schists, together with remarks on metamorphism.   The most
conspicuous feature of the schist area, as may be inferred from
previous remarks, is the great anticline of foliation running in
a direction about 35° W. of S. through the heads of Loch Goil, Loch
Striven, and Loch Riddon, and the hills about a mile north-west of
Tighnabruaich.   There is no doubt that this anticline is a true arch
of an early foliation ; but scarcely perhaps an anticline of bedding.
The authors (and more especially Mr. Clough) apparently conclude,
after much weighing of the evidence, that at least five of the groups
on the north-west side of the anticline are unrepresented on the south-
east side, notwithstanding some apparent points of resemblance.

Lines of actual rupture contemporaneous with the schist-making,
comparable to the "thrusts" of the north-west of Scotland, probably
do not occur anywhere in Cowal, except on the smallest scale, such
as strain-slips with throws not exceeding a few inches.   The
numerous faults which have been mapped and which have effective
throws, are all later than the schist-making, and break up the
minerals and planes of schistosity instead of helping to form them.
To the question regarding the agents which produced the general
metamorphism of the district, Mr. Clough considers that it would
be premature to reply ; but he does not consider that there is any
exposure of igneous rock which would account for it.   The alteration
effected by the Glen Fine granite, for instance, does not extend for
more than a mile, and is of quite a different character.

The direction of the boundary fault between the Schists and the
Old Red Sandstone is nearly parallel to that of the centre of the
anticline.   This fault cuts off a shred of Upper Old Red Sandstone
rocks, which thus appear at the extremity of the peninsula that
terminates in Toward Point.   They consist, in the main, of red
breccias and sandstones mixed with occasional blood-red and
variegated shales ; calcareous sandstones and magnesian limestones
are numerous on a certain horizon.   One of the sections which best
illustrates the relations between the red marls and the metamorphic
schists occurs on the shore just to the south of Inellan pier.

Chapters x to xiv are devoted to the igneous rocks (unfoliated).
A small part of the igneous complex of Garabhal Hill, etc., comes
within the district.   These are, in fact, granitites with a tendency
to pass into a coarse dioritic rock ; the granitic rocks are generally
characterized by abundant porphyritic crystals of orthoclase felspar.
Considerable attention is paid to the character of the metamorphism
near the edge of the plutonic rock, chiefly with a view to contrast
the metamorphism special to its neighbourhood with that further
away near the anticline of Cowal.

Hornblende-porphyrites and felsites are classed together, since the same porphyritic constituents, viz., felspar, black mica or chlorite, sometimes hornblende, and scattered quartz blebs, occur in both. These rocks behave in the field in the same way as the lamprophyres (presently to be mentioned), generally forming sheets which run roughly with the foliation of the schists ; they are of limited extent. An intrusive boss of some importance is also described as hyperite, the rock consisting of hypersthene, augite (diallagic in part), plagioclase (more or less lath-shaped), iron-ores, and interstitial quartz.

Of the older igneous rocks are those described under the terms lamprophyre and mica - trap. It is only when the mica is macroscopically prominent that the latter term seems applicable. By a gradual decrease in the amount of mica the mica-dolerites may pass into rocks of more normal doleritic aspect. In all these early dolerites which have been examined the augite differs from that of the Tertiary basalts in belonging to the pale form, malacolite, and for the most part occurring porphyritically. In the north and east of Cowal these lamprophyres are exceedingly numerous, but they are not known within a distance of four or five miles of the Upper Old Red Sandstone boundary. They rarely form vertical dykes ; when they do so, these dykes usually run in a different direction to that of the basalts. Most frequently they occur as sheets with varying and not very steep hades to the horizon. They do not keep to the bedding or foliation of the schists, but may be constantly seen cutting across their crumplings. It is evident that all the movements in connection with the foliation of the schist had ceased before their intrusion. Though thin and inconstant, the lamprophyres are of considerable interest in working out the geological structure of the district, and a greater help than the basalts. This is because the majority of the faults are of later date than the lamprophyres, and throw them, so that they help to indicate the different faults and even the amount of their respective throws, independently of the schists.

An inspection of the geological map will show that parts of Cowal are seamed by basaltic dykes : this subject is very fully treated in the Memoir. Basalts, dolerites, and tachylites constitute the group, with which even augite-andesites are included. Thin margins or selvages of distinctly glassy rock, tachylite, are common, but not to be found without close search. One of the most curious features of basaltic dykes, especially noticeable on the coast, is the tendency for some to weather in relief, whilst others form recesses sometimes hollowed out into caves. The authors consider that the size of the grain is often a determining factor in these cases. The intimate structure of the basaltic rocks is treated of at considerable length.

With respect to the relative age of the dykes, the broad east-and-west dykes are regarded as older than the basalts having a north-west direction. " If we suppose the early east-and-west dykes to be of Carboniferous age, the interval of time between them and the north-west dykes must be immense ; for there can be no doubt that many of the latter belong to the same set as those which, still with a north-west direction, are seen in the island of Mull to intersect

the bedded basalts of Tertiary age." The very conspicuous east-and-west dykes at Ardlamont Point are not crossed by any running north and south ; but, since these are regarded as continuations of the two large dykes crossing the island of Bute, where one of them is clearly cut by later Tertiary dykes, we may infer that the Ardlamont dykes are of earlier date than the Tertiary period. Similar conclusions result from the detailed examination of other districts. Within this area only five intrusions have been recognized as trachyte : these are all dykes, which are considered to be later than the basalts.

Three chapters are devoted to the general geological structure of particular districts, and the numerous sections given in the text are of great service to the readers in this connection. The structure of the country about Lochgoilhead, for instance, is particularly interesting on account of its proximity to the anticline. Moreover, since the much frequented coach-road through Hell's Glen traverses this region, it enjoys the advantage of being easily accessible.

Two chapters, illustrated by a special map (Clough), are devoted to Glacial deposits. The following features are indicated in the map :— (1) Landslips ; (2) marine and fresh-water alluvia and peat in basin-shaped hollows ; (3) boulder-clay and sandy drift without definite moraine shapes ; (4) drift with well-defined moraines. The direction of the striæ ranges from S.W. through S. to S.E., with few exceptions.

The remaining chapters deal with such subjects as marine and fresh-water alluvia, peat, landslips, blown sand, prehistoric remains, geological aspects of the scenery, and economic resources.

In the appendix Mr. Teall makes some general remarks on the petrography of the district. After insisting on the well-known fact that, in a complex series of stratified deposits, the coarser-grained sediments retain traces of their original character long after all such traces have disappeared from the finer-grained deposits, he proceeds to illustrate the point with reference to the gneissose grits (the schistose grits and greywackes of the Memoir) so largely developed in the Southern Highlands. Although distinctly gneissose in structure and composition, they differ markedly from igneous gneisses in their relation to the other rocks with which they are associated, and frequently contain relics of original grains of quartz, often bluish in colour, and felspar. The rocks of this class are crystalline schists essentially composed of quartz, felspar, and one or two micas : they are therefore gneisses in the usual sense of the term. Where conspicuous traces of their clastic origin remain they may be termed gneissose grits ; when all, or nearly all, such traces have disappeared they may be termed granulitic gneisses : they pass by insensible gradations into felspathic mica schists.

Plates i to v are reproductions of photographs of Natural Rock Exposures, taken by Mr. R. Lunn. The Geological Survey of Scotland is to be congratulated on these most effective pictures of contortion, which are at once instructive and picturesque. The other plates are likewise very good of their kind, and the volume generally may be deemed a most satisfactory contribution to geological literature.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—December 15, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read :—

1. "On the Pyromerides of Boulay Bay, Jersey." By John Parkinson, Esq., F.G.S.

After briefly noticing the literature of the subject, the author describes the altered rhyolites of Boulay Bay. One variety, the commonest, is of a dark-red colour, showing flow-structure ; another is porphyritic ; a third, near the centre of the Bay, has a pale-greenish matrix enclosing fragments, which, however, are due to flow-brecciation. Large pyromerides occur in two localities ; in the more interesting, that north of the jetty, the structure of the rock indicates either a very peculiar magmatic differentiation *in sitû* or (more probably) the mixture of two magmas differing in their stage of consolidation.

From study of a series of specimens of the pyromeridal rock, the author arrives at the following conclusions :—(1) The rock shows marked flow-structure and at times bands which indicate a slight difference in its composition, the latter tending to assume a monili-form outline. In such the microscopic structure corresponds with that of the pyromerides, and exhibits traces of radial crystallization. (2) These afford a passage into somewhat oval pyromerides, with rather tapering ends and irregularly mammillated surfaces. (3) From these sometimes a single one seems to be thrown off, while lines of pyromerides or little lumps of similar material are scattered about the matrix. (4) Many of the pyromerides are solid throughout ; others have a central cavity filled with quartz.

The author describes varieties of the pyromerides. They are generally deep-red in colour, and exhibit (*a*) fluxion-structure, made more distinct by minute black microliths; (*b*) a radial structure ; (*c*) a "patchy" devitrified structure (with crossed nicols) ;—the second (*b*) being not always present. The matrix is usually of a greenish tint, showing devitrification-structure and sometimes a trace of perlitic structure.

The pyromerides frequently exhibit more or less crescentic cracks, due apparently to contraction, which have been filled by quartz. Sometimes also they scale off in rudely crescentic shells. In one locality a variety with good spherulites, about as large as a pea, passes into one showing a fluxion-structure and pyromerides, having traces of radial structure as well as clots and irregular "wisps," suggestive of a stiffer material broken up by one more liquid.

As the result of his studies, the author thinks that while very regular spherulites do occur, apparently in consequence of radial crystallization round a centre, the pyromerides are due to the mixture of two magmas slightly different in composition and fluidity, the less plastic of the two being sometimes drawn out into streaks, but at others forming lumps, in which, where their form is suitable, a radial

structure is subsequently developed. He concludes by comparing the pyromerides of Boulay Bay with specimens from other localities described by MM. Delesse and Lévy, Professor Iddings, and Miss Raisin, or collected by himself, and by discussing the quartz-filled cavities which occur in certain cases. These he regards as originally vesicles, and not due to any subsequent decomposition.

2. "On the Exploration of Ty Newydd Cave near Tremeirchion, North Wales." By the Rev. G. C. H. Pollen, S.J., F.G.S.

In November, 1896, a Committee was formed, consisting of Dr. H. Hicks, Dr. H. Woodward, and the author, for the purpose of exploring this cavern, which is situated in the same ravine on the east side of the Vale of Clwyd as the well-known caverns of Ffynnon Beuno and Cae Gwyn, explored about twelve years ago by Dr. H. Hicks and Mr. E. B. Luxmoore. Grants have been made by the Royal Society and by the Government Grant Committee for the purpose of carrying on the explorations ; and though a considerable time must elapse before the work is completed, the results already obtained are of so much importance that the author has thought it advisable to bring them before the Society. In the work of exploration he has throughout been ably assisted by the theological students of St. Beuno's College. The cavern had been in part broken into by quarrying operations, but the chambers and tunnels were completely filled up with more or less stratified deposits, and had remained entirely untouched.

Although the ground above the cavern is strewn over with drift and erratics from the North and from the central areas of Wales, not a fragment of anything but immediately local material has been discovered in the cavern itself, showing clearly that the deposits in the cavern had been carried in by water before the Northern and Western ice had reached this area. The work has been carried on almost continuously throughout the year, and most of the material has been removed for a distance of over 60 feet from the entrance. The height of the cavern above sea-level is 420 feet, or about 20 feet above the floor of the Cae Gwyn Cave.

The following points appear to the author to be now fully established :—

(1) The material in the Ty Newydd Cave, as in the lower parts of those of Ffynnon Beuno and Cae Gwyn, is of purely local origin. Of this he can speak with confidence, as the question was before him from the beginning, and the gravels were examined with minute care for erratics.

(2) This local deposit is of earlier date than the Boulder-clay with Western and Northern Drift. This was proved by the finding of granite- and felsite-boulders abundantly at higher levels and over the cave, and in one case filling the upper part of one of the fissures communicating from above with the cavern.

(3) The occurrence of the tooth of a large mammal (*Rhinoceros*) in the lower part of the cave shows that the animal was contemporary with, or of earlier date than, the infilling of the cavern by the local drift.

II.—January 5, 1898.—Dr. Henry Hicks, F.R.S., President, in the Chair.

Professor Judd drew attention to the outline geological maps of England and Wales on the scale of 30 miles to the inch, for the use of schools and colleges, presented by John Lloyd, Esq. These were reproduced, by permission of the Science and Art Department, from the maps in use at the Royal College of Science, South Kensington.

The following communications were read :—

1. " On the Structure of the Davos Valley." By A. Vaughan Jennings, Esq., F.L.S., F.G.S.

Evidence is brought forward to show that the level area, about four miles in length, near Davos is occupied by superficial deposits, and that the lateral talus-fans there have been cut through at a relatively recent date since their accumulation ; that the northern end towards Wolfgang is blocked by moraine-material of great thickness, but for which the Davoser See would drain north to the Landquart, carrying with it the waters of the Fluela and Dischma ; that the contour-lines suggest the former existence of a far larger lake stretching south towards Frauenkirch, and that in that part there is proof of the previous existence of a great detrital fan sufficient to account for the existence of the lake in question.

It is shown that the former ice-movement was not from the present watershed between the tributaries of the Landwasser and Landquart, but from a spot farther south.

The author concludes that the main valley-systems were marked out in Pre-Glacial times, and that at one time there was a watershed somewhere between Davos Platz and Frauenkirch. During the Glacial Period moraine-material was heaped up across the valley below the Hörnli, and held up the waters to the south, forming a great lake of which the present Davoser See is a relic, the outflow being probably over a low saddle near the present Wolfgang ; during this time a great moraine and detrital fan existed across the valley to the south, and the lake for a long time was thus prevented from draining in that direction. After the Glacial Period the northern moraine was subjected to little erosion, but the southern one, formed from the first of looser material, was rapidly cut back by the Sertig Bach, and in time the barrier was so weakened as to cause that end of the lake to be tapped, and at that time the terraces opposite Frauenkirch may have been levelled, while the flow over Wolfgang would be stopped, and the Fluela and Dischma streams turned southward ; the Landquart would then cut away the margins of the talus-fans which had been accumulating in the lake.

2. " Sections along the Lancashire, Derbyshire, and East Coast Railway between Lincoln and Chesterfield." By C. Fox-Strangways, Esq., F.G.S. (Communicated by permission of the Director-General of H.M. Geological Survey.)

The portion of the line considered in this paper occupies a distance of about forty miles, and runs nearly at right angles to the strike of all the beds from the Lias to the Coal-measures.

The lower part of the Lias and the Rhætic beds are entirely concealed; but grey marls overlying red marls occur about half a mile east of Clifton Station, and at the station the Red Marl of the Keuper comes on in force. The alluvial deposits of the Trent, pierced to a depth of from 25 to 30 feet, consist principally of loam overlying varying thicknesses of sand and gravel. Horns of red deer were found at a depth of 25 feet. At Dukeries Station white flaggy Keuper sandstones appear from beneath the Red Marl, and probably represent the eastward extension of the Tuxford Stone. A deep well here has been bored to a depth of 644 feet from the present surface, and details of the section are given in the paper. South of Kirton there is a deep cutting in the Waterstones, and after leaving the escarpment the line enters on the great dip-slope of the Bunter Pebble Beds, which are shown at Ollerton and at intervals for four miles beyond this. There are no sections in the Lower Red and Mottled Sandstones; and west of Warsop the line crosses the dip-slope of the Magnesian Limestone. Details of the sections in this rock are given.

Between Scarcliff and Bolsover the line crosses the Permian escarpment in a tunnel, the whole of which is in the Coal-measures; these are high up in the series, and contain no coal-seams of value. They are not stained red.

West of Arkwright's Town Station is a very complete section of beds representing the Middle Coal and Ironstone series (the most valuable part of the Derbyshire Coalfield), of which full details are given, most of the important coal-seams being readily recognized; and the author describes some remarkable features in the relationships of some of the sandstones to the other deposits.

The absence of Glacial beds is of much interest; not a trace of genuine Boulder-clay has been seen along the whole line.

OBITUARY.

GEORGE HARRY PIPER, F.G.S.

BORN APRIL 8, 1819.   DIED AUGUST 26, 1897.

THE subject of this brief notice, the second son of the late Captain E. J. Piper, R.N., was born in London in 1819, in the neighbourhood of Regent's Park, where his family resided. His parents removed to Herefordshire in 1829, taking their son George, then a boy of ten years old, with them. Naturally an observant youth, country life and pursuits, after London, had a great attraction for him, and he speedily became interested in studying the birds, trees, and flowers, and early learned to fish and shoot. When only fourteen, however, his health gave way, and he had to remain in bed for about three years, suffering from a lame leg, and was never entirely free from pain during the remainder of his life. As a consequence of this, his education was carried on at home, in a more or less desultory manner. Nevertheless, he was a keen

scholar, and at about eighteen years of age he was duly articled to the late Mr. Thomas Jones, Attorney of Ledbury; and having served his master and duly passed his examinations in law, he was admitted as a Solicitor in 1849, and from that time commenced to practise in Ledbury, where he continued in his profession until his death. He was joined in partnership by Mr. C. E. Lilley in 1886, and was one of the oldest solicitors in the county. In addition to his private practice he also held appointments as Commissioner to Administer Oaths, Perpetual Commissioner, etc., Deputy-Registrar, and in 1865 Registrar, of the County Court and High Bailiff of the Court, which offices he held up to the time of his death.

Mr. Piper took a keen interest in the progress and work of the Horticultural and Natural History Societies of the County of Hereford, and had filled the position of President both of the Woolhope Naturalists' Field Club and the Malvern Naturalists' Field Club. To these Societies he communicated many papers, and with them he did much excellent work in botany, local archaeology, and geology, more especially in the latter field of research.

Mr. Piper's geological work was carried on for years in association with the late Rev. W. S. Symonds, M.A., F.G.S., of Pendock Rectory, Tewkesbury; Dr. Bull of Hereford; the Rev. P. B. Brodie, M.A., F.G.S., and other enthusiastic workers.

The greatest geological achievement performed by Mr. Piper was the carrying out successfully, after many years of patient explora- tion, the complete examination and recording, foot by foot, of the famous section near the railway tunnel at Ledbury, comprising the series of deposits from the Aymestry Limestone, through the Upper Ludlow rocks; the Downton Sandstone, with *Pterygotus*; the Ledbury shales, consisting of red, grey, purple shales, and grey marl-beds, with *Pteraspis, Auchenaspis, Cephalaspis, Onchus, Pterygotus, Lingula cornea*, etc.; followed by Lower Old Red Sandstone, with *Pterygotus, Pteraspis*, and *Cephalaspis*, etc.

In Mr. Symonds' paper "On the Old Red of Herefordshire" he writes of the Passage-Beds at Ledbury: "Having again visited Ludlow, and compared the Passage-beds of that district with those of Ledbury, I am convinced that nowhere perhaps in the world is there such an exhibition of Passage-beds presented to the eye of the geologist as at the Ledbury Tunnel on the Worcester and Hereford Railway." See H. Woodward's "Brit. Foss. Crustacea" *(Merostomata)*: Pal. Soc., part iii, 1871, p. 99.

The rich collection of fossils which Mr. Piper formed from the Ledbury Tunnel Section, and from other localities in the neighbour- hood, will, it is believed, shortly find a home in the British Museum (Natural History), Cromwell Road, where so many of his fine Cephalaspidian fishes have already been presented in past years, including the superb group of twelve individuals of *Cephalaspis Murchisoni*, preserved in one block of Old Red Sandstone—forming Plate x in Mr. Arthur Smith Woodward's Catalogue of Fossil Fishes in the British Museum (Natural History), Part ii, 1891, p. 189—

from the Passage-beds, Ledbury, presented by Mr. George H. Piper
in 1889.

Mr. Piper was elected a Fellow of the Geological Society of
London in 1874, but his numerous scientific papers will mostly
be found in the Transactions of the Woolhope Club.

He was for many years local Hon. Secretary of the Royal Agri-
cultural Benevolent Institution, and took a deep interest in all matters
relating to agriculture, and especially the cultivation of fruit and
of roses.

He largely assisted in the publication of " The Herefordshire
Pomona," and was with the late Dr. Bull selected to visit Normandy
to inquire into the subject of fruit-culture there and to exhibit
Herefordshire fruit. These gentlemen returned with several prizes
awarded at the Rouen Exhibition for fruit grown in their own
county.

It would be impossible here to convey a just idea of the large and
varied fields of scientific activity and social benevolence to which
Mr. George Piper devoted his long and useful life; but the testimony
of respect shown for him by his fellow-townsmen of *all classes* at
his funeral might be cited as good evidence that he had not lived
in vain. He was not only highly accomplished in many literary
and scientific fields of inquiry, but " he was known to all as a genial,
upright, and courteous gentleman, whose life was not spent for
himself alone, but most largely for the good of others. In him the
inhabitants of Ledbury and its neighbourhood have lost an able
lawyer and a much respected friend." (From Mr. F. Russell's speech
in Ledbury County Court.)

MISCELLANEOUS.

A BIBLIOGRAPHY OF NORFOLK GLACIOLOGY, INCLUDING THE CROMER
CLIFFS, WITH THE FOREST-BED SERIES. By W. JEROME HARRISON,
F.G S. (Reprinted from the *Glacialists' Magazine* for March, June,
and September, 1897.)—This work of 91 pages contains all the titles
and brief abstracts of most of the papers dealing with the Cromer
Forest-bed and the Glacial Drifts of Norfolk, published between
1745 and 1897. To workers on East-Anglian geology this will
henceforth be an indispensable work of reference, and all will feel
greatly indebted to Mr. Harrison for the labour and care bestowed
on the work. Two years ago he prepared a similar work on Midland
Glaciology.

A BIBLIOGRAPHY relating to the Geology, Palæontology, and
Mineral Resources of California, has been compiled by Captain
Anthony W. Vogdes (California State Mining Bureau, Bulletin
No. 10). This is arranged, not chronologically, but according to
the several sources of publication ; there are some explanatory notes
and there is a good index. The list includes works published up
to 1896.

ORIGINAL ARTICLES.

I.—The Earliest Engraved Geological Maps of England and Wales.

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

IN a previous article,[1] a sketch has been given of what is known concerning the origin and history of the early manuscript maps of William Smith. I have shown that concerning these maps, though they were not *published*, in the technical sense of that term, there exists a satisfactory body of external evidence with regard to the period of their preparation, while they furnish in themselves abundant proofs that they must have been constructed at the dates inscribed upon them. These facts have been so generally recognized that—since the clear statements on the question which have been made by Fitton, Farey, Sedgwick, and Phillips—no one has ever thought of either questioning the antiquity of the maps or denying to William Smith the honour of being the first to construct a true geological map of England and Wales.

But I find that, even with regard to the later maps and sections of William Smith, which were actually engraved and published, there still exists a certain amount of uncertainty. Maps have been publicly ascribed to Smith, with the preparation of which he certainly had nothing to do; while, on the other hand, some of the most important works issued by him have altogether failed to attract the attention which they deserve.

Immediately after the preparation of the Manuscript Map of England and Wales in 1801, the question of its publication, on a larger scale, was seriously taken in hand by Smith and his friends. A prospectus dated Mitford, near Bath, June 1st, 1801, was prepared by William Smith, and extensively circulated by Debrett of Piccadilly (opposite to Burlington House), asking for subscribers to a work that was to be entitled " Accurate Delineations and Descriptions of the Natural Order of the various Strata that are found in different parts of England and Wales, with Practical Observations thereon." The author promised that this work should contain " a correct map of the strata, describing the general course

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[1] Geological Magazine, n.s., Dec. IV, Vol. IV (1897), p. 439.

and width of each stratum on the surface, accompanied by a general section, showing their proportion, dip, and direction ; the map and sections, to make them more striking and just representations of nature, will be all given in the proper colours." Smith's friend Richardson urged that a Latin edition of the book should be issued with the English one, and it is certain that if this had been done, all possibility of contesting Smith's claim to priority would have been destroyed.

Unfortunately, however, the failure of the publisher Debrett, and the limited means and numerous business avocations of William Smith, prevented the realization of these projects. Thanks, however, to the splendid loyalty of Smith's numerous friends—especially Richardson, Townsend, and Farey—there exists such a body of evidence concerning Smith's discoveries and teaching, all published between the years 1801 and 1815, that no impartial judge can for one moment hesitate in assigning to Smith that priority so strenuously claimed for him by Fitton, Farey, Sedgwick, and Phillips.

Nor can it be justly asserted that the treatment of Smith by his contemporaries was other than generous and forbearing. In 1802 prizes of fifty guineas were offered by the Society of Arts for " mineralogical maps of either England, Scotland, or Ireland, on a scale of not less than 15 miles to the inch," and the offer was renewed year by year down to 1814, when the prize for the English Map was claimed by and awarded to William Smith. As Phillips remarked : " At this moment, any map, however crude and incorrect, professing to be a mineralogical map of a part of the British Islands, would have been a source of lasting reputation to its editor ; any account of the principal facts then ascertained near Bath would have been welcomed with admiration. Had Mr. Smith been exposed to this ungenerous rivalry, he must have sunk under the grief and vexation of being anticipated in his map by some inferior compilation, and in his other labours by notices which, in consequence of his wandering habits and laborious profession, it would have been more easy for others than himself to have drawn up. But nothing of this kind happened."

That a knowledge of William Smith's ideas and discoveries had by this time become very widely diffused, not only in this country, but all over Europe, and even in America, there is abundant evidence. Manuscript copies of his original table of strata with their fossils had been widely circulated, and every facility had been given to those interested in the subject to make transcripts of the maps which were so freely exhibited by their author. At agricultural meetings of all kinds Smith was a constant attendant, exhibiting and lending his maps for inspection ; while reports of his explanations of maps and sections not unfrequently found their way into the newspapers. At Trim Street in Bath, in the year 1802, and a little later near Charing Cross, London (Craven Street), a collection of maps and sections, with an illustrative series of fossils, was arranged, and exhibited freely to all who chose to call. This collection of fossils, which

after a fire at Craven Street in 1804 was removed to Buckingham Street, was purchased by the Trustees of the British Museum in 1816. It originally consisted of 2,657 specimens, belonging to 693 species, collected at 263 different British localities; and such portions of it as can be identified have been brought together and arranged according to William Smith's original plan in the British Museum (Natural History) at South Kensington, by the pious care of Dr. Henry Woodward.

It must indeed be confessed that, between the years 1801 and 1815, not only did William Smith seem to act as though he were absolutely careless of his claims to priority as a geological investigator, but it is difficult to conceive how he could have adopted plans more calculated to give rise to controversy as to the validity of those claims.

In 1805 Smith's large and detailed geological map of Somersetshire was completed and publicly exhibited, and a project was started by Sir John Sinclair, the President of the Board of Agriculture, and Mr. Crawshay, a warm friend of Smith, to attach the great geological pioneer to the corps of Engineers then commencing the Ordnance Survey of the country : had this been done, the establishment of the English Geological Survey would have been antedated by no less than thirty years. But this project, as well as attempts made by Sir Joseph Banks and other friends to procure the publication of Smith's map by subscription, were doomed to failure. Smith's wandering life, his unfamiliarity with literary work, and his disinclination to engage in it, no less than the constant attraction of field-research, by which he was continually making additions and corrections in his maps, all conspired to render difficult the publication, in a worthy manner, of the great work which he had produced.

In 1807 Greenough, with the aid of a few mineralogical friends, founded the Geological Society. By that date we are told that the idea of publishing Smith's geological map was so generally recognized as having been abandoned, that, among the undertakings recommended to the infant society as especially worthy of its attention, was that of the compilation of a Geological Map of England and Wales. The idea was warmly espoused by the Society, and the work was entrusted to Greenough, by whom the task was commenced in 1808.

It should always be borne in mind that this work of Greenough, though of great value in itself, was an undertaking of a totally different kind from that of William Smith. Smith was a great original discoverer and creator, and almost every entry on his map was the result of his own personal observation. Greenough, on the other hand, was essentially a clever and an industrious compiler. He received, from the first, valuable assistance from such men as De la Beche, Buddle, Farey, and other geologists ; Aiken contributed a geological sketch of Shropshire, and Fryer one of the Lake District ; while Buckland and Conybeare both made valuable contributions to the work. Most important of all was the circumstance

that the actual engraving of his map was entrusted to a geologist who is second only to William Smith himself in his contributions to English stratigraphical geology. Thomas Webster, in his letters to Sir Henry Englefield, published in 1815, had shown that he had unravelled many of the complexities of the English Tertiary strata, and laid the foundation of a correct classification of the beds which underlie the Chalk in the South-East of England; and it was to Webster that we owe the actual preparation and engraving of the Greenough Map.

Many years afterwards, Greenough published a Geological Map of India—a country which he had never visited—by bringing together all the scattered observations recorded in journals or existing in manuscript in the Archives of the India House.   It would not be correct to speak of Greenough's Map of England and Wales as a mere compilation like his Map of India, for it is evident that in the case of the former map he took much pains in verifying and correcting information upon the ground, as is vouched for by Conybeare and other authorities.   On the other hand, Greenough's claim that his map should be regarded as an independent work, when compared with that of William Smith, is one that no geologist who has studied the question can reasonably allow.   In saying this we do not for one moment impugn the good faith or question the honesty of Greenough.   Owing to the unfortunate procrastination of William Smith in the matter of publication, many of his ideas and discoveries had become public property, even before the commencement of the century, and Greenough may very well have been quite unaware how much of the current information on the succession and distribution of the English strata was directly traceable to the labours of Smith.   In 1865, when the Greenough Map had become the property of the Geological Society, and a third and revised edition was being prepared, a Committee of the Society, which included Godwin-Austen, Murchison, Prestwich, and Phillips, deliberately recommended, as the result of their inquiries, that the map should henceforth bear the imprint " *based on the original map of William Smith* "; and every unprejudiced student of the history of geology will agree that the action of the Council in adopting this suggestion was a wise and just one.   Apart from his industry and perseverance in Cartography, it must be admitted that the claims of Greenough to be regarded as a pioneer in geological research cannot for one moment be compared with those of William Smith. In the same year that his map appeared, Greenough published his work " A Critical Examination of the First Principles of Geology "; and an inspection of this work will satisfy any geologist that even at that date he held the most uncertain views concerning the use and value of fossils, and, indeed, upon all geological principles that were not included in the creed of the straitest sect of the Wernerians.

In 1812 Greenough laid the first draft of his map before the Council of the Geological Society, and in the same year William Smith at last found a publisher for his great work in the enterprising John Cary.

While constructing the small manuscript geological map of England and Wales, William Smith became convinced, as he tells us, that "the intricacies in the marginal edges" (of the strata) " were such that I found to mark point by point, as the facts were ascertained, was the only way in which I could proceed safely. My experience in what I had done upon the Somersetshire Map was sufficient to convince me of this, and that to make a map of the strata on a scale as large as Cary's England (five miles to an inch) with sufficient accuracy, much of it should first be drawn on a larger scale."

The delay in publishing the work certainly resulted in the Map of England and Wales being much fuller in detail than it would have been if issued in 1801. Instead of the eight colours used in the early map, we find no less than twenty colours employed in the engraved map of 1815 ; and three other spaces were introduced into the legend, though left uncoloured. We also find separate indications used for collieries, lead-mines, copper-mines, tin-mines, and salt and alum works, while the distribution of the great areas of granite and other igneous rocks were fairly indicated. One very important feature of the map was the inclusion of a section from Snowdon to the south-east of England, in which the superposition and dip of the strata and the formation of escarpments and intervening vales by the agency of denudation are clearly illustrated.

The chief defects in the famous map of William Smith, which was at last published on August 1st, 1815, were as follows :—The representation of the Tertiaries was very inadequate, no indication of the Crags being given, the Isle of Wight Tertiaries, the Bagshot Beds of Southern England, and the Boulder-clays of East Anglia being all confounded together, and the relations of these to the London Clay being left obscure. The Wealden area was altogether unsatisfactorily treated, the argillaceous strata being coloured as " Oaktree Clay " and the arenaceous as ironsand (Lower Greensand, etc.). Lastly, the Jurassic estuarine strata of North Yorkshire were confounded with the " carstone and ironstone " of the South-East of England. On the other hand, it is interesting to note that Smith had already learned at this early date the existence of strata lying between the Old Red Sandstone and the slaty rocks of Wales and Cumberland. These have a tablet assigned to them in his legend with the description " various alternations of hardstone, limestone, and slate," though the information he possessed was not sufficient to enable him to extend proper colours for them to the map. This is probably the earliest notice of the strata afterwards made so famous by the researches of Murchison and his coadjutors.

The period following the issue of his great geological map was one of much activity to William Smith. In the year which witnessed the publication of the map (1815) he issued " A Geological Table of British Organized Fossils which identify the Courses and Continuity of the Strata " ; and in the following year he prepared the first part of his " Strata identified by Organized Fossils," only four parts of which out of the seven contemplated ever saw the light. In 1817 Smith published an enlarged section from Snowdon to London.

This very important work, which was issued by Cary on July 15, 1817, illustrates in a remarkable manner the clearness of Smith's views regarding both the underground structure of the country and the relations of the forms of the surface produced by denudation to that structure.

In May, 1819, there appeared seven other geological sections by William Smith, illustrating the structure of various parts of England, viz.: (1) From London to Brighton through Lewes; (2) through Dorsetshire and Somersetshire to Taunton; (3) through Hampshire and Wiltshire to Bath; (4) through Norfolk (Yarmouth to Lynn); (5) through Suffolk to Ely; (6) through Essex and Hertfordshire; and (7) between London and Cambridge. In all these sections the relations of the strata with the forms and altitudes of the hills are well illustrated, the only points open to serious criticism being the representation of the relations of the London Clay to the strata above and below it, and the nature and succession of the Wealden beds.

In this same year, 1819, William Smith commenced the publication of his "New Geological Atlas of England and Wales," a work which, like so many of his undertakings, was unfortunately left unfinished. Two parts of this Atlas appeared in the year named: the first, containing Norfolk, Kent, Wilts, and Sussex, being dated January 1st; and the second, containing Gloucester, Berks, Surrey, and Suffolk, bearing the date of September 1st. In fulness of detail these county maps are far superior to the corresponding portions of the map of 1815, and they exhibit in not a few cases evidences of great advances in Smith's knowledge.

It was on November 1st of the same year that Greenough's Geological Map of England and Wales made its appearance. A glance at this map will show that in many respects it exhibits considerable advances in geological cartography as compared with Smith's map of 1815, or even with the later county maps. But it must be remembered, as already pointed out, that the work was really based on that of Smith, that for the Tertiary formations and the strata below the Chalk Greenough had the invaluable collaboration of Thomas Webster (who engraved the map), and that for all the other parts of the country many of the Fellows of the Geological Society supplied numerous very valuable contributions.

On February 1st, 1820, there appeared the third part of Smith's Atlas, containing the Maps of Oxford, Bucks, Bedford, and Essex; and in the same year Cary, who published all Smith's maps, issued a "New Geological Map of England and Wales, reduced from Smith's Large Map, for those commencing the Study of Geology." This map does not differ in any essential feature from the map of 1815, from which it was reduced. The scale of the map is nearly the same as that of a reduction of the Greenough Map, published in 1826 by J. Gardner; and this latter map has been frequently though erroneously ascribed to William Smith.

In the following year (1821) appeared the fourth part of the

Atlas. It is a very important work, namely, the Geology of the County of York, in four sheets. This is one of the finest of Smith's works. It is full of admirably worked out details. In the West Riding, the outcrops of the chief of the grit-beds are represented on the map with their relations to the coal-seams, and a fine vertical section of them is given; and in the north-east of the county, Smith clearly defines the estuarine strata of the Lower Oolites as follows: "Sand Rock and Grit Freestone of the Moors, lying over the Alum Shale" (Upper Lias), "and, in Scarborough Castle Hill, under the Oolite or Calcareous Freestone. A thin coal in the cliffs is worked on the Moors at Danby and other places." In this work we see the fruits of Smith's residence at Scarborough, which commenced in the year 1820.

The maps of Part V of the Atlas (Leicester, Nottingham, Huntingdon, and Rutland) were printed in 1821, but the part, according to Phillips, did not make its appearance till 1822. Two years later Part VI, with the Maps of Northumberland, Cumberland, Durham, and Westmoreland, was issued, and this was the end of this very important undertaking, though Phillips informs us that "other parts to complete this work were left in a state of forwardness." With the exception of a little "Synopsis of Geological Phenomena," a single folio sheet printed at Oxford in 1832 at the Meeting of the British Association, the Geological Atlas of England and Wales was the last of William Smith's published works. It is perhaps not generally known that the plates of Smith's Atlas seem to have been acquired from Cary by the well-known map-publishers Messrs. Crutchley, and the sixpenny County Maps for many years issued by that firm contain the lines and legends of William Smith's maps.

In attempting to solve various questions that have arisen in connection with the history of these early geological maps of the British Islands, I have received much valuable assistance from Mr. F. W. Rudler, F.G.S., the Curator and Librarian of the Jermyn Street Museum. And to the same gentleman the Department of Science and Art is indebted for the gift of a number of maps which have proved to be of great value in making more complete the series exhibited in the Science Museum.

II.—On the Flame-Reaction of Potassium in Silicates.

By Grenville A. J. Cole, M.R.I.A., F.G.S.,
Professor of Geology in the Royal College of Science for Ireland.

WHEN recently examining a series of igneous rocks for the Geological Survey of the United Kingdom, I required a ready method for the determination of potassium in the felspars, whether they occurred as porphyritic crystals or as microlites in the ground-mass. The ordinary flame-reaction has always been recognized as unsatisfactory in the presence of sodium, and the use of blue glass has been long recommended, of a sufficient thickness to cut off a sodium flame, the potassium flame then coming through alone.

The blue glass usually supplied with blowpipe-cabinets is far too thin, and any strong sodium flame will appear through it as a violet one. On using blue glass 5 mm. thick, all but the strongest light of an intense sodium flame is cut off, and the column or band of flame that does reach the eye appears blue and not violet. On securing, after experiment, a blue glass, or combination of glasses, which gives only this effect, potassium may be safely looked for, and will readily be recognized, even alongside the blue flame due to the presence of an unusual proportion of sodium.

Lithium, it may be observed, is cut off by a much less thickness of blue glass, and can generally, as in lepidolite and spodumene, be recognized by the eye alone, when the assay is held in the very outermost sheath of the Bunsen flame, or barely touching the flame at all.

The difficulty, however, in the case of potassium is that the flame is often so feeble that some doubt exists as to its occurrence when viewed through 5 mm. of blue glass. Hence intensification has been sought, in the case of silicates, by mixing the assay with powdered gypsum, a method recommended by Bunsen. On thorough heating, even 3 or 4 per cent. of potash reveals itself in this manner; and Professor Szabó[1] was confident that he could detect even 1 per cent.

The great value of Szabó's results to geologists is their quantitative character; but his determinations of potassium involve the dipping of the assay into powdered gypsum, instead of its complete powdering together with the gypsum. The latter method I have found to be far more certain; but it is obviously impossible to pick up again on the platinum loop, after powdering, the whole of the assay selected, or a known bulk of it. Hence even the results with gypsum have given little satisfaction in practice.

It seemed, however, that decomposition of the assay in a bead of sodium carbonate might get rid of the difficulties surrounding the reaction. We should always have the satisfaction of knowing that what we saw could not be due to sodium, for this flame would be eliminated by testing our blue glass in each case on the bead alone. Moreover, the most refractory silicates would be dealt with even more completely than when intimately powdered up with gypsum.

Since the simple support used in testing this reaction, and in all such work in the laboratory of the Royal College of Science for Ireland, was described in the GEOLOGICAL MAGAZINE,[2] it may seem appropriate to furnish the details of this later process here.

The ordinary observations, as arranged by Szabó, may be gone through first, on an assay of the dimensions used by that author. In place of the observation with gypsum, I would venture to substitute the following. In many cases, such as the determination of the presence of potassium in the groundmass of a lava, it may suffice as the only observation to be made.

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[1] "Ueber eine neue Methode die Feldspathe zu bestimmen," p. 34; Budapest, 1876.

[2] G. Cole, "A Simple Apparatus for Flame-Reactions": GEOL. MAG., 1888, p. 314.

(i) From a crushed and pure sample of the silicate or groundmass, select a bulk of about two cubic millimetres. This is about twice the bulk used in the ordinary Szabó reactions.

(ii) Place the cone on the star-support round the lower part of the Bunsen-burner, the flame rising some 15 cm. above it.

(iii) On the end of the platinum wire make a loop about 2 mm. in outer diameter; dip it into water—all ordinary waters are sufficiently free from potassium—and pick up on it powdered sodium carbonate. Fuse this into a bead covering the loop.

(iv) Examine the flame produced by this bead through 5 mm. of blue glass, and note that the blue column in the flame has no violet fringe.

(v) Remove the bead from the flame, dip it into water, and pick up the selected particle or particles of the assay.

(vi) Fix the wire on the support, so that its loop falls in Szabó's position, in the edge of and enveloped by the flame, and 5 mm. above the top of the cone. Leave it for two minutes, noted by the watch.

(vii) Then examine the resulting flame edgewise, i.e. with the plane of the blue glass upright and parallel to the length of the wire. If potassium is present, a violet flame will be seen, on the inner side of the blue column produced by the intense sodium. The *intensity of colouration* is as important quantitatively as the extent of the flame. This flame is persistent for ten minutes or more, and may thus be examined at leisure.

(viii) In some few cases, a further intensification may be required. Remove the bead, dip it into a drop of strong hydrochloric acid, and insert again in the flame. The flames from the chlorides thus formed rival those produced by the sulphates under the best conditions of the experiment with gypsum.

I find it sufficient to tabulate the results obtained by the method described in paragraph vii under three grades :—

Grade 1 = about 4 per cent. of potash.

" 2 = " 8 " "

" 3 = " 12 " "

I would advise each worker, however, to establish these grades for his own eye and his own blue glass, upon specimens of known and analyzed minerals.

Where only the qualitative result is required, the flame may be viewed from the back, i.e. along the platinum wire, when a violet flame of varied intensity will easily be detected, occupying almost all the region covered by the flame rising from the bead.

As examples of the use of the scale above suggested, the following results may be quoted. The burner used was 9 mm. in inner diameter; the cone was 5 cm. high, and its top was 35 mm. above that of the burner; the flame was 18 cm. high, and 145 mm. above the top of the cone.

Grade less than 1.—Oligoclase, Ytterby. Flame just perceptible in some experiments. Average of six published analyses gives $K_2O = \cdot62$ per cent.

Albite, Amelia Court House, Virginia.   No result. $K_2 O = \cdot 43$.
Albite, Zöptau, Moravia.   No result.

Grade 1.—Apophyllite, Squire's Hill, near Belfast. $K_2 O$ probably $= 4$ or 5 per cent.   Analyses of other apophyllites give $3 \cdot 10 - 6 \cdot 30$.
Biotite, Miask.   This is a low result, but one analysis gives $K_2 O$ as low as $5 \cdot 61$, while the potash in biotite from other localities may sink to less than 1 per cent.

Grade between 1 *and* 2 (1·5).—Elæolite, Brevig. $K_2 O = 5 \cdot 17$.
Elæolite, Magnet Cove, Arkansas. $K_2 O = 5 \cdot 91$.
Anorthoclase, Pantelleria. $K_2 O$ varies from $2 \cdot 53$ to $5 \cdot 45$.
Obsidian, Lipari. $K_2 O = 5 \cdot 1$.
Pitchstone, Corriegills. $K_2 O = 4 \cdot 7$.
Groundmass of Phonolite of the Schlossberg, Teplitz.   The bulk-analysis of the rock has $K_2 O = 6 \cdot 57$.
Groundmass of Phonolite of the Schlossberg, Brüx.   This is full of small nepheline crystals.

Grade 2.—Muscovite (probably Russian). $K_2 O$ probably $= 9$ or 10 per cent.
Biotite, Burgess, Canada.   Intensified to 2·5 by H Cl. $K_2 O$ probably about 8 per cent.

Grade between 2 *and* 3 (2·5).—Porphyritic Orthoclase (Sanidine) in trachyte of the Drachenfels, near Bonn.   Average of five analyses gives $K_2 O = 9 \cdot 7$.
Groundmass of Phonolite, Schloss Olbrück, Eifel.   Rich in minute leucite crystals.   Compare with the figures above given for phonolites rich in nepheline or nosean.

Grade 3.—Microcline, Pike's Peak.
Orthoclase from drusy cavity in granite, Slieve Donard, Mourne Mountains.
Orthoclase (Adularia), Schwarzenstein, Zillerthal.
Leucite. $K_2 O = $ about 20 per cent.

Evidently all true orthoclases, with their $K_2 O = $ about 13 per cent. (theoretical 17 per cent.), come in grade 3.   Soda-orthoclase will give 2·5, and anorthoclase 1·5 or even lower.
Spodumene, with its good lithium flame visible to the naked eye, gives no result through the blue glass used in these experiments.
Lastly, the advantages claimed for the employment of sodium carbonate in place of gypsum are :—(1) The certainty in each case that the sodium flame is clearly differentiated from that of potassium ; we have a large quantity of sodium present, and we have eliminated its effects.   (2) Complete decomposition of the assay.   (3) Security against loss of the assay when picked up on the moistened bead and inserted in the flame.   It is quickly fused in and absorbed. (4) Since the operation is always performed in the presence of sodium, there is no need for elaborate cleaning of the wire after each experiment, or for the use of distilled water.

III.—On *Oudenodon* (*Aulacocephalus*) pithecops from the Dicynodon Beds of East London, Cape Colony.

By H. G. Seeley, F.R.S., Professor of Geology, King's College, London.

THE genus *Oudenodon* of A. G. Bain, 1856, was adopted by Sir Richard Owen, and defined as comprising Anomodont reptiles of the type of *Dicynodon*, but absolutely toothless. Still, they were referred to a family Cryptodontia, under the belief that the teeth were immature and had their development arrested, so that they never descended to the adveolar margin. A transition might easily be made from the caniniform production upward of the alveolar border seen in *Oudenodon* to the small teeth in *Dicynodon dubius* and *D. recurvidens*, which are in contrast to the great lateral ridges formed by the roots of the teeth in most species of the genus. The species *strigiceps* was referred first to *Dicynodon* and then to *Oudenodon*. Owen described eight species, which differ from each other in the elongation of the head, in the form of the preorbital region and its prolongation in front of the nares, in the forms of the orbits of the eyes, and the anterior nares, and in the median postorbital region being either a sharp ridge or a more or less flattened concave channel. These characters might have been used to define genera.

The species fall, more or less easily, into two groups, and this is also true for *Dicynodon*. The same characters differentiate the short-nosed from the long-nosed species of both types, suggesting that the genera based on presence or absence of teeth in this case are artificial. Thus, the short-nosed Oudenodons are almost indistinguishable except as species from the short-nosed Dicynodons ; and the long-nosed Oudenodons similarly approximate in skull-shape to the long-nosed forms of *Dicynodon*.

I therefore propose to divide *Oudenodon* into two subgenera.

The short-nosed types, with a wide flattened concave region between the temporal vacuities, the parietal foramen in its middle length, and orbits more or less circular and directed forward and upward, are represented by the species *O. Baini*, *O. raniceps*, and *O. megalops*. They may be indicated by the name AULACOCEPHALUS.

The prognathous species have the orbits more lateral, the parietal foramen just behind the orbits, and a sharp median ridge between the temporal vacuities which may extend along their length or be limited to a part of it. This group is represented by the species *O. magnus*, *O. prognathus*, *O. brevirostris*, and *O. Greyi*, and may be indicated by the name RHACHIOCEPHALUS.

In the same way I would divide *Dicynodon* into two subgenera.

The short-nosed species have a broad concave parietal interspace between the outwardly inclined faces of the postfrontal bones, which make the inner borders of the temporal vacuities. The parietal foramen is in the middle of this area. The nares are scarcely seen when the skull is viewed from above, and owing to the shortening of the snout the orbits are directed forward. The species include *D. Baini*, *D. tigriceps*, and presumably *D. testudiceps*, and may be defined by the name AULACEPHALODON.

The prognathous type, with a median crest between the temporal vacuities, includes the species *D. lacerticeps*, *D. leoniceps*, *D. pardiceps*, and *D. feliceps*. They are grouped under the name RHACHICEPHA-LODON. I have no doubt that one-half of *Oudenodon* with the concave parietal region should be closely associated with the similarly characterized half of *Dicynodon*, and that the half of *Oudenodon* with a parietal ridge should be associated with the Dicynodonts which have the same character. Yet owing to the absence and presence of teeth in the two groups there may be some convenience in keeping the types distinct. In tabular form these species may stand thus :—

OUDENODON.

Aulacocephalus.	*Rhachiocephalus.*
Baini.	magnus.
raniceps.	prognathus.
megalops.	brevirostris.
? strigiceps.	Greyi.

DICYNODON.

Aulacephalodon.	*Rhachicephalodon.*
Baini.	lacerticeps.
tigriceps.	leoniceps.
testudiceps.	pardiceps.
	feliceps.

Almost all these specimens were obtained from the Graaff Reinet district and the Fort Beaufort district, at the time when Cape Colony was expanding to the east, and Mr. A. G. Bain was engaged in making military roads. The *Aulacephalodon tigriceps* is from the Gonzia River, Kaffraria; and *Aulacocephalus raniceps* from East London. As the strike of the beds is the same from Graaff Reinet to East London, ESE., it is probable that these fossils occur upon a definite geological horizon, above the zone of *Pareiasaurus* and *Tapinocephalus*, and below the zone of *Ptychognathus* (*Lystrosaurus*), near the bottom of the Middle Karroo, in what have been termed the Beaufort Beds.

Many years ago Mr. McKay, of East London, sent to this country a small collection of fossils from the black slaty rocks of the East London district. Professor Huxley in 1868 selected one of these as the type of the genus *Pristerodon*, described in the GEOLOGICAL MAGAZINE for that year, Vol. V, p. 201, Pl. XII.

The collection also included a small *Oudenodon* now catalogued in the British Museum (Natural History) under the number R. 1819, which is distinct from all described species and may be referred to as *Aulacocephalus pithecops*. It is somewhat crushed, and is remarkable for its small size, being only three inches long. It is distinguished by the very large size of its nearly circular orbits, which are placed in the middle length of the head, have a diameter of $\frac{8}{10}$ inch, and approximate closely to each other, so that the frontal interspace between them is narrower than the concave parietal area, which is its hinder prolongation. The species is defined from *O. magnus* by the concave parietal region; from that species and

O. prognathus by wanting the anterior angle to the eye. It is separated from *O. Greyi* by the same characters, as well as by wanting the large anterior nares of that species, and by having the temporal vacuities elongated from front to back. It has a relatively longer nose than *O. megalops*, has not the eyes so far forward as in *O. Baini* or *O. brevirostris*; and the skull is much narrower than in the East London species *O. raniceps* and differs in its proportions, being of thin and delicate build, while *O. raniceps* has the bones relatively strong.
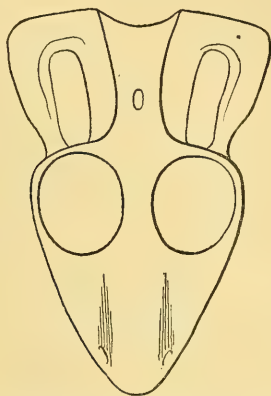
Oudenodon (Aulacocephalus) pithecops, Seeley, sp. nov.
From the Dicynodont Beds of East London, Cape Colony. Restored from [R. 1819].
Preserved in the Brit. Mus. Nat. Hist. ⅓ less than natural size.

The skull is depressed, about twice as wide as high, and measured transversely in front of the orbits, it is half as wide as long. The preorbital region forms nearly an equilateral triangle, conical, rounded from above downward and from side to side. Towards the extremity of the snout, on each side there is a longitudinal depression, extending from the orbits forward to the nares. Those openings were small, and at present are obscured with matrix.

The orbits almost suggest the eyes of a lemur in their large circular form; their chief direction is upward and outward. The interspace which divides them is about one-third the diameter of an orbit. The maxillary border extends back as far as the front of the orbit, below which it is notched out and gives place to the malar bar, which contracts a little behind the orbit from above. In side view it is prolonged back parallel to the alveolar margin, uniting in the usual way with the squamosal, and with the vertical bar of the postfrontal bone which descends behind the orbit. The external squamosal element of the zygoma is inclined obliquely outward, and as it extends backward becomes deeper by ascending. Its upper edge is on a level with the base of the orbit in the malar portion at the back of the orbit, but the concave upper outline of the zygoma is on a level with the middle of the orbit, where the arch terminates posteriorly. It is there inclined inward at an angle

of 45°, making the outer hinder angle of the head, which is its widest part.

The upper surface of the skull suggests a sort of cruciform pattern owing to transverse extension outward of the narrow bars of the postfrontal bones which margin the back of the orbits. The parietal region is concave from side to side, margined in length by sharp curved ridges which approximate towards each other in advance of the middle length. In that narrowest part of the parietal the ovate parietal foramen is situate. In those curved lateral ridges run the sutures, which separate the flattened oblique posterior plates of the postfrontal bones from the parietals, till near the squamosal, when the postfrontal descends from the parietal ridge upon the squamosal in the usual way. These oblong postfrontal plates make right angles with the margins of the parietal bones to which they are external; they face towards the zygoma, and posteriorly the postfrontal and zygomatic areas unite in a concavity which emarginates the squamosal bone, and forms the upper lateral outline of the back of the head, on each side of the narrower and shallower concave parietal area between. The temporal vacuities are fully half as long again as wide, and well exposed laterally owing to the low level of the zygoma.

The brain-case appears to be closed by the usual bones which form the vertical occipital plate. They are slightly displaced. The supra-occipital bone is quadrate and single. The interparietal is above it. There is no evidence that the exoccipital bones form the occipital condyle in the way affirmed for *Oudenodon raniceps*, but the exoccipital bones are large. There is no descending quadrate pedicle, but the quadrate bone is short; and the articulation for the mandible appears to be above the level of the occipital condyle, though that structure is not clearly shown.

Seen from the side the superior contour of the head is gently arched from front to back.

It will thus be evident that this species is distinct, and in some details of the articulation for the lower jaw shows characters which are exceptional in the group to which it belongs, though all the short-nosed species have the skull depressed behind and wide from side to side.

IV.—Narrative of a Geological Journey through Russia.

2. Finland (*continued from p. 15*).

By Geo. F. Harris, F.G.S., M.S.G.F., etc.

PROCEEDING in a westerly direction from Tammerfors, we stopped near the station of Siuro to examine some railway cuttings where good sections of gneissose rock and mica-schist, both of Pre-Bothnian age, occur. Macroscopically, the gneissose rock is distinctly and regularly foliated, having small, lenticular, streaks of quartz abundantly disseminated. Locally, however, the section in the field exhibits much contortion; and thin, irregular, veins of quartz, manifestly of secondary origin, are not uncommon.

Under the microscope this gneissose rock presents evidence of great strain and mechanical movement. The quartz, the most abundant mineral present, has been crushed to such an extent as to assume a cataclastic structure, and nearly all the fragments show characteristic mechanical deformation. In addition, the fragments have been arranged in closely packed layers, and where the shearing proved too great for them they have been broken through along these layers; in the undulating cracks thus formed mica occurs in some abundance. It is this structure which renders the rock so distinctly foliate. Felspars are not common in my hand-specimens, and those present are also much broken up. In one micro-slide, however, I find a rather large fragment of a triclinic felspar, much altered by crushing; it is too far gone to enable it to be satisfactorily determined, but presents the general features of microcline. This comparatively large fragment forms the nucleus of a lenticular, augen-like structure, bounded for the most part by mica, interrupted here and there by minutely crushed quartz which invaded the nuclear area. Many of the quartz fragments in the rock exhibit secondary enlargement.

This gneissose rock at Siuro occurs near the junction of mica-schist with an immense *massif* of porphyritic granite.

The next section we examined was in the railway cutting, a little to the west of the station of Suoniemi, where the Pre-Bothnian mica-schist is well exposed. This rock presented no points of special interest. It is reddish-brown in colour, fine-grained, and well foliated. In thin sections, under the microscope, it is found to consist of deformed angular fragments of quartz interspersed amongst orientated minute films of sericite. Large masses of muscovite occur in blocks by the side of the railway, but I did not see them *in situ*.
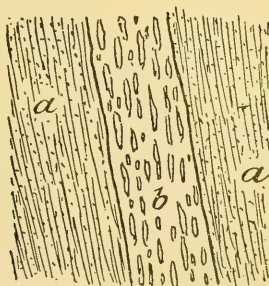
Fig. 3.—Section in a "leptite" quarry, Mauri, Finland.

A railway cutting near Kulovesi showed an indescribable mixture of schist and small veins of granitic rock, on the top of which were a few feet of glacial clay said to be of marine origin, but we saw no fossils. It was an impalpable mud of brownish-green colour.

Walking northwards from this place for a couple of miles, we came to the hamlet of Mauri, and penetrating a wood found a most interesting exposure (Fig. 3) of a rock called by Mr. Sederholm

"leptite." It may be described as a foliated arkose, containing, however, much minute quartz. The rock is salmon-pink in tint A conglomerate of the same material runs through the quarry This has been severely dealt with; the metamorphic action which rendered the sandstone foliated has drawn out the original pebbles into long lens-shaped patches, the major diameters of which, in all cases, are parallel to the folia. Macroscopically there does not appear to be much mica; but micro-examination proves that that mineral is fairly abundant in exceedingly minute flakes. To the naked eye all the mica appears white, or bronze-coloured, though thin sections of the rock demonstrate the existence of a little biotite. Evidently the colourless mica has been produced at the expense of alkali-felspars, and the felspathic constituents as seen in the rock, as it stands at present, have largely become saussuritic. The larger fragments of quartz are very interesting. If I dared use the term in reference to a foliated rock I should say that they act as phenocrysts, for that is exactly what they resemble when one first glances at them under the microscope. They are scattered amongst the exceedingly minute fragments of quartz, altered felspar, and mica, which form a kind of groundmass, out of which they stand conspicuously; and they have been broken up into small fragments by the crushing and shearing to which the rock has been subjected, whilst they present the usual phenomena of cataclastic structure.

The evidence in the field is clearly borne out by micro-examination. I wish we had had more time at this spot, for I feel convinced that much light on an interesting phase of dynamo-metamorphism would be shed by a careful examination of the district. This leptite is foliated enough to place it beyond the pale of an ordinary arkose, and yet not sufficiently to cause it to be regarded as a true schist.

In respect to the relative age of this rock—unfortunately, its junction with the schists near Kulovesi railway station is a fault, and along that line of junction was the only hope of determining its position with reference to the older rocks of the district. At the same time, it is believed that it is younger than the granites of the area, as these latter are brought up against, but do not cut through it. Following the classification detailed in the last article, this leptite and conglomerate are distinctly Pre-Cambrian. But they are, no doubt, much younger than the Pre-Bothnian gneiss.

The next day was devoted to an examination of some rocks on the shores of Lake Näsi (Näsijärvi). We set out in two enormous barges which had been decked over for the occasion, and these were drawn by two very fussy little steam-tugs. It is almost needless to say that nearly all Tammerfors came out to see us off. After a boisterous passage to the other side of the lake, our first *point d'appui* was the locality where "archæan fossils" are found. The landing, and then slipping over many hundred yards of well-polished rock with beautiful glacial striæ, proved rather exciting, which excitement was considerably

accentuated as two or three members fell into pools of water conveniently arranged by Nature in big and deep holes in the immediate vicinity of the "Pre-Cambrian organic remains."

The "archæan fossils" gave rise to an animated discussion. There, on the smooth surface of the phyllades, we saw some circular and ovoid markings outlined by black carbonaceous-looking rings. Nobody seemed to know what they were, and it is to be observed that no one even ventured to give them a generic and specific name " in order that they may hereafter be identified." Vague remarks about "fossil wood" and "impure phyllades" closed the visit to this spot.

Re-embarking, we went to an island in the lake, where a remarkable phenomenon awaited investigation. I have said (p. 15, *ante*) that the Bothnian schists in the neighbourhood of Tammerfors are characterized by the presence of conglomerates on several horizons. As we landed on this island the large pebbles in one of these conglomerates, many of them 3 and 4 inches in diameter, were very conspicuous, and the bed here cropping out must be many yards in thickness. Although indurated, and to a certain extent otherwise metamorphosed, this conglomerate is fresh enough to enable each pebble to be clearly made out, or defined from amongst its neighbours. On the beach the rock is much weathered, and decomposition has set in on the surface of the majority of the pebbles, which are pitted with small holes. Beautiful little faults, having a throw of a foot or so, are seen in several places; they go right through the pebbles, and slickensides is not an uncommon phenomenon.

The structure of this archæan conglomerate exhibits a few points of interest. In addition to the larger stones mentioned there is much grit and fine quartzose sand, the grains of the latter being angulate. The larger pebbles are for the most part fragments of volcanic rocks presenting large phenocrysts of a triclinic felspar. It is difficult to determine the precise nature of these volcanic rocks, but in one of my micro-preparations there is certainly a small pebble of "labrador porphyry." The extinction angles of four large phenocrysts of the felspar in this are $+34$, $+36$, $+36$, $+38$, indicating labradorite. These phenocrysts, however, are much altered and have many inclusions. The augite is not very satisfactory and cannot be distinctly identified; I infer its former existence by green decomposition products in small phenocrysts having the approximate appearance of augite.

In addition to these pebbles of volcanic rocks the conglomerate is made up of pieces of rolled phyllade. Mr. Sederholm remarks [1] that all the rocks represented by these pebbles crop out to the south of the conglomerate, and there is, therefore, no reason to suppose they have travelled very far. But he mentions some strangers to the district as occurring therein, viz., "deux variétés de granite ou syénite quartzifère, et une diorite quartzifère."

[1] Guide xiii, "Les Excursions en Finlande," p. 4.

Perhaps the principal point of interest in this Archæan conglomerate is the change which some of the smaller fragments have undergone. These adhere to each other for the most part, but here and there is some well-developed granular quartz which acts as a partial cement. The smaller clastic material consists of pieces of plagioclase, fragments of uralitic augite, of quartz, and perhaps of olivine. There has been a great deal of alteration and secondary development in these fragments and the cement. That might have been surmised from the condition of the augite, as just mentioned, almost completely altered into uralite ; whilst the olivine is partially changed to biotite and similar products. Running through this finer clastic material and the cement are roughly parallel lineations of uralite, which is also seen bordering some of the larger pebbles. It is accompanied by occasional minute flakes of biotite.

The rough attempt to produce foliation in this conglomerate and much of the change induced in the pyroxene was doubtless brought about by the same processes which converted the neighbouring volcanic tuffs into uralite schists—for the conglomerates alternate with " beds " of these schists.

Leaving this interesting little island we went across the bay of Hormistonlahti, and landed to make a further examination of the conglomerates and to inspect the uralite schists. The whole of the rock is vertically disposed. These dark-green schists have not been very much altered ; their foliation is not conspicuously marked, though distinct enough when closely examined. The volcanic ejectamenta are small, but the fragments, as seen under the microscope, are sufficiently large to enable their basic character to be distinctly made out, and they do not seem to have suffered much in the conversion of the tuff into a metamorphic rock. As will be readily understood, the uralite is for the most part orientated and is the principal assistant in producing the foliate structure. This mineral is most completely formed, and actinolitic needles are not only spread all over it, but project from its sides in characteristic fashion. The needles also have a direction parallel with the folia and impart a semi-fibrous aspect to the mineral.

A brisk walk along the beach enabled us to see that the uralite schist was remarkably uniform in character for long distances ; I did not observe any contortion in it. There appeared to be but few exposures inland, a mantle of glacial beds spreading over the surface of the ground and masking the solid beds beneath. But you cannot see far in this part of Finland after you have left the lake-side. The glacial beds give rise to a luxuriant vegetation, and though the trees are not very tall they are sufficiently numerous and close enough together to prevent one from observing much more than arises along the immediate vicinity of the route traversed.

Regaining the barges, we made an earnest attempt to negociate the lake ; the little steamers did their best, and in a short time we had covered 12 or 14 miles, in a northerly direction. Landing again some few miles south of Teisko, opposite a grand section in the glacial beds, full of boulders and small fragments of rock,

we climbed a hill to examine an outcrop of granite. We also got out to look at some diorite which has broken its way through the granite. The outcrop of the diorite is very small, not more than a few yards across; but the granite extends for hundreds of miles over this part of Finland. It is the typical Post-Bothnian granite alluded to *ante*, pp. 14, 15. Thin sections show the diorite to be a rather formidable compound; for it is a quartz-mica-hornblende diorite, the whole being much decomposed. There is a considerable quantity of opaque iron disseminated throughout, and my slide shows both black and white micas, though the latter is very rare.

In a little time we arrived at the house of the hospitable proprietress of Teiskola, the most northerly point of our journey; and later on the little tugs took us back down the lake some 20 miles to Tammerfors, sending myriads of sparks from the wood fires flying out of the funnels on the way, the display resembling " fireworks " in the cold night air.

Up early the next morning, we trained to the station of Suinula, a mile and a half from which place we visited an exposure of gneiss. Farther on, along the railway line, near Orihvesi, we came to some large railway cuttings exhibiting the contact between the Tammerfors schists and the porphyroid granite. There seemed to be much difference of opinion as to the precise nature of this junction, which latter, however, was most clearly shown. Our Director, Mr. Sederholm, said that the junction was " mechanical." In the same section is a whiter granite, younger than the schists, which often contains tourmaline.

The porphyritic granite contains many fragments of schist which have been to some extent absorbed by it. The micro-structure of such a fragment shows it to be a typical biotite schist, but having a little white mica; the quartz is in small angular grains and exhibits the usual cataclastic phenomena. Many of the larger quartz crystals have been crushed *in situ*, the original boundaries of each of these little groups being clearly definable.

Retracing our steps from Orihvesi to Halimaa, we went for a long drive to Kangasala, where we made our first personal acquaintance with åsar. This gives me an opportunity for saying a few words concerning the superficial deposits of Finland. The greater part of the solid rocks of the country are covered by morainic deposits. These are specially well developed, and form one continuous sheet in the north, central, and eastern portions of the land. In the south-central parts this sheet is much interrupted by innumerable lakes, along the shores of which some of the best sections are exposed. The country along the eastern boundary of Finland from near the north of Sweden to the shores of Lake Ladoga is all mapped as " morainic deposits." They are a monotonous series of mixed gravels and sands. On the other hand, in that portion of the country bordering the Gulf of Bothnia and the Gulf of Finland, Glacial and Post-Glacial clays are well developed, and crop out in every little river valley for many miles inland. The greatest expanse of this clay is to the south of Uleåborg, and in the immense tract of

country to the north of Åbo and Helsingfors. Near Uleåborg, also, are extensive deposits of Post-Pliocene sand, smaller patches of which are met with at intervals in the western parts of the country and bordering the Gulf of Bothnia. In the interior of Finland this sand also occurs, and large outcrops are mapped to the north-east of Teisko and near Lake Ladoga, and on towards St. Petersburg; in the southern part of Finland, however, it is but sparingly represented, and it does not appear to occur at all in the northern part of the country above Uleåborg.

Perhaps, the most interesting glacial deposits of Finland are the åsar and stratified terminal moraines, which in some instances stretch uninterruptedly for many miles across the country. We had abundant opportunity of examining these at typical localities, as will presently be described.

Confining attention to the neighbourhood of Tammerfors for the moment, I may remark that the geologists of Finland are of accord that glacial phenomena there are not so simple as in other parts of the Grand Duchy. Messrs. Sederholm and Ramsay state[1] that there are several systems of glacial striæ. The predominating directions are "S. 25°–30° E. et S. 60°–65° E. (côté frappé au N.–W.)." To the south of Tammerfors the striations run W.–E., and sometimes N. 65° E. These diverse directions are explained as being formed during the retreat of the ice; but to the north of the town there are striæ running S. 5° E., and belonging without doubt to a more recent system, which is connected with a large terminal moraine found to the north-west of Tammerfors and which, by its configuration and sandy composition, resembles an ås. What is believed to be the oldest system of glacial striæ in the district is in the country to the south of the town where the grooves run N. and S. The morainic gravel throughout is remarkably uniform. The glacial clays in the southern part of Lake Näsi are recognized as marine "*Yoldia*-clays," and there is also a fresh-water deposit.

<center>(To be continued.)</center>

V.—The "Irish Elk," *Cervus giganteus*, in the Isle of Man.

By P. M. C. Kermode, Esq.,
Hon. Sec. Isle of Man Natural History and Antiquarian Society.

IN September last the Committee appointed by the British Association to "examine the conditions under which remains of the Irish Elk were found in the Isle of Man" commenced excavating at Close-y-garey, near Poortown; but owing to the unusual amount of water, considerable labour and expense were incurred in the preliminary work of draining, and by the 25th September the grant was exhausted.

Our local Committee thereupon took up the work, issuing a circular for subscriptions, the response to which enabled them to carry on the excavations with such success that on the 30th

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[1] Guide (op. cit.), p. 8.

September portions of what appeared to be a perfect specimen were disclosed in the undisturbed marl.

The dub, or old marl-pit, in question, lies in a hollow in the glacial drifts, about half a mile south of the Peel Road Railway Station, on the east side of and close to the line. It had about sixty years ago been worked for marl, and the present well-defined banks mark out a rectangular hollow about three feet below the surrounding surface, measuring about fifty yards square.

Across one corner of this a trench was dug to carry off the water, and the operations of the Committee were confined to a triangular area on the west side of the trench, measuring about 15 yards east and west by 30 yards north and south. We excavated all over this space to a depth of nine feet and more. The first four excavations being through ground which had previously been disturbed yielded no definite results, but at one point, about 10 yards from the north bank and 8 yards from the west, a few elk-bones were met with in the disturbed soil. These and some other bones were submitted to Professor Boyd-Dawkins for examination, and he finds among them, belonging to this species, fragments of maxilla, the sixth cervical vertebra, the second lumbar vertebra, and a fragment of a rib.

The last excavation, about the centre of our area, brought us to the undisturbed marl at a depth of about three feet. On testing this I found it to extend to a depth of 10 feet 6 inches at a point about eight yards east of the bank, but four yards nearer to the bank it did not reach a greater depth than eight feet. Between this and the bank it appeared to have been disturbed.

In this bed of white marl, at a depth of about nine feet from the surface, we found the remains of a complete skeleton, lying on its right side, the head towards the bank, the legs drawn up to the body. We considered it necessary to get it out the same day (Saturday), as already many people had been to the place the previous evening, and some one had broken off a piece of the exposed antler. Had time allowed we should have endeavoured to have cleared away the marl from around the bones and had them entirely disclosed and photographed. Time, however, did not allow of this, and as it was very wet we probably should not have succeeded anyhow. Deemster Gill, Mr. Crellin, the Rev. S. N. Harrison, and I therefore took very careful note of the position of the bones as they were gradually uncovered and removed.

So perfect was the skeleton that we had no difficulty in doing so. The bones were nearly all in juxtaposition and in a fair state of preservation. The left antler had fallen back over the lumbar vertebræ; it was rather decayed, the tines had fallen off, and the beam was missing. The other antler had dropped down by the cervical vertebræ, and, except for the beam, was in good preservation, but in lifting it from the marl the tines dropped off. Unfortunately the skull had decayed away and only a portion of the left lower jaw and fragments of the upper jaws remained.

The left antler is the larger; it measures across the palm

15 inches, allowing for a piece of the front edge which has decayed away; the right measures 13 inches. With the tines restored, they are respectively 56½ inches and 53 inches long, and the beam would have been at least 10 inches more. They show six points or tines, besides the brow-tines, which had fallen off, the part where they joined the beam having decayed away.

On laying the bones in position I find that the animal must have been about 18 hands or six feet high at the shoulder. The fact of its having antlers shows it to have been a male; and their size and number of tines, that it was an adult. One of the ribs had been broken, no doubt the result of fighting with another buck in the rutting season, and had healed again. The teeth are in excellent preservation, showing no sign of weakness or decay. The limbs are perfect, all the small bones having, I think, been recovered; the vertebræ also are sound and appear to be all present. The right shoulder-blade, which lay beneath the other, is badly decayed, as are many of the ribs, but I think they can be pretty well restored, and, but for the missing skull and the beams of the antlers, the bones when articulated and mounted will make a perfect skeleton.

Having secured this specimen, we continued our excavations in an easterly direction, but very quickly got through the marl, and again found the soil to have been disturbed as far as our trench.

With regard to the formation in which it was found, the British Association Committee will no doubt have a full report for the meeting at Bristol next September. The result of all the excavations, allowing for the very disturbed state of the ground, shows the following beds :—

					ft.	ins.
A. Disturbed soil and peat, an average of about	...	...			3	0
B. In one place a blue clay or silt was observed resting on the white marl.						
C. White marl, containing the elk-remains	...	...	...		6	6
D. Blue marl	...	...	...	...	1	0
E. Red sand with gravel	...	...	...	...	0	3
F. Brown clay	...	...	...	...	0	3
G. Sand and gravel } ? Glacial drift		...	...	...	0	3
H. Clay·		...	...	...	4	0

As stated above, the whole surface had been lowered about three feet in digging for marl; the peat had for the most part been removed, and a great deal of the marl also; indeed, we were fortunate in finding this one spot in which the marl itself had not been disturbed.

The finding of detached bones shows that other individuals of this species had perished here, and is consistent with what we were told, namely, that a specimen had been seen when digging for marl, and that the antlers of yet another had been taken out and sold. We were told also that two skulls without antlers had been seen on the east side of our trench.

Samples of the marl and other beds were forwarded to Mr. James Bennie of Edinburgh, for preparation and microscopical examination, and so far as we have heard, the peat appears to be an ordinary lake peat, without anything very distinct about it. The marl contains no

fresh-water shells, but there seems to be a great number of Ostracoda, also some Chara-seeds. The Arctic crustacean *Lepidurus glacialis* and the Arctic willow *Salix herbacea*, which we found in our previous excavations at Ballaugh, seem to be absent from this section. Mr. Clement Reid, of H.M. Geological Survey, has kindly undertaken the determination of the vegetable remains, and we hope therefore to be able to give further information on the subject in our Report to the British Association.

In recording this latest discovery of the remains of the great deer, it is of interest to recall the fact that the first specimen to have been set up, if not, indeed, the first almost perfect skeleton found, is that now at Edinburgh, which was found at Ballaugh in the Isle of Man in 1819. Altogether we have been able to trace remains of about twelve individuals, and possibly more may yet be met with, so that a herd of this noble beast must have existed here after the kingdom of Man became an island. It is more easy to account for its disappearance in so small an area than for its original presence ; the best explanation of the latter being that suggested to the writer by Mr. G. W. Lamplugh—that it had crossed over on the ice.

It is somewhat remarkable that no other contemporary remains have been met with, unless we may now except *Equus caballus*, some bones of which we found at Close-y-garey. From their appearance Professor Boyd-Dawkins thinks these may possibly be of the same age : most unfortunately they were only met with where the soil had been disturbed, but they at least suggest grounds for further search, which I hope we may be able to undertake in the near future.

VI.—Notes on the Red-Deer, *Cervus elaphus*, Linn.[1]

By G. Pringle Hughes, Esq.

THE Red-Deer (*Cervus elaphus*), or common stag, is a native of the more temperate regions of Europe, Asia, and North America. In Great Britain it has its freedom limited to the Highlands of Scotland, where, however, it is carefully protected, and affords the *crème de la crème* of British field-sports to the practised rifleman and mountaineer.[2]

In early English History, when the marauding disposition of the people made cattle a precarious property, the wild deer, which depastured the country in large numbers, afforded the staple article of food. Large hunting parties were collected, and as many as 1,000 stags are recorded as having been taken at one of these gatherings.[3]

The true stag and deer are at once distinguished by the presence of deciduous branching antlers in the male, the female being in nearly

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[1] Read before the British Association, Toronto, in Section D (Zoology), 1897.

[2] The shooting of some of the deer forests, of from 25,000 to 35,000 acres, is let for between £3,000 and £4,000 per annum.

[3] The ballad of Chevy Chase records such a wholesale slaughter, though the history of field-sports relieves the statement of any suspicion of poetic license.

all cases destitute of such weapons. These appendages vary much in character, being cylindrical or rounded in some species, and flattened and palmate in others. They are bony outgrowths from the frontal bones of the cranium, and, being developed periodically,[1] have an important physiological significance. An extraordinary supply of blood seems to be provided for these bony outgrowths at the spring of the year, and the vessels surrounding the frontal eminences enlarge. This increased vascular action results in the secretion of formative bony matter, producing a swelling or budding at the summit of the frontal bones, at the spot where the horns of the previous season had separated. In the early condition the horn is soft and yielding, and it is protected only by a highly vascular periosteum and delicate integument, the cuticular portion of the latter being represented by various fine hairs, closely arranged. From this circumstance the skin is termed "the velvet." As development goes on, a progressive consolidation is effected; the ossification proceeds from the centre to the circumference, and a medullary cavity is ultimately produced. While this is taking place a corresponding change is observed at the surface. The periosteal veins acquire a great size, and by their presence occasion the formation of grooves on the subjacent bone. At the same time osseous tubercles, of ivory hardness, appear at the base of the stem. These coalesce by degrees, enclosing within their folds the great superficial vascular trunks, which are gradually closed and cease to flow. The supply of nutriment being thus cut off, the first stage of excoriation is accomplished by the consequent shrivelling up and decay of the periosteal and integumentary envelope. The full growth of the antlers is now terminated, and the animals, being aware of their strength, endeavour to complete the desquamation by rubbing them against any tree or other hard substance that may lie in their path. This action is termed burnishing. After the rutting season the antlers are shed, to be again renewed in the ensuing spring; and every year they increase in development, until they attain their maximum growth.[2]

The fossil remains of deer, which have been plentifully found in this country and the North of India, indicate that when unmolested by man and in a wild state they attained a far greater size and probably age than at the present day.

The period of gestation of the hinds extends over 8 months, the young being produced in the month of May. During the winter both sexes collect in vast herds; but in the rutting season the stags

[1] "In the Deer (*Cervidæ*) the antlers consist wholly of bone which grows from the frontals, the periosteum and finely-haired integument, called 'velvet,' coextending therewith during the period of growth; at the end of which the formative envelope loses it vascularity, dries, and is stript off, leaving the bone a hard insensible weapon. After some months' use as such the horns, or more properly 'antlers,' having lost all vascular connection with the skull, and standing in relation thereto as dead appendages, are undermined by the absorbent process and are shed; whereupon the growth of a succeeding pair commences. The shedding of the antlers coincides with that of the hair, and, with the renewal of the same, is annual."—*Owen*.

[2] See Richardson's "Museum of Natural History."

frequently engage in the most desperate encounters, and sometimes the antlers are inextricably fixed by the tines, both animals being left to perish with interlocked weapons.

> " As when two bulls for their fair female fight,
>   Their dewlaps gored, their sides all smeared in blood."
>
> VIRGIL: *Æneid*, xii, 715.

Antlers of Red-Deer, *Cervus elaphus*, Linn.

Found by G. P. Hughes, Esq., beneath a peat deposit, Cresswell Bog, eastern base of the Cheviot Hills ; and preserved at Middleton Hall, Northumberland.

The specimen of which I submit a photograph is, I have reason to believe, hardly surpassed for size and preservation by any other examples from the peat deposits of Great Britain. The late Earl of Malmesbury, who was for many years tenant of the Auchnacary deer forest in Scotland, and moved among sportsmen of the first rank at home and abroad, saw these antlers, in company with another great sportsman and deerstalker and intimate friend of Sir E. Landseer, the Earl of Tankerville, and was of opinion that only in a few German collections in Hesse Cassel, etc., on the sites of

the vast forests of Franconia and Thuringia, where giant specimens of Mammalia at one time abounded, would their equal be found. I have, therefore, thought it desirable, as I have no descendant of my own, to have this specimen photographed, and a copy sent to some of our national Museums and Societies, in order to have the existence of this fine pair of antlers of *Cervus elaphus* recorded in proper form.

MEASUREMENT OF THE ANTLERS PRESERVED AT MIDDLETON HALL, WOOLER, NORTHUMBERLAND.

		ft.	ins.
1. Width from inside to inside of the crowns		2	8
2. Length of the beam to leading crown tine		3	6
3. Width from outside to inside of beam at crown		3	10
4. Circumference of the crowns (left)		3	5
,, ,, ,, (right)		3	8
5. Length of brow antlers (left)		1	8
,, ,, ,, (right)		1	7
6. Width of skull at stem			6
7. Circumference of stem at base			10
8. Number of points upon the two stems or beams			21

"This set of antlers, with several of less size, with entire skeletons of red-deer measuring 15 hands in height, one foot taller than the red-deer now extant, were exhumed from a lacustrine deposit of marl and peat known as the Cresswell Bog, at the eastern base of the Cheviot Hills. The following is the section of deposits in descending order as given by Mr. G. Tate, F.G.S., Secretary to Berwickshire Naturalists' Club :—(1) Peat, in which are prostrate trees of hazel and birch, and also hazel-nuts : from 2 to 4 feet in thickness. (2) Marl, in which have been found skeletons of red-deer, teeth of the boar, and great numbers of fresh-water shells : 8 feet thick. (3) Blue Clay, a few inches in thickness. (4) Boulder-clay and gravel."—*Transactions of Berwickshire Nat. Club,* 1860.'

These facts give a tolerably clear history of the succession of events at this spot. During the Boulder-clay period the district was covered with water up to a considerable height. This period, with its subarctic climate, its glaciers and floating icebergs, passed away, and the present conformation of the British Isles was to a great extent assumed. Where this specimen was found a small lake had been left, in which for ages mollusks lived and bred, for the accumulation of 8 feet of marl, chiefly formed of their shells, indicates a considerable lapse of time. Deer and boar living along its margin, or coming to it for drink, or, I may add, pursued by wolves or Neolithic man, occasionally found a tomb beneath its waters and yielding marl. In the course of time the waters were partly drained off, but the ground being adapted for the growth of mosses, peat was formed over the marl, and trees and bushes growing around were time after time carried by floods and winds into the marshy ground, which they have contributed to increase and solidify.

VII.—The Contact-Rocks of the Great Whin Sill.

By W. Maynard Hutchings, F.G.S.

(Concluded from the February Number, page 82.)

IN describing " An Interesting Contact-Rock" (Geol. Mag., March and April, 1895) I gave its analysis, showing :—

Potash ...	...	...	...	...	...	1·25 per cent.
Soda ...	...	...	...	...	...	2·01 ,,

And in this rock also the great relative increase in soda corresponds with the appearance of albite among the new minerals.

But, as stated above, we also have cases of great alteration *without* increase of soda; as, for instance, the two intensely affected shales described from Rowntree Beck and Winch's Bridge, both very rich in alkali, and both showing still a normal excess of potash. And, again, three other specimens of completely altered rocks from near contact give :—

Potash	3·15 per cent.	...	4·24 per cent.	... 3·40 per cent.
Soda	1·20 ,,	...	1·22 ,,	... 0·87 ,,

In these the mica is all regenerated, with chlorite, as described, but there is no sign of any new felspar.

Without burdening this paper with too many figures, I may say that in between these extremes of great alteration of alkali-ratio, and no alteration at all, come determinations giving an intermediate result—soda has increased beyond the normal limits, but still not to the extent of exceeding the potash, as for example :—

Potash	...	...	...	3·55 per cent.	... 1·60 per cent.
Soda	...	...	...	2·20 ,,	... 1·31 ,,

If soda-transfer takes place, we should expect to find evidence of it in the less pure sandstones, as well as in the shales, those with argillaceous interstitial matter being really only diluted shales. I have determined the alkalies in three specimens of altered sandstones, as follows :—

Potash	...	0·25 per cent.	... 0·55 per cent.	... 0·23 per cent.
Soda	...	2·46 ,,	... 2·71 ,,	... 1·12 ,,

Here there is in each case a very decided excess of soda, and the *total* alkali contained is much more than would be expected in consideration of the relatively small amount of original argillaceous material. These determinations, as far as they go, would strongly countenance the idea of transfer of soda in some form, and tend also to show that the sandstones have taken it into combination, and held it, out of proportion to the shaly deposit contained in them.

Tests of some of the limestones have also been made, for the same reason, that where less pure they contain argillaceous material, and should show the alteration of alkali-proportion if it has taken place. Of the following two analyses, A represents a specimen from within a few inches of contact, containing a quantity of garnet and

a good deal of recrystallized silica. B is a rock practically free from minerals other than calcite—only a very few garnets and a little quartz :—

				A.			B.	
Silica	...	...	...	40·90	per cent.	...	4·60	per cent.
Alumina	...	...	...	5·45	,,	...	1·95	,,
Ferric Oxide	...	...	...	7·85	,,	...	0·85	,,
Lime	...	...	..	29·42	,,	...	51·27	,,
Magnesia	...	...	...	2·17	,,	...	1·65	,,
Potash	...	...	...	0·28	,,	...	0·19	,,
Soda	...	...	...	0·74	,,	...	0·71	,,
Carbonic Acid	...	...	...	10·06	,,	...	37·50	,,
Water	...	...	...	2·80	,,	...	2·15	,,
				99·67			100·87	

A portion of B was dissolved slowly in dilute cold hydrochloric acid, the residue filtered and dried, and its alkalies separately determined. It gave :—

Potash	...	...	...	...	...	...	0·35	per cent.
Soda	...	...	...	...	...	...	0·78	,,

Another limestone, completely recrystallized, and showing grains and small indeterminable crystals of foreign matter, gave :—

Potash	...	...	...	...	...	...	0·26	per cent.
Soda	...	...	...	...	...	...	0·81	,,

This rock, dissolved in dilute acid, gave a residue which, after filtration and ignition, was 6 per cent. of the original material, and contained :—

Potash	...	...	...	...	...	...	0·58	per cent.
Soda	...	...	...	...	...	...	6·30	,,

All the above show large excess of soda, but amongst the limestones, also, we find contradictory results. Thus, one altered bed containing augites, etc., gives :—

Potash	...	...	...	...	...	...	2·55	per cent.
Soda	...	...	...	...	...	...	0·62	,,

Another hand-specimen shows sugary white limestone, together with a layer of brown hornfelsy rock, due to impurer material. The alkali-contents are :—

				White Limestone.		*Brown Layer.*	
Potash	...	...	...	0·30 per cent.	...	5·79 per cent.	
Soda	...	...	...	0·07	,,	... 1·40	,,

At my request, Mr. Garwood collected a series of specimens representing the succession of beds downward from the Whin Sill to the basement conglomerate, at Falcon Clints, in Upper Teesdale; as I thought it would be of considerable interest to make alkali-determinations in them, and at the same time examine them microscopically and note the nature and intensity of the alterations. The particulars of the section at this point, as given to me by Mr. Garwood, are as follows :—

WHIN SILL, 100 FEET THICK.

		Feet thick.
No. 1.	Limestone, with garnets, etc., where impure ; white and sugary where pure, but containing patches of altered shaly matter, sandstone, etc.	24
No. 2.	Shale, weathered	12
No. 3.	Limestone	10
No. 4.	Shale, weathered	6
No. 5.	Limestone	2
No. 6.	Sandy shale	3
No. 7.	Limestone, hard blue, with fossils	8
No. 8.	Flaggy sandstone	10
No. 9.	Shale with nodules	8
No. 10.	Basement conglomerate	2

Total of sedimentary beds 85

The specimens examined gave results as follows :—

No. 1. This limestone has been described above, so far as concerns the garnet and idocrase-bearing hornfelsy alteration-product, of which an analysis was also given. This analysis showed a large excess of soda. But it was another hand-specimen from the same locality, with both pure limestone and a layer of the hornfelsy material, which gave the figures just quoted, showing potash in large excess over soda.

In this limestone-bed occur patches and lenticular masses of altered sandstone and shale. A specimen of such a sandstone shows, in the sections, that it is rather coarse-grained, with a good deal of interstitial matter of originally argillaceous nature, with fine-grained quartz. This matter is all intensely altered, showing some newly-formed mosaic of quartz and a little felspar, a lot of white mica in beautiful tufts and bunches, and here and there patches of newly-crystallized, glassy-clear groups of well-twinned plagioclase crystals, some of them identifiable as albite. The alkali-contents of the rock are :—

Potash ... ... 0·55 per cent.
Soda ... ... 2·71 ,,

A patch of shale from the same source shows alteration on the usual lines—much of the indefinite new " speckly " product, white mica, chlorite, etc., with " spots " containing more chlorite, less mica, and great aggregations of rutile grains. It contains :—

Potash ... ... 4·82 per cent.
Soda ... ... 1·48 ,,

No. 2. This was a moderately quartzy shale. The quartz is not much affected, but the main mass is greatly altered, chiefly to speckly matter and white mica, the latter often forming clear patches and circular spots of larger, clearer flakes of muscovite, or of muscovite and chlorite. The rock contains :—

Potash ... ... 5·36 per cent.
Soda ... ... 2·93 ,,

No. 3. Limestone, originally impure with argillaceous matter. The bulk of it is not highly altered, not even rendered coarsely

crystalline. But there are many "spots" in the sections, in which, among a good deal of indeterminable matter, some chlorite, etc., are a good many small bits and prismatic crystals of augite. Some augite occurs also outside these spots, but not much. The alkalies are :—

Potash	...	...	...	...	...	2·55	per cent.
Soda	...	..	...	...	...	0·62	,,

No. 4. A main mass of fine-grained shale, in which are bedded good large quartz fragments, with numerous flakes of clastic mica, and a good many grains of calcite. The coarser constituents are not altered, but the finer portion has been completely regenerated, giving rise to a small-grained dim sort of mosaic, with a little new mica, and showing here and there larger patches of this and of chlorite. This rock contains :—

Potash	...	...	...	...	...	3·55	per cent.
Soda	...	...	...	...	...	2·76	,,

No. 7. This limestone is very much recrystallized, but does not show any distinct new minerals, being only slightly impure :—

Potash	...	...	...	...	...	0·26	per cent.
Soda	...	...	...	...	...	0·81	,,

No. 8. A sandstone converted into a quartzite. There was very little interstitial matter, which is now much altered, but details cannot be made out :—

Potash	...	...	...	...	...	0·23	per cent.
Soda	...	...	...	...	...	1·12	,,

No. 9. This is the bed described as "an interesting contact-rock," the main characteristics of which were recapitulated above, so that no description need be given here. It was pointed out that the bed varies more or less in composition in different parts, being more or less quartzy, etc. As since I first described it I have made some more alkali-determinations on various specimens, it may be worth while to add them here :—

			per cent.	per cent.	per cent.	per cent.	per cent.
Potash	...	...	1·01 ...	0·47 ...	1·60 ...	2·71 ...	0·70
Soda	..	...	1·92 ...	1·10	1·31 ...	1·35 ...	1·33

The last is from a sample representing a large number of the "nodules," which were carefully detached from the rock.

We do not know how far from the contact the metamorphism caused by the Whin Sill was capable of extending, but we have here an instance of very great alteration at over 80 feet distance, and may safely say that the action would have continued much further. From published observations on the subject, it does not seem usual for the contact-zone of basic dykes or sheets to be as extensive as this.

The interpretation of the chemical determinations above given does not seem to be an easy or a satisfactory business, owing to their contradictory nature. Many of them show an undoubted access of soda, at least—that conclusion seems to be unavoidable,

unless it can be shown that there are shales, and argillaceous sand-
stones and limestones, among the Lower Carboniferous beds, and
indeed in the particular districts in question, containing soda in
some such ratio to potash as is disclosed by these determinations.
On the other hand, it is difficult to explain the fact that such soda-
rich alteration-products alternate with others, derived apparently
from quite similar original rocks, in which, as we saw, soda has
not increased, or has increased in a far less degree.

Supposing some compound of soda to pass from the igneous
magma into the invaded beds, we can readily explain to ourselves
how it could come about that purer limestones show little or no
trace of its action. Solutions containing this compound of soda
could permeate the limestone, and pass into beds of shale, etc.,
beyond it, without being in any way permanently taken up and
combined with it; and in course of time the limestone would be
freed from the merely mechanically held soda; whilst in the
complex silicates of the shales would be offered a material with
which introduced soda would easily enter into new and permanent
combinations. But we cannot very well explain how it is that one
bed, or part of a bed, of shale takes up so much more than another.
We must leave this, for the present, as one of the many things
which we cannot yet make clear.

Looking at those rocks which show a considerable amount of
soda-felspars, and carefully observing the part these felspars play
in the structure of the rock, and their relationships to the other
minerals, it does not seem possible to conclude otherwise than that
the soda-increase and formation of these felspars and these structures
were all part of the one process of contact-metamorphism and
recrystallization of the rock-constituents. No later introduction of
soda, by percolation of solutions from the cooled and weathering
igneous rock, is at all consonant with what we see. And this is
equally true of those beds in which, though we find soda in excess,
we cannot detect any felspar with the microscope, and are led to
assume that the soda is combined in the abundant new mica
developed, in the "speckly" intermediate material, and in other
new products.

In this rather indefinite and unsatisfactory position we must,
apparently, leave this part of the subject for the present, at all
events so far as the Whin Sill is concerned. Having devoted
a good deal of time and trouble, both to "looking it up" elsewhere,
and to trying to obtain evidence from our most favourable British
opportunity of studying it, I make no apology for dealing with it
at some length, even though, unfortunately, not conclusively. It
touches one of the most important points which still stand first for
consideration on our way to an understanding of the true nature and
processes of contact-metamorphism.

Incidentally, it is worth pointing out that the series of alkali-
determinations given above, supplementing as they do my previous
analyses of fireclays and shales, quite definitely dispose of the
contention, often put forward, that none of these deposits contain

enough alkali to justify the belief that they could be the early material of true clay-slates, etc.

It is not, however, in this chemical question, nor yet in the mere cataloguing and description of the new minerals produced, that the great interest of the contact-rocks of the Whin Sill is centred. This interest mainly lies in the observation of the nature of the *structures* produced, and the relationships of the minerals to one another; and in the comparison of these structures with those of rocks from great contact-areas round granite intrusions, as well as with those of others, of similar composition, which have been subjected to intense dynamic and deep-thermal conditions, but not, so far as we know, to the action of any intrusions of igneous masses.

When a shale is highly altered by contact with the Whin Sill, we get in most cases, as has been shown, a splitting-up of the complex micaceous mineral of which it largely consists, into a purer, more highly developed white mica, which we may in general designate as muscovite (though to some extent it may consist of paragonite or of an intermediate stage), and into a chloritic mineral. Both the mica and the chlorite crystallize in the rock in all directions, quite irrespective of the stratification-plane in which the original micaceous minerals lie flat. A certain criss-cross structure is at once produced; it commences as soon as the contact-effect is noticeable at all, becomes more and more pronounced in the more highly developed cases, and is often accentuated by the formation of rosettes and sheaves of mica and chlorite. These effects and appearances are all the more striking because they are produced on an original material of such low development. We pass at one step from a rock with no white mica, no chlorite, and no criss-cross structure, to one in which all these things are in full evidence. At granite-contacts we may often see exactly the same products in the altered rocks, but they are then frequently, in that sense, not so striking; because in most cases the rocks acted upon have been in a much higher stage of development; they were not elementary shales, but slates, in which a good deal of formation of mica and chlorite had already taken place. The final result is, however, the same in both cases, and is also the same whether the granite acts on a mere shale or on a slate; we get a pure white mica, and a corresponding separation of chlorite or its equivalent in biotite, cordierite, etc., all crystallized in every direction in the rock.

To make out the minerals and the structures in the Whin Sill rocks we may need high powers, whereas we may see all these things with low powers, or a pocket-lens, in the sections from a granite-contact; but this is a matter of no importance, and is related to nothing beyond the respective bulks of igneous rock concerned, and probably also the greater or lesser depths of the invaded rocks, with corresponding differences of their initial temperatures. The same considerations apply also to the frequent abundance of certain special minerals at granite-contacts, and their absence, or rarity, in the Whin Sill rocks. Leaving aside these conditions of mere size and intensity, the results are strikingly

parallel ; and a concurrent examination of a series of rocks from the two sources does not fail to impress one with the idea of how relatively slight and mild a degree of contact-action is required to bring about certain very definite and characteristic effects. I have compared these Whin Sill rocks over and over again with contact-rocks from several localities, and quite recently, whilst once more passing them in review in connection with the putting together of these notes, I have had the opportunity of looking at them side by side with a fine series from Scotland. One can often pick out examples of both, which, barring certain minerals (as e.g. kyanite), are so exactly similar in structure and general nature, that the slide from the granite-contact might be almost imagined to be derived from one from the Whin-contact by some process akin to photographic "enlargement," every detail being reproduced.

But, on the other hand, we may compare these Whin Sill sections with any number of examples of rocks which have suffered the most intense degrees of crushing and shearing, and which have been under enormous depths of cover, without being able to find in these latter any signs of even a *commencement* of the characteristic *structures,* or more than a very moderate amount of the mineralogical development. Such rocks as these, as I have shown in former notes (e.g. GEOL. MAG., July and August, 1896), certainly display a decided degree of advance beyond the clays and shales from which they started. We have the formation of new mica and of chlorite, going along the same chemical and mineralogical lines as in contact-action ; but it does not seem to be able to pass beyond relatively moderate limits, giving us a still impure mica. And in the matter of structure the limits are still more restricted. We do not get beyond a felted and wavy mass of mixed mica and chlorite ; there is no growth of crystals of mica at all angles and in all directions, no criss-cross structure, no rosettes and sheaves, and no sign anywhere of crystallization of chlorite. Neither do we ever see any trace of the amorphous, or semi-amorphous, and speckly material passing upwards into definite mica, etc., which I have pointed out as so frequently characteristic of rocks which have recrystallized under contact-action. Nor do we see in such rocks any trace of biotite or other special minerals which we know so well in contact-rocks. Yet all these things which we may thus find to be absent from some most ancient sedimentary rocks after they have had every allowance of time, dynamic action, and depth-conditions, we see can be produced in similar materials, almost instantly, as it were, by the action of a relatively insignificant amount of igneous magma intruded among them ; the evidence in the special case before us being quite beyond the possibility of confusion or question, as to the fact that these effects are wholly due to the intrusion and to nothing else, and thus much simpler and clearer than often is the case in granite areas.

These observed facts, and the considerations arising out of them, duly weighed, seem to lend a reasonable degree of probability to the conclusion I have suggested on other occasions, viz., that so

far as our present actual *knowledge* goes, there are structures and mineralogical developments which, whenever we see them, even in moderate degrees of evolution, we are not only justified in ascribing to contact-metamorphism, but which we have not an atom of reason or evidence for attributing to any other cause, no other cause having as yet ever been *proved* to produce them; and certainly not dynamic action, as to which we can collect plenty of very clear evidence that it has failed over and over again to bring about even the beginnings of them, under the very circumstances which ought to be most favourable for its doing so.

When we look at this matter quite calmly, it certainly does seem rather strange that the " blessed word " dynamometamorphism has been allowed to exercise such a spell over our minds in directions in which it can hardly be said to have ever made good its pretensions. Here were rocks of sedimentary origin, showing very great and striking mineralogical developments. They also showed beyond question that they had undergone great dynamic action. Therefore the latter was the cause of the former. In how many cases has there been but little better evidence than this to support its all-embracing claims, which were made to explain everything without proper proof! And at the same time we have, all around us, examples of the fact that what dynamic action has been asserted, but not proved, to do, is done not only by every great intrusion of granite or other igneous rock, but by even quite small intrusions also.

Let a great area of sedimentary rocks be altered by the action of igneous masses which we cannot see ; then let powerful dynamic action follow, and there we have at once a fine example of the marvellous recrystallization and formations of new minerals which dynamic metamorphism has brought about, shutting our eyes to other cases in which even more intense action, on similar materials, has effected practically nothing of the sort.

If we take simply what we at present *know*, and can prove over and over again, and separate it from what is certainly not at all proved, no matter how strong the *a priori* evidence may sometimes appear, it would seem to be quite reasonable if we were to regard certain microscopic structures of altered sedimentary rocks as probably indicating that the alteration took place under the influence of contact-metamorphism, no matter whether we can actually see the igneous rock concerned in it or not. On a similar line of reasoning from what we know, we might also draw the same inference from the development of certain minerals in such rocks, not only the specially so-called " contact-minerals," but others as well. Thus, the presence of undoubtedly newly-formed biotite in altered shales and slates should point the same way, till we have some evidence that any other process known to us can be proved to have the power of producing it. And it might even not be going outside the safe ground of induction if we were to include very highly developed and individualized muscovite, and certain forms of chlorite, under the same head.

Of these several points, that of *structure* certainly appears to be

the most important, and the safest on which to rely, whenever we find it. But we know that dynamic action may have more or less completely effaced this structure, and in a great number of cases has done so.

We know on what lines this effacement proceeds, and with what sort of new structures it replaces those it has modified or destroyed. It is, however, not uncommon to find that, even in greatly affected "dynamic" areas of this description, the action has not embraced the whole of the rock, and from among rolled-out, sheared, and puckered schists, may come specimens showing, more or less perfectly, the contact-structures which we seem to have good grounds for always recognizing as such.

NOTICES OF MEMOIRS.

COMPASS VARIATION AFFECTED BY GEOLOGICAL STRUCTURE IN BUCKS AND MONTGOMERY COUNTIES, PA.[1] By BENJAMIN SMITH LYMAN.

THE Journal of the Franklin Institute, October, 1897, contains an interesting paper by Mr. B. Smith Lyman, formerly State Geologist to Japan, describing a remarkable coincidence between the axis of a set of curves of magnetic variation in Bucks and Montgomery Counties, Pennsylvania, and a great deep-seated fault in the New Red strata below ending westwards in the axis of an anticlinal fold. Both the curves and the fault are shown on an accompanying map. From this paper we extract the following passages :—

The magnetic curves were mapped some years before the beginning of the recent Geological Survey, that for the first time fully proved the peculiar structure ; but the curves had no influence whatever in the interpretation of the geology, and the correspondence was not perceived until long after the geological map was printed.

The magnetic map was made about the year 1883, by the Water Department of the city of Philadelphia, for use in its excellent topographical survey of the Perkiomen and neighbouring valleys under Mr. Rudolph Hering. The map records the results of a number of determinations of the magnetic declination made by the Water Department itself and by the Coast Survey and by other observers, and curves of equal declination were drawn for every tenth of a degree. The curves are so extremely at variance with the simple, nearly straight lines of earlier, less detailed maps, as either to show extreme confidence in the accuracy of the observations, or perhaps even to excuse a suspicion of the possible incorrectness of the curves in some way, especially in view of the acknowledged want of precision of some of the observations, and the absence of any obvious topographical or other occasion for such

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[1] Reprinted from the Journal of the Franklin Institute, October, 1897. Mining and Metallurgical Section : Inaugural Meeting, held April 28th, 1897.

great irregularity.   But the curves are in the main beautifully confirmed and thoroughly vindicated by the underground geology.

The striking feature and dominant peculiarity of the curves is a very strong bend convexly north-eastward near New Hope and Lambertville, on the Delaware; but gradually changing towards the west, so that the curves near Shwenksville and Boyertown point still more sharply south-eastward. The axis of the bend in the curves is, then, itself greatly bent, nearly to a right angle. The Geological Survey of the two counties, begun at the end of 1887, has proved beyond a question the existence of an enormous fault, of about 14,000 feet, in the rock beds, almost precisely on the line of the Delaware River end of that magnetic axis, and following the same course past Doylestown, gradually dying out, and west of that town turning north-westward, passing north of Shwenksville, disappearing there as a fault, but continuing as a sharp anticlinal to the border of the New Red and of Montgomery County, 5 miles north-east of Boyertown.

The geological structure of the map of 1893, published by the State Geological Survey, was drawn without the least reference to the magnetic curves, and, indeed, without any knowledge at that time of the slightest correspondence between them and the geology. The geological map gives the direction and amount of the dip at a couple of thousand points, amounting to a complete demonstration of the structure, and to a full proof of the situation and extent of the fault and of the sharp anticlinal into which the fault runs. The topography also given on the same map shows that there is no one strongly-marked ridge following the course of the axis of the magnetic curves. Indeed, there are more decided topographical indications in the way of long, rather high ridges in other directions. Furthermore, the form of the outcropping rock beds, sedimentary or igneous, does not correspond in any degree with the magnetic curves.

Moreover, some light is perhaps thrown upon the obscure subject of terrestrial magnetism. It is true, the nature of the relation between the magnetic and geological phenomena is not so easily determined; but it seems to become certain that the internal structure of the earth's crust has an important influence upon terrestrial magnetism, even if it be not in any degree its first cause. Terrestrial magnetism and its changes have sometimes been considered explainable by solar influences alone, no longer by direct action of the sun as a magnet, but by the sun's heating the atmosphere or the earth's crust. The present phenomena seem, however, to point to more strictly terrestrial processes as the true cause, and to suggest that the solar influence may partly at least be exerted through the attraction of gravitation as well as through heat. The enormous and locally unequal strains produced by the contraction of the earth's crust in cooling would be particularly liable to be affected by the presence of a deep fault or by a sharp anticlinal. Such lines would be places where the crust has yielded and is readier to yield, and consequently where the strain has

been to some extent relieved and is less. The recent occurrence of earthquakes along the New Jersey end of this very fault-line shows that the resistance there is less, and that the remaining strain must likewise be less. On such a comparatively weak yielding line the rock beds in readjusting themselves, even where there is no violent earthquake, must occasion a certain amount, not only of strain, but of friction and heat that might give rise to electrical currents. A decided magnetic effect, too, has sometimes been observed to accompany earthquakes, and in some cases to precede them. In like manner, the strains and yielding or readjustment that may be occasioned by the attraction of the sun and moon might apparently cause electrical currents ; and, in fact, magnetic disturbances have been found to correspond, like tides, with the place of those heavenly bodies. Again, the broken or arched form of the rock beds may permit at least a temporary local variation in the temperature of the crust, as affected by the earth's hot interior, that could occasion electrical earth currents. Terrestrial magnetism seems, then, to arise not only from the manifold action of the sun's heat upon the air and the earth's crust, but from the internal movements of the crust and from the tidal effect of the sun and moon upon the air, ocean, and solid earth.

The author does not admit that the magnetic curves could have been produced by any known deposits of iron-ore or trap, near or distant ; comparing such an idea to the ancient Oriental tales of the loadstone that drew men's boot-nails, or the seaside mountain that pulled the bolts out of ships' sides. He adds :—" Deposits of magnetic iron-ore, though differing much in magnetic force, seldom directly affect the most delicate magnetic needle at a distance of more than a few hundred feet."

REVIEWS.

BRITISH DEER AND THEIR HORNS. By JOHN GUILLE MILLAIS, F.Z.S., etc. With 185 text and full-page illustrations, mostly by the Author, assisted by Sidney Steel, two by E. Roe, and photographs ; and a series of unpublished sketches by Sir Edwin Landseer. Imp. 4to ; pp. xviii and 224. (London : Henry Sotheran & Co., 37, Piccadilly, and 140, Strand, W.C. 1897.)

(PLATES III AND IV.)

MR. MILLAIS is already favourably known to the public as the author of " Game-Birds and Shooting Sketches " and " A Breath from the Veldt," both rich in illustrations. Although a thorough sportsman, and, like his father, the late Sir John Everett Millais, Bart., R.A., a born artist, Mr. John Guille Millais combines with these qualities sufficient of the true naturalist and palæozoologist, to lead him in his " History of British Deer and their Horns " to enter upon a brief account of the ancient types of deer which inhabited these Islands in prehistoric times,

and whose skeletons and antlers preserved in the British Museum (Natural History), Cromwell Road, or in other kindred institutions, now form their only record.   Many of these Mr. Millais has sketched with commendable fidelity.   It is difficult to separate the extinct *Alces latifrons*, found in the Cromer Forest Bed and at Happisburgh and Corton, and on the Dogger Bank, from the living elk (*Alces machlis*) found subfossil at Cleveland, Yorkshire, and in about thirty-one English, Scotch, and Irish localities, and which still survives in Norway and in Canada.

To the same northern category also belongs the reindeer (*Rangifer tarandus*), which is recorded from more than eighty localities in this country, is still living in Northern Europe, Asia, and America, and is believed to have survived in Caithness until the middle of the twelfth century.   Of fossil varieties of the true deer, *Cervus polignacus*, *C. Brownii*, and *C. Savini*, little need be said. They are forms closely related to the existing fallow-deer (*C. dama*).   *Cervus Dawkinsii* and *C. Fitchii* are most probably related to the elk (*Alces machlis*) ; *C. verticornis*, *C. tetraceros*, and *C. Sedgwickii* are all from the Norfolk Forest Bed at Cromer, Bacton, and Kessingland.   *C. tetraceros* has the beam more or less straight, with the tines rounded, simple, and springing all from one side of the beam.   *C. Sedgwickii* has the beam flattened and more arched, and the tines, although upon the same plane, are flattened and branched.

There is yet another extinct deer (the *Cervus giganteus*), the largest of all the Cervidæ, whose remains have been obtained not only in great abundance, but in so perfect a state, in Ireland that entire skeletons are to be seen in many of our Museums, whilst the antlered skulls adorn many noble residences in England, Scotland, and Ireland.   Formerly known as " *Megaceros Hibernicus* " or as " the gigantic Irish elk," yet it is in no wise related to the elk, although frequently spoken of as such.   It is in every respect a true deer, and in many of its characters (save that of size) not unlike our existing fallow-deer.

When it is stated that these deer frequently measure 9 feet across the antlers, the weight of which is as much as from 80 to 90 lbs., one is astonished at the amount of vital energy in such a beast as would enable it to throw out year after year such a mass of osseous matter in the short period of four months, for the horn-growth of the *Megaceros* doubtless followed the same rules as those which govern the horn-growth of other deer to-day.

" In the British Isles this deer seems to have been most numerous in Ireland, where remains are found below all the peat-bogs in the lacustrine shell-marl.   In County Limerick the greatest number of heads has been dug up, notably in the extinct Lake of Loch Gur, where literally hundreds of them have been unearthed.   In 1875, Mr. R. J. Moss made excavations in the bog of Ballybethag, 9 miles south-east of Dublin, and during the summers of 1876–77 twenty-six heads and three complete skeletons were procured. Below the great bog, in the vicinity of Tullamore, is another

productive district, as is also the margin of Loch Derg (Co. Galway) and Killowen (Co. Wexford).

"The first tolerably perfect skeleton of *Megaceros* was found in the Isle of Man, and was presented by the Duke of Athole to the Edinburgh Museum in 1820." [1] In 1896 a second, nearly perfect, example of *Megaceros* was obtained near Poortown in the same island. (See p. 116.)

In England the remains of this great deer are rare. The first skull and antlers were dug out of the peat-moss at Crowthorpe in Yorkshire. About twenty-nine localities are recorded, but the remains are exceedingly fragmentary. In France its remains are said to have been found near the foot of the Pyrenees ; in the valley of the Oise it has been found associated with the mammoth, the rhinoceros, the musk-ox, the reindeer, and hippopotamus. There is one skull with imperfect antlers in the British Museum from as far east as the Government of Orbowschen, in Russia. Complete heads and antlers have recently been found in the south-west of Scotland.

There is good evidence for the conclusion that after the great deer had spread into Ireland, and probably long before its extinction in this country or in Western Europe, Ireland must have become isolated from England, and during a long succeeding period the *Cervus giganteus* lived and flourished in that island, and was neither exterminated there by prehistoric man nor by any of the Carnivora, but by a great and gradual change which took place in the climate of that country. This change, in which Scotland and a part at least of England also partook, was an increase in cold and a settled humidity of climate, tending to a great growth of peat, which in time filled up the former extensive fresh-water lakes, once so abundant, and injuriously affected the forest growth over large areas of the country. With this change the great Irish deer died out; but its remains show that it was living there before the growth of *Sphagnum* or bog-moss had taken place, for they rest in the shell-marl beneath the peat. This shell-marl is really composed of the accumulated deposit of dead and decomposed shells of fresh-water *Unio*, *Anodon*, and *Limnæa*, so that it represents a long and tranquil period of time during which conditions were favourable to forest growth, and consequently to the deer and the other denizens of the woods and waters.

We give a diagram-sketch by Mr. Millais of the way the Irish deer occurs beneath the peat (see Woodcut). The man who searches for the megaceros-heads uses a rod about 25 feet in length. First of all he takes a survey of the bog, and from long experience knows where to commence his probing in what seems a likely spot. Should the iron strike stone or gravel, he knows by the gritty feel, whilst horn gives a dull thud, and by turning the rod round and round the searcher is able to tell of what nature is the substance he has struck.

[1] This skeleton from the Isle of Man was described by Baron Cuvier in his "Ossemens Fossiles," tome iv, pl. viii, fig. 1.
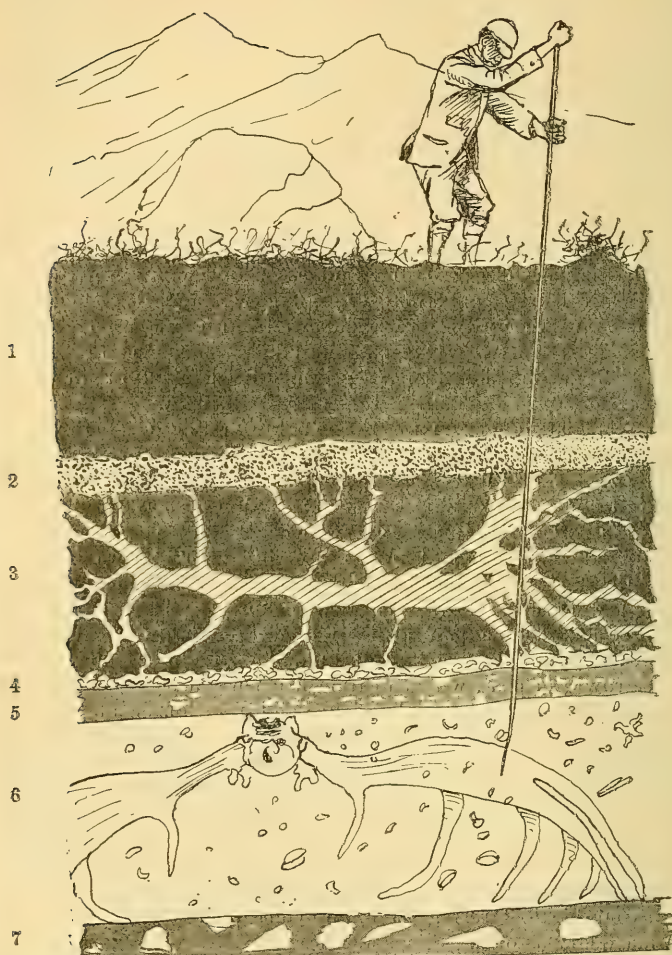
HOW THEY HUNT THE IRISH DEER AT THE PRESENT DAY.

Showing mode of finding the heads, and the strata in which they are generally imbedded.

1. Peat (top layers), 3 feet.
2. Gravel, 6 inches.
3. Peat (lower layer with trees), 3 feet.
4. Layer of oak-leaves, 3 inches.
5. Blue clay (mixed with shells), 6 inches.
6. Lacustrine shell-marl (with remains of *Megaceros*, and fresh-water mollusca), 3 feet.
7. Blue clay, mixed with subangular stones.
    (Thickness shown in diagram, about 12 feet. Many of the peat-bogs are *far thicker*.)

Many a time a day's digging only produces a head not worth lifting, owing to its being broken in many pieces, or perhaps it is only a dropped antler.

As to the causes which have led to the extirpation of the larger mammalia, we do not think it necessary to postulate a universal cause or agent of destruction before which all the big herbivora were swept away. Professor Owen long ago pointed out that the large mammals were always the first to suffer from floods or from droughts ; events which happen most frequently within the tropics, but which may occur occasionally in almost any country.

Nor can we look at the accumulated · results of subaerial and diluvial action, especially in such an extensive region as Argentina, without perceiving that æolian agencies—wind-storms, dust-storms, rain-storms, and floods—acting on the Sierras and higher plateaux for thousands of years, have led to the gradual accumulation of those vast masses of fine material which have built up the great Pampean formation, while along the course of the great alluvial valleys cut through its deposits by the rivers flowing from the north, lie buried many hundreds of giant Mylodons, Megatheria, and Glyptodons, once the denizens of the wooded region of Central South America.

The discovery of thousands of remains of great wingless birds in the superficial deposits of New Zealand has no connection whatever with the destruction of giant Edentates in South America, nor with giant deer in Ireland, save that man the destroyer was for a long period absent from the scene, and the *Dinornis* and its kindred enjoyed for many centuries undisturbed possession of their island-home, the *Harpagornis*, a large hawk, being the only bird of prey, and no Carnivora having reached New Zealand except seals.

With man came the hunter-element (see Plate III), and the "fire-stick" ; and the forests, being not unfrequently accidentally lighted, the affrighted game (whether deer or Moas) fled towards the water to escape from the fire, and met their death by drowning in the morasses they attempted to ford.

In Australia the destruction of the large Marsupialia was probably not unfrequently caused by drought, which has so often proved fatal to the flocks and herds of the squatter in our own time. There, too, also local floods often prove, as in South America, most destructive, although of short duration, and these may even in a single night affect a vast area of country.

Mr. Millais has figured many fine antlers of Irish deer, notably those forming part of the complete skeleton of *Cervus giganteus* in Sir Edmund Loder's Museum at Leonardslee (pp. 4 and 9) ; and four heads on p. 19, from Loch Gur, from the Royal Dublin Society, from County Waterford, and from Limerick, which illustrate remarkable divergences in mode of growth. The antlers in these specimens have lost their original crescent-form and become too much flattened out. This may either have been caused when the antlers were softened from lying in the bog, or afterwards, when mounted, they have bent downwards by their own weight. Originally they were certainly more V-shaped. On pp. 14 and 15 are given

two views of a splendid head and antlers from near Tullamore,
Ireland, in the possession of the Duke of Westminster, in which
the palms are enormously developed.

There are remains of 19 individuals in the British Museum,
comprising 4 complete skeletons, 3 antlered males and 1 of a (horn-
less) female ; 2 skulls of hinds from Naull, Co. Dublin ; 8 skulls
with antlers which have no special locality save " Later Tertiary
deposits, Ireland"; 1 head from Red Bog, Dunshaughton, Ireland ;
1 skeleton from Axe Corey, Co. Wexford ; 2 skulls of males with
shed antlers from the Dogger Bank ; and 1 head from Russia.

The remaining types of British Deer—the " Red-deer " (*Cervus
elaphus*) ; the " Fallow-deer " (*Cervus dama*) ; and the " Roebuck "
(*Capreolus caprea*)—are so well known in the living state, that
they would appear to have little claim on the attention of the
palæontologist.   When, however, we study the Pleistocene deposits
of our Island, we are led to find that even these denizens of our
parks have a more or less remote geological history, not wholly
devoid of interest.

Taking the red-deer as the typical representative of a great group
of Cervidæ, which are spread over Europe, North Africa, Asia (north
of the Himalayas), and North America, we find these are mainly
characterized by the conformation of the antlers.   In this type the
brow- and bez-tine are both present ; the beam is nearly cylindrical,
subdividing into two or more points at the summit.

The group of allied species would include the red-deer (*Cervus
elaphus*) ; the Canadian wapiti (*C. Canadensis*) ; *C. maral* ; the
Thian-shan deer (*C. eustephanus* or *C. Leudorfi*) ; the Amurland deer
(*C. xanthopygus*) ; *C. corsicanus* ; the Barbary deer (*C. barbarus*) ; and
possibly also the Hangul or Cashmir deer (*C. Kashmiriensis*).   Our
brickearths, cave-deposits, and peat-bogs also yield evidence of
deer-remains far larger in size than those now living, so that
there can be little doubt that, ancestrally at any rate, the great
red-deer and the wapiti were closely related.

In Flower & Lydekker's great work on Mammals, living and
extinct, stress is laid on the absence of a cup at the surroyals,
as distinguishing the wapiti from the red-deer ; nevertheless, many
red-deers' antlers have no trace of the cup whatever.   Indeed,
after studying a long series of them one cannot help feeling
that the richly crowned antlers of certain red-deer from the peat,
notably the pair obtained from the bed of the River Boyne at
Drogheda, Ireland (part of the Egerton Collection), owe their
unusual development to specially favourable environments and
abundance of food, as exemplified in the collection of magnificently
crowned heads preserved in the Castle of Moritzburg by H.M. the
King of Saxony (sixty of the choicest of which have been figured
by Dr. A. B. Meyer, Director of the Royal Zoological Museum in
Dresden, in two volumes, royal folio, one vol. published in 1883
and one in 1887).

In Mr. Millais's work (p. 23) he writes : " The Warnham deer are
second to none in this country in the matter of body and horn.

Their origin, however, is quite recent, and even after the introduction of the Stoke deer, by which the herd was strengthened some years ago, they were in no wise remarkable until the late Mr. F. M. Lucas took them in hand and began a series of experiments with a view to improving the pasture—about 250 acres in extent. Every alternate year he dressed the land with bone-dust, the effect of which soon made itself felt. The nutrimental qualities of the grass seemed to be improved 70 per cent., yielding exactly what was wanted for fattening and horn-growing. Half the park is reserved for hay, so the red-deer, which number about 100, have no great extent of ground to range over and very little winter-feeding. Nevertheless, they thrive and have continued to improve steadily since 1884, when the dressing was first tried, and at the present time a four-year-old Warnham stag is better than an adult animal in most other English parks." (See Pl. IV.)

Mr. Millais gives on p. x an illustration of a pair of antlers grown by a stag living on an open heather-covered mountain (Castlewellan, Ireland), with but little wood-shelter at the base. Two other heads on pp. 130–1, one from Braemore forest, Ross-shire, the other from Eskdale, and the pair of fossil antlers from Bakewell, Derbyshire (figured in Pl. II, GEOL. MAG., Feb. 1898), may serve to illustrate the simpler form of red-deer antlers in which the cup and highly-branched crown are but little developed; the beam may be of great strength, but it and the tines are well-formed, symmetrical, and well-adapted for offence and defence. This type appears to be a mountain-dwelling, hardy, fighting stag. The crowned antlers with such a large number of points (often from thirty to forty) are found in the peat-deposits, and belonged to stags which must have been as well-fed in a natural state as are those in Mr. Charles Lucas's park at Warnham Court, or in the German deer-forest of the King of Saxony at Moritzburg. Clearly, in these latter instances, the excessive richness of the growth of antlers is a luxury which would only be found exceptionally in a wild state, and must require special care for its proper maintenance even in a park-herd (or under domestication).[1]

Passing over the fallow-deer as affording less geological interest, we come lastly to the little roebuck, *Capreolus caprea*, a small form of deer and a truly wild denizen of our woods, being found in Dorsetshire, Hampshire, and Essex, in the south, in the west in Wales, away north to Scotland, and widely over Europe and Western Asia. The male is somewhat over 2 feet in height at the withers, of a dark reddish-brown colour in summer, with a white patch on the rump. The small antlers stand close together at their base, have a short rugged beam, rising vertically, then bifurcating, the posterior branch again dividing. The roe-deer dates from the

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[1] Mr. Lydekker, F.R.S., informs the writer that there is a magnificent series of red-deer antlers to be seen in the Hall of Hampton Court Palace, where they may have been since the days of its founder, the famous Cardinal Wolsey, in 1525, or since its rebuilding by Wren in 1690.

Pliocene period, and is doubtless related to several other small Cervidæ, some of which, like the Chinese water-deer, are hornless forms.

We must now part with Mr. Millais, but we do so with regret. We cannot imagine a more charming book for the Library table of a country house than his " British Deer and their Horns."

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

January 19, 1898.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read :—

1. " On some Gravels of the Bagshot District." By Horace W. Monckton, Esq., F.L.S., F.G.S.

The author refers to his papers on Gravels South of the Thames published in the Quart. Journ. Geol. Soc. for 1892 (p. 29) and 1893 (p. 308), and gives some additional details.

He suggests that the occurrence of stones which have been very little rolled or waterworn in gravels at certain localities affords evidence of the presence of ice in the water by which those gravels were deposited, and that the position of some sarsens which he describes is due to the same agency.

He gives details and exhibits photographs of a number of sarsens which he has seen *in situ*.

2. " On the Occurrence of Chloritoid in Kincardineshire." By George Barrow, Esq., F.G.S. (Communicated by permission of the Director-General of the Geological Survey.)

The rock containing the chloritoid was first found *in situ* at the entrance to the little gully at the head of Friar Glen Burn, near Drumtochty Castle. It has since been observed at many places along a belt of country extending from the coast north of Stonehaven nearly as far as the North Esk.

The rock is easily recognized by the presence of numerous white spots, which are always present and are larger than the chloritoid. The chloritoid and the spots vary in size, being largest when the rock is most crystalline (a schist), and smallest when it is least crystalline (a slate). The mineral appears as minute glistening scales in the schist, but in the slate it can be recognized only with the aid of the microscope.

The optical characters are described, and shown to be identical with those of the mineral from the Île de Groix, and with those of the ottrelite from Ottré and Serpont.

An account of the methods adopted to obtain a pure sample is given. Several analyses were made, and it was proved that as the purification increased the analyses approximated more and more closely to the analysis of the mineral from the Île de Groix.

The final result was as follows :—

Si O₂	26·00
Al₂ O₃	40·05
Fe O	19·50
Fe₂ O₃	5·05
Mg O	2·88
Loss on ignition	6·00
Total	**99·48**

The author discusses some of the published analyses, and suggests that many of the discrepancies may be due to impurities in the material analyzed.

CORRESPONDENCE.

THE AGE OF THE RAND BEDS.

SIR,—In the GEOLOGICAL MAGAZINE, 1897, p. 549, Mr. W. Gibson states that I have obtained fossils of doubtful Carboniferous age from a dolomite associated with the Gat's Rand Beds. I am not aware of having made such a statement, and it certainly does not occur in the paper alluded to ("The Occurrence of Dolomite in South Africa," Q.J.G.S., vol. L, p. 561). In fact, so far as I am aware, no fossils of any kind have hitherto been discovered in the Dolomite of this country.   DAVID DRAPER.

JOHANNESBURG, *Dec.* 31, 1897.

THE OCCURRENCE OF *PLACOPARIA* IN THE SKIDDAW SLATES.

SIR,—In the course of my work on the Graptolite Fauna of the Skiddaw Slates I have come across two specimens of the trilobite *Placoparia*. No mention of this form is made by Postlethwaite and Goodchild in their paper on the " Trilobites of the Skiddaw Slates " (Proc. Geol. Assoc., vol. ix, p. 455), and as it is known to be characteristic of a definite horizon in other localities, it seems worth while to place on record the occurrence of this genus in the Lake District. The specimens in question come from two different localities, Outerside and Ellergill, and are in the Woodwardian Museum. The Ellergill specimen is a recent gift from Professor H. A. Nicholson.   GERTRUDE L. ELLES.

WOODWARDIAN MUSEUM, CAMBRIDGE, *February*, 1898.

OBITUARY.

OSCAR FRIEDRICH VON FRAAS.
BORN JANUARY 17, 1824.   DIED NOVEMBER 22, 1897.

WE regret to announce the death of the veteran geologist Dr. Oscar von Fraas, of Stuttgart, Director of the Royal Würtemberg Museum of Natural History. He was born at Lorch, in Swabia, in 1824, and after his ordinary education at school he proceeded to the University of Tübingen. There he devoted special attention to

theology, with the intention of entering the Church; but he was at the same time also deeply interested in natural science, and he attended the lectures of Quenstedt, who filled him with enthusiasm for geology and palæontology. He worked hard in collecting fossils and making geological observations in Swabia, and when he had the opportunity of spending a year in Paris, in 1847, he attended the lectures of D'Orbigny and Elie de Beaumont at the School of Mines. On returning to his native country, Fraas followed his theological profession, and from 1850 to 1854 he was pastor of Laufen a. d. Eyach. In 1854 he became Conservator of the Department of Mineralogy and Palæontology in the Royal Würtemberg Museum at Stuttgart, an office which he held until a few years ago, when, on the retirement of Dr. von Krauss, he succeeded to the Directorship, and left his son, Dr. Eberhard Fraas, in charge of the minerals and fossils. In the course of his official labours, Dr. Oscar von Fraas not only made the Stuttgart collection one of the finest in Europe, and enriched it with Swabian fossil batrachians, reptiles, and mammals, many of which are absolutely unique; he also published popular writings to interest the people in his work, and carried on a long series of researches, of which the results appear in more than sixty papers and memoirs. Most of these relate to the geology, fossils, and prehistoric archæology of Würtemberg; but some also recount his experiences in the East, which he visited in 1864–5, and again in 1875. He paid special attention to the geology of the Lebanon; and the scientific results of his journeys through Syria are collected in a small volume entitled "Aus dem Orient," which was published in two parts (1867 and 1878). Among his larger memoirs, those on the Miocene Mammalian Fauna of Steinheim (1870), and on the armoured reptile *Aetosaurus* from the Swabian Trias (1877), are especially important contributions to knowledge. Dr. Oscar von Fraas was elected a Foreign Correspondent of the Geological Society of London a few days before his death.

LIEUT.-COLONEL CHARLES COOPER-KING, F.G.S.

Born February 4, 1843.   Died January 16, 1898.

CHARLES COOPER-KING, Lieut.-Colonel Royal Marine Artillery (retired), died at his residence, Kingsclear, Camberley, Surrey, on the 16th of January, 1898, aged nearly 55 years. The only son of Major U. H. King, R.M., Light Infantry, he was born at Plymouth. He was at school there until the end of 1859, passed into the Royal Marines as a Marine Cadet in January, 1860, second on the list, and joined H.M.S. "Excellent." He passed as a Second Lieutenant R.M. at the Royal Naval College, Portsmouth, first on the list (1862); and, recommended for the R.M. Artillery, he was gazetted at Fort Cumberland. In 1864, he was appointed to command the detachment of Marines on H.M.S. "Scylla" in the China seas and Japan. He was promoted to First Lieutenant in 1865; and rejoined headquarters (Eastney) in 1867. He passed (fourth) into the Staff College, July, 1868; and in August he

married Harriet, daughter of the late C. V. Garrett, of Southsea. Passing out of the Staff College, first on the list, and specially recommended, he went through the usual course of study and practice in regimental duties at Aldershot, and the long course of gunnery at Woolwich and Shoeburyness (1871). He was appointed Instructor of Tactics, Administration, and Law at the Royal Military College at Sandhurst, 1872; and was Professor of the same subjects 1878–1885. His promotion as Captain dates November, 1875, and Major by Brevet, 1879. He retired from the Service February, 1886; and devoted his time and energy as a military instructor or "coach," preparing subalterns of the 'Militia for commissions in the Army. He leaves two daughters and five sons; two of the latter are Lieutenants in the Army.

After the systematic study of geology and chemistry was eliminated from the curriculum at the Staff College, and the professorships thereof had ceased, Colonel C. Cooper - King succeeded Major Mitchell as Lecturer on Geology in 1886. Dealing also with such other branches of Natural Science as the officer-students could find time to study, his synopsis of these lectures on "Applied Science" embraced not only the land, but water (fresh and salt), air and weather, magnetism and electricity, as well as food and forage. Colonel Cooper-King drew a large class to geology, both in the lecture-room and the field; for, being a military expert himself, his explanations of the science in relation to military tactics and battlefields were well appreciated.

Whether on the blackboard or on paper, his apt and facile illustrations of geological conditions and natural-history facts were very acceptable to his students and his scientific friends. Always observant, and ready with pen and pencil, his notebooks were rich with reminiscences of places and people, visited or met with, at home and abroad. In spite of frequent illness, due to rheumatism and heart-failure, his energy spurred him to persist as a hard worker, whether in the study on literary matters, in the field as military correspondent, or in his class-room among military students. Many of his friends in the Army remember with pleasure, and often with gratitude, the advantages they received from his teaching, as private instructor or at college; and, indeed, he was always ready to help, both cadet and officer, with advice and solid information.

He was an Assistant-Examiner in Geology, Geography, and Physiography for the Science and Art Department (South Kensington) and the Civil Service Commission for twenty years.

As literary work, we may notice his books—"On Map and Plan Drawing," "History of Berkshire," "George Washington," "The British Army," and "The Story of the British Army," the last-mentioned lately published. He was Editor of the "Great Campaigns in Europe," and for some time of "The United Service Magazine." Reviews, notices, and miscellaneous pieces by C. Cooper-King are scattered in different periodicals.

In his "History of Berkshire" (E. Stock, London, 1887), a good

knowledge of geology underlies his sketch of the county and description of the ways and doings, not only of prehistoric man in the region, but of the many events in historic times during the conquests and civil wars of Berks. The natural features, which have had an effect in the development of the county since the first nomad lived and fished along the banks of the Thames down to the time in which we live, are carefully considered. We have here a sketch of the evolution of the county, in its races, its homes, fortresses, arts of life, domestic and military ; and in its ecclesiastical, military, municipal, and civic relations.

In this, too, his antiquarian knowledge gave his story vigour and accuracy. The ancient camps and earthworks were ably elucidated in the Transactions of the Newbury District Field Club, of which he was a worthy honorary member.

His clear and succinct account of the Stone Implement Station in Wishmoor Bottom, near Sandhurst, Blackwater, and Camberley, with a good plan and an explanation of the structure of the ground, is published in the Journal of the Anthropological Institute, vol. ii, No. 6 (January, 1873), pp. 365–372, pls. xx and xxi. Also noticed in the Brit. Assoc. Report for 1872, Sections p. 190.

Colonel Cooper-King was elected a Fellow of the Geological Society in 1872. In 1875, he communicated to that Society a paper, written in conjunction with his friend T. Rupert Jones, on some newly exposed sections of the "Woolwich and Reading Beds" at Coley Hill, Reading, Berks (Quart. Journ. Geol. Soc., vol. xxxi, pp. 451–457, pl. xxii). The features then exposed were correlated with those of neighbouring sections described by Buckland and Rolfe many years ago, and more lately by Prestwich and Whitaker. Two zones of clay-galls were particularly described, and the beds and levels from which these balls of clay (and ochreous nodules) were derived were carefully indicated.

Together with the same friend, Colonel C. Cooper-King had long studied the conditions and characters of the Bagshot Sands ; and his acute observation and thoughtful conclusions must be regarded as having given value to the papers on the Bagshot district published in the Proceedings of the Geologists' Association, vol. vi, 1880–81, pp. 319, 429, etc.

His high grade in college work indicated his mental capacity, strong will, and power of endurance ; and his subsequent career showed his versatility and broad intellectual grasp, also his determination to use his gifts for the benefit of his country and especially of those around him.

Thus a man of talent, of great capabilities, of high attainments, and enormous energy, conscientiously and willingly exercising his powers for the good of others, and working hard for the support of his family even to the last, has passed away, like a goodly fruiting tree torn away by the ruthless tide of a flooded river, which will distribute the seeds in far-off places, where, like those previously shed, they must produce good results.

                                                    T. R. J.

ORIGINAL ARTICLES.

I.—The Earliest Geological Maps of Scotland and Ireland.

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

THE first geological map of Scotland has a history not less interesting than that of Smith's famous map of England; seeing that what Smith accomplished, single-handed, for the southern part of Britain, John Macculloch did, with the same independence of all extraneous aid, for the northern half of the Island. Smith's fame has happily been long since vindicated; but, owing to a variety of circumstances, Macculloch has never received full credit for his grand work; on the contrary, his fair name and even his veracity have been too often cruelly aspersed. Macculloch, though of Scotch descent, was born in the Channel Islands, and educated first in Cornwall and afterwards as a medical student in Edinburgh. He was an excellent chemist and mineralogist, and brought to the study of geological problems an amount of exact scientific knowledge rare in those who at that day turned their attention to the subject. Commencing life as an Army-surgeon, he in 1803, when thirty years of age, was made Chemist to the Board of Ordnance, though the appointment did not prevent him from practising privately as a medical man at Blackheath from 1807 to 1811. In the latter year, however, he gave up medical work and was sent to Scotland to make inquiries as to the best rock suitable for powder-mills. Subsequently, a Commission was formed to ascertain what mountain in Scotland would prove most suitable for experiments similar to those carried on by Maskelyne at Schiehallien, to determine the earth's density.

In this way Macculloch was led to spend much time in travelling about Scotland and in studying the rocks of the country, and between the years 1811 and 1821 he each year devoted portions of every season to geological work in the North. In 1814 he received the appointment of "Geologist to the Trigonometrical Survey," a post to which it had been proposed, as we have already seen, to appoint William Smith in 1805.

John Macculloch was an original member of the Geological Society, and soon became one of the most active workers in it. His paper entitled "Account of Guernsey and the other Channel Islands" was the first which was honoured with a place in the Transactions of the Society, and many other valuable memoirs from his pen found

a place in succeeding volumes.   Macculloch was the fourth President of the Geological Society, occupying the Chair from 1816 to 1818. In 1819 Macculloch published, in two volumes with an Atlas, his "Description of the Western Islands of Scotland, including the Isle of Man, comprising an Account of their Geological Structure, with Remarks on their Agriculture, Scenery, and Antiquities." The maps and sections of this work must be admitted to be of extraordinary merit, when the imperfect topographical data at the author's disposal are taken into account.   His sections, illustrating the relations of igneous to stratified rocks, are of great value, and exhibit a very marked advance on anything of the kind that had ever been produced before.

In 1826 Macculloch, who had collected a vast mass of information concerning the geology of Scotland, received a commission from the Lords of the Treasury to construct a geological map of the country. While he was thus employed, Macculloch received a regular salary from the Government, and, when the map was completed, it was engraved and coloured by the order and at the cost of the Treasury. Macculloch finished the field-work in 1832, and by the middle of 1834 the coloured map was ready for publication, and was, with accompanying memoirs, sent in to the Treasury.

Unfortunately, however, various circumstances seem to have delayed the publication of the work.   There being no Ordnance Map of Scotland at the time, Macculloch was compelled to employ the best private map which then existed—that of Arrowsmith— on which to insert his geological work.   All who have endeavoured to do any serious geological mapping in Scotland, before the publication of the Ordnance Map, will sympathize with Macculloch in his disappointments—frequently verging on despair—in trying to adequately represent the geological structure of the country on such an imperfect topographical basis as that of Arrowsmith's Map. Macculloch's Geological Map of Scotland, which has recently been characterized by a very high authority as "perhaps the most remarkable achievement of the kind which up to that time had been accomplished by a single individual," long remained almost unknown to and neglected by geologists.   In 1851 Murchison referred to it as being "usually known as Macculloch's Map," and as being "so replete with errata that it would be a waste of time to attempt to enumerate them."

Macculloch belonged neither to the school of the Neptunists nor to that of the Plutonists, and not to take a side in those days of embittered controversy was in itself almost accounted a crime.   In the accuracy of his mineralogical and petrographical knowledge, and in his insistence on the importance of such knowledge to the field-geologist, he resembled the disciples of Werner; but by the accuracy of his description of the relation of igneous to sedimentary masses he did more than any other geologist to confirm and establish the principles so well shadowed forth by Hutton.   When William Smith's teaching of the value of fossils in classifying strata had spread, so as to meet almost universal acceptance among geologists

south of the Tweed, Macculloch unfortunately found himself too old, too conservative, and too opinionated to accept the new views and to give them the welcome which they deserved.

In spite of omissions and defects, which it would be easy to point out in any great pioneer work of the kind, Macculloch's Map is a splendid production, and all subsequently published maps of the country have been based upon it. In one important respect the map, as finally published, did not do justice to Macculloch's acumen and research. As is well known, he very early made out the true relations and age of the Torridon Sandstone and its infraposition to the Durness Limestone, in which latter rock he was the first to detect fossils. Murchison and Sedgwick, however, vehemently opposed his views, maintaining that the Torridonian was nothing but Old Red Sandstone faulted down ; and, in deference to their authority, Macculloch allowed his earlier and correct interpretation to fall into abeyance.

If we seek for the causes of the neglect and injustice with which John Macculloch's great work has been so long treated, they are not difficult to discover. In the first place, Macculloch, excellent mineralogist and able geologist as he undoubtedly must be admitted to have proved himself, was a man with many eccentricities of character—some of them not of the most amiable kind—and he became extremely unpopular during the later years of his life. In England, and especially among his earlier associates of the Geological Society, his contempt, strongly felt and often offensively expressed, for "mere amateurs" could scarcely tend to make his company agreeable in circles where geology had been so widely cultivated by unprofessional workers.

In Scotland, a supposed want of patriotism, indicated by a tendency to point out faults in the national character of the Highlanders, was a characteristic of Macculloch which made him the subject of the most rancorous attacks. Embittered by this isolation, and smarting under what he regarded as the undeserved neglect of his work and the unmerited aspersion of his character, Macculloch in some of his later works assumed an air almost of omniscience, and poured unmitigated contempt on all advances in geological science in which he had not taken a share. Macculloch died as the result of a carriage accident in Cornwall within a year of the completion of his map, and when it was only just on the point of being issued to the public. The earliest copies published bore the imprint "A Geological Map of Scotland by Dr. MacCulloch, F.R.S., etc., etc. Published by order of the Lords of the Treasury, by S. Arrowsmith, Hydrographer to the King" ; and one such copy, originally the property of the late John Phillips, which came into my possession on the death of that geologist, I have handed over to the Geological Society, where it is preserved, side by side with the immortal work of Smith. But the title and description of the map were unfortunately merely engraved on a loose sheet to be pasted over the title of the topographical map ; and, after the death of Macculloch, this description was, either by accident or design, usually omitted, and the

geological map was issued as though it were the work of Arrowsmith. It must certainly be admitted that Macculloch's strictures on the topography of the map were of such a character as to be only too well calculated to produce resentment in the minds of the publishers.

From this sketch of the history of Macculloch's Geological Map of Scotland, it will be seen that the first Government Geological Survey carried on in the British Islands was that of Macculloch. It is often said that the work of the Government Survey originated in the grant of £300 per annum made to De la Beche in 1832 to aid him in his labours in the South-West of England. But as we have seen, Macculloch was in 1814 appointed Geologist to the Trigonometrical Survey, and in 1826 was commissioned and paid by the Treasury to make a regular survey of the country ; and his map finished before the date of the first grant made to De la Beche was published at the national expense. This first geological survey of Scotland by Macculloch has therefore just the same right to be regarded as a Government Survey as the second survey of the country which was commenced in 1854 by the late Sir Andrew Ramsay, and is now being carried on by many workers with such admirable skill and energy.

James Nicol's Geological Map of Scotland—a work of great merit —which was issued about 1846, bears much the same relation to Macculloch's map that Greenough's map does to that of Smith's. Nicol's work could not have been executed had not Macculloch's map been in existence, but the younger geologist was able from his own investigations, and by collecting and incorporating the work of many fellow-labourers in the same field, to make his map of Scotland a much more complete and trustworthy work than the original of John Macculloch.

The Geological Map of Ireland by Sir Richard Griffith is well worthy of taking a place side by side with Smith's England and Wales and Macculloch's Scotland. Griffith, who, though born in Dublin, received his scientific training in London and Edinburgh, entered the Government service as an Engineer and Surveyor in 1809, when only twenty-five years of age. For nearly fifty years he was constantly employed, travelling in all parts of the country, examining bogs, mines, and agricultural properties, carrying on the " Perambulation or Boundary Survey of the parishes, baronies, and counties," and making that assessment of the land so well known as "Griffith's Valuation."

In 1812, when Greenough laid the first draft of his Map of England and Wales before the Geological Society, he appears to have pressed upon the attention of his friend Richard Griffith the desirability of undertaking a similar work in Ireland, and in the summer of that year the first draft of such a map was made by Griffith with the aid of notes supplied by Greenough. This draft appears to have been continually added to and improved down to the year 1821, when a proposal for its publication was made by the author in a letter to the Royal Dublin Society. Nothing, however, came of this proposal ; and it was not till 1835, when

1a.

1c × 2.

1d × 4.

1b

3 × 5

4a.

4b.

2 × 4

4c.

5 × 8

Egyptian Echinoidea.

3×5

$2 \times \frac{2}{3}$

$1a$

$1b$

4

Egyptian Echinoidea.
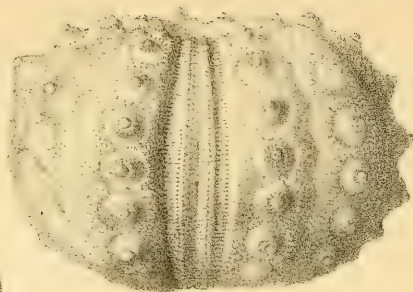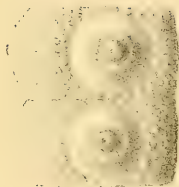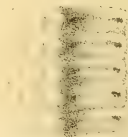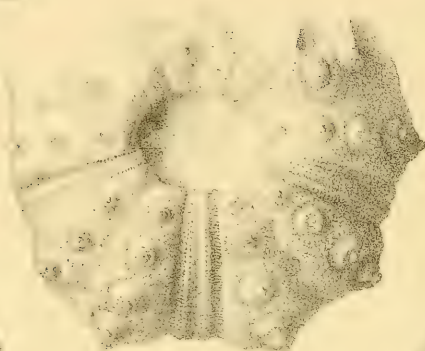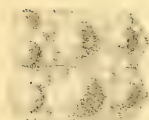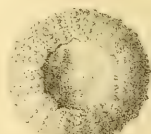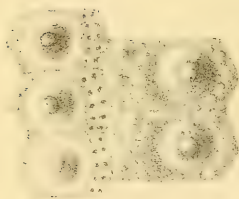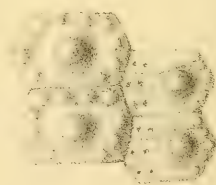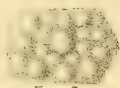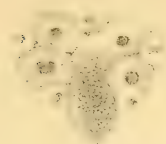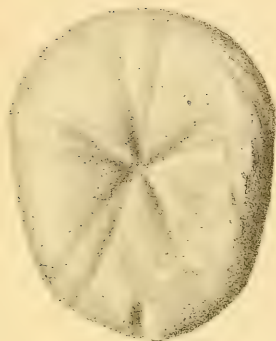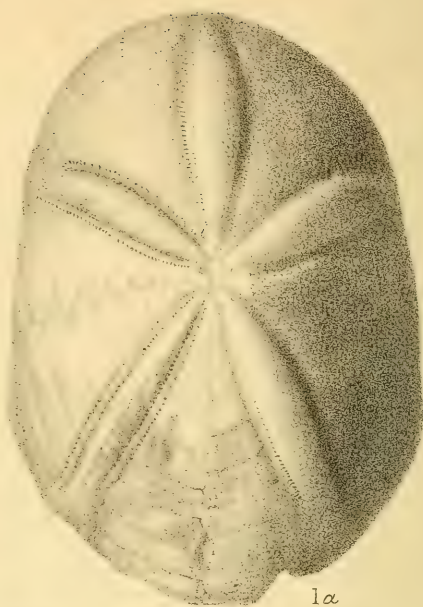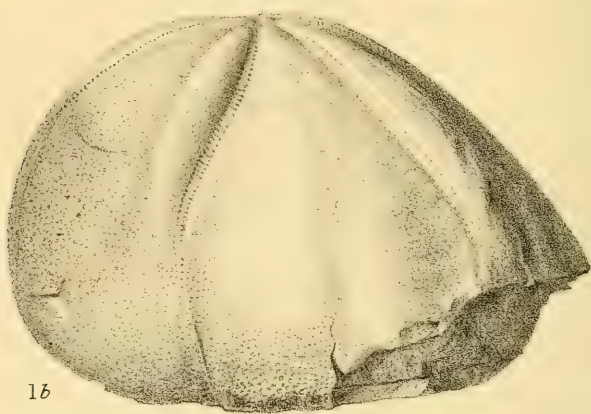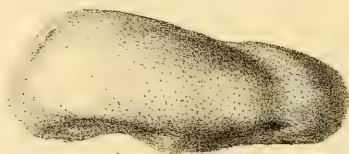
Griffith was President of the Geological Section of the British Association at the Dublin Meeting, that he was able to publicly exhibit in a complete form his Geological Map of Ireland. In the following year, the Irish Government ordered this map to be reconstructed and engraved on a scale of one inch to four miles by the Board of Ordnance. Before the map could be issued, however, Griffith drew up for the Railway Commissioners a work entitled an "Outline of the Geology of Ireland," which contained a reduction of his map, with many of the details omitted. This small map, which was issued in April, 1838, must be regarded as the first complete geological map of Ireland that was regularly published. I have not been able to ascertain whether any of Griffith's earlier manuscript maps are in existence. In August, 1838, the large geological map of Ireland appears to have been exhibited at the British Association Meeting in Newcastle; but it was not regularly published till March, 1839. A second edition of the map was published in 1855 by order of the Treasury.

The Wollaston Medal, which was in 1831 awarded to William Smith for his Geological Map of England and Wales, was in 1854 presented to Sir Richard Griffith for his Geological Map of Ireland. The three pioneer Geological Maps of England, Scotland, and Ireland have now been placed in juxtaposition in the geological gallery of the Science Division of the South Kensington Museum, where they are open to examination and comparison with the earliest geological maps published in France and other countries. A study of these maps will serve to demonstrate the priority claimed, and justly claimed, by Fitton, for the geological maps of this country over those of any other part of Europe.

The Geological Map of the Basin of Paris by Cuvier and Brongniart was published in 1810, while William Smith's early maps had appeared in 1799 and 1801; and the maps of England, Scotland, and Ireland, by Smith, Macculloch, and Griffith respectively, were published in 1815, 1835, and 1838, the first complete Geological Map of France, that of Elie de Beaumont and Dufrenoy, making its appearance in 1840.

II.—A COLLECTION OF EGYPTIAN FOSSIL ECHINOIDEA.

By J. W. GREGORY, D.Sc., F.G.S.

(PLATES V AND VI.)

THE first collection of Egyptian fossils sent for determination by Captain Lyons, R.E., Director of the Egyptian Geological Survey, to the British Museum, includes an interesting series of Echinoidea, which has been intrusted to me for examination. It is hardly necessary to state that our knowledge of the fossil echinid faunas of Egypt is mainly due to M. P. de Loriol-le-Fort, who has described a large series in two admirable monographs.[1]

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[1] P. de Loriol, "Monographie des Échinides contenus dans les couches nummulitiques de l'Egypte": Mém. Soc. Phys. Hist. nat. Genève, vol. xxvii (1881), pp. 59–148, 11 pls. "Eocaene Echinoideen aus Aegypten und der libyschen Wüste": Beitr. Geol. Pal. libysch. Wüste, Abth. ii, Ht. 1, Palæontogr. Suppl., 1883, pp. 1–59, 11 pls.

The echinids in the Egyptian Geological Survey Collection include 79 specimens, which are referred to 15 genera and to 30 species, of which three are new.   The horizons are known in each case, but the localities are not stated for one set, which apparently belong to an old collection preserved in the Cairo Museum.

The horizons represented are as follows :—

> Pleistocene.
> Middle Miocene—Helvetian Series: Siuah.
> Upper Eocene—Bartonian Series.
> Middle Eocene—Mokattam Series.
> Lower Eocene—Libyan Series.
> Cretaceous—Turonian.

Genus RHABDOCIDARIS, Desor, 1856.

1. RHABDOCIDARIS LIBYENSIS, n.sp.

DIAGNOSIS.

Test large and depressed; width much greater than the height. The shape is decagonal, with the sides all concave.   The ambulacral areas occupy deep depressions, while the central suture of the interambulacral areas is also depressed.

Interambulacra.—Each vertical series consists of nine or ten plates. The tubercles are very prominent, the bases are perforated, and the mamelons strongly crenulate.   The scrobicular areas are not confluent, but separated by one or two lines of granules.   The scrobicular circles are well developed, the granules being much larger than those covering the rest of the plates.   The tubercles are separated from the ambulacral suture by a series of small crowded granules, of which there are four or five rows at the ambitus.   The granulated area between the tubercles and the median interambulacral suture is about twice as wide as on the other side; it is ornamented at the ambitus by six or seven rows of granules.

Ambulacral plates.—About eleven correspond to an ambital interambulacral plate.   The pores of each pair are very wide apart, but are connected by a well-developed groove.   The granular area down the middle of the ambulacrum is wide, and consists of two large and one or two small granules on each ambulacral plate.

Apical area large, pentagonal.

DIMENSIONS.

	mm.
Height of test	35
Diameter of test	54
Diameter of apical system	18
Ambulacrum: width of poriferous zone at ambitus ...	2
width of interporiferous zone at ambitus ...	4
Interambulacrum: height of ambital plate	7
width of ambital plate	13
width of median granulated area of interambulacrum at ambitus ...	4

DISTRIBUTION.— Lower Eocene — Libyan Series : near Assiut; Coll. Geol. Surv. Egypt, No. 629.

FIGURES. — Pl. V, Fig. 1*a*, test from the side ; *b*, from above.
Fig. 1*c*, two ambital interambulacral plates, × 2 diam.   Fig. 1*d*,
two ambital ambulacral plates, × 4 diam.

AFFINITIES.—This echinid is most nearly allied to *Rhabdocidaris
itala* (Laube),[1] which has been described from the Egyptian Eocene
by M. de Loriol-le-Fort. The principal difference between them
is that in *R. itala* the tubercles are non-crenulate, whereas in
R. Libyensis they are strongly crenulate. The tubercles are also
taller. The shape of the test is more like that of *R. Zitteli*, Lor.,[2]
but in that species the granulated areas of the interambulacra are
much more restricted.

The third echinid with which it must be compared is *Porocidaris
Schmideli* (Münst.),[3] with which it agrees in the crenulation of the
tubercles. But the new species has not the slits around the bases
of the mamelons ; the interambulacral plates are much taller ; in
a British Museum specimen (No. 75,669) of *P. Schmideli* the height
of the ambital plates is to the width as 9 : 13 ; and in *P. Schmideli*
the epistroma consists of coarser and more uniform granules.

Genus PSAMMECHINUS, L. Agassiz, 1846.

1. PSAMMECHINUS DUCIEI, Wright, 1855.

SYNONYMY.—See Gregory, "Maltese Echinoidea" : Trans. Roy. Soc.
Edinb., vol. xxxvi (1891), p. 590.

DISTRIBUTION.—Up. Miocene—Tortonian : Malta. Mid. Miocene—
Helvetian : Egypt ; Coll. Geol. Surv. Egypt, No. 822.

There is a broken specimen of a *Psammechinus* in the collection
which agrees in the characters shown with this well-known Maltese
species. The granulation of an ambital plate of the Egyptian
specimen is shown on Pl. V, Fig. 3. The species has not pre-
viously been recorded from Egypt. An allied African species is
P. Soubellensis, Per & Gauth.,[4] in which, however, one tubercle on
each interambulacral plate is much larger than the rest of the
horizontal series.

2. PSAMMECHINUS LYONSI, n.sp.

DIAGNOSIS.

Test small ; somewhat conical above, with tumid, well-rounded
sides. Base flat. Seen from above the shape is sub-pentagonal,
but with well-rounded angles.

Ambulacra.—Each ambulacral series consists of about thirteen
plates, each of which bears a single conspicuous tubercle. The
pore pairs are arranged in well-curved triplets. A double series of
miliary granules runs down the middle of each area. The scrobicular
areas of adjacent plates in the same vertical series are confluent.

[1] *Cidaris itala*, G. C. Laube, "Ech. vicent. Tert. Geb." : Denk. Ak. Wiss.
Wien, vol. xxix, pt. 2 (1869), p. 9, pl. i, fig. 3.
[2] De Loriol, 1883, Beitr. libysch. Wüste, vol. ii, pt. 1, p. 8, pl. i, figs. 1, 11.
[3] *Cidarites Schmidelii*, Münster, in Goldfuss, Petref. Germ., vol. i, p. 120, pl. xl,
fig. 4. De Loriol, 1883, op. cit., p. 9, pl. i, fig. 10.
[4] Peron & Gauthier, Ech. foss. Algér., vol. iii, fasc. 10 (1891), p. 252, pl. v,
figs. 1-4.

Interambulacra of about ten plates in each vertical series. Each plate bears a prominent tubercle. The miliary granules are abundant and well developed. The scrobicular circles are complete, those on the upper border of one plate completing the circle of the plate above.

Peristome very large; branchial slits deep.

DIMENSIONS.

							mm.
Height of test	...	...	...	...	...	...	5·5
Diameter of test	...	...	...	...	...	...	9·5
Width of ambulacrum at ambitus	...		...	...	...	3·5
Width of interambulacrum at ambitus		...	...	...	2·3
Diameter of peristome	...	...	...	...	...	4·5

DISTRIBUTION.—Mid. Miocene—Helvetian : Egypt ; Coll. Geol. Surv. Egypt, Nos. 977, 988.

FIGURES.—Pl. V, Figs. 4a and b, a test from the side and from below, × 2 diam. Fig. 4c, ambital plates, × 8 diam. Fig. 5, ambital plates of another specimen, × 8 diam.

AFFINITIES.—The species, by its unituberculate, multigranulate interambulacral plates, belongs to the series of species which Pomel grouped as the genus *Arbacina*; while by the deep, narrow branchial slits it is allied to the same author's *Oligophyma*.

Its nearest ally is *Psammechinus subrugosus*, Pomel,[1] from the Pliocene of Oran, in which the mamelon of the primary tubercles is much larger, there are some secondary interambulacral tubercles, and the ambital interambulacral plates are longer.

Psammechinus lævior, Pomel,[2] from the same deposits, has a more scanty epistroma.

The specimen illustrated by Pl. V, Fig. 5, resembles the *Arbacina asperata*, Pomel,[3] from the Pliocene of Oran, but in that form the tubercles have a much larger, flat mamelon, which is about two-thirds instead of one-third the diameter of the boss. It also resembles a small Persian Miocene *Psammechinus affinis*, Fuchs,[4] in which the scrobicular circles are complete on each plate, so that the adjacent scrobicular areas are separated by two lines of granules instead of by only one.

Oligophyma cellensis, Pomel,[5] is another ally, but that has a much smaller peristome and longer, lower interambulacral plates.

Genus COPTOSOMA, Desor, 1858.

1. COPTOSOMA THEVESTENSE, Per. & G.

Cyphosoma Thevestense, Peron & Gauthier, 1879 : " Ech. foss. Algér.," fasc. vi, p. 105, pl. xiii, figs. 5–8.

DISTRIBUTION.—Turonian : Tebessa, near Constantine, Algeria. Turonian (?) : Abu Roasch, Egypt ; Coll. Geol. Surv. Egypt, No. 50.

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[1] Pomel, " Pal. Algér.," Zooph., fasc. 2, Ech., livr. 1 (1885), pl. C, xii, figs. 1–4.
[2] Ibid., pl. C, xii, figs. 5–8.
[3] Ibid., pl. C, xi, figs. 5–8.
[4] Fuchs, " Tert. Ech. Persien " : Sitz. Ak. Wiss. Wien, vol. lxxxi, pt. 1 (1880), p. 99, pl., figs. 6–16.
[5] Pomel, op. cit., pl. C, x, figs. 1–7.

REMARKS.—This species is represented by three specimens. The pores are in arcs of five to six pairs in each compound ambulacral plate. The specimens agree with the Algerian type in all important respects. The ambulacral plates are unituberculate, and each tubercle is surrounded by a complete scrobicular circle, so that the scrobicular areas are not confluent. The tuberculation of an Egyptian specimen is shown on Pl. V, Fig. 2.

Genus LAGANUM, Gray, 1825.

1. LAGANUM DEPRESSUM, Less.

SYNONYMY.—See A. Agassiz, "Revision of Echini," pt. i, 1872, p. 138.

DISTRIBUTION. — Recent : Pacific and Indian Oceans, Red Sea, Persian Gulf. Pleistocene : E. Africa ; Suez ; Coll. Geol. Surv. Egypt, No. 968.

REMARKS.—The collection includes six specimens of a *Laganum* from the Pleistocene of the Suez Canal (Coll. Geol. Surv. Egypt, No. 968). The specimens appear at first sight to differ from the typical *L. depressum*, as the margins are tumid, and there is a depression around the test between the apex and the margin. This character is described by Professor A. Agassiz in *L. Bonani*,[1] whereas the test of *L. depressum* is said[2] to have thin margins. The shape of the petals in one or two specimens is also different from the typical *L. depressum*, as the petals are more pointed at their outer ends. Examination, however, of the large series of *L. depressum* in the Zoological Department shows that these characters vary so much in this species that the Egyptian fossils may be safely referred to it. Some specimens registered as 58. 5. 15. 154, have equally pointed petals ; others from the Kingsmill Islands have the petals pointed at the ends, but the poriferous zones are broader ; while in some other specimens the pore-zones are as narrow as in the fossil specimens from Suez. Among the many varieties of *L. depressum* these specimens are most nearly allied to *Laganum attenuatum*, L. Ag.,[3] with which they agree in the circular actinal depression and the general shape of the test. Some of the six specimens have the external shape of the variety *L. ellipticum*, L. Ag.,[4] and others have the more strongly pentagonal shape of the typical *L. depressum*.[5]

L. attenuatum is a variety most typical of the Red Sea and Persian Gulf.

Genus SCUTELLA, Lam., 1816.

1. SCUTELLA SUBROTUNDA var. PAULENSIS, L. Ag.,[6] 1841.

REMARKS.—This echinid is represented in the collection by two Miocene specimens (No. 995), of which one is broken. The

[1] A. Agassiz, Revision Echini, pt. iii (1873), p. 517.
[2] Ibid., p. 518.
[3] L. Agassiz and Desor, "Cat. Raiss." : Ann. Sci. nat., vol. vii (1847), p. 132.
[4] L. Agassiz, Mon. Scut., p. 111, pl. xxiii, figs. 13, 14.
[5] Cf. ibid., pl. xxiii, figs. 1–3.
[6] *Scutella Paulensis*, L. Agassiz, Monogr. Scutelles, 1841, p. 83, pl. xix, figs. 8–10.

echinids agree with *S. subrotunda* (*non* Leske) in the length of the
petals, whereby they differ from the Tongrian *S. striatula*, Marc.
de Serr. They differ from the typical *S. subrotunda*, Leske, by the
absence of the notch in the posterior margin of the test behind the
anus. In this character they agree with *S. Paulensis*, L. Ag.; but
they differ from L. Agassiz's type of that form by their greater
equality of length and breadth. Agassiz remarked the close
resemblance of *S. Paulensis* and *S. subrotunda*; and it seems to me,
as the shape is inconstant, that the former species should be reduced
to a variety of the latter, characterized by the absence of the notch
and by the less branched actinal furrows. The branching of the
furrows is, however, inconstant; they are not well marked in the
specimens; but in some areas the furrows branch once as in
S. Paulensis, whereas in other areas there are distinct secondary
branches as well.

The original locality of *S. Paulensis* is St. Paul-trois-Chateaux,
near Dax, and its horizon is Lower Miocene or Langhian.[1]

Fuchs has described two Egyptian Miocene *Scutellæ*. In *S.
rostrata*, Fuchs,[2] from Siuah, the posterior margin is curved and not
truncate; and the interporiferous areas of the petals is broader
than in the two echinids of the Egyptian Survey collection. The
general shape of these specimens agrees with that of *S. ammonis*,
Fuchs,[3] in which the petals are a little shorter; thus, the length of
the anterior petal is $\frac{8}{15}$ of the distance from the inner end of the
petal to the anterior margin of the test, whereas the same proportion
in these specimens is $\frac{2}{3}$.

Genus CONOCLYPEUS, L. Agassiz, 1839.

1. CONOCLYPEUS DELANOUEI, De Loriol, 1881.

Mém. Soc. Phys. Hist. nat. Genève, vol. xxvii, p. 82, pl. ii, fig. 17.
Var. MILVIFORMIS,[4] nov.

DISTRIBUTION. — Libyan Series: Coll. Geol. Surv. Egypt, *ex*
No. 858. Pl. VI, Fig. 2; two-thirds natural size.

REMARKS.—Five specimens in the collection agree in all essential
respects with De Loriol-le-Fort's *C. Delanouei*, except that the shape
is not elliptical but somewhat kite-shaped. The greatest width is
a trifle anterior to the peristome; the sides thence run straight
backward, converging slightly till opposite the anterior margin of
the periproct; thence they bend sharply round to the well-curved
posterior extremity. As De Loriol's figure (17*a*) is not regularly
elliptical, and as the test shows a tendency towards this kite-shaped
base, it seems unnecessary to make a new species for these echinids.
But the difference is so constant in the five specimens that it is
desirable to notice it as a varietal character.

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[1] e.g. Depéret, " Classification et parallelisme du Système Miocène ": Bull. Soc.
géol. France, ser. 3, vol. xxi (1893), p. 176.
[2] Fuchs, Beitr. libysch. Wüste, vol. i (1883), p. 48, pl. xvii, figs. 4–6.
[3] Fuchs, ibid., p. 48, pl. xiv, figs. 1–4.
[4] From *milvus*, ' a kite,' the test being kite-shaped.

Genus RHYNCHOPYGUS, D'Orbigny, 1855.

1. RHYNCHOPYGUS ZITTELI, De Loriol, 1883.

"Beitr. libysch. Wüste," vol. ii, pt. 1, p. 18, pl. ii, figs. 9–11.

DISTRIBUTION. — Mokattam Series : Minieh (De Loriol-le-Fort) ;
Coll. Geol. Surv. Egypt, *ex* Nos. 862, 863.

REMARKS.—The echinid referred to this species differs from the
type only by being slightly broader in proportion to its width.

Genus ECHINOLAMPAS, Gray, 1825.

1. ECHINOLAMPAS TUMIDOPETALUM, n.sp.

DIAGNOSIS.

Test large and tall, subconical, rising from a level base. Seen
from above the shape is sub-elliptical, but the posterior half is
broader and fuller than the anterior part.

Apical area and mouth subcentral.

Ambulacra.—The petaloid portions are very swollen and upraised.
The inequality in the length of the poriferous zones of the antero-
lateral pair of petals is considerable. The petals are long, reaching
nearly to the margins. The poriferous zones are narrow ; the inter-
poriferous area is long, lanceolate.

Floscelle well developed ; the bourrelets large and conspicuous.

DIMENSIONS.

						mm.		Crushed specimen. mm.
Height	...	...	...	...	...	48	...	49
Length	...	...	...	...	...	78	...	79
Breadth	...	...	...	...	...	65	...	56
Length of petal of antero-lateral ambulacrum						38	...	35
Width of petal of antero-lateral ambulacrum						11	...	10·5
Width of poriferous zone of ditto	...		...		...	2	...	2
Width of interporiferous zone of ditto		...		...		7	...	6·5
Distance of apex from anterior margin				...		38	...	35
Distance of mouth from anterior margin				...		35		

DISTRIBUTION.—Miocene : Coll. Geol. Surv. Egypt, Nos. 966, 972.

FIGURES.—Pl. VI, Fig. 1*a*, a specimen from above ; Fig. 1*b*, the
same specimen from the side : nat. size.

AFFINITIES.—This species is represented in the collection by
four specimens, of which three are somewhat broken, while the
fourth is a little deformed by lateral pressure. The most striking
character of the species is its swollen ambulacra, which are of the
type met with in *Echinolampas stellifera*, from the Calcaire Grossier.
From this species *E. tumidopetalum* differs by its greater size and
more conical test.

Among known species of *Echinolampas* this most nearly resembles
E. Anguillæ, Cott.,[1] from which it differs by the tumid petals and by
the more conical form of the test. The outline seen from above or
below is almost identical with Cotteau's figures 7 and 8 of his
West Indian species. *Echinolampas florescens*, Pom., var. *coarctata*,[2]

[1] G. Cotteau, "Descr. Ech. tert. St. Barth. et Anguilla" : Handl. k. Svens.
Vet. Akad., vol. xiii, No. 9 (1875), p. 24, pl. iv, figs. 5–8.
[2] A. Pomel, "Ech. Kef. Ighoud" : Mat. Carte géol. Algérie, ser. i, Pal. (1885),
p. 26, pl. iii, figs. 12–14.

has a high test of much the same form as *E. tumidopetalum*; but the petals are much broader, shorter, and more leaf-like and the floscelle less conspicuous.

2. ECHINOLAMPAS GLOBULUS, Laube, 1869.

" Ech. vicent. Tert. Geb. " : Denk. Ak. Wiss. Wien, vol. xxix, pt. 2 (1869), p. 24, pl. iv, fig. 5.

DISTRIBUTION. — Lower Eocene—Libyan Series : near Assiut, Egypt (De Loriol-le-Fort) ; Coll. Geol. Surv. Egypt, No 631.

Ten specimens of this variable species from the Lower Eocene near Assiut.

3. ECHINOLAMPAS AMYGDALA, Desor, 1847.

Agassiz & Desor, "Cat. Raiss.": Ann. Sci. nat., Zool., ser. 3, vol. vii, p. 164.

There is one echinid in the collection (*ex* Nos. 862–3) the proportions of which agree with those of the Egyptian specimen, which, according to De Loriol, is the typical form of this species. The species was based by Desor on an Egyptian fossil. The dimensions are as follow :—

	Coll. Geol. Surv. Egypt.		De Loriol-le-Fort.
Length	42 mm.	...	30–38 mm.
Breadth	20 mm.	...	—
Ratio of breadth to length ...	·48	...	·50
Height	32 mm.	...	—
Ratio of height to length ...	·76	...	·74

DISTRIBUTION.—Mokattam Series : Mokattam (De Loriol-le-Fort). Libyan Series : Coll. Geol. Surv. Egypt, *ex* Nos. 862–3.

4. ECHINOLAMPAS PERRIERI, De Loriol, 1881.

Mém. Soc. Phys. Hist. nat. Genève, vol. xxvii, p. 95, pl. v, fig. 2.

DISTRIBUTION.—Mokattam Series : Mokattam, Thebes (De Loriol-le-Fort) ; Coll. Geol. Surv. Egypt, *ex* No. 859.

The collection includes a small specimen from the Mokattam Series, which appears to be referable to *E. Perrieri*, Lor., though that species was described from the Upper Eocene beds of the Siuah Oasis. M. de Loriol-le-Fort did, however, record a doubtful specimen from the Mokattam beds of the Beharieh Oasis.

The dimensions are as follow :—

	De Loriol.		Egypt. Geol. Surv., *ex* No. 859.
Length	52–62 mm.	...	46 mm.
Breadth	—	...	38 mm.
Ratio of breadth to length ...	·82	...	·83
Height	—	...	20·5 mm.
Ratio of height to length ...	·42–·45	...	·44

5. ECHINOLAMPAS LIBYCUS, De Loriol, 1883.

" Beitr. libysch. Wüste," vol. ii, pt. 1, p. 31, pl. v, figs. 1–3.

DISTRIBUTION.—Mokattam Series : Siuah (De Loriol-le-Fort) ; Coll. Geol. Surv. Egypt, one specimen *ex* No. 859.

No. 859 in the Egyptian Survey Collection includes two specimens which are clearly specifically distinct. The larger specimen has the

following dimensions, which are those of *E. Libycus* and *E. sub-cylindricus*, Des. But the characters of the petals show that the Egyptian Survey specimen is nearer to the former. The specimen is broken at the posterior end, so the specific determination is somewhat uncertain.

DIMENSIONS.

Length	...	...	...	...	...	...	70 mm.
Breadth	...	...	...	...	...	...	55 mm.
Ratio of breadth to length	...	...	...	...	...	·786
Height	...	...	...	...	...	...	35 mm.
Ratio of height to length	...	...	...	...	...	·50

6. ECHINOLAMPAS AMPLUS, Fuchs, 1883.

" Beitr. Kenntn. Miocaenfauna Aegypt. " : Beitr. Geol. Pal. Lib. Wüste, vol. i, p. 45, pl. xiv, figs. 5–8.

DISTRIBUTION. — Miocene : Siuah and Geneffe (Fuchs) ; Coll. Geol. Surv. Egypt, No. 643 ; near Wady Jiaffra, between Cairo and Suez, Camp No. 9.

Genus EUPATAGUS, L. Agassiz, 1847.

1. EUPATAGUS COTTEAUI, De Loriol, 1881.

Mém. Soc. Phys. Hist. nat. Genève, vol. xxvii, p. 139, pl. xi, figs. 8–10.

DISTRIBUTION.—Libyan Series : near Thebes (De Loriol-le-Fort) ; Coll. Geol. Surv. Egypt, *ex* Nos. 861 and 867.

2. EUPATAGUS LIBYCUS, De Loriol, 1883.

" Beitr. libysch. Wüste," vol. ii, pt. 1, p. 52, pl. xi, fig. 4.

DISTRIBUTION. — Libyan Series : El Guss Abu Said, west of Farafrah (De Loriol-le-Fort) ; Coll. Geol. Surv. Egypt, three specimens *ex* No. 868.

Genus HYPSOPATAGUS, Pomel, 1883.

1. ? HYPSOPATAGUS LEFEBVREI (De Loriol), 1881.

Macropneustes Lefebvrei, De Loriol, 1881 : Mém. Soc. Phys. Hist. nat. Genève, vol. xxvii, p. 131, pl. ix, figs. 7–9.
Hypsospatangus Lefebvrei, Cotteau, 1886 : Pal. franç. Terr. tert., vol. i, Eoc. Ech., p. 96.

DISTRIBUTION.— Libyan Series : near Assiut, Minieh, and El Guss Abu Said, west of Farafrah (De Loriol-le-Fort) ; ? Assiut ; Coll. Geol. Surv. Egypt, *ex* No. 631.

The only specimen that may belong to this species is one that is so much broken at the hinder end that it is not possible to determine whether a fasciole was present. The shape of the petals is, however, nearer to that of *Hypsopatagus* than to *Eupatagus*.

2. HYPSOPATAGUS, sp.

Libyan Series : Coll. Geol. Surv. Egypt, *ex* Nos. 862–3, 867.

There are two echinids in the collection which are elongate forms of *Hypsopatagus*, but they are too ill-preserved for description. The outline of one is shown on Pl. VI, Fig. 4, which presents

a considerable resemblance to the *Eupatagus Siokutensis*, Fuchs,[1] which has, however, a more cordate or elliptical test.

Genus HEMIASTER, Desor, 1847.

1. HEMIASTER SCHWEINFURTHI, De Loriol, 1883.

" Beitr. libysch. Wüste," vol. ii, pt. 1, p. 34, pl. viii, figs. 3–5.

DISTRIBUTION. — Libyan Series : El Guss Abu Said, west of Farafrah (De Loriol-le-Fort) ; Coll. Geol. Surv. Egypt, *ex* Nos. 862–3.

PERICOSMUS, L. Ag., 1847.

1. PERICOSMUS LATUS, Ag. & Des., 1847.

Agassiz & Desor., op. cit., p. 19, pl. vi, figs. xvi, 1.

REMARKS.—This well-known echinid is represented in the collection by two specimens from the Miocene (Geol. Surv. Coll. Egypt, No. 964). They agree with Agassiz's cast (M 23), but differ slightly from Agassiz & Desor's figure by the fact that posteriorly the test slightly overhangs the periproct, which cannot be seen from above. The specimens agree with Cotteau's admirable description of the species ;[2] and the posterior extremity of the test agrees with his figure of *P. Orbignyi*, Cott., to which he applies the same description as to *P. latus.* Hence the Egyptian form agrees with Cotteau's description better than with the original figure. The echinids differ from *P. Orbignyi*, Cott., by the greater equality of length and breadth, the dimensions being 75 mm. and 76 mm. respectively.

2. PERICOSMUS PERONI, Cott.

G. Cotteau, " Faune terr. tert. Corse " : Ann. Soc. Agric. Lyons, ser. 4, vol. ix, 1877, p. 314, pl. xiv, figs. 3, 4.

DISTRIBUTION. — Helvetian : Corsica ; Egypt ; Coll. Geol. Surv. Egypt, No. 659.

The collection contains three broken *Pericosmi*, which have the anterior apex, steep anterior slope, and long posterior slope characteristic of *P. Peroni*, Cott. Two of the three echinids are too broken for satisfactory determination, but a third shows the form of *P. Peroni* fairly well.

Genus LINTHIA, Merian, 1853.

1. LINTHIA ASCHERSONI, De Loriol, 1883.

" Beitr. libysch. Wüste," vol. ii, pt. 1, p. 37, pl. ix, figs. 1–4.

DISTRIBUTION.—Libyan Series : Gebel Ter, near Esneh, and west of Farafrah (De Loriol-le-Fort) ; Coll. Geol. Surv. Egypt, *ex* Nos. 862–3.

2. LINTHIA ESNEHENSIS—ASCHERSONI.

Linthia Esnehensis, De Loriol, 1883 : " Beitr. libysch. Wüste," vol. ii, pt. 1, p. 39, pl. ix, figs. 5, 6.
L. Aschersoni, De Loriol, 1883 : ibid., p. 37, pl. ix, figs. 1–4.

[1] Fuchs, " Tert. Ech. Persien " : Sitz. Ak. Wiss. Wien, vol. lxxxi, pt. 1 (1880), p. 100, pl., figs. 17–20.
[2] G. Cotteau, " Faune terr. tert. Corse " : Ann. Soc. Agric. Lyons, ser. 4, vol. ix, pp. 310–12.

There is in the collection a specimen which is intermediate between the above, but nearer, if anything, to *L. Esnehensis.* The relative dimensions are as follows :—

	Esnehensis.	Aschersoni.	Egypt. Surv. Coll.
Length	30–42 mm.	26–37 mm.	36 mm.
Ratio of breadth to length	1–1·10 ...	1 ...	1·02
Ratio of height to length	·73 – ·80 ...	·65 – ·67 ...	·74

But the Egyptian Survey specimen has the shallow anteal notch and broader anterior ambulacrum of *L. Aschersoni*; the ridge of the posterior interradius is higher than in *L. Aschersoni*, but lower than in *L. Esnehensis.* The apical disc of this echinid is shown on Pl. VI, Fig. 3.

DISTRIBUTION.— *L. Esnehensis*, Lor., Libyan at Gebel Ter, near Esneh (De Loriol-le-Fort). *L. Aschersoni*, Lor., Libyan at Gebel Ter, near Esneh, and west of Farafrah.

The above-mentioned Egyptian fossil is from the Libyan Series (De Loriol-le-Fort), *ex* Nos. 864–5.

3. LINTHIA CAVERNOSA, De Loriol, 1881.

Mém. Soc. Phys. Hist. nat. Genève, vol. xxvii, p. 111, pl. viii, figs. 8–10.

DISTRIBUTION.— Libyan Series: Gebel Omm-el-Renneiem ; El Aouhi, near Edfou ; Djebel Fatira (De Loriol-le-Fort) ; Coll. Geol. Surv. Egypt, *ex* No. 867.

4. LINTHIA DELANOUEI, De Loriol, 1881.

Mém. Soc. Phys. Hist. nat. Genève, vol. xxvii, p. 109, pl. vii, fig. 12.

DISTRIBUTION.—Mokattam Series : Mokattam (De Loriol-le-Fort). Libyan Series : Gebel Ter, near Esneh (De Loriol-le-Fort) ; Coll. Geol. Surv. Egypt, *ex* No. 996.

The collection includes one large, well-preserved specimen of this species. Its dimensions are :

							mm.
Length	...	...	...	...	...	...	60
Breadth	...	...	...	...	...	...	57·5
Height	...	...	...	...	...	...	45
Distance of apical system from anterior margin				...	...	25

5. LINTHIA (?) COTTEAUI, Tournouer, 1870.

SYNONYMY.

Periaster Cotteani, Tournouer, 1870, " Éch. calc. à aster. sud-ouest France ": Actes Soc. linn. Bord., vol. xxvii, p. 33, pl. xvii, fig. 5.

Linthia Cotteaui, Cotteau, 1886 : " Pal. franç. Terr. tert.," vol. i, Éch., p. 241, pl. lxxv.

DISTRIBUTION.—Mid. Eocene : Hastingues, Landes (Tournouer & Cotteau). Libyan Series : Egypt ; Coll. Geol. Surv. Egypt, *ex* No. 868.

REMARKS.—The generic position of this species seems to me doubtful. The dimensions of the specimen assigned to it are as follow :—

in one of them the ambulacral furrow is considerably larger than in the other. It seems unnecessary to regard this as a specific or varietal difference, for it may be either sexual or a seasonal variation, the anterior furrow being enlarged to serve as a marsupium.

EXPLANATION OF PLATE V.

FIGS. 1*a* and 1*b*. *Rhabdocidaris Libyensis*, nov. sp., from the side and from above; nat. size. Fig. 1*c*, ambital interambulacral plates of the same, × 2 diam. Fig. 1*d*, ambital ambulacral plates of the same, × 4 diam.

FIG. 2. *Coptosoma Thevestense*, Per. & G., ambital plates, × 4 diam. Turonian: Abu Roasch.

FIG. 3. *Psammechinus Duciei*, Wright, ambital plates of Egyptian specimen, × 5 diam.

FIGS. 4 and 5. *Psammechinus Lyonsi*, nov. sp. Fig. 4*a*, side view, × 2 diam.; Fig. 4*b*, actinal view, × 2 diam.; Fig. 4*c*, ambital plates, × 8 diam. FIG. 5. Ambital interambulacral plates of another specimen, × 8 diam.

EXPLANATION OF PLATE VI.

FIGS. 1*a* and 1*b*. *Echinolampas tumidopetalum*, nov. sp., abactinal and lateral views; nat. size.

FIG. 2. *Conoclypeus Delanouei*, Lor., var. *milviformis*, nov., actinal surface; two-thirds nat. size.

FIG. 3. *Linthia Esnehensis—Aschersoni*, apical disc, × 5 diam.

FIG. 4. *Hypsopatagus*, sp., side view; nat. size.

III.—THE ORIGIN OF THE VALE OF MARSHWOOD IN WEST DORSET.[1]

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

THE great sheet of Chalk which, with the subjacent Greensand and Gault, stretches through so large a part of Southern England and underlies the whole of the Hampshire Basin, terminates abruptly in West Dorset. There is no doubt that the Upper Cretaceous rocks once spread continuously over the Jurassic hills east of Bridport and across the Vale of Marshwood, and were united to the corresponding beds in East Devon, where the Chalk and Greensand are so conspicuous in the cliffs near Beer Head.

To those who are unacquainted with geological methods this statement may seem highly imaginative, since, at the present time, there is a broad intervening tract, from the centre of which all traces of Cretaceous strata have been removed, and around which only a few isolated patches or outliers of Greensand remain as relics of their former extension; yet to the eye of a geologist these very outliers, of which Pilsdon Pen is one, are clear and certain proofs that a continuous sheet of the same material once overspread the whole area.

The physical features of this area may be briefly described, as they are not likely to be familiar to those who do not live in the west of Dorset. The Vale of Marshwood is an area of low ground, most of which lies between 100 and 200 feet above the sea; its length is about five miles and its breadth three; its floor consists of the clays of the Lower and Middle Lias, and it is encircled by steep

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[1] This paper is reprinted, with some alterations, from the Proceedings of the Dorset Nat. Hist. and Ant. Field Club, vol. xviii, and is published with the permission of the Director-General of the Geological Survey of Great Britain.

slopes formed by the yellow micaceous sands of the Marlstone Beds, the cincture of the hills being only broken on the south by the gaps through which the rivers Char and Simene escape to the sea and by a dry gap or pass above Chideock.

The hills on the north side of the Vale are higher than those on the south side, and they form the watershed dividing the valley of the Axe from the valley of the Char, which occupies the greater part of Marshwood Vale. Pilsdon Pen and Lewesdon Hill are the highest hills in Dorset, Pilsdon being 907 feet and Lewesdon 894 feet, according to the latest Ordnance Survey Map. It is only on the Blackdown Hills in Devon that the Upper Greensand reaches a greater height than this, and these hills, although so much farther west, do not attain to more than 930 feet.

It is obvious, therefore, that there must be some local reason for the great height to which the Greensand reaches in Dorset, and yet I am not aware that any geologist has accounted for the fact.

It may seem a paradox to say that the height of the Greensand hills and great hollow of the Vale of Marshwood are due to one and the same cause, yet it is true that they are so closely related to one another that the history of the one involves the history of the other. This history begins with the uplift of the strata which took place in Miocene or Pliocene times, and bent the beds into a dome-shaped elevation, or *pericline,* i.e., an area in which the strata are bent up so as to dip outwards in all directions from a central spot or axis.

I propose to ascertain the probable whereabouts of this centre by a consideration of the levels through which the base of the Upper Greensand passes in East Devon and West Dorset. It might be thought that this spot could be found more easily by examining the arrangement of the Jurassic rocks on the borders of the Vale of Marshwood, but though these undoubtedly show the existence of an anticlinal axis running in an east-and-west direction from which the strata slope to north and south, the curve to east and west is not so apparent in them because they had received a decided easterly tilt before the Greensand was deposited on them. Moreover, the Jurassic rocks are broken by many faults, and only a few of these affect the Cretaceous strata, for most of them seem to date from the Purbeck and Wealden periods, when the above-mentioned tilting was produced.

It is therefore by the position and relative heights attained by the base-line of the Gault and Greensand that the periclinal uplift of this district can best be determined, and by transferring the boundary-lines from the published Geological Survey map to the six-inch county maps, we can easily trace the rise and fall of this base-line. The boundary-lines on the old Geological Survey map are not everywhere correct, but I have good reason to believe that this particular boundary is sufficiently accurate for our purpose. The map (Fig. 1) is based on the new one-inch Ordnance map, and the geological lines have been partially revised, so that it is more accurate than the old Geological Survey map.

Fig. 1.—Geological Map of a Portion of West Dorset.
Scale half an inch to a mile.

Chalk   Upper Greensand   Lower Oolite   Up. Lias and Marlstone Sand   Clays of Mid. and Lower Lias   Fault

Commencing with a traverse from west to east through Pilsdon and Lewesdon, and starting the base-line of the Greensand at Secktor, near Axminster, we find it there to be only about 320 feet above sea-level, and thence it rises gradually eastward till it reaches 580 feet at Birdsmoor Gate, 700 feet at the southern end of Pilsdon, and about 770 feet on Lewesdon. Between Lewesdon and Beaminster there are several faults breaking the Jurassic rocks, but it is not certain that any of them displace the Cretaceous series, and on Hackthorn Hill the base of the Greensand is close to the 500 feet contour. The distance from Lewesdon to this point is four miles, and, assuming the fall to be gradual, it is a little, but not much more, rapid than the rise from the west up to Lewesdon.

Taking next a traverse through the southern outliers near the coast, we find the Cretaceous base-line in Black Ven Cliff at about 320 feet above the sea. Thence it rises to about 350 feet in Stone Barrow, and 400 and more on Golden Cap and Langdon Hill, and finally to about 500 feet on Eype Down. Then comes a space of four miles occupied by low ground near Bridport, and when Greensand is next found on Shipton Hill, its base has fallen to 400 feet, sinking still lower eastward to 300 feet at Askerswell. Along this line of country, then, as along the first, we seem to have a gradual rise and fall in the height of the Cretaceous base-line.

We will next trace the rise and fall of the same line from north to south. This is best shown on the western side of the area. North of Thorncombe village the base of the Greensand lies at about 450 feet, on the south side of that outlier in the same latitude it is nearly 500, by Lambert's Castle it is about 600 feet ; thence it falls to 550 feet below Coney's Castle and to 350 feet at Stonebarrow, $2\frac{1}{2}$ miles further south.

On the eastern side of the district the regularity of the rise is broken by faults, but we find it rising to a maximum of 600 feet on Drakenorth Hill, east of Poorton, falling thence rapidly both to the north and to the south. Even where it is faulted up again on Eggardon Hill it does not seem to get much above 400 feet, and at Combe, near Litton Cheney, it is down to about 300 feet.

We may fairly assume that the centre of the uplift, or pericline, will be found by drawing lines between the points where the base-line reaches its greatest height, namely, from Lambert's Castle to Drakenorth Hill, and from Lewesdon to Eype Down. The inter-section of these lines occurs a little east of Monkswood, above the low ridge which forms the watershed between the Char and the head branch of the Simene brook. We may take this spot as the approximate centre of the pericline, which appears to have an elliptical shape, its longest axis being from east to west and its shortest from north to south. We can even form a good estimate of the height to which the base of the Greensand reached over this centre by prolonging the actual rise of the base-line in the Pilsdon outlier, for at the north end of Blackdown, by Stony Knap, it is at 500 feet, rising thence to 700 feet below the Pen, and if this rise were continued south-eastward to the spot above mentioned it would

bring the base to a height of 877 feet. Assuming the thickness of the Greensand there to have been 180 feet, the Chalk would have come in at about 1,150 feet.

The relative levels of sea and land varied, of course, at different epochs of Tertiary time, but we are quite warranted in believing that there was a time when the Chalk and Greensand formed a continuous mantle over the rocks which now occur in West Dorset. Let us next consider how this mantle of Cretaceous material has been so largely removed from the district in question.

When the country was raised above the level of the sea at the close of the Oligocene period it must have undergone considerable erosion from the planing action of the sea waves, and if the flexures were commenced at that time the anticlines would suffer most. We know very little about the history of this part of England during the Miocene and Pliocene times, but the final result of the successive upheavals and denudations was to leave a surface of erosion which was planed across the flexures, and both upheaval and denudation had been carried on to such an extent that the Chalk had been either entirely or almost entirely removed from the central parts of the anticlinal areas.

This surface of erosion was what our American cousins call a *peneplain*, that is to say, it was not a level plain or plateau, but had its slight irregularities and slopes, and had, moreover, a summit elevation from which it sloped in more than one direction. A consideration of the present watersheds and of the river-courses in Dorset and the adjacent counties leads us to infer that the original watershed of this peneplain lay to the north and west of the line now occupied by the Chalk escarpment.[1] It probably trended from somewhere in the neighbourhood of Wincanton at a high level above Sherborne and Yetminster to Beaminster Down, and thence over Lewesdon and Pilsdon to the hills between Axminster and Lyme. The western part of this line, from Beaminster Down along the ridge on which Lewesdon and Pilsdon stand, is still the watershed between the streams which run southward and those which drain into the rivers Parret and Axe.

It will be noticed that this watershed does not coincide with the longer axis of the Marshwood pericline, but lies to the north of it. In order, therefore, to understand the drainage system of this part of Dorset we must imagine a time when the surface of the land sloped gently both northward and southward from the line above-mentioned. On this surface there was a certain accumulation of clay, pebbles, cherts, and flints, the heavy and insoluble relics of the Eocene, Greensand, and Chalk which had been destroyed; remnants of this deposit, which is generally called "the clay with flints," still remain on the tops of the higher hills.

The rain flowing down the southern slope of this surface gathered into streams, which cut channels for themselves through the Chalk

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[1] See " Origin of the Valleys of North Dorset," in Proc. Dorset N.H. and A.F. Club, vol. xvi, p. 5.

and Greensand. They ran, of course, high above the present surface, and their courses were prolonged far to the southward before reaching the sea ; indeed, during the Miocene and again in the later Pliocene time it is probable that most of the English Channel was dry land, and that these Dorset streams were merely tributaries of a large river which ran westward down the valley of the Channel.

Now the slope along which these streams made their way was planed across the summit of the low dome or pericline, which has been described ; and as we have calculated the base of the Greensand on this summit to have been about 100 feet higher than it is at Lewesdon, where the thickness of Greensand at present is not more than 130 feet, and as the surface sloped southwards from Lewesdon, there cannot have been much Greensand left over the central area of the pericline when the streams began to make their valleys. Hence, as they deepened their channels they would quickly cut through the Greensand on the central area and would soon enter the Jurassic beds on which the sand rests ; these beds are the Midford Sand, the Upper Lias clay (which is thin), and the Marlstone Sands.

As soon as any stream cut into the Upper Lias the water on the overlying sands would issue in the form of springs. Thereby the volume of the streams would be increased and at the same time landslips would take place, as is always the case where springs issue from sand overlying a clay. The valleys would be rapidly widened, and during periods of upheaval they would be deepened also. Much of this work was probably done during the Glacial Period, and was finally completed during the time when the raised beaches of the South Coast were being elevated to their present height. Over the western part of the pericline the Midford Sands and Upper Lias are absent ; that is to say, they were planed off before the Greensand was deposited, and the latter rests directly on the Marlstone Sands. Here the process of valley erosion would continue till the base of these sands was reached, when strong springs would be thrown out by the underlying *margaritatus* clays, and these clays would be for a certain distance exposed along the valley bottoms.

We must remember that all this time the slope of the valley-ways was less than the southerly inclination of the beds on the southern curve of the pericline ; hence the rivers, after cutting
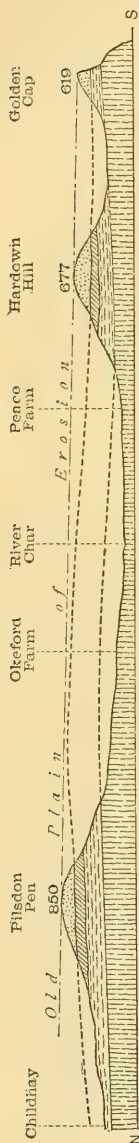
Fig. 2.—Section across the Vale of Marshwood along the broken line on the Map.

through the lower clays for a space, would again enter the Marlstone Sand and still further south would again enter the Upper Lias and Midford Sand, as shown in the diagram (Fig. 2).

Now, where the sides of a valley consist of clay, they are rapidly acted on by rain and frost and are made to recede by frequent landslips, but where they consist of firm and dry sand there is very little slipping and the valleys remain comparatively narrow. Thus it came to pass that a wide tract of clay was gradually exposed over the western part of the periclinal area, while to the southward the rivers pass through valleys with steep slopes on each side, the intervening tracts rising into a succession of hills, some of which are capped by patches of Inferior Oolite and others by remnants of the original covering of Greensand.

These southern hills are well seen by anyone standing at the foot of Pilsdon Pen, and they look as if they would present an impassable barrier to any river running southward from the watershed on which the observer stands.

The rivers which now drain the district are the Char and the Simene, while the Brit drains the eastern part of the periclinal area, and they all make their way through gaps in the southern hills. But, besides the valleys of these rivers, there is a wide gap at the head of the valley of the little river Chid, which runs through Chideock, and I think it probable that this gap was part of the valley of a river which had a more northern source. There is little doubt that in some cases one river-system extended itself at the expense of another, the lateral tributaries of the one encroaching on the area drained by the other, and sometimes entirely cutting off or capturing the headwaters of the adjacent river.[1]

The present course of the Char is so different from the comparatively straight courses of the Simene and the Brit, that it suggests the idea of its having absorbed the tributaries of an eastern neighbour. The col at the present head of the Chideock valley does not rise above 250 feet, the hills on each side being double that height, and I am inclined to think that there was a time, before the valleys were carved out to their present depth, when three rivers traversed the Vale of Marshwood, and that the ancestor of the Chid was one of them. The final sculpturing of the country took place during and soon after the close of the Glacial Period, and it was probably then that the capture by the Char of the upper tributaries of the Chid was accomplished.

In conclusion, I may briefly call attention to the points of resemblance and difference between the Vale of Marshwood and the Weald of South-Eastern England. Both are elliptical periclinal areas, both have been truncated by planes of (presumably marine) erosion, and both have rivers, which, after traversing the inner plain, pass through gaps in the southern escarpment to reach the sea. In the Weald, however, the watershed coincides roughly with the longer

[1] For a case in Lincolnshire described by the author, see Quart. Journ. Geol. Soc., vol. xxxix, p. 596, 1883.

axis of the pericline, and the streams run both northward and south-
ward, so that both lines of escarpment are trenched by river-valleys.
In the case of the Dorsetshire Weald the original watershed was
outside and north of the central axis, so that all the streams ran
southward and only the southern border is trenched by river-valleys.

In both areas, too, the denudation of the central region has laid
bare a large tract of clay, and on this clay-soil fine forests of oak-
trees came into existence. The great forests of the Weald were
famous for their oaks, which in former days contributed largely to
the " wooden walls of England." In the western country the Vale
of Marshwood was equally celebrated for its oak-trees, and when
ships were largely built in the South of England they were much in
demand. Many hundreds of fine oak trunks have been taken from
the Vale and shipped from Lyme and Bridport. The trade indeed
has not entirely ceased, and such cargoes are still embarked at the
small port of West Bay, below Bridport; few, however, now come
from the Vale of Marshwood, for its woods have disappeared, and
the only oaks that remain are hedgerow-trees.

With respect to the isolation of Pilsdon and Lewesdon Hills,
this has been effected by the excavation of the intervening spaces ;
in technical language they are " hills of circum-denudation." The
interspaces are the heads of the valleys formed by the action of rain
and springs on the slopes of the old watershed. The tributaries of
the Axe have trenched it on the north, while on the south side the
strong springs thrown out at the base of the Marlstone Sands have
eaten backward some little way into the ridge of the original water-
shed, causing the actual water-parting to retreat northward. This
recession has taken place principally near the villages of Pilsdon
and Bettiscombe, while Lewesdon may really be very nearly on the
site of the original ridge of the watershed.

The same process has taken place near Beaminster, where the
spring-heads which furnish the headwaters of the Brit have un-
doubtedly eaten deep into the Chalk and Greensand area, and there
the escarpment is still receding, as the frequent scars of landslips
testify.

It will be seen, therefore, that the history of the evolution of the
present physical features of West Dorset involves the consideration
of many agencies and many conditional phases. Here, as elsewhere,
rain, rivers, snow, frost, and heat have been the principal agents at
work, but in order to understand how their operation has resulted in
the particular arrangement of hills and valleys which we see around
us, we must form some conception of the conditions under which
they started to work, and we must remember that their working
powers have always been guided and modified by the changes in the
relative height of sea and land, those slow movements of upheaval
and subsidence to which every portion of the earth's crust has been
repeatedly subjected.

IV.—A Revindication of the Llanberis Unconformity.

By the Rev. J. F. Blake, M.A., F.G.S.[1]

Preliminary Remarks.

IN a paper published in the Quarterly Journal of the Geological Society for 1893,[2] I gave an account of the evidence that led me to conclude that certain conglomerates and associated rocks occurring for some distance north-east and south-west of Llanberis, which had hitherto been considered to lie below the workable Cambrian Slates of that area, were in reality unconformable deposits of a later date than those slates. In the year 1894 Professor T. G. Bonney and Miss C. Raisin published in the same Journal[3] a controversial paper criticizing my statements and conclusions.

It may seem rather late in the day to be replying to a criticism made so long ago, and reasons for the apparent delay must therefore be given. At the reading of their paper before the Society I welcomed it as an attempt to examine the district I had described, and it was only on reading it in full that I realized its true character. I was then just leaving for India, and though a large part of the criticisms might have been replied to at once, there were statements in it which could only be explained and accounted for after another visit to the ground, and this I was unable to make till my return, when I at once presented my reply to the Society—their Journal being, in my opinion, the proper place for it to appear in. As the Council, however, are of a different opinion, such part of my reply as refers especially to the criticisms on my work is here presented in a modified form with additional remarks.

There was nothing in that paper which in any way suggested to my own mind that I might be wrong, but I can well understand that anyone reading it might believe that my conclusions were so ill-founded that a short visit to the district by another observer might suffice to upset them. My object, therefore, here is to show that it is not I but my critics who are in error.

The question whether a certain conglomerate in North-West Carnarvonshire is conformable or not to the underlying rocks may seem at first sight to be of no great consequence, but it involves the larger question as to where the base of the Cambrian system is to be drawn—that is to say, what beds are to be included in or excluded from the Pre-Cambrian series; and this is a matter in which some of the foremost of present and past geologists have interested themselves.

This being the case it is probably unnecessary here to point out the bearings of the several factors involved. It will suffice to note what views of the subject have been taken by different observers, in order to show how far my own views or those of my opponents coincide with or differ from those of others.

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[1] The substance of a paper read to the Geological Society on December 1st, 1897, with additional remarks.
[2] Vol. xlix, pp. 441–446.
[3] Vol. L, pp. 578–602.

History of Previous Opinion.

The older view expressed by Sir A. Ramsay in his "Geology of North Wales"[1] (A) is too well known to require much explanation. He regarded the felsite here exposed as a single mass which had intruded into, and in places completely altered, the adjacent conglomerate.   He based his view principally on the fact that the matrix of the conglomerate closely resembles the felsite, even to the porphyritic crystals, the passage between the two being quite gradual.   We must not suppose that such a geologist as Sir A. Ramsay was misled in this matter, as some subsequent writers have suggested, by so simple a thing as the obscurity of the pebbles in an unweathered block.   On the contrary, more than one of these writers have described the rocks in which his statements are verifiable as felsites.   Such rocks may be seen near the Llanberis road, on the summit of the felsite crag in the tramway section, on the slopes of Clegyr, and on Mynydd-y-cilgwyn, and here certainly Sir A. Ramsay's explanation is suggested, though further observations, here and elsewhere, render it untenable.   When, however, we reject it we must admit that a conglomerate can be deposited on a felsite in such a way that it is impossible to say where one begins and the other ends.   His explanation also accounted for "the capricious variation of the strata adjoining the porphyry," which otherwise might have suggested to him an unconformity.

The first attempt to upset Sir A. Ramsay's explanation came from Professor Hughes and Dr. Hicks, the latter publishing his views (B) in 1878.[2] He considered (1) the felsite at Moel Tryfaen to belong to the same series as the rocks in the adit beneath the hill, and (2) both to be overlain unconformably by the conglomerate ; but he gave no proof of the latter conclusion beyond a supposed N.W. dip of the "metamorphic rocks," the Cambrian conglomerate having, according to him, a N.E. dip.   But he pointed out that the conglomerates contained pebbles "appearing to resemble the rocks *in situ* near," and stated of these conglomerates that "here, as in all other Welsh areas, they strongly define the base of the Cambrian."

Of the rocks of Llyn Padarn he says, "it is more than probable that we have in the series here some contemporaneous lavas," and "the pebbles in the conglomerates are usually identical in character with the rocks below."   He does not, however, point out what is the nature of "the rocks below," though they must have included the felsite.

In 1879 Professor Bonney published a paper on the district (C).[3] It gave the result of "working over parts of the district [including the Bangor area] on several days in September, 1878."   From internal evidence it would appear that the author visited Moel Tryfaen and returned by the Bettws Garmon road, walked from Cwm-y-glo to Llanberis by the railway, and returned part of the

[1] Mem. Geol. Survey, vol. iii.
[2] Q.J.G.S., vol. xxxiv, pp. 147–152.
[3] Q.J.G.S., vol. xxxv, pp. 309–320.

way by the road, climbing the slopes above, and also went along the tram-line on the other side of Llyn Padarn from the head of the lake to Llys Dinorwig. He accounts for the differences between himself and "the officers of the Survey" by their being "occasionally misled by the superficial aspect of the rocks."

Part of this paper it is necessary to quote. Speaking of Moel Tryfaen, he says: "The conglomerate contains pebbles of the same purplish quartz-felsite, generally 2–4 inches diameter, but sometimes a foot or more, together with angular fragments of purple slate. On the western side about one-fourth of the fragments are felsite, the remainder slate—green and purple, and a dull green grit resembling one in the underlying series. The fragments of purple slate are rather more numerous on the eastern side. The strike of the conglomerate appeared to be about E.N.E. and W.S.W. . . . and the bedding, as it seemed to us, dipped to the N.N.W. at a high angle, but . . . it was difficult to be sure of this" [Dr. Hicks had made the dip N.E.]. The quartz-felsite he takes to be a lava-flow, because (1) it shows flow-structure in parts ; (2) a band of slate is intercalated in it and is not conspicuously altered ; (3) it is associated in places with an agglomerate.[1] He also gives a section along the tramway by Llyn Padarn, which will be referred to later on.

One among his conclusions is that "further examination will probably discover more agglomerates, and perhaps further sub-divide the lava-flows," and in speaking of Moel Tryfaen, "where the quartz-felsite must be very thick," says, "appearances suggest that there is a marked physical break between this [the Cambrian conglomerate] and the subjacent sedimentary series."

Up to this time, therefore, the only alternative to Sir A. Ramsay's view was, that there was a single conglomerate forming the base of the Cambrian, and that it lay unconformably on, or was separated by, a marked physical break from the rocks below, whether felsitic or sedimentary, whose fragments also its pebbles resembled ; the only variation being that Professor Bonney figured the conglomerate in his tramway section[2] as conformable, but said nothing about it in his text.

In 1885 Professor Green (D) described part of this section,[3] which he considered to show that "the conglomerate rests on these rocks with the strongest possible unconformity." As to the age of the conglomerate, he only says that it is "taken to be the base of the Cambrian rocks in that district." At the reading of

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[1] All these reasons seem to me to have now disappeared. We have learned that flow-structure may be found also in an intrusive rock (see Sir A. Geikie in G, postea, p. 93), the "slate" is a greenstone dyke, and the agglomerate may be a fault breccia. Even the proof of the felsite being of earlier age than the conglomerate would not now, if that conglomerate is post-Llanberis, prove it to be non-intrusive, and there remains only the fact that it is always followed, in regular succession, by its own débris, or what is considered to be such, and this seems sufficient.

[2] Op. cit., p. 315.

[3] Q.J.G.S., vol. xli, pp. 74–79.

this paper Professor Hughes expressed his agreement that here
" the newer series " is " absolutely unconformable to the older,"
and Dr. Hicks said that " from the present evidence it is clear that
an unconformity does exist."   Professor Bonney, however, said that
Professor Green's reading of the section (which differed from his
own) might be the correct one, but he felt very doubtful.

It was this general consensus of recent opinion, that there were
Pre-Cambrian rocks exposed in this district, that led me to examine
it in connection with the Pre-Cambrian rocks of Anglesey, announcing
my results in 1888[1] (E).   At the time of writing that paper I was
no better acquainted with this part of the district than other writers
upon it, but I was led to accept the recent opinions (1) that the
felsite was a lava-flow and not intrusive, and (2) that the con-
glomerate to the east was derived from it.   But no evidence had
been given for regarding the conglomerate as the base of the
Cambrian, and accordingly I considered it might be high up in that
series.   Nor could I then see proofs of unconformity at Moel Tryfaen,
while the unconformity shown by Professor Green I could not deny,
but I tried to discount it by quoting his opinion that it did not
necessarily indicate any great difference in age.[2]   I thus considered
the felsite to be part of the Cambrian succession, in spite of accepting
all that previous writers had given reasons for.   As to the con-
glomerate, quoting previous observers, I considered that the pebbles
were of Cambrian age, and yet took the containing rock to be one
of the higher conglomerates in that series.

In 1891 Miss C. Raisin traversed my conclusions as above (F).[3]
In this paper, amongst many minor criticisms, she made one
of great weight (in addition to the correction about the " slate ").
Speaking of Moel Tryfaen, she said : " We should have to believe
that at some epoch, after the deposition of one of Mr. Blake's
successive conglomerates, the slates of which we now speak were
deposited, indurated, modified, and worn down to form some of the
Moel Tryfaen pebbles—a process of rapid manufacture indeed."
This was used as an argument for an unconformity below the
conglomerate, which she was then in favour of, even though she
could not observe it in Professor Green's section, where she con-
sidered it as only " locally absent."

Five days previous to the reading of this paper Sir A. Geikie
treated of the district in his Presidential Address (G).[4]   He denied
that the conglomerate forms the base of the Cambrian, or is un-
conformable on the rocks below, and, in fact, he agreed exactly with
my then published views.   But he could not see the unconformity

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[1] Q.J.G.S., vol. xliv, pp. 271–290.

[2] In this same paper I endeavoured to support the Cambrian age of the felsite
by finding its base.   Therein I mistook a squeezed relic of a dyke for slate, with
the result that the section, which I thought proved my point, proved nothing, either
for or against it.   In a later paper (F) Miss Raisin did me the service of pointing
out this mistake, as I have much pleasure in acknowledging.

[3] Q.J.G.S., vol. xlvii, pp. 329–342.

[4] Ibid., Proc.

where Professor Green described it, and was not, therefore, forced as I was to discount its teaching.

In 1892 I published a detailed account of the Cambrian succession (H),[1] from which it appeared that instead of there being only one Cambrian conglomerate at the base, there were several at different horizons in the series. The facts about the Llyn Padarn felsite and conglomerate were postponed to a later paper. This later paper (I), published in 1893,[2] is the one which has been criticized by Professor Bonney and Miss Raisin conjointly in the paper now being replied to (K).[3] Prior to the observations therein recorded, most of which were entirely new, I had considered that there was no unconformity beneath the Llyn Padarn — Moel Tryfaen conglomerate, except the supposed local one shown by Professor Green, but these observations forced me to conclude that Professor Hughes and Dr. Hicks were right in their conjecture that such an unconformity occurred, and that it indicated, in the words of Professor Bonney, a "marked physical break." Notwithstanding this, I still agreed with Sir A. Geikie in considering that there were several conglomerates in the Cambrian series, each in relation to its own felsite, but I removed from that series the great one at Moel Tryfaen and Llyn Padarn.

It thus appears that at that time the whole difference of interpretation rested solely on the question as to what were the rocks on which the conglomerate lay unconformably. Dr. Hicks supposed them to be Pre-Cambrian, because the samples he collected in the Moel Tryfaen adit seemed more altered than the Cambrian rocks with which he was acquainted. I held them to be part of the ordinary Cambrian series. I was accompanied in the examination of the adit section by Mr. Robert Lloyd, who has spent his life amongst these rocks and knows them well, and he recognized them at once by their local names. I also exhibited to the Geological Society samples of all that I collected there, without anyone claiming them as anything but Cambrian.

But, of course, this difference was fundamental. If the conglomerate in one place is unconformable to the rocks immediately below the purple slates, we may reasonably expect that in other places it will be unconformable to the latter also, as they follow the former in regular sequence, and in this case the whole proof of there being anything Pre-Cambrian here is entirely destroyed.

Under these circumstances it is certainly remarkable that Professor Bonney and Miss Raisin, in their criticism upon my paper, do not attempt to show that the rocks in the Moel Tryfaen adit are Pre-Cambrian, but endeavour to demolish my stratigraphy, in which, if successful, they would destroy their own former views and approximate to those which now, on further evidence, I have discarded, and which were nevertheless equally fatal to the idea of there being any proof of the existence of Pre-Cambrian rocks in the district.

[1] Q.J.G.S., vol. xlviii, pp. 243–262.
[2] Q.J.G.S., vol. xlix, pp. 441–466.
[3] Q.J.G.S., vol. l, pp. 578–602.

The various views on this district may now be thus summarized:

   A. A general unconformity indicates the commencement of a new series.—*All.*

   B_1. There is no unconformity in this district. — *Ramsay*; at Moel Tryfaen, *Bonney, Raisin.*

   B_2. The unconformity is local only.—*Geikie*, formerly *Blake.*

   B_3. The unconformity is general. — *Hughes, Hicks, Blake*; formerly *Bonney, Raisin.*

     Conclusion 1. There is no break in the series here.—*Ramsay, Geikie, Bonney ? Raisin ?* formerly *Blake.*

     Conclusion 2. The great conglomerate forms the base of a new system.—*Hughes, Hicks, Blake*; formerly *Bonney, Raisin.*

   C_1. The Moel Tryfaen conglomerate is Cambrian, therefore the underlying beds are Pre-Cambrian.—*Hughes, Hicks*; formerly *Bonney, Raisin.*

   C_2. The beds below the Moel Tryfaen conglomerate are Cambrian; therefore there is no evidence of Pre-Cambrian rocks here, and the age of the conglomerate is doubtful.—*Blake.*

Professor Bonney and Miss Raisin's general Objections.

The authors commence by characterizing my conclusions as "a new and revolutionary hypothesis"; but it will be seen from the foregoing account that the idea of an unconformity is by no means new. The nature of the rocks in the Moel Tryfaen adit can scarcely be called a "hypothesis," and it is this that is revolutionary in its results, the further extension of the unconformity, which no doubt is new, being thus rendered quite natural. My suggestion also of there being more than one felsite, had been anticipated by Professor Bonney in C.

As a first objection my critics ask: "To what epoch (from the Menevian onwards) do these so-called Post-Llanberis sediments belong, and where in the adjacent districts may we find beds that can be correlated with them?" "Of this problem," they say, I have not "succeeded in offering a solution." When they wrote this they cannot have considered my words (p. 465): "It seems to me most probable that they are extensions of the immediately overlying rocks." These overlying rocks (the Bronllwyd Grit and its associates) do not belong to any epoch from the Menevian onwards, but lie below that formation and below all fossiliferous rocks, except the Penrhyn pale slates with *Conocoryphe viola.* The authors have totally misunderstood my suggestion; moreover, that suggestion about the probable age of the conglomerate may be wrong without affecting the question of the unconformity.

Next they take me to task for saying that we must see whether this unconformity be local or not, for according to them "it can be no local phenomenon." Plainly it is because I take for granted that a "marked physical break" (Bonney) can be no local

phenomenon that I propose to see whether the supposed break is local or not by way of testing its existence.

The next difficulty is " the necessity of twice uncovering the felsite," which, they say, I have " not even considered." Certainly I have not. Why should not felsite be uncovered twenty times in the course of its history ? As I do not understand what the difficulty is, I may be wrong in supposing it to result from a mixture of ideas. It may be their idea that there is in this district an unconformable conglomerate at the base of the Cambrian series, and it is my idea that there is an unconformity above that series. I do not hold both. As to all the conglomerates but one, I accept Professor Hughes' and Sir A. Geikie's explanations as to how a contemporaneous lava-flow may be denuded before it is covered up by any other stratum, and thus yield its pebbles to an overlying conglomerate. It is only when the conglomerate has to lie on the felsite unconformably that the latter wants uncovering.

The next difficulty is thus expressed: " Curiously enough the Llanberis strata, though they have been so completely planed down, have not contributed any large amount of fragments; only ex- ceptionally do we find these or slaty pebbles of any kind, as, for example, at Moel Tryfaen." Here the authors give themselves completely away. If there be a single pebble, exceptional or other- wise, really deposited with the conglomerate and derived from the Llanberis strata, then the former must be younger than the latter. Probably the authors do not mean what the words imply, but for " these " we must understand " pebbles resembling these, but not really derived from them." Even then the statement reads curiously with reference to Moel Tryfaen, after Professor Bonney's description in C, that about three-quarters of the pebbles on the western side are " slate, green and purple," etc., as quoted above, while " on the eastern side the fragments of purple slate are rather more numerous." He then believed in the unconformity. The statement, however, that the Moel Tryfaen conglomerate is exceptional in containing slate pebbles is based on defective information. The slopes of Y Bigl show, in certain parts of the conglomerate, quite a number of purple slate fragments, of such large size and so angular that I really cannot suppose them to have come from any distance ; and the workable slates close by are just like them. They are found also on Mynydd-y-cilgwyn and between Moel Rhiwen and Moel-y-ci. We must remember, too, that purple slate is not a kind of rock likely to be left in large fragments far from its source of origin ; it would soon break down into mud and form a new rock like the original. Of this we find several examples, which render the stratigraphy difficult.

So far from the alleged absence of pebbles of rocks like the adjoining ones being a difficulty, their frequent presence and their distribution are strongly in favour of an unconformity, as formerly argued by Miss Raisin. It is these slate pebbles that distinguish, when present, the great conglomerate from others which are intra- formational. Sir A. Geikie proposed to account for them by the

breaking up of the circumjacent deposits during a volcanic eruption, but this explanation is untenable because, as pointed out by Dr. Hicks, the pebbles are of rocks already cleaved. The conglomerate runs in a long line, and its pebbles change character with the rock near which it lies. Near the felsite it becomes most felsitic. On Y Bigl and further north, as also at Moel Tryfaen and Mynydd-y-celgwyn, where it lies nearest purple slate, the fragments like that rock are most abundant, and where at Moel Tryfaen it approaches nearest the upper side of these slates, it contains strange, un-recognizable fragments. In this it shows the character of a shore deposit.

Although the general objections of my critics are thus disposed of, I do not in the least demur to their conclusion, that " the detailed evidence ought to be of the strongest and clearest nature if it is to establish the supposed unconformity." That is just what it is. ·

The Moel Tryfaen District.

This is the district in which Professor Bonney (C) argued that there was a marked physical break, and Miss Raisin (F) that we see here the base of a series. But now that I give definite proofs of the unconformity they cannot believe it.

Dealing with the summit conglomerate and the small amount of any conglomerate in the adit section, these authors say " there seems on our theory no other explanation possible than that this con-glomerate is faulted out, and the broad outcrop at the summit might be partly due to such disturbance." We are not told, however, what " our theory " is, nor where the conglomerate is faulted out from, nor how much of the broad outcrop " might be " due to such disturbance. This " explanation " is put forward without any detail that should give us the slightest clue to its meaning, and if we try to guess we are confronted with the puzzling remark, " this seems suggested by the changed dip in the associated green grits on the summit." What the dip was previously and how determined we are not told, so I think it useless to speculate on their meaning.

The authors disagree with me when I say that there is no green grit on the summit. I will only remark that the green grit seen by them is not the green grit which I referred to, which was one occurring between the conglomerate and the purple slates, while, so far as I can judge by the dip given, their " green grit " is part of a small band of false-bedded grit associated with a different kind of conglomerate of white weathering pebbles, near the opposite side of the outcrop. Here one block shows the dip they state, N.N.W., while an adjacent block shows the opposite, S.S.E.

Referring to my description of the wide spread of conglomerates and grits on the north side of the hill and their generally horizontal trend in an east-and-west direction, the authors differ from me again, at least by implication. I stated that there was a line of crags showing a dip of not more than 5° to the east, and also in a lower part a lenticle of fine grit running almost horizontally

in a conglomerate. It is not positively stated that these observations are incorrect, but only that " we took the dip on several blocks and surfaces, of which four at least were clearly shown varying from 15°–25° generally to the S. of E. or S.E." ; from which it is left to be inferred that these statements are incompatible with mine. But they are not. I have seen " blocks and surfaces " showing the dips mentioned, but they are isolated blocks lying on the eastern slope of the hill, and it is not certain that they are *in sitû*. I did not even look for dips on such blocks, as dips are worse than useless unless the rocks are certainly *in sitû*. But even in that case these dips, combined with the more persistent ones of the crags, would not affect my argument to any material extent. But with such rocks as these, and so exposed on the slopes of a rounded hill, it is not by isolated dips, which are liable to all kinds of accidents, but by the direction of the outcrops that the strike may best be determined. In this case, if we walk on a level line round the base of the north side of the hill a little above the pathway, we keep on conglomerate, but if we anywhere mount a little and take another contour-line, we keep upon grits. This would indicate that the junction between them, i.e. bedding of both, was not far removed from the horizontal in a direction across the hill.

The further remarks about this district are —(1) That the conglomerate of the lower crags is not like that of the summit, as it does not contain the large slate pebbles. It is true that the pebbles of cleaved rock with the appearance of slate are not so large as in the latter, but there are many of them. (2) That whereas I said of a certain area that it was all covered with conglomerate and grit, in fact no small part consists of unbroken sward. This is only true of that part which I called " the lower slopes," and which I distinguished from the part all covered with conglomerate and grit. (3) That it is remarkable that the conglomerate, if unconformable, does not spread over on to the purple slates. This has not been proved to be the case, and if true is easily explained. The fault which bounds the purple slates is probably a thrust-plane which lifted them and their covering above the level of the conglomerate on the other side, and they have been worn back to that level by denudation, which necessarily first removed the conglomerate. Probably also ice has swept all débris away.

In this district, then, my critics have brought no valid objections against my conclusions, and have failed to propose any reasonable alternative. Meanwhile they have not touched the argument from the great spread of the conglomerate and its associates over a very wide area on the surface of the hill, while nothing but a 3 feet band is found in the adit,[1] nor the still more cogent argument that, whereas the conglomerate here lies on, or is next to, a great mass of banded slate, in the neighbouring hill of Mynydd-y-cilgwyn it lies entirely on felsite, and continues round to the western side of it.

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[1] I might add that this is not quite like the summit conglomerate, but such arguments are of little value.

But I cannot understand what they would gain by success in their contention. If instead of one unconformable conglomerate it were granted that there were two or three conformable ones, they would belong to the adit series, or to the purple slate series, or to both, but in no case could they be the base of the Cambrian system, or give any assistance in proving the existence of Pre-Cambrian rocks in the neighbourhood.

<div style="text-align:center">(To be continued.)</div>

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—February 2, 1898.—Dr. Henry Hicks, F.R.S., President, in the Chair.

The President announced that Dr. Charles Barrois, Secretary of the Organizing Committee of the Eighth International Geological Congress, which will be held in Paris in 1900, would shortly come to London to invite the Geological Society to the Congress, and to consult the Fellows with regard to the proposed excursions and the subjects of discussion.

The following communications were read :—

1. "Contributions to the Glacial Geology of Spitzbergen." By E. J. Garwood, Esq., M.A., F.G.S., and Dr. J. W. Gregory, F.G.S.

The extent of glaciation of Spitzbergen has been exaggerated, for there is no immense ice-plateau, but normal glaciers with some inland sheets and Piedmont glaciers. These differ from Alpine glaciers, as they are not always formed from snow-fields at the head, and though some of the glaciers (as the Baldhead Glacier) have tapering snouts in front, most have vertical cliffs. Chamberlin's explanation that the latter are due to the low angle of the sun is insufficient, and they seem to be caused by the advance of the ice by a rapid forward movement of its upper layers. The ice of these upper layers falls off and forms talus in front, over which the glacier advances, carrying detritus uphill with it, and producing a series of thrusts. The Booming Glacier illustrates cases of erratics carried in different directions by the same mass of ice.

The deposits of the Spitzbergen glaciers are of four types :— (1) moraines of Swiss type ; (2) those formed mainly of intraglacial material ; (3) those formed of redeposited beach-material ; (4) deposits of glacial rivers and reassorted drifts. The materials of the second are subangular and rounded ; scratched and polished pebbles and boulders are abundant, and the fine-grained matrix, which is frequently argillaceous, is often well laminated and false-bedded. Some of these drifts are stratified, others unstratified, and contorted drifts occur. This type of moraine is remarkably like some British Boulder-clay. The third class is sometimes formed by land-ice, at other times beneath the sea ; the latter shows stratification. The

superglacial and intraglacial streams, so far as seen, were usually clear of drift. Under the fourth head an esker in a tributary of the Sassendal is described.

The direct geological action of the marine ice is of four kinds : transport of material, contortion of shore-deposits, formation of small ridges of boulder-terraces above sea-level, and striation, rounding, and furrowing of rocks along the sea-shore.

Traces of former glaciation are described in the case of the Hecla Hook beds, and of certain beds of late Mesozoic or early Cainozoic age in Bunting Bluff.

Under the head of general conclusions, the authors state that they have discovered no certain test to distinguish between the action of land-ice and marine ice ; that there is no evidence to prove that land-ice can advance far across the sea; and that there is evidence, which they regard as conclusive, of the uplift of materials by land-ice. They note that the mechanical processes connected with the advance of the glaciers are of three kinds. All the material seen transported by the glaciers was superglacial or intraglacial, and not subglacial. Some striation of intraglacial material is caused by differential movement of different layers of ice. The advance and retreat of the Spitzbergen glaciers is very irregular, and apparently due to local changes. The observations of the authors support the views of those who ascribe a limited erosive power to glaciers. Lastly, the theory that glacial periods occurred as a consequence of epeirogenic uplifts receives no support from Spitzbergen.

2. "On a Quartz-rock in the Carboniferous Limestone of Derbyshire." By H. H. Arnold-Bemrose, Esq., M.A., F.G.S.

The paper describes the occurrence in the field and the microscopic structure of a rock consisting essentially of quartz, which is found in the Mountain Limestone in several localities. It occurs in irregularly-shaped bosses and veins, and shows no signs of stratification.

Its close association with a quartzose limestone, which in turn passes into an ordinary limestone with few, if any, quartz-crystals, leads to the inference that it is a silicified limestone.

The microscopical structure of a number of thin slices of these rocks is described. The quartz-rock is seen to be made up of quartz-grains which generally interlock closely, but sometimes possess a crystalline outline and contain zones of calcite. Fluor is occasionally present.

The quartzose limestone is usually a foraminiferal limestone containing a large percentage of quartz, which occurs as separate crystals and as aggregates of crystals. The latter and the small quartz-veins have a structure similar to that of the quartz-rock. The former often contain zones of calcite and penetrate organisms. The residue consists of quartz-crystals.

The author considers that the quartz-rock is not a gritty limestone, altered by the growth of crystalline quartz around the detrital grains, but that it is a limestone replaced by quartz. The gradual

passage from the quartz-rock through a quartzose limestone to an ordinary limestone, the presence of chert, of part of a foraminifer, and of pieces of quartzose limestone in it, support the opinion that it is an altered limestone.

II.—Annual General Meeting.—February 18, 1898.

Dr. Henry Hicks, F.R.S., President, in the Chair.

The Secretaries read the Reports of the Council and of the Library and Museum Committee for the year 1897. In the former the Council referred to the uninterrupted financial prosperity of the Society and to the continued increase in the number of Fellows.

During 1897 the number of Fellows elected was 59 : of these 41 qualified before the end of the year, making, with 13 previously elected Fellows, a total accession of 54 in the course of the twelve-month. During the same period, the losses by death, resignation, and removal amounted to 51, the increase in the number of Fellows being 3.

The total number of Fellows, Foreign Members, and Foreign Correspondents, which on December 31st, 1896, was 1,329, stood at 1,333 by the end of 1897.

The balance-sheet for the year 1897 showed receipts to the amount of £3,610 19s. 3d. (including a balance of £768 3s. 0d. brought forward from the previous year), and an expenditure of £2,887 16s. 3d. There was an actual excess of expenditure over current receipts of £45, but the excess was entirely due to expenditure of a non-recurring character, and there still remained at the end of 1897 a balance of £723 3s. available for the extraordinary expenditure contemplated in the estimates submitted to the Fellows.

The completion of Vol. LIII of the Society's Quarterly Journal was announced, as also the publication of No. 4 of the Record of Geological Literature added to the Society's Library, and of Part II of the General Index to the first Fifty Volumes of the Quarterly Journal.

An address was presented to Her Majesty by the President and Council, on their behalf and on that of the Fellows, on the occasion of the Sixtieth Anniversary of her Accession ; and three delegates were nominated to represent the Society at the International Geological Congress held at St. Petersburg.

The attention of the Council had been drawn by Sir Archibald Geikie to the manuscript, in the Society's possession, of part of the Third Volume of Hutton's "Theory of the Earth." He had freely offered his services as editor, and it was proposed to print and publish the work during the present year.

Reference was also made to the work done by the Committee appointed in connection with the International Catalogue Committee, and to the Index slips issued with the current number of the Quarterly Journal.

In conclusion the awards of the various medals and proceeds of donation funds in the gift of the Society were announced.

The report of the Library and Museum Committee enumerated the large additions made to the Society's Library during the past year, and referred to the continuance of the work of labelling and registering the specimens in the Museum by Mr. C. Davies Sherborn.

In handing the Wollaston Medal (awarded to Professor Ferdinand Zirkel, F.M.G.S., of Leipzig) to Mr. J. J. H. Teall, for transmission to the recipient, the President addressed him as follows :—Mr. Teall :—

The Council of the Geological Society have this year awarded the Wollaston Medal to Professor Zirkel, as a mark of their appreciation of the great services which he has rendered to Geological Science, especially in the department of Petrology. His " Lehrbuch der Petrographie," the first edition of which was published more than thirty years ago, is an indispensable adjunct to the library of every petrologist. A comparison of the two editions of this monumental work, the second of which has only recently appeared, illustrates in a most striking manner the enormous advance which has taken place in petrographical science during the interval—an advance in no small measure due to the influence exerted by Professor Zirkel, both as a teacher and as an original worker.

His classic memoir on the " Microscopic Structure and Composition of Basaltic Rocks " was one of the first publications in which the results of the examination of an extensive series of microscopic sections were made known. It marks an epoch in the history of petrography, not only because it greatly extended our knowledge of this important group of rocks, but also because it gave a great stimulus to the study of thin sections under the microscope. It must always be a source of gratification to British geologists that this important work was dedicated to our distinguished Fellow and revered master, Henry Clifton Sorby.

It is impossible for me to review all Professor Zirkel's important contributions to Geological and Mineralogical Science, but there is one other that I cannot pass over in silence. I refer to his " Geological Sketches of the West Coast of Scotland." In this memoir Professor Zirkel applied the methods of microscopic analysis, for the first time, to the wonderful records of Tertiary volcanic activity which abound in that region. As an original observer he has made his mark in the history of our time, and as a Professor he has won the esteem and affection of many enthusiastic students. It only remains for me now to request you to transmit to Professor Zirkel this Medal, and at the same time to express to him our great regard and our sincerest wishes that he may long enjoy health and strength to continue his important researches in those branches of Geological Science for which he has already done so much.

Mr. Teall, in reply, read the following letter, which he had received from Professor Zirkel :—" Mr. President,—

" The honourable award of the Wollaston Medal is for me one of the most gladdening events of my life. Yet I cannot say whether I am more pleased or surprised at the unexpected announcement that I should be considered worthy of so brilliant a distinction, which has been bestowed by this highest tribunal of Geology only on the most illustrious British and Foreign votaries of the science. But to-day all feelings are merged in one of gratitude to the Members of the Council, who have taken so generous and favourable a view of my modest labours. As, much to my regret and disappointment, I find myself unable to attend the Annual Meeting, I must trespass upon your kindness to express by these written words my heartfelt thanks and best acknowledgment for the great honour conferred upon me, of which the most ambitious may well be proud. I receive the Medal as a token of indulgence and encouragement, and it will be an incentive to me still to strive to be more worthy of it and of your confidence. Probably I never should have been able to do what I have done, but for the wise example and kind instruction of my old master, Henry Clifton Sorby. The tie of personal friendship which connects me with so many fellow-workers in your country since those bygone days, when Murchison, Lyell, and Ramsay favoured the young foreigner with their attachment—this tie will be strengthened to-day, and the Geological Society's prosperity and usefulness will never cease to be the object of my warmest wishes."

The President then handed the balance of the proceeds of the Wollaston Donation Fund (awarded to Mr. E. J. Garwood, M.A., F.G.S.) to Mr. A. Strahan, for transmission to the recipient, addressing him as follows :—Mr. Strahan,—

At the last Meeting of the Geological Society we had the pleasure of listening to a communication by Mr. Garwood and Dr. Gregory which adds much to our knowledge concerning the Glacial Geology of Spitzbergen. Last year he also gave an address at one of the " At Homes " of the Society, which was highly appreciated by those present. These amply testify to his ability to carry on explorations in difficult regions, where strength of purpose and special training are indispensable to success. Other geological questions have also occupied his attention ; and I may here mention the paper by him in the Geological Magazine on " Magnesian Limestone Concretions " as an interesting contribution to a vexed question, and his paper and reports on Carboniferous Fossils, the result of much labour among the Carboniferous rocks of the North of England. The Council, in making him this Award, hope that it may act as a stimulus to further researches in those fields in which he has already shown such marked ability, and that he will accept it also as a token of appreciation for what he has already accomplished.

Mr. Strahan, on behalf of the recipient, read the following reply :—" Mr. President,—

" I desire to thank you and the Council of this Society for the honour conferred upon me in awarding to me the Balance of the Proceeds of the Wollaston Fund.

" Some years ago, it occurred to me that the Carboniferous beds in Britain might be capable of subdivision into life-zones, similar to those already established in Belgium and elsewhere ; but, after several years' work, I realized that the task was much too great for the time at my disposal, and I am glad to say that the work is now being carried on by a Committee of the British Association.

" My last two summers have been devoted to work in the far North ; and the kind encouragement and assistance which I have received to-day will be a great incentive to the continuance of that work."

The President then handed the Murchison Medal (awarded to Mr. Thomas F. Jamieson, F.G.S.) to Mr. Horace B. Woodward, for transmission to the recipient, addressing him as follows :—Mr. Horace Woodward,—

The Murchison Medal, with the sum of Ten Guineas, has this year been awarded by the Council of the Geological Society to Mr. Thomas F. Jamieson, in recognition of his long and important researches among the Glacial Deposits of Scotland. It is an interesting fact that Mr. Jamieson's first papers were communicated to this Society through Sir R. Murchison, the founder of this Medal. From the year 1858, when he read a paper before the Society on the Pleistocene Deposits of Aberdeenshire, up to the present time, Mr. Jamieson has continued his researches with unabated enthusiasm, and the Geological Society has received many valuable communications from him. The list includes papers on " Drift and Rolled Gravel of Northern Scotland " in 1860, and " Ice-worn Rocks of Scotland," 1862, in which he describes great erosion by ice-action and the presence of boulders far above the parent rock, and gives a sketch-map of Scotland showing the direction of the Glacial markings. In 1863 was published his well-known paper on the Parallel Roads of Glen Roy, in which he claims that they are beaches of fresh-water lakes— the lakes having originated from glaciers damming the mouths of valleys and reversing their drainage. Further papers on Glacial questions were communicated by him to the Society in 1865, 1866, 1871, 1874, 1882, and 1891, and he may, I think, claim to have done more probably than any other man for the Glacial Geology of Scotland. It must not be forgotten also that this Society always received the first fruits of his labours, and that his most important papers are to be found in our Quarterly Journal. These papers are full of carefully observed facts, and abound in valuable suggestions, and many of the views advocated by him in some of his earlier papers have been since further advanced by him and other observers in this and other countries. I will ask you, therefore, to be good enough, in

transmitting this Medal to Mr. Jamieson, to express to him the admiration of the Council for the energy and ability with which he has for so long a period, and with such signal success, prosecuted researches among the newer deposits in Scotland.

Mr. Horace B. Woodward replied in the following terms :—Mr. President,—

I esteem it an honour to receive this Medal on behalf of Mr. Jamieson, for no one has laboured more ardently, no one more successfully, than he, in interpreting the Pleistocene records of North Britain. He bids me say :—

" I regret much that my distance from the Metropolis will not allow me to be present at the Annual Meeting of the Society. It has also prevented me from taking any part in the pleasant Evening Meetings, which I regret even still more. I think I have been present on only one occasion, and that was before I became a Fellow of the Society, which is a good long while ago.

" It is gratifying, however, to find that, although so far away, and so little known personally to the Council of the Society, they have not only kept me in remembrance, but have done me the honour of awarding to me the Murchison Medal. This I shall value the more as it recalls the recollection of the warm-hearted Sir Roderick, from whom I received much kind attention many years ago. Although then a young man, and quite a stranger to him, I found no one more ready to help me in every way that he thought would be useful. This was a bright feature in his character, which struck me much at the time, and has always kept his memory green in the breast of the present recipient of his Medal."

I may add that I am sure that Mr. Jamieson will be gratified by the kindly remarks which you have made in reference to his work.

In handing the balance of the proceeds of the Murchison Geological Fund (awarded to Miss J. Donald, of Carlisle) to Mr. E. T. Newton, for transmission to the recipient, the President addressed him as follows :—Mr. Newton,—

On one occasion only has the Geological Society previously granted an Award from its Funds to a Lady. This was in the year 1893, when Miss Raisin, so well known to us by her petrographical and stratigraphical work, was the recipient. On the present occasion a lady who has attained distinction as a palæontologist has been selected by the Council to receive an award from the Murchison Fund, and the Fellows generally will, I feel sure, believe that in making this Award to Miss J. Donald the Council has acted wisely and justly. In the Quarterly Journal of this Society are five important papers by Miss Donald. The first, in the year 1887, " Notes upon some Carboniferous Species of *Murchisonia*" ; followed in 1889 by " Descriptions of some New Species of Carboniferous Gasteropoda" ; in 1892, " Notes on some New and Little-known Species of Carboniferous *Murchisonia*" ; in 1895, " Notes on the Genus *Murchisonia* and its Allies" ; and, in the forthcoming Quarterly Journal, " Observations on the Genus *Aclisina*, De Kon., with Descriptions of British Species and of some other Carboniferous Gasteropoda."

Previous to taking up the study of fossil shells, which I understand she did at the instigation of Mr. J. G. Goodchild, F.G.S., Miss Donald had well prepared herself by previous studies of recent shells, and we find in the Transactions of the Cumberland and Westmoreland Association of Literature and Science, so far back as 1881, some notes by her on the " Land and Fresh-water Shells of Cumberland." Miss Donald has not only visited very many of the collections in this country, but also those in the Continental museums, for the purpose of studying fossil shells, and she is still untiring in her zeal in collecting information for future work. When transmitting this Award to Miss Donald you will be good enough to say that the Council hope it will be accepted, not only as a token of appreciation of the excellent work which she has already accomplished, but in the hope that it may be some incentive to her to continue her palæontological researches among the Palæozoic rocks.

Mr. Newton, in reply, said :—Mr. President,—

It is with peculiar pleasure that I receive this Award on Miss Donald's behalf, for it is a rare occurrence for a lady to receive one of the Society's Awards, and having

for some years watched and appreciated the conscientious and painstaking labour by which Miss Donald has accomplished a very admirable piece of work, it is particularly gratifying to find that this work has met with the appreciation of the Council of the Geological Society.

As Miss Donald cannot be present to receive this award personally, perhaps I may be allowed to read an extract from her letter:—

"Will you thank the President and Council most heartily on my behalf for the great honour which they have conferred by awarding to me the balance of the proceeds of the Murchison Fund. The news came to me as a great surprise, for I had previously deemed it no small honour that my papers should have been considered worthy of publication in the Quarterly Journal of the Society, and this higher recognition will certainly prove an encouragement to further research and, I hope, better work. My studies have been a source of great pleasure to me, and I feel that there is still much to be found out, even with regard to the genus *Murchisonia*, to which I have hitherto devoted the greater share of my attention."

The President then handed the Lyell Medal (awarded to Dr. Wilhelm Waagen, F.G.S., of Vienna) to Dr. W. T. Blanford, for transmission to the recipient, addressing him as follows:— Dr. Blanford,—

Owing to ill-health, Dr. Waagen is unable to be present to receive the Lyell Medal, with the sum of twenty-five pounds, which the Council of the Geological Society have awarded to him, in appreciation of his excellent Palæontological work. Just twenty years ago (Feb. 1878) Dr. Waagen was a recipient of the Lyell Fund, soon after his retirement, owing to ill-health, from the Geological Survey of India; and his work was, on that occasion, referred to in terms of great admiration by the then President, Prof. Martin Duncan, and by Dr. Oldham, who was deputed to receive the Award on his behalf. Of the works published by Dr. Waagen, I may mention an important paper, " On the Classification of Upper Jurassic Beds " (those of Southern England included) in 1865, and in 1869 one on " The Subdivisions of Ammonites," of which full abstracts appeared in the Quarterly Journal of the Geological Society in 1865 and 1870. When in India he described the Ammonites of the Kach Jurassic beds, and his great knowledge of the Ammonitidæ enabled him to work out the succession in detail. Another most important work was his description of the fossils from the Cambrian, Carboniferous, Permian, and Triassic of the Salt Range in the Panjâb, and his account of the geology in the " Palæontologia Indica." His untiring devotion to his work is well known to all those who have been in any way associated with him, and his careful and zealous labours have placed him in the front rank of palæontologists. I now ask you to be good enough to forward to Dr. Waagen this further token of esteem, with every expression of good-will, from the Council of the Geological Society.

Dr. Blanford replied in the following terms :—Mr. President,—

I am glad that I am able to comply with the request of my old friend and colleague Dr. Waagen, that I would represent him on this occasion and receive for him the Lyell Medal of the present year.

May I be allowed to express my own gratification at the award ? Few geologists, I think, will question the value of the Palæontological work done in connection with the Geological Survey of India since that Survey was first organized under the late Dr. Thomas Oldham. Dr. Waagen is now the only survivor of the first three Palæontologists who between them occupied the post from 1862 to 1883. As, moreover, Dr. Waagen has been continuously engaged in the study of Indian Palæontology, and in contributing to the Survey publications, from the date when he first joined the Indian Survey to the present day, he is the author of a much larger share of the work than either of his colleagues.

As you, Sir, have already stated, the proceeds of the Lyell Fund were awarded to Dr. Waagen just twenty years ago, in 1878. There has rarely, I believe, been an occasion on which the intentions of the great geologist who founded this fund have been more thoroughly carried out. Sir Charles Lyell desired that the interest of this fund should be given for the encouragement of Geology or of any of the allied sciences by which Geology has been most materially advanced. At the time when the fund was awarded Dr. Waagen had left India, broken in health, and in serious

difficulty through having to resign his appointment on the Indian Survey, on account of his inability to resist the effects of a tropical climate. I know as a fact that the Award was a great encouragement to him, and I think the volumes which he has since published in the "Palæontologia Indica," containing his descriptions of that marvellous series of Salt Range fossils from Lower Cambrian to Trias, and his masterly summary of the Geological results, have thoroughly justified the award that was made.

In a letter which he wrote to me recently, Dr. Waagen said : "The decision of the Geological Society's Council to award to me the Lyell Medal is greatly gratifying to me, and I have to express to the Society my most heartfelt thanks. These I beg you to express to the Society, as my health is yet too untrustworthy for me to go to London and do so myself. I hope yet to do some work, though my chief work has been done. I hope to finish the Indian Trias ; the Nautilidæ and Gasteropoda are in manuscript finished, and the Pelecypoda will soon be commenced. I hope to finish the whole by the end of this year.

"The Medal will give me a new impulse to go on with the work. . . . . So I beg you to receive it on my behalf and to express my most hearty thanks to the Society for it."

It only remains for me, Sir, to thank you on behalf of Dr. Waagen for having added to the value of the Medal by the manner in which you have spoken of his services to science.

In presenting to Mr. H. Woods, M.A., F.G.S., a moiety of the balance of the proceeds of the Lyell Geological Fund, the President addressed him as follows :—Mr. Woods,—

The Geological Society has already received some important communications from you, and I hope that these will be followed by many others. In your paper on the Igneous Rocks of the Neighbourhood of Builth you have successfully applied not only your petrological knowledge, but also your palæontological experience in working out the stratigraphy of an interesting and complicated region ; and your paper on the Fossils of the Middle Chalk is a very valuable contribution to the study of the Fauna of the British Cretaceous Rocks. Your "Catalogue of Type Fossils in the Woodwardian Museum" is indispensable to all working palæontologists ; and your "Elementary Palæontology," written primarily for Cambridge students, has been found so useful that it is now, I understand, adopted as a textbook, not only in many places in Britain, but also in the Colonies and in America. I have much pleasure in handing to you this Award on behalf of the Council of the Geological Society, in testimony of your past work, and in the hope that it may be of some aid to you in your future labours.

Mr. Woods, in reply, said :—Mr. President,—

It is with much pleasure and gratitude that I receive this fund which the Council have been good enough to award me ; and I can assure you, Sir, that I shall lose no opportunity of continuing the work to which you have referred. Although the greater part of my time is occupied by official duties in the lecture-room and museum, yet it is encouraging to hope that, as a teacher, I may be an indirect means of helping forward palæontological investigation.

In my "Catalogue of Type Fossils in the Woodwardian Museum," of which you have so kindly spoken, I endeavoured to give not only a list of types, but also a record of the persons who have enriched the collections in our museum, and amongst those benefactors you, Sir, occupy a prominent place.

The President then presented the other moiety of the balance of the proceeds of the Lyell Geological Fund to Mr. W. H. Shrubsole, F.G.S., addressing him as follows :—Mr. Shrubsole,—

For many years your name, as well as that of two of your brothers, has been well known to the Fellows of this Society, and it is a pleasure to me to hand to you, on behalf of the Council, this moiety of the Lyell Fund, in testimony of the valuable services rendered by you to Geological Science.

Although during your long residence at Sheerness you were engaged in business, you lost no opportunity of advancing the science of Geology, to which you had

become so ardently attached, and by your exertions you greatly added to our knowledge of the Fauna and Flora of the Lower Eocene of the Isle of Sheppey.

Amongst your discoveries, which have been described in the Quarterly Journal of this Society, may be mentioned the wing-bones and skull of a bird allied to the albatross, named by Owen *Argillornis longipennis* (Quart. Journ. Geol. Soc., 1878) ; a new genus and species of Estuarine Gasteropods, described by Lieutenant-Colonel Godwin-Austen in 1882 ; and the remains of a giant turtle, named by Owen *Chelone gigas* (Quart. Journ. Geol. Soc., 1889). I understand that your collections of fossil fruits were also of great use to Baron von Ettingshausen and Mr. Starkie Gardner in working out the Flora of the Eocene ; and that all your choicest specimens (including another new bird's skull) have been always transmitted to the British Museum so soon as discovered. Those who are acquainted with your labours will feel that this Award of the Council has been given to a thoroughly meritorious fellow-worker, and a most patient original scientific investigator.

Mr. Shrubsole replied in the following terms :—Mr. President,—

This part of the present proceedings has made me realize that, once again in my experience, the unexpected has happened. Only this time, unlike many previous experiences, the unlooked-for circumstances are, so far as I am concerned, entirely pleasant and beneficial. In view of what has happened, I am constrained to say that it affords me very great gratification that this distinguished Society has seen fit to include me in its roll of honour, and to present me with a substantial mark of its favour.

It is, indeed, very pleasant to me to find that the geological work carried on quietly and alone for a good many years has now received ample recognition, and has had the stamp of your approval bestowed upon it. Although I had no co-workers in Sheppey from whom to derive encouragement and assistance, yet I always met with kind and helpful attention from all geologists with whom occasionally I came in contact. I have never applied to any Fellow of this Society, or to any official of our Museums, for help in the determination of specimens, without obtaining all that I wanted ; and the value of this was enhanced by the extremely courteous way in which it was rendered.

There are gentlemen here—there are others who have passed away—whom I shall always remember with gratitude, for having thus assisted me when I was a geological neophyte. As to the future ; I hope that I may be able to render some further scientific service.

It is true, as you can see, that I am no longer troubled with the immaturity of youth, yet I feel that a reserve of energy remains, for which I hope opportunity of exercise may still be found.

Although I no longer reside at Sheppey, I am keeping in touch with the place and am well represented there. You may rely upon it that no new or rare fossils will escape notice through any lack of attention on the part of my helpers or myself. In this and in other ways I hope to manifest a keen interest in geological pursuits so long as life shall last.

In presenting to Mr. E. Greenly, F.G.S., a portion of the proceeds of the Barlow-Jameson Fund, the President addressed him as follows :—Mr. Greenly,—

The Council of the Geological Society have awarded to you the sum of twenty pounds from the Barlow-Jameson Fund, in recognition of your scientific labours, and to aid you in the important researches which you are now so assiduously carrying on among the older rocks in Anglesey. The experience which you gained when on the staff of the Geological Survey in the North-West of Scotland has enabled you already to attack some of the problems connected with the older rocks with much success ; and many are looking forward with great interest to the further results of your labours. I must not omit to mention that, though no longer a member of the Geological Survey, you have continued to work as assiduously, and with the same attention to minute details, as when on that staff, and that the expenses, which must have been considerable, have been hitherto defrayed out of your private income. This is a strong testimony to the love which you entertain for that science which you were led to adopt as a profession, mainly, I believe, through attending the lectures of Professor Bonney at University College, London. It gives me much pleasure to hand you this Award on behalf of the Council.

Mr. Greenly, in reply, said :—Mr. President,—

I wish to express my sincerest thanks to the Council of this Society for the great honour which they have conferred upon me. It is also, Sir, additional pleasure to receive it at your hands, when I think of your own pioneer researches in the same field. With regard to my own work, its present field was chosen because I wished to continue to utilize the experience and training for which I am so deeply indebted to the Geological Survey. Mapping itself I continue to do, not merely because I have faith in it as a method of research, but because it is a pleasure, and I know of no more delightful employment. Nevertheless it is a method which involves much that might be called drudgery, with no apparent reward. At such times this Award will ever be an encouragement to persevere, as I hope to do while I have strength and opportunity.

The President then proceeded to read his Anniversary Address, in which he first gave Obituary Notices of several Fellows and Foreign Members deceased since the last Annual Meeting, including J. J. Steenstrup (elected F.M. in 1879), A. des Cloizeaux (elected F.M. in 1884), T. C. Winckler (elected F.C. in 1874), E. D. Cope (elected F.C. in 1881), O. Fraas (elected F.C. in 1897), Rev. P. B. Brodie (elected a Fellow in 1834), J. C. Moore (elected in 1838, Secretary in 1846), S. Allport (elected in 1869), Brooke Cunliffe (elected in 1845), Rev. S. Haughton (elected in 1853), Sir A. W. Franks (elected in 1867), Rev. R. Hunter (elected in 1868), S. Laing (elected in 1858), H. Drummond (elected in 1877), and Sir J. Maitland (elected in 1890).

He then dealt with the Evidence of the Antiquity of Man obtained from Ossiferous Caverns in Glaciated Districts in Britain, and maintained that the remains of the extinct mammalia found in them must have been introduced before any of the Glacial deposits now in or upon them could have been laid down : therefore either before, or so early in, the Glacial period that there could not have been at the time any considerable amount of snow on the neighbouring mountains, or glaciers even in the higher valleys.

From caverns in glaciated areas in North and South Wales, where Palæolithic implements have been found in association with remains of the extinct mammalia, facts have been obtained which make it certain that the implements were those of man living at the same period as the extinct animals in those areas, and therefore of Pre-Glacial age. It has also been shown that, as the cold increased, the higher valleys became filled with glaciers and the caverns became uninhabitable. That afterwards, as the snow-line and glaciers descended lower and lower, some of the caverns were subject to inundations, which not only disturbed and rearranged the deposits previously in them, but wholly or partially filled them up with local materials. That in the Vale of Clwyd, North Wales, the local glaciers gradually coalesced with those from the western and northern areas, and a mixed material was distributed over the district to a height of over 600 feet, burying the ossiferous caverns beneath it. During this time also water re-entered some of the caverns, redisturbing in part the earlier contents and depositing some of the mixed drift over that previously accumulated in the caverns.

While these caverns were occupied as dens by the hyænas, northern and southern animals commingled in the valleys and on the great plains reaching out from them to the area now covered by the Irish Sea.

From numerous examinations made of undisturbed Glacial deposits in Wales, the North of England, and Scotland, it has also been proved very clearly that the extinct mammalia, whose remains are found in association with the implements of Palæolithic man in caverns, must have lived there before those deposits had been laid down, as their remains always occur at the base or in the lower parts of the drift, and never above it. Further, there is not a particle of evidence to show that the extinct mammalia ever revisited those areas after the close of the Glacial period.

III.—February 23, 1898.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read:—

1. "On some Submerged Rock-Valleys in South Wales, Devon, and Cornwall." By T. Codrington, Esq., M. Inst. C. E., F.G.S.

The author describes various valleys in which the solid rock is reached at a considerable depth below sea-level, on the sides of Milford Haven and in the Haven itself; beneath the Tivy, Tawe, and Neath, the Wye, the Severn, the Bristol Avon, the Dart, the Laira, the Tavy, the Tamar, and other rivers. In the case of the Dart the rock-bottom has been found at one place at a depth of 110 feet below water-level, and in the case of other rivers at various depths less than this. The deposits show that some of the infilling took place after the period of submerged forests, and much before this, for frequent cases of glacial deposits filling the bottoms of these submerged valleys are recorded.

The fact that in the Solent and Thames the glacial deposits border the sides of the valleys, and do not occur at the bottom as in the case of the valleys described in the paper, indicates that the latter are older than the former, though they present features similar to those of some of the valleys of the North-East and North-West of England.

2. " Some New Carboniferous Plants, and how they contributed to the Formation of Coal-Seams." By W. S. Gresley, Esq., F.G.S.

The author, in a paper published in abstract in the Society's Quarterly Journal for May, 1897 (vol. liii, p. 245), argued that certain brilliant black laminæ in coal, and similar materials found among some mechanical sediments of the Coal-measures, pointed to the former existence of an aquatic plant. In the present communication he describes structures in the pitch-coal laminæ of bituminous coal and in the glossy black layers of anthracite which he believes to be indications of two other kinds of plants, and states that he has examined structures which may be due to some other kinds of vegetation.

CORRESPONDENCE.

THE FORMATION OF SOIL.

SIR,—That the mode of formation of surface-soil is generally supposed to be due chiefly to the accumulation of the dust and ashes of dead vegetable matter and of animals, and their ceaseless action while alive within and upon it, and to the decomposition of the sub-soil or of the rocks immediately below the soil, brought about and ever going on by atmospheric agencies and changes, rain being the principal agent, seems a correct statement to make. But as to *how* and *why* this soil came into existence and grows, those who have studied the matter do not appear to be agreed or to have found a fully satisfactory answer : for instance, one student would attribute the phenomena chiefly to the action of worms ; another, to ants, beetles, etc. ; a third, to plant-decayed vegetation ; a fourth, to rock-weathering ; a fifth, to rain. Without doubt, all of these have been more or less instrumental in soil-making, while the last —rain—would seem to be the *one thing needful*—the essential agent.

Now it seems to me that additional light may be obtained on this interesting subject if we consider it as follows :—

(1) I postulate that for every soaking or even moistening of the surface by a shower of rain or snow, etc., which is followed by a spell (whether short or long) of bright and warm weather, *evaporation* is caused.

(2) That such periods of evaporation imply *a rising upwards of a portion of the water through the soil,* to escape as vapour.

(3) That if such evaporation goes on after each shower or storm, there is ever going on in the soil a downward and upward gentle and invisible flow or movement of moisture, which pervades every particle of the soil-forming materials, in manner somewhat analogous to the flow of sap in a tree.

(4) That water flowing or soaking among rock-particles and remains of animal and vegetable substances must ever be changing its chemical composition, and also that of the ingredients of the soil ; therefore, the constant up-and-down creep or pulsative action of the moisture through the solids of the soil must be working a gradual change in the chemical and the physical condition of

the soil, no matter how slowly or feebly the process operates or proceeds.

(5) That such implied decomposition, deformation, destruction, reunion, and new combinations of particles and substances of the soil explain why some soils are more fertile than others where science fails to find any difference in them; while others prove less fertile than experiment would indicate or suggest.

(6) That the almost daily recurring changes of weather and less frequent seasonal changes, both as to temperature and humidity, with the help of animals, decay and finally crumble and disperse exposed wood, etc., until it is gone, and suggests how thoroughly the same repetition of precipitation and evaporation is also working, though unseen, just below the grass.

If this incessant oscillating or slow-motion progress of the water through the soil be a fact, then I should suppose that where it has operated with greatest vigour, there, other things being equal, would the soil be thickest and most productive; and *vice versá*, where the surface evaporation was most sluggish. Possibly the heavy rains and intervals of high temperature of the tropics account for the great fertility of their soils as much or more than for their richness as regards composition.

It will thus be seen that the leading idea in these propositions is *evaporation*—the upward motion (capillary attraction) of the contained-water of the soil working upon the inorganic and organic solid constituents of it, *in conjunction with the descent of moisture* in the forms of rain, snow, fog, etc.   W. S. GRESLEY.

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SECTION EXPOSED AT THE DRY DOCK, TROON, AYRSHIRE.

SIR,—The section of rocks exposed in the Dry Dock being constructed at Troon, Ayrshire, may be worthy of preservation in the GEOLOGICAL MAGAZINE. It is as follows :—

						Feet.
A. " Forced " or Artificial material	...	...	...	...	...	8
B. Bedded, coarse-grained trap	...	...	...	...	...	8
C. Volcanic dust	...	...	...	...	...	7
D. ,, ,, bluish ...	...	...	...	...	...	1
E. Grey, fine-grained, banded rock	...	...	...	...	...	$1\frac{1}{2}$
F. Water of Ayr Hone stone (seen)	...	...	...	...	...	8

A. Consisted of general rubbish, with fragments of pottery, etc., but not very old.

B. Towards the north end of the dock works this bed was much thicker, having apparently at that point *cut out* the beds below it to some depth, the " bedding " of the *upper* part of *the trap* being quite regular.

C. This bed had at one time been worked in a pit, the dock works having cut through the old workings. Six feet was the depth of the bed taken out by the pit, the working places being about fifteen feet wide. Nothing historical is preserved as to this pit, but there is a tradition that contraband goods were hid in the workings, and the material from the mine—which has been called " china

clay "—exported to France. About the middle of the dock works this so-called " china clay " was yellowish at the top part, whitish in the middle, and bluish at the bottom. It is exceedingly fine-grained, c in be scratched with the nail, and falls to powder readily on exposure to the weather ; but when put into an open fire and raised to a good red heat it will scratch glass.

D. This bed is perhaps just an extra-dark band of C.

E. Transition bed from D to F.

F. This bed does not differ from the real *Water of Ayr Hone* or *Whetstone*, and has already gained a reputation as a whetstone and polisher. It is of various shades of colour from light grey to dark grey—the lighter the colour the softer the material—but they all show the peculiar " mirl " of the Water of Ayr stone. Bed E has also this " mirl," showing that it is a transition stage between the " china clay " and the " Hone " bed.

All the beds below the trap exposed in the dock works are perhaps just fine volcanic dust deposited in water, and some of them are more or less stratified, although the stratification is often very faint.

The Hone bed contains nodules of a greenish material with a little *pyrites* and *mica* (white), some of the nodules showing concentric rings towards the outside; and the bedding planes of E have a slight sprinkling of mica.

The trap B is probably an intrusive bed—Whin Sill—and has hardened the " china clay " at its junction with that material. This hardening is well seen towards the north end of the dock, where the clay has been somewhat mixed up with the trap. On the west shore of Troon Point, trap, very coarse in appearance from weathering, is also seen at one or two points to have clay inclusions, the clay in both the above cases being converted into *hornstone* or *porcellanite*, and this substance, like the heated clay, also scratches glass.

The position of the beds is somewhere in the Upper Coal-measures (of Scotland).

The Water of Ayr Hone-bed crops out near Carreath, three miles east from the dock section, and is at present worked in two places, on the Ayr Water to the south of Torbolton, as a polisher and whetstone, ten miles south-east from the dock section. This seems to point to a powerful Carboniferous volcano having existed in the neighbourhood, the fine dust from which appears to have been deposited in pretty still water (probably fresh). Ferns (which I have seen) have been found embedded in the Hone-stone at the Water of Ayr Works.

In the dock section I observed no organic remains, but some parts of the " china clay " bed have faint light-coloured markings, suggestive of worm-tracks. JOHN SMITH.

P.S.—On Saturday last a number of the members of the Geological Society of Glasgow, at my invitation, visited the Troon section and were much pleased with what they saw, the Hone or Whetstone bed being an entirely new deposit to all of them.—J. S.

MONKREDDING, KILWINNING.

14th March, 1898.

OBITUARY.

SAMUEL A. MILLER.

Born August 28, 1837.   Died December 18, 1897.

This well-known American writer, who was born at Coolville, Athens Co., O., Aug. 28, 1837, and died at Cincinnati, O., Dec. 18, 1897, in his 61st year, was a man, as was said in his funeral oration, " singularly self-poised and self-centered," and no admirer of British palæontologists, nor, for the matter of that, a follower of any leaders in science, in his own country or elsewhere. Yet palæontologists of every land owe him their thanks for the useful work that will long keep his name in memory—" North American Geology and Palæontology," that invaluable guide to the scattered literature on the fossils of North America, and not least to the prolific labours of Mr. Miller himself. Scientific workers, too, may, not without advantage to themselves, respect a man who recked naught of authority, but sought out for himself that which he believed to be good. In these days of milk-and-water compliment and pusillanimous log-rolling, it is bracing for a writer who thinks no little of his work to be told suddenly in broad American that he is a " shallow pretender, overgrown with self-conceit." Mr. Miller's flat contradictions were, moreover, not to be ignored, for they were based on actual observation, usually made on the fine specimens of his own large collection. Had Mr. Miller not been a busy lawyer, one, too, with a high reputation among his colleagues, an active citizen and politician, and for a while the editor of a weekly paper, he would doubtless have found time to obtain that wider knowledge and deeper grounding in the natural sciences, the want of which did so much to cause his work to be regarded with suspicion and disfavour even in cases where it was deserving of better treatment. What Mr. Miller lacked in technical training, he made up by his energy. He was one of the founders of the Cincinnati Society of Natural History, and for several years edited the *Journal* of that body ; also during 1874–5 he edited and published the *Cincinnati Quarterly Journal of Science*. He undertook palæontological work for the States of Ohio, Indiana, Missouri, Illinois, and Wisconsin. His great catalogue of North American fossils underwent evolution through three very different editions, and continued to be brought up to date by appendices. We learn that he had in preparation a monograph on the Cephalopoda, the manuscript of which is left in a nearly completed state. The Ohio University, of which he was a graduate, conferred upon him in 1893 the degree of Ph.D.

Sturdy, both morally and physically, with a pronounced individuality reflected in his strongly marked face and determined mouth, Samuel A. Miller was not a man to pass through or to quit this world unnoticed. His grave is appropriately marked by a rough log of fossil wood from Arizona on a massive pedestal of New Hampshire granite.   F. A. B.

ORIGINAL ARTICLES.

I.—Professor J. W. Spencer on Changes of Level in Mexico.

By Prof. Edward Hull, M.A., LL.D., F.R.S., F.G.S.

THROUGH the courtesy of Professor J. W. Spencer, I have received an early copy of his paper on the "Great Changes of Level in Mexico and the Interoceanic Connections," [1] containing the observations and conclusions derived from a visit paid to this region in 1895, with the special object of determining on the spot whether the suggestion that the drainage of what is now the Gulf of Mexico formerly crossed the Tehuantepec Isthmus into the Pacific. This paper is not less interesting and important than the previous memoir by the same author on the "Reconstruction of the Antillean Continent," a résumé of which has appeared in the Geological Magazine (April, 1895) by the pen of Mr. A. J. Jukes-Browne ; but in this latter case Professor Spencer was dealing mainly with facts and inferences based on physical features under submerged areas of the Atlantic Ocean, while in the present case he has to deal with phenomena visible to the eye of the observer.

It will be recollected that in expounding the hypothesis of a former Antillean Continent the idea of a submergence of the Mexican region and the Isthmus of Tehuantepec, sufficient to allow of interoceanic communication, was in the author's mind a necessary corollary. The "drowned rivers" and their present affluents, such as the Mississippi, being shut out from the Atlantic, required an outflow in the opposite direction into the Pacific. The position of this outflow Professor Spencer has now determined with what appears absolute certainty in the "divide" of the Tehuantepec Isthmus at levels of about 1,000 feet above the ocean ; but before describing this channel of interoceanic communication in more detail, some account must be given of the Mexican topography, as very clearly described and illustrated by photographs and drawings by Professor Spencer.

The region presents the aspect of a series of steps or plateaux, from the most elevated at a height of 10,000 to 11,000 feet above the ocean down to the coastal plains, forming, in the author's view, "base-levels of erosion," and breaking off in escarpments which are intersected by ravines or cañons, cut back by the rivers to greater or less distances into the plateaux themselves. The levels differ

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[1] Bull. Geol. Soc. Amer., vol. ix, pp. 13–34.

somewhat in height in the Mexican plains and the isthmus, sloping
downwards from the continental tracts towards the Tehuantepec
Isthmus.   Thus the coastal plains of Mexico (which are continuous
with those of the United States) descend from a level of 1,600 to
1,700 feet to 325 feet in the isthmus, where they abut against the
base of the high plateaux.   It is inferred that these plains represent
pauses in the emergence or subsequent submergence of the region, and
represent on the land the features represented by the "drowned
plains and river-valleys" of the Atlantic coast, the West Indian
Islands, and the Mexican Gulf.   They are generally covered by loam,
gravel of rounded pebbles, or calcareous marl with shells ; some-
times of lacustrine, sometimes marine, origin.   Most important
amongst the Tertiary deposits is the "Coatzacoalcos formation"
of the Tehuantepec Isthmus on the northern side, and so called from
the river of that name which traverses the formation.   It consists
of calcareous clay, of uniform texture and horizontal stratification,
containing a large number of marine forms collected by the author
and determined by Dr. W. H. Dall.   Of the fossils found 34 per cent.
are not known to be living forms, so that they may be regarded as
of late Miocene or early Pliocene age ; but as the characters of the
living fauna of the deeper waters of the Gulf of Mexico are only
partly known, Dr. Dall suggests that the fossils collected represent
a much larger percentage of living forms than those named in the
list given in the memoir of the author.   It does not appear to what
altitude this formation extends, but it has suggested to Professor
Spencer that there may have been many Pliocene connections
between the Gulf and Pacific Ocean throughout a distance of 200
miles during the greatest submergence.   Inland from Vera Cruz
a belt of Tertiary limestone and marl has been mapped by the
Geological Survey of Mexico, reaching levels of 2,350 to 2,800 feet
above the sea, which may not improbably be representative of the
Coatzacoalcos formation.

The "Lafayette" and "Columbian" formations, each uncon-
formable to the other, are found occupying eroded basins in these
middle Tertiary strata, rising to high altitudes, and indicating
deep Mid-Pleistocene depression, on the supposition that they
represent deposits formed along the sea-margins of the period.
In any case, however, the inference of a deep submergence during
the Pliocene stage seems inevitable.   According to the author, the
Lafayette formation seems to have succeeded the Coatzacoalcos in the
Tehuantepec region without any considerable physical disturbance
intervening ; but on the Pacific side the mechanical materials were
replaced by a white soft limestone with water-worn pebbles.   It would
be of interest to know whether this limestone contained marine forms,
and if so, whether of existing species.   We must now refer to the
position and nature of the divide (or neck of land) which at a late
Pleistocene epoch formed the floor of the connection between the
Gulf of Mexico and the Pacific.   The details given by the author
are illustrated by photographic views.   The Tehuantepec highland is
at this spot reduced to the narrow width of only 25 miles, bounded
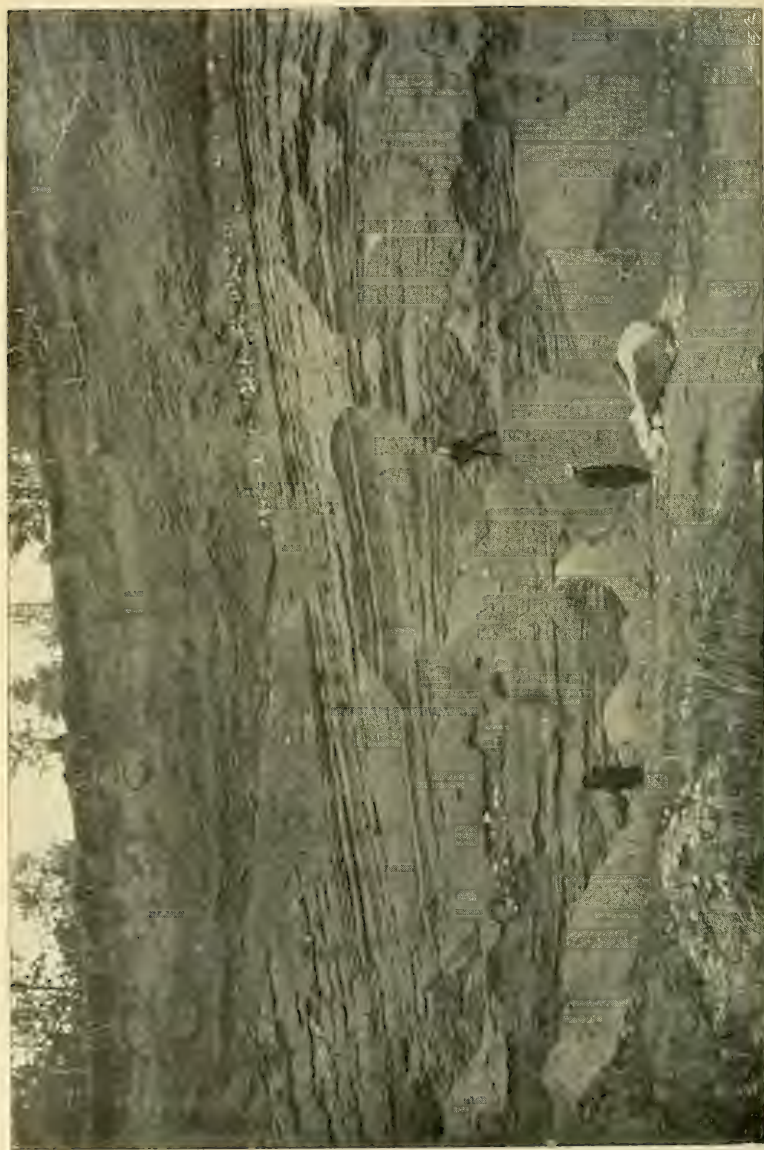
by two coastal plains. The high plateau of Mexico, with levels up to 10,000 feet, here descends for a distance of 60 to 80 miles, to levels of 2,000 to 4,000 feet, and at the divide is (as already stated) only about 1,000 feet above the level of the ocean; but on both sides of the saddle there are base-levels of lower altitudes. The rock consists of earthy sandstone; and on the Pacific slope facing the city of Tehuantepec are old sea-cliffs and caves at levels of 400 feet. The floor of the divide is traversed by a "geological canal," at a level of 776 feet above the ocean, and is covered by gravel, from 4 to 8 feet in depth, of quartz and soft sandstone pebbles, the latter being well rounded; this gravel is more thinly scattered over the adjoining slopes to a height of 150 feet. The isthmus was evidently swept over by ocean-currents passing through the straits during submergence; and its elevation has been so recent that only short cañons have been cut into the base-levels and terraced plains adjoining. Another line of communication was recognized at the pass of Tarifa, a dozen miles eastward of that of Chivela above described; and there are other current-swept depressions in this region through which the waters on both sides are considered to have had intercommunication, though at higher levels. It should be added that the stratified gravel of the divide is continuous with that covering the terraced plains on the Gulf side of the divide.

The author considers that this oceanic connection was as old as the Columbian (Mid-Pleistocene) epoch, and was contemporaneous with the great emergence of the Antillean Continent and Eastern America. It is a splendid illustration of the Lyellian doctrine of the interchange of land and sea, which geological phenomena bear testimony to from early, down to recent, times, and which serves as a key to many problems in terrestrial physics. Finally, it must not be forgotten that the biological evidence of the former oceanic communication across the Isthmus of Panama is not less clear than is the physical. The late Dr. W. B. Carpenter identified 35 species of molluscs, out of 1,400 Pacific forms, as occurring on the Atlantic side of this region; the number having been since increased to 100 species, by the observation of Mr. Charles T. Simpson; while, according to the late Dr. G. B. Goode, there is absolutely no resemblance between the deep-water fishes on the two sides of Central America.

II.—The Surface Geology of the North of Europe, as illustrated by the Åsar or Ösar of Scandinavia and Finland.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

PLATE VII.

IN a previous paper I ventured to emphasize the opinion, now very generally held, that, whether by a gradual process or spasmodically, the Northern and Central parts of Scandinavia have been rising from the sea-level since Tertiary times, and that, so far as we know, this rise has not been interrupted by intervals when the movement has been one of depression. The movement has, in fact,

been constantly in one direction. If this be true, it follows as certainly as any physical fact follows its efficient cause that, other conditions being the same, the climate of Scandinavia, like that of Greenland, has been continually growing more severe, and is more severe now, than it was when the higher Norwegian raised beaches were deposited.

The other conditions, however, have, so far as we can judge, not been uniform. One of them, and that a very important one, has in all probability altered, and that is the one which gives Norway and Britain their exceptional climate, and which diverts the isothermal lines of Western Europe from their normal route across Asia and America in places on the same latitude. This is the Gulf Stream. There are very strong reasons (and I have formulated some of them in my " Glacial Nightmare ") for believing that at the close of the Tertiary period the so-called Gut of Florida was blocked by solid land, and in consequence the warm waters of the Gulf of Mexico did not then get into the North Atlantic. If the Gulf Stream were non-existent, it is clear that the climate of the two sides of the Atlantic would be more alike than they are now along the same latitudes. That this was so is proved by the more Arctic types of molluscs which then lived on the coasts of Scandinavia and Scotland, and by the evidence of the existence of Alpine and Arctic plants at lower levels and in lower latitudes in Western Europe, as shown by Nathorst and C. Reid. This conclusion is not only reasonable, but seems incontrovertible. It does not mean that North-Western Europe was then dominated by a Glacial climate and Glacial conditions, but only that it was more or less assimilated in regard to its climate to Canada and New England.

As we have also seen, the evidence is very strong and conclusive, and has convinced almost every Swedish geologist, that not only has the greater part of Scandinavia and Finland risen greatly in altitude in the last geological period, but that this wide area has in a large measure been actually submerged under the sea since Tertiary times, and that its rise after this submergence was the last great fact which affected its surface.

I have argued that it was this submergence which did so much to polish and mammillate its rock-surfaces, effects which I hold to be the results in a very large measure of the eroding forces of the sea in a tempestuous latitude, and not of the hypothetical ice-sheet of which we have read so much. I will add another argument to those already used. If the terraces on the Norwegian coast really mark, as the Norwegian geologists argue, the differential rate of elevation of the coast, which has caused the cutting back of the cliffs to be more rapid at one time than at another, it is clear that the *polished rock faces* of Norway cannot be due to anything but the corroding sea, for these faces have been worn back many feet while the coast has been rising, and cannot therefore retain any polish or smoothness they may have acquired in the times preceding the upheaval. If they were polished by ice, the ice must have acted, not before, but after the elevation, which is a *reductio ad absurdum*. Apart from

this, the facts presented by the general contour and face of the country seem to me to inevitably point the same lesson. Whether we examine the string of islands which fringe so much of the coast of Scandinavia, and which project from the surrounding water like so many gigantic whales' or porpoises' or turtles' backs ; or whether we examine the thousand islands of the Mälar Sea or the Åland Archipelago, with the same contours, or the mammillated surfaces which the gneissic and granitic rocks of the interior districts of Sweden and Finland bear, they seem to me to present a complete parallel to the contour of the islands of the Arctic archipelago north of America, and of the islands off the coast of Greenland, where the lines of drift wood and the stranded whales far above high-water most conclusively point to the whole land having recently risen from the sea. In these latter cases, the Arctic navigators who have seen the phenomena, and the geologists who have described their voyages, have agreed that the North American archipelago and the islands off Greenland have had their contours smoothed and rounded by that most effective of denuding agencies, a shallow ocean loaded with gravel and other débris, and not by an ice-sheet, which does not in fact exist there. Nor, to take another illustration, can we separate in any way, it seems to me, at Trollhättan and elsewhere the polishing and smoothing of the interior and of the lips of the Giants' Cauldrons, which are confessedly the result of the aqueous action just named, from the polishing of the inclined rock-surfaces on which they occur. There is absolute continuity between them. They all seem to me to concur with the upraised shell-beds, the great masses of false-bedded and stratified sands on the wide upland plains of Dalecarlia, and the other evidences which have been collected by the Swedish geologists, and to which I have referred in a previous paper, to show, not that the country has been swathed in ice, but that it has recently been the bed of a shallow and tempestuous sea. This conclusion is of the highest importance. It is not, of course, new. Without going back to the primitive geologists of the early part of the last century, who wrote before the incubation of the Glacial monster, it struck some of the very earliest critics of that theory, who had examined the problem very thoroughly on the ground itself.

Böhtlingk, an experienced observer and a great traveller in Lapmark and Finmark, to whom we owe the conclusive evidence against polar ice-caps, says : " In Scandinavia, Finland, Lapland, and the surrounding countries we find, to the height of 800 feet, the most unquestionable marks of the constant retreat of the sea occasioned by a continued rise of the land. In consequence of this circumstance Scandinavia, during the first half of the alluvial period, was still an island, and the tongues of land of Russian Lapland, Finland, Esthonia, the government of Olonetz, as well as those parts of the government of Archangel situated to the east of the White Sea, were covered by the sea," etc. (Ed. Journ., vol. xxxi, 1841, pp. 354, 355.)

Robert, the very able geologist of the Recherche Expedition, writing as far back as 1843, says : " La mer me semblait polir,

canèler, creuser, rayer des roches de manière à leur faire prendre la physionomie de ceux qui s'offrent aujourd'hui un peu au dessus de son niveau sur toutes les côtes de la Scandinavie."   Elsewhere he concludes that the sea once occupied a large part of Russia, and that Scandinavia then formed an archipelago.   I have myself zigzagged across Sweden in various directions on my recent third visit to that country, and been continually impressed by the same conclusion.

The most powerful and important evidence has yet to be quoted, however, and it is forthcoming from what every intelligent person, who has traversed Sweden with the view of studying its recent geology, must consider to be in their way the most interesting and stupendous phenomena probably in the world : I mean the Swedish åsar or ösar.   I am writing this paper in the very midst of them, and have had some special opportunities of examining them.   The latest writer on Swedish geology, and one of the ablest, Nathorst, in his "Sveriges Geologi," published in 1894, after examining the various theories which have been forthcoming to explain them, has to confess that the problem is still unsolved.   To use his own words, " vilja vi dock på samma gång uttryckligen betona, att vi ännu icke betrakta frågan såsom slutligen afgjord " (op. cit., p. 243)—" we must expressly state that we cannot consider (or look upon) the question as finally settled."

The åsar are such a notable feature in the landscape of Sweden that it is not surprising they should have been observed and their peculiarities described at an early period.   Their main features were, in fact, pointed out by Swedenborg at the beginning of the last century, and have been enlarged upon by every succeeding explorer.   The Swedish geologists divide the åsar into two classes— the åsar properly so called, built up of masses of rolled stones, and the sand-åsar, composed chiefly of sand.   While it is easy to find specimens of each of these, it is also very easy to find others where masses of rolled stones and beds of sand or of tough clay or brick-earth pass into each other very much as they do in the Cromer cliffs. A good example is the fine ås upon which Upsala is built, and in which we can study the internal structure admirably, since it has been recently excavated right through (vide Pl. VII).   There we can see in the course of a few yards the passage from a mass of rounded boulders into sand.   The sand in some places is almost continuous, and in others has banks of clay intercalated in it.   The contour of the åsar, as Swedenborg long ago pointed out, differs with the nature of their contents, the stony åsar having steep sides, while the sandy ones have much rounder outlines.   The stones which form such a great part of the åsar (except certain specimens occurring in their upper parts) are invariably rounded and water-worn, and would be well described by the phrase applied to some of the East Anglian gravels, viz. "cannon-shot gravel."   The åsar are found in all parts of Sweden from Scania to Norland, and in Finland and Northern Russia they form, as is well known, huge banks and ramparts.   In some cases they run with great uniformity in shape and breadth for long distances, their direction being

wonderfully continuous. So uniform are they that, as Brongniart pointed out, the roads in some places, as from Upsala to Wendel, from Enköping to Nora, from Hubbo to Moklinta, etc., run along their crest. Sometimes they spread and widen out a little, forming nodes like so many knots on a cord. Frequently the continuous line is interrupted by a gap or a series of gaps, so that instead of a uniform bank there are a number of huge circular or oval mounds. They consist generally of a main trunk, with a number of small subsidiary lateral branches running into them like the affluents of a river, and sometimes they have satellites attached to them in the shape of eskers and kame-like mounds. They are as sharply marked off from the adjoining plain on either side as a railway embankment is. In some cases, notably in Finland, they do not run in parallel lines, but vary in direction, sometimes even crossing each other, but in Sweden their direction is singularly parallel, as may be seen from the admirable maps published by the Swedish geologists, notably that by Törnebohm. The enormous size and cubical contents of these gigantic mounds can only be appreciated by those who have seen them on the spot and followed them for miles.

According to Erdmann, the well-known Upsala ås, which runs from the mouth of the Dalelf to Södertom, south of Stockholm, is about 200 kilometres long. The ås of Koping, as far as it is at present traced, from Nyköping to the Dalelf, is about 240 kilometres in length. The ås of Enköping runs from near Trosa in Suder-mannia to Loos in Helsingland, and is from 300 to 340 kilometres long, while the ås of Badelunda, running from Nyköping in Suder-mannia to the parish of Rättvik in Dalecarlia, is about 300 kilometres long. According to Erdmann, the åsar west of the watershed between Lake Wenern and Lake Wettern run N.N.E.–S.S.W., while east of that line they run from N.N.W. to S.S.E.

Erdmann also gives the elevation at which some of the principal åsar have been traced. "In Jemteland, N. and N.W. of Storojo, to 1,000 or 1,200 feet; in Herjeadal, near Hede, to 1,300 or 1,400 feet; in Dalecarlia, in the parishes of Malung and Idre, to between 1,000 and 1,300 feet; in the government of Elfsborg, in Vestrogothland and east of Ulricehamm, to 1,100 feet; at Jönköping, in Småland, near to Lake Almesäkra, to about 1,000 feet; but Törnebohm informed Mr. Geikie that in the northern parts of the country they occur at an elevation of 2,000 feet." Their height varies, the average being about 50 or 100 feet high, but in many places they run up to 100 metres or more, while they sometimes sink to 20 or 30 feet. Their breadth, too, varies, the normal breadth being from 30 to 50 paces, but in some cases, as at Upsala, where there is a spreading node, their breadth runs to 200 or 250 yards. From these facts the cubical contents of the åsar may be guessed. They are often somewhat wider and higher at their northern end, that is, at their inception, than further on. In the low flat country their contour is very uniform, but in the upper and more hilly districts, where they chiefly abound, they have a tendency to become broken up into strings of separate mounds and kame-like masses. Their materials,

in so far as they consist of boulders, have in every case where they have travelled, and we can trace the mother rock *in sitù,* moved from north to south, and were never in the reverse direction.

One of their most important features, and one which has been a great deal too little noticed in the various theories which have been forthcoming to explain them, is the fact that they traverse the country quite irrespective of its contour, going uphill and downhill, and athwart the natural drainage. On this point I will quote the language of a first-rate authority, Erdmann. After saying that they sometimes run along the valleys, sometimes on the mountain flanks, and sometimes on the plateaux, he adds (in italics) the words : "C'est ainsi qu'elles continuent leur cours lointain, franchissant les plateaux, les vallées, et les plaines, et ne semblant en aucune manière s'inquièter des reliefs divers actuels du pays." ("Exposé," etc., p. 41.) This is a conclusion drawn from the Swedish åsar. The Finnish ones are quite as remarkable, traversing lakes and watersheds without any hesitation.

As I have said, a large portion of the åsar consist of masses of rounded stones of various sizes up to 2 feet in diameter. These rounded stones are not mixed with angular erratics. The latter, when they occur, do so in the upper and more sandy and loamy layers, or scattered over the åsar's backs, nor, so far as I could observe, do they contain stones of exceptional size. These, again, chiefly occur in the sandy beds or on the backs of the åsar. Their contents are not sorted according to their size, but the stones generally lie with their longer axes parallel to the direction of the ås in which they are found. The beds of sand and the sandy åsar are in nearly all cases more or less stratified. They are frequently false-bedded, and the beds which show the false-bedding have their lines very pronounced, the angular wedges of sand and the lenticular masses being on a large scale and very marked. The uppermost layers of the åsar often consist of stiff blue clay or of finely sifted and laminated brickearths, containing in places numbers of diatoms and marine shells, but never, so far as I know, fresh-water débris or land molluscs. These beds of brickearth and clay occur only at the top of the åsar, where they are often intercalated with sand beds very irregularly disposed, just as they are in the beds of contorted drift in the Cromer cliffs, and they are generally continuous with the mantle of similar loam that covers the intervening country. I cannot follow Erdmann and Geikie in separating these superficial layers in the åsar from the beds below. So far as I can judge (and here, again, the present condition of the cutting at Upsala is very pregnant with meaning), they pass continuously down into them, and are merely later phases of one deposit, just like the similar phases we see in the drift beds of East Anglia. Lyell, Murchison, and others, who examined the åsar with care and skill, and whose judgment was in this case unwarped by *a priori* theories of the origin of the åsar, treated the superficial beds containing marine shells as belonging to the same period as the lower beds, which are barren and consist largely of boulders.

Let us now consider the theories which have been adopted to explain the åsar. In the very early days of the Glacial fever—if I may coin an incongruous but not inappropriate phrase—when Agassiz reigned supreme, they were pronounced to be moraines. This conclusion is one of those which form the despair of rational science, for beyond the fact that they are heaped-up mounds of earth and stones, there does not seem to be a single feature about them resembling moraines. The stones they contain are rounded, water-worn boulders, in no way like glacier stones. Scratched stones, or those with flat sides, are never found in them. The beds of sand and clay they contain are sifted out and separated from the boulders, and are stratified and absolutely different to the mixed-up heterogeneous " muck " forming moraine stuff. The shells they contain in their upper layers are marine shells, many of them perfect and of very delicate texture. Marine shells and diatoms are not the product of ice-sheets or of glaciers, and do not occur in moraines. Putting their contents aside, their other features are quite different to moraines. Terminal moraines, which are the only kind of moraines distinctly resembling some phases of the åsar in contour, are always planted athwart the line of march of the ice. The åsar, on the contrary, are all roughly parallel to the line in which the stones have moved, and to the line also kept by the striæ on the rocks. If moraines at all, the åsar must therefore be medial or lateral moraines. Who has ever seen lateral or medial moraines made up of water-worn boulders and of stratified sands and brickearths containing marine shells, or seen them ranged in a large series of parallel mounds with subsidiary branches, and with no high lands in between from which their contents could be derived? But I need not press the argument further.

Berzelius, in a letter to Professor Leonhard written as far back as 1841, says : " Agassiz' friend Desor visited us in September last year, and on seeing the immense boulder deposits which in this country are named åsar, stated without hesitation that these phenomena could not be explained by glaciers, and that they were not moraines." (Q.J.G.S., iii, 76.)

Durocher also long ago analyzed the various features of the åsar in a masterly manner, comparing them point by point with moraines and their structure, and showed how completely they differed from them. Reclus, who, although not a professed geologist, has treated geological problems with great intelligence in his great geographical work, is not less emphatic in his conclusion. Murchison and Verneuil and other " old masters " who examined the problem on the ground were of the same opinion. Nor do I know of any Scandinavian geologist who now maintains the view that the åsar are moraines. If there be any geologists that do so anywhere, it must be in America, where the most extravagant school of glacialists survives, and where official geology is so dominant, and every officer of the Survey is apparently so dragooned by the conditions of the service, that they follow their bellwethers with commendable loyalty and discipline.

If not moraines, what are the åsar? Hisinger suggested that they might be the remains of a gigantic denudation, the intervening deposits having been swept away. This view, while it did not in any way explain the internal structure of the åsar, merely professed to explain their external shape and distribution. It has been completely analyzed by Törnebohm, and shown to be quite untenable; nor do I know anyone who now holds it, or who in fact professes to understand how such a denudation could come about. What kind of diurnal or other denuding agency would permit of these ramparts of soft materials remaining as they are when the rest of the beds were swept out? Whence could it come? How could it work so as to move up and down the country irrespective of its contour? Where has the débris of the gigantic denuding process gone to? How is it that the covering of the åsar, which is formed of finely levigated brickearths, is also the covering of the intervening plains on either side? But I will not argue against a cause which has no defenders, nor kill again the corpses which Törnebohm slew.

Every Scandinavian geologist known to me now admits that the åsar are in some way the result of aqueous action. The contour of their surface, the rounding and arrangement of the boulders in them, with their longer axes symmetrically placed parallel to the lines of the ramparts, the stratified sands and laminated clays, the current bedding, the presence of shells and diatoms, are all conclusive that the åsar are the result of aqueous action in some form or other; and Mr. James Geikie himself, who represents the high-water level of English and Scotch glacialism, says "all geologists admit that the åsar are in the main water-formed accumulations." Erdmann, Törnebohm, Nathorst, and all the other Northern geologists known to me, are of the same opinion. When we come, however, to discuss the particular kind of aqueous agency to which the åsar may be assigned, and the method in which it worked, the unanimity at once ceases.

The superficial resemblance of the åsar, when drawn on a sheet of paper, to rivers with a main trunk and branching off into smaller affluents, perhaps first suggested the idea that they had something to do with rivers and river action; a view which has prevailed very considerably in textbooks, but which seems to me to be absolutely untenable.

Two theories of the fluviatile origin of the åsar have been propounded, one treating them as the result of subaerial rivers and the other as subglacial streams. I would first criticize the general theory of fluviatile origin.

In the first place, as we have seen, the åsar do not run along level surfaces nor along continuous slopes; but they frequently run up and down hill. Sometimes they are found at a height of 2,000 feet and sometimes only a few feet above the sea-level, and they run up and down the undulating country keeping the same general direction. Now whatever movements are possible with ice under certain conditions, by which it may

be able to move up and down slightly undulating districts, and sometimes to creep uphill to a moderate extent, it would be an entirely new and surprising fact that water could do so, unless contained in a pipe and forced up by pressure behind. This is an initial difficulty of the first moment, and is in fact absolutely conclusive. Water, except in a pipe, cannot move contrary to gravity, cannot travel up and down hill, or mount a slope; and it does not matter whether the water is in a channel open to the sky, or in a channel covered with an arched tunnel of ice. It is therefore impossible on this ground alone that the åsar could have been deposited by rivers of any kind, unless the contour of the country has entirely and radically changed since they were laid down.

This is by no means the only objection to the fluviatile theory of the åsar. Their shape, when viewed in section, is quite opposed to a fluviatile origin. Rivers which run very slowly and carry much mud, instead of depositing that mud entirely in deltas, sometimes, no doubt, raise their own beds, like the lower Rhine and some rivers of Eastern England do, and in this way make themselves solid aqueducts along which they flow. These solid aqueducts, however, have not the shape or contour of åsar, with their often steep and sharply inclined sides. This contrast in contour is even more marked in the heaps of débris which form the beds of subglacial streams. Nor can I see how rivers of any kind could raise their beds to the portentous height of the åsar and yet be so narrow. Rivers, again, must have banks, and if of fluviatile origin the åsar should form channels running along their crests. The solid aqueducts we have experience of elsewhere are none of them very high, but are always breached and broken through after a time, when the river escapes and forms itself another channel, leaving the old bed meandering like a gigantic snake in the valley bottom. We cannot conceive such solid aqueducts remaining intact until they have been raised to a height of 300 or 400 feet.

Another difficulty presents itself when we compare *the contents* of the åsar with those of such river-channels as we can examine. Rivers which elevate their beds by gradual deposits are necessarily sluggish and slow-flowing rivers. When rapid, rivers become scouring agencies and not depositing ones. How is it possible to conceive of a sluggish river depositing these enormous masses of cannon-shot gravel — not of laying down a few yards of such gravel when there is an occasional rush in the stream, but a rampart a hundred miles in length and fifty yards high? The position is incredible. The Nile, the Rhine, the Indus, the Amazon, all these deposit beds, but they are beds of finely sifted mud. Again, in depositing stones, rapid rivers sift them according to their specific gravity, and do not mingle them higgledy-piggledy as they are mingled here. If it was a river that deposited these mountains of boulders, it must have been a very violent torrential river, and its force quite portentous along its whole course. If so, how is

it that it did not scour and move away all the sand and brickearth, and carry them down to its lower reaches, instead of laying them down along their whole course? All torrential rivers known to me have clean-washed, stony, and gravelly beds, with deltas or reaches lower down, formed of the lighter materials of denudation.

But in bespeaking torrential rivers of this kind in Sweden we are postulating a virtual impossibility. The level of Sweden is too low and too flat to afford such rivers. To get rapid rivers we must have steep slopes in their beds. Of course we have a rapid flow enough at places like Trollhättan, on the Gota river, and in other gorges where we have rapids like we have in the gorges of the Rhine; but there is no deposit like an åsar deposit in these gorges now. We cannot conceive any deposit of any kind long remaining in such places, nor does it seem possible that these gorges existed when the åsar were made. Elsewhere than at these gorges the rivers of Sweden are quiet and slow-moving, and deposit, not great masses of huge boulders, but sand and silt and mud. They must have been slower and less efficient as dynamical instruments when the level of the country was much lower, as apparently was the case in Sweden in so-called Glacial times. Again, the rivers of Sweden naturally flow from west to east, or N.W. to S.E., in channels in which they drain the upper plateau by running downhill to the sea, while, as we have said, the åsar run from north to south, right across the present river-channels and right across the lines of drainage of the country.

Again, rivers make deltas. When they have run their course, and get on to fairly level ground, they deposit fan-like stretches of mud and clay. There are no similar phenomena in the case of the åsar, which do not terminate as deltas at all, the flat spreads of gravel sometimes occurring in connection with them being torrential, and not like river deltas.

Rivers naturally have wider and wider channels as we move away from their sources to their mouths, and as their supply of water increases from their several feeders, and consequently as their loads of débris increase. This means that their beds become wider and deeper as we proceed downwards along their course. They are thus quite different to the more or less uniform ramparts called åsar, which chiefly differ in bulk in the fact that they are bigger at their initial stage than later on.

It seems absolutely impossible to correlate the åsar of Dalecarlia and those of Finland, some of which actually cross one another, and others are united by cross pieces, with any river-beds, whether subaerial or subglacial. Again, rivers of any size generally contain fresh-water shells or other débris. The åsar, on the contrary, when they contain shells at all, contain *marine* shells only. Rivers do not deposit marine shells.

Lastly, we must not forget that although we are considering the åsar as substantive phenomena apart altogether from other deposits, it is only for convenience of treatment. We cannot, in fact, separate the åsar and their contents from the sporadic and other deposits of

the same kind occurring elsewhere. The åsar are only heaped-up ramparts of materials which occur in the areas lying between them in a less prominent fashion, in some cases as scattered boulders, in others as continuous beds of sand and gravel and brickearth. Especially is this so with the brickearth or loam which often forms their upper layers. This is really part of the continuous mantle of the country. Such different deposits occur virtually at all levels. How is river action to account for these complementary phenomena? Rivers cannot spread over a whole country so vast as Sweden. They would cease to be rivers, and would become quite transcendental, like Baron Munchausen's dreams, and if they did so they would interfere with each other's beds, and the ramparts would have been levelled down. It is clear that in finding an efficient cause for the åsar we must find one which will also explain the deposit of the drift occurring outside them. Apart from and altogether beyond these difficulties is the supreme meteorological objection as to whence the rainfall was to come to fill these stupendous rivers, running parallel to one another, quite near together, and forming such a web of rivers as was never seen elsewhere. Where is the gathering-ground and where are the watersheds which could produce such a congeries of rivers? This is an important matter to those among us who believe in inductive methods in science. It is apparently of no consequence to those geological alchemists who are continually engaged in extracting palm-oil out of paving-stones. We cannot understand any meteorological or physical change which could supply the necessary rainfall for such rivers.

On every possible ground, therefore, known to me it seems quite impossible to connect the åsar with river action. This is not my view only; it was the view of my master, Murchison, also. He says: "However it may be argued that in mountainous tracts torrential rivers and their feeders may have descended as they do now, and may thus have produced rounded materials in valleys, the argument is, at all events, perfectly inapplicable to the formation of the Swedish åsar. These linear ridges have not only been accumulated in long *trainées* and lengthened mounds on terraces high above the valleys, but offer appearances entirely unlike those produced by rivers."

This view is, in fact, also endorsed by Professor James Geikie *in regard to subaerial rivers.* He says: "Banks of gravel and sand no doubt accumulate in the beds of rivers, but if the rivers were to disappear such banks would not form prominent ridges rising abruptly above the general level of the surrounding land. They would, moreover, coincide throughout any course with the lowest level of the valley, but our åsar, although they trend with the general inclination of the land, do not slavishly follow the line of lowest level, showing an independence of the minor features of the ground, sometimes winding along one side of a valley and sometimes along the other." ("Great Ice Age," p. 169.)

While Professor Geikie rejects Törnebohm's theory of the åsar having been the result of the action of subaerial rivers, he is willing

to accept the notion of D. Hummel and P. W. Strand that they may have resulted from the action of subglacial streams, and apparently also favours that of Dr. Holst, who assigns them to streams flowing over the surface of the ice. Now in regard to these theories, it seems to be forgotten by every glacial geologist that a subglacial river or a river flowing on the surface of a glacier differs from other rivers merely in that it flows under a long tunnel or archway of ice, or over a bed of ice instead of a bed of sand or gravel. In every other respect it is a river, and every difficulty which has been already pointed out in regard to the explanation of the åsar by river action of any kind is as potent and conclusive against these postulated glacial or glacier rivers as it is against ordinary rivers. In addition they present special difficulties of their own. Let us first look at the theory of Holst. It is quite true that when the sun beats upon the back of a glacier small streams are sometimes seen on its melting surface, which run for a few yards and then disappear down a crack or a crevasse. Nowhere, not even on the vast ice-plains of Greenland, do these small streams now grow into rivers; and in order to do so we must suppose that the ice was marked by no cracks or crevasses, and in the particular case of Scandinavia that in a singularly broken and uneven country an ice-mantle could exist without any crevasses or cracks draining its surface. But suppose it could, whence could it derive the materials for making gravel, or the great boulders, when the whole country was, *ex hypothesi,* blanketed with ice, and no exposed rocks were visible? And having got hold of rocky débris, how were these supraglacial streams to roll the millions of great boulders of granite, gneiss, and basalt, which form so large a part of the åsar, into their rounded and water-worn shapes, and accumulate them in dykes and embankments a hundred miles long and a hundred yards high? and how is it that the rest of the glacier's back or some part of it was not uniformly strewn with angular and unrolled, or with rolled débris, which should have remained when the glacier melted alongside of the åsar? Assuredly the whole idea is incredible, and it is incredible how sober, thoughtful men in our century should have tried to impose it upon science.

III.—Notes on the Affinities of the Genera of the Cheiruridæ.

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

IN a former number[1] of this Magazine the evolution of the sub-genera of the single genus *Cheirurus* has been discussed, and it is now proposed to examine the mutual relations of the other genera of the Cheiruridæ. Some diversity of opinion has existed as to the genera which may be grouped together to form this family. Barrande[2] put only the following five genera into it: *Cheirurus, Sphærexochus, Placoparia, Staurocephalus,* and *Deiphon.*

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[1] Reed, Geol. Mag., Dec. IV, Vol. III (1896), pp. 117 and 161.
[2] Barrande, Syst. Sil. Boh., vol. i (1852), pp. 335 and 766.

The last-mentioned genus was only provisionally united with the others. Salter,[1] while omitting *Placoparia* from the above list, added *Amphion*, which Barrande placed in the family containing *Encrinurus*, etc. The genus or subgenus *Sphærocoryphe* was also really included by Salter, but under the name of *Staurocephalus*? *unicus*. The genera *Encrinurus, Cybele,* and *Zethus* were also given by Salter as belonging to the Cheiruridæ, but with a query against each of them. Zittel[2] places the following genera in this family : *Cheirurus* (with its subgenera, *Cheirurus*, s.s., *Cyrtometopus, Sphærocoryphe, Crotalocephalus, Eccoptocheile, Pseudosphærexochus,* and *Nieszkowskia*), *Areia, Deiphon, Onychopyge, Placoparia, Sphærexochus,* ? *Crotalurus, Staurocephalus, Amphion, Diaphanometopus.* Of these, *Crotalurus* must certainly be at once removed to another family and group, because of the course of its facial suture.[3] More recently, Beecher,[4] in a valuable and suggestive paper on the classification of trilobites, has enumerated the genera and subgenera in this family thus : *Cheirurus, Actinopeltis, Amphion, Anacheirurus, Ceraurus, Crotalocephalus, Cyrtometopus, Deiphon, Diaphanometopus, Eccoptocheile, Hemisphærocoryphe, Nieszkowskia, Onychopyge, Pseudosphærexochus, Sphærexochus, Sphærocoryphe, Staurocephalus, Youngia.* Eliminating the subgenera we get the following : *Cheirurus, Amphion, Deiphon, Diaphanometopus, Onychopyge, Sphærexochus, Sphærocoryphe, Staurocephalus,* and *Youngia. Sphærocoryphe* must, in my opinion, be accorded generic rank. The genera *Placoparia* and *Areia* are placed by Beecher in the Encrinuridæ on account of their larval features, which suggest their union with this more primitive and less specialized family. In fact, he would apparently regard these two genera as morphologically the lowest in the phylogenetic list of the members of his order Proparia, which comprises the four families Encrinuridæ, Calymenidæ, Cheiruridæ, and Phacopidæ.

Omitting the imperfectly known and extra - European genus *Onychopyge,* we may concentrate our attention on the other genera which have been accorded a place in the Cheiruridæ, and all of which are found in Europe. The four genera *Placoparia, Areia, Amphion,* and *Diaphanometopus* are those whose true position is most a matter of doubt. Schmidt,[5] for instance, hesitates somewhat in retaining the two last genera in the Cheiruridæ ; and the different views of Salter, Barrande, Zittel, and Beecher with regard to *Amphion* and the others have been mentioned above. The question can only be decided by the characters which one considers as essential to the family. But it is a matter of minor importance how we group together the genera in a system of classification, so long as we understand their phylogenetic relations. In *Areia,* in the first

[1] Salter, Mon. Brit. Trilob. Palæont. Soc. (1864), p. 2.

[2] Handbuch der Paläontologie (1885), vol. ii, p. 616.

[3] In Zittel's " Grundzüge der Paläontologie " (1895), this genus is omitted from the Cheiruridæ.

[4] Amer. Journ. Sci., vol. iii (1897), p. 89.

[5] Mem. Acad. Imp. Sci. St. Petersb., vol. xxx, No. 1 (1881) : Rev. ostbalt. Tril., Abth. i, pp. 190, 195.

place, the absence of facial sutures separates it from all the other genera in the Cheiruridæ, while this feature, combined with the absence of eyes, the pentamerous lobation of the head, the expanded termination of the glabella, and the presence of the pleural row of puncta on the neck segment (in *A. Bohemica*), and the close resemblance of this segment to the thoracic segments are larval features which indicate a very low stage of development and a comparatively small amount of differentiation.   The Bohemian species of the subgenus *Eccoptocheile* resemble it in the row of puncta on the inner portion of the pleura, the number of the thoracic pleuræ, and the notch on each side of the glabella in the front border of the cephalon ; and Barrande himself remarks that *Areia* approaches most closely the species *Ch. claviger, globosus*, etc., belonging to the s.g. *Eccoptocheile.* The hypostome is analogous to that of *Cheirurus*, and the ornamentation of the cheeks is similar.   As I have remarked in my previous article on *Cheirurus*, the pygidium appears frequently to follow an inde- pendent line and different rate of development to the other parts of the body, and is, therefore, of doubtful value in tracing affinities. In *Areia* it shows only two segments on the axis and two pairs of pleuræ. It is only in *Nieszkowskia* and in one species of *Sphærexochus* (*Sph. latens*, Barr.) amongst the Cheiruridæ that we find the pleuræ of the pygidium numbering two.   But this does not show affinity, for in *Nieszkowskia* there has been reduction, absorption, and crowding out of the last pair by the hypertrophy of the first ; in *Sph. latens* there has been fusion of the last pair of pleuræ into a terminal piece ; but in *Areia* the second and third pairs of pleuræ alone seem to have been developed.

The fact that the Cheiruridæ show on the whole a high degree of differentiation and specialization, and have in the main lost the features of immaturity, while on the other hand the Encrinuridæ show a much lower stage of development and retain more larval or primitive characters, leads Beecher to place the genus *Areia* in the latter family.   But from the several points of resemblance of this genus to the early species or subgenera of *Cheirurus*, and from its retention to maturity of certain larval and early phylo- genetic features exhibited in some genera or subgenera which undoubtedly belong to the Cheiruridæ, I am inclined to place it in this family, and to regard it as a primitive form in which the ordinary ontogenetic development has been irregularly arrested.

Turning now to *Placoparia*, we find also in it many primitive features.   The dorsal furrows are usually described as bifurcating in front, one branch running forwards and the other turning outwards at right angles.   This latter branch may possibly represent one of the furrows we find on the cheeks in *Areia*.   At any rate, the narrow marginal cheeks, combined with the absence of eyes, are primitive characters found only in the larvæ of higher trilobites.   The facial suture ends also at the genal angle, recalling the less highly differentiated *Opisthoparia* of Beecher, in which the facial suture cuts the posterior border of the head-shield.   The pentamerous

lobation of the glabella is also distinct, and this character, together with the presence of the ridge on the pleura, is considered by Barrande to unite the genus with the genera *Cheirurus* and *Sphærexochus*. But the former character is a larval one, retained to maturity in many utterly distinct genera, and the pleural ridge is shared by *Encrinurus*. The hypostome is entirely different to that of *Cheirurus*. The number of the thoracic segments (11–12), though the same as that of some species of *Cheirurus*, is in itself an almost valueless character. The pygidium alone is a treacherous guide, but its general resemblance to some of the *Eccoptocheile* group is worthy of notice. In *Pl. Zippei* there are five rings on the axis, but in *Pl. Tournemini* only four. Instability in the number of segments in the pygidium and thorax is generally characteristic of the less highly specialized forms.

It does not seem possible to establish any definite line of ancestry or affinity by which we may link *Placoparia* with other known genera ; we must therefore regard it as an aberrant member of the family, diverging at an early period from the main stock, and not directly giving rise to any of the later forms.

The genus *Amphion* possesses a somewhat specialized head-shield, for the first side-furrows on the glabella are shifted forwards to the anterior border, and a small supplementary central furrow appears in some species between them. The presence of an epistome and pits on the cheeks are, as Schmidt says, points of resemblance to *Cheirurus*, but these characters are of different values. Eyes, though small, exist on the free cheeks, and the course of the facial suture is similar to that in *Sphærexochus*. The large and variable number of segments (14–18) in the thorax appears to indicate that the genus was still suffering evolution and was in a plastic condition, and the large number of body-rings alone is usually considered as a primitive feature. Thus Beecher has said that the indefinite multiplication of segments is to be regarded as a primitive character, expressive of an annelidan style of growth. On the other hand, the ridged pleuræ and the absence of any furrow on their surface recall *Sphærexochus*, and are apparently non-primitive features. The pygidium, with six rings on its axis and five pairs of pleuræ with free ends (of which the two last may be fused into one plate, as in *Amphion pseudo-articulatus*), reminds us of the multisegmented pygidia of some Encrinuridæ, and does not show any points specially associated with the Cheiruridæ. Barrande placed this genus with the Encrinuridæ chiefly on account of its numerous body-segments, but from the above review of its main characters the evidence for its location amongst the Cheiruridæ appears to be stronger. It is clear, however, that it branched off from the main stem at an early period, and pursued a somewhat independent line of development and specialization. Its stratigraphical antiquity also leads us to place its divergence at an early date.

The Russian genus *Diaphanometopus*[1] seems allied to it ; the

[1] Mem. Acad. Imp. Sci. St. Petersb., vol. xxx, No. 1 (1881) : Rev. ostbalt. Tril., Abth. i, p. 195.

head-shield shows many points of resemblance; the pygidium is
similar, and the short furrow on the anterior edge of the inner
portion of each pleura of the thorax may possibly correspond to that
in *Amphion*, which Salter says exists beneath the crust.   There are
only twelve body-segments in the single species which has been
recorded.   From want of material for examination I cannot say
more about its affinities.

   The remaining genera can have their relations indicated with more
certainty.   The genus *Sphærexochus*, as described in my previous
article, is led up to by *Pseudosphærexochus*.   In the latter the posterior
branch of the facial suture cuts the outer margin of the head-shield
only a short way in front of the genal angle, and the basal lobe of
the glabella is incompletely circumscribed ; in *Sphærexochus* the
suture cuts the margin at the genal angle itself, and the basal lobe
is completely circumscribed by a strong furrow.   In *Pseudosphær-
exochus* the body-segments are twelve in number and the rounded
pleuræ bear a nearly obsolete line of puncta ; in *Sphærexochus* the
body-segments are reduced to ten,[1] and the last traces of the puncta
have completely disappeared ; the pleuræ also are shortened by the
reduction of the length of their outer portion.   In *Pseudosphærexochus*
the pygidium shows four pairs of pleuræ with long pointed free
terminations; in *Sphærexochus* the number is reduced to three—or
even to two in one species,[2] *Sph. latens*—the last pair or pairs having
disappeared, perhaps by fusion followed by absorption, as suggested
by *Sph. latens* and by *Sph. bohemicus*,[3] where the second pair forks.

   It is especially interesting to find in this highly specialized
trilobite—the culmination of one line of differentiation of the
Cheirurid stock—that there is a tendency to revert to the more
primitive condition of the Opisthoparia by the migration backwards
towards the hind border of the head-shield of the marginal point
of section of the posterior branch of the facial suture.   The free
cheeks are connected by a narrow linear band representing the
epistome which is apparently fused with them, for the facial sutures
unite in front of the glabella and no twin sutures connecting them
with the hypostomal suture have so far been discovered.   It would
seem as if the obliteration of these connecting sutures was another
fact in evidence of the high specialization of the genus.   I do not
attach excessive importance to the fact that the cheeks are only
ornamented with fine tuberculations, and lack the characteristic pits
of the typical Cheiruridæ, for we know how completely well-defined
and important surface markings, such as pleural and glabellar
furrows, may become faint or disappear, how the pleural puncta of
some forms may gradually be obliterated, and how tubercles may
vary in size and be present or absent in closely allied species.
Barrande has figured and described the hypostome of *Sphærexochus*,

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[1] Salter (Mon. Brit. Trilob., p. 78) says there are eleven segments, but only
figures ten.
[2] Barrande, Syst. Sil. Boh., vol. i, Suppl., p. 113, pl. ix, fig. 3.
[3] Ibid., p. 112, pl. vii, figs. 5, 6.

and it can easily be derived from that of a typical *Cheirurus* by a broadening and flattening of its several parts.

Turning now to another branch of the family, we find in *Sphærocoryphe* the forerunner and ally of the peculiar genus *Deiphon.* The relations of *Sphærocoryphe* to *Cyrtometopus* have previously[1] been discussed. Some of its leading characteristics we find repeated but more accentuated in *Deiphon.* Thus, in *Sphærocoryphe* the enormously inflated anterior portion of the glabella and the faintness of the first and second side-furrows foreshadow the condition found existing in *Deiphon,* in which the two pairs of furrows have disappeared and the glabella has a regular globular form. In several species of *Sphærocoryphe* (as, for instance, *Sph. Hubneri* and *Sph. unicus*) the basal lobes of the glabella are distinct, but in *Sph. cranium* they are very faint, and thus prepare us for their complete absence in *Deiphon.* Again, in *Sphærocoryphe* the free cheeks are merely small triangular plates, bearing the eyes, wedged in on the anterior border of the fixed cheeks; in *Deiphon* the reduction in size of the free cheeks has proceeded so far that they are only represented by the eyes and a small part of the doublure of the head-shield. The fixed cheeks in *Sphærocoryphe* bear one or more tooth-like processes on their front edge; in *Deiphon* the fixed cheeks are so narrowed and modified as to form long spines, but they still bear the tooth-like process on their front edge, as in *Sph. granulatus.* In the thorax we find on the pleura in *Sphærocoryphe* a longitudinal furrow, and in the Bohemian individuals of *Deiphon Forbesi* there is also a similar, though fainter, furrow present.[2] The reduction in the number of the body-segments to nine is certainly in this genus, as in *Sphærexochus,* a sign of high specialization when we consider it in conjunction with its other characters, but the loose build of the body and absence of fulcrum seem to be reversions to the more archaic types, and to represent the gerontic and degenerate stage in the phylogeny of the group. The migration of the eyes forwards to the anterior edge of the head-shield is also distinctly a retrogression to the larval con- dition, for it has been proved[3] that the eyes first appear on the anterior margin of the dorsal shield in the protaspis, and move backwards in subsequent stages of growth.

The pygidium in *Deiphon* has only one pair of pleuræ—the first pair; but this pair is enormously developed. The pleuræ of the other segments are aborted; but four segments are traceable on the axis. This great development of the first pair of pleuræ is likewise foreshadowed by *Sphærocoryphe,* for in *Sph. unicus* the first pair is much enlarged, while the posterior ones are reduced. There seems

[1] Geol. Mag., Dec. IV, Vol. III (1896), p. 118.

[2] Salter says (Mon. Brit. Trilob., p. 88) that the pleuræ are ungrooved, but in his figures of the species (ibid., pl. vii, figs. 1–12) furrows are shown. Barrande both describes and figures the furrows (Syst. Sil. Boh., vol. i, Suppl., p. 115, pl. ii, figs. 19, 20). Perhaps, as Barrande suggests, for this and other reasons the Bohemian and English species are not identical.

[3] Beecher, Amer. Geol., vol. xvi (1895), p. 177, and references.

to be a frequent tendency in the Cheiruridæ for the posterior pairs
of pleuræ to be reduced, and we find it remarkably exhibited
in *Nieszkowskia*. In regard to *Deiphon*, though the morphological
value of its various characteristics may be a matter of dispute, yet
its high degree of specialization must be generally acknowledged,
and we would place it at the end of this branch of the family.
Beecher[1] has also briefly stated that he is of this opinion, and he
associates with it the Australian genus *Onychopyge*.

Turning now to the aberrant and imperfectly known form *Youngia*,
distinguished by Lindström[2] as a separate genus, we find there are
only three species established, and of these only the head-shields
have been discovered. One of them (*Y. trispinosus*) is found in the
Penkill mudstones of the Girvan district. The characters of its
head-shield link it on the one hand with *Pseudosphærexochus*, and on
the other with *Sphærexochus*. The spiniform fixed cheeks recall
Deiphon, but their development is not so extreme ; the neck spine is
a marked feature, but does not seem to be of phylogenetic importance.
In some species of *Acidaspis* and *Lichas* a spine is developed in the
same place, while other closely allied species are destitute of this
ornament. Bernard[3] has compared this organ, which is often a mere
tubercle, with the dorsal organ of *Apus*, and suggests that it was
poisonous.

Lastly, the genus *Staurocephalus* demands our attention. This genus,
though frequently stated to be allied to *Sphærocoryphe* on the strength
of its abnormal glabella, possesses in reality many important dis-
tinctive features. The hypertrophy of a portion of the glabella has
in my opinion more of a physiological than of a morphological value.
In the style and extent of the inflation of the glabella of these
two genera a considerable difference is found to exist on careful
examination. In *Staurocephalus* it is only the frontal lobe which is
inflated and projects so conspicuously over the front border of the
head-shield ; the first side-furrows are very strong, and unite across
the glabella in a continuous groove, thus sharply marking off the
globular frontal lobe. The hinder portion of the glabella is parallel-
sided, and has two pairs of furrows marking off the lobes distinctly,
but the basal lobe is not circumscribed. In *Sphærocoryphe* excessive
development is shown by the glabella as a whole, with the exception
of the basal lobes, which are in the form of nodules. The facial
suture in *Staurocephalus* cuts the outer border of the head-shield
posteriorly, so that the free cheeks are of a fair size, but in
Sphærocoryphe the free cheeks are relatively very much smaller
and of a different shape, owing to the forward course of the posterior
branch of its facial suture. In fact, the two branches of the facial
suture in *Sphærocoryphe* meet at a very acute angle, while in
Staurocephalus they meet at almost a right angle. This feature,
from what we now know of the ontogenetic and phylogenetic history

[1] Amer. Journ. Sci., vol. iii (1897), p. 201.
[2] Ofver. Kongl. Vet. Akad. Forhandl., 1885, No. 6, pp. 49–51, T. xiii, figs. 11, 12.
[3] Bernard, Q.J.G.S., vol. L (1894), pp. 422–4.

of the free cheeks, must be taken as of considerable importance. The marginal spines on the head-shield of *Staurocephalus Murchisoni* may perhaps be regarded as merely the multiplication of the one or two pairs present in *Sphærocoryphe*, but a marginal fringe of spines is of but little morphological value, for we find it in the most widely separated forms, such as *Areia* and *Acidaspis*, as well as in closely allied species. The cheeks of *Staurocephalus* are not pitted like most of the Cheiruridæ, but are tuberculated, and in this respect, as well as in the stalked eyes, resemble some of the Encrinuridæ. But surface ornaments may have too much importance attached to them, and I doubt if they are often of more than specific value. The thoracic segments show a considerable resemblance to those of some genera of the Encrinuridæ in their shape, their rounded and ridged surface, and the fulcrum, beyond which they are sharply bent down. These features are suggestive, and seem to be of considerable value in this case in indicating the relationship of this strange genus. A furrow exists on the anterior edge of the pleuræ of *St. Murchisoni*, as Salter described, and a similar one occurs in the same position in *Encrinurus.* This furrow may perhaps not be homologous with the ordinary diagonal or longitudinal pleural furrow of other genera, but it is a common feature in *Encrinurus* and *Staurocephalus* which is worthy of notice. In *Sphærocoryphe* the thoracic pleuræ are not ridged, and the furrow which is present on them runs along the central line. However, we are not precluded from supposing the possibility of its obliteration when we recall the case of *Sphærexochus* and *Pseudosphærexochus.* In the pygidium of *Staurocephalus* we see again the impracticability of deciding affinities by this member. The pygidium of one species (*St. globiceps*) shows a close resemblance to that of *Sphærocoryphe unicus*, and in each form the first pair of pleuræ is much enlarged at the expense of the others. But the less specialized pygidium of *St. Murchisoni* is completely different, and while retaining the Cheirurid character of a small number of segments, yet in its general shape, and the form and course of the pleuræ, it strikingly reminds us of some species of *Amphion*, and, more remotely, of some species of *Cybele* and *Encrinurus.* Barrande has remarked that its pygidium shows a particular analogy to that of *Ch. tumescens.* From the foregoing consideration of some points in the anatomy of *Staurocephalus* I am led to conclude that its affinities are rather with the Encrinuridæ than with the Cheiruridæ, and that its resemblance to *Sphærocoryphe* is more superficial than real, and is probably an instance of isomorphism. The pygidium in any genus is too variable a feature to be of much use in determining true relationships, but in the simplest and least modified form of this member, as represented in *St. Murchisoni*, it is deserving of notice that there are indications of an alliance with the Encrinuridæ. It may here be remarked that in the latter family the large number of segments on the axis of the pygidium probably does not represent so large a number of coalesced pygidial segments, but is due to the secondary subdivision of the original segments. Finally, we must come to the

conclusion that *Staurocephalus* diverged from some early Encrinurid, and while retaining several of its ancestral characteristics underwent a development under somewhat similar conditions as *Sphærocoryphe*, leading to similar adaptive changes in certain points of its structure.

IV.—A REVINDICATION OF THE LLANBERIS UNCONFORMITY.

By the Rev. J. F. BLAKE, M.A., F.G.S.[1]

(Concluded from the April Number, p. 178.)

The District South-West of Llyn Padarn.

THIS is undoubtedly the most difficult district to deal with, and one in which I have had to change my views on certain details. Still, there is one part of it where the evidence is very clear, namely, the ground between the railway and the road at the Tan-y-pant inlet. This was apparently not examined by Professor Bonney when he visited the locality, and its teaching is evidently not appreciated by his coadjutor. They say that the section at what they call "the supposed junction" is undoubtedly very difficult. One thing, however, is clear, since we all agree about it. The junction of a rock of felsitic character with one like a purple slate is *vertical*. There are here only two alternatives : either the felsite is intrusive into the purple slate, as the junction at first sight certainly suggests, or the purple rock was deposited on the felsitic one. In spite of appearances, we agree to reject the former alternative ; but my critics seem to think they are correcting me when they agree with me in accepting the latter. The only possible difference between us is, that what I called felsite, including therein, as I remarked in a note, "felsitic ash," they call "felsitic grit." This difference, which, as far as I am concerned, is merely one of words, is quite irrelevant to the argument that the junction-line between two deposits must have been at first approximately horizontal, and have been subsequently turned on end. But the neighbouring conglomerate lies in a hollow on the present upper surface of the felsite, and must therefore have been deposited after the rocks had been turned on end, and therefore be of later date than the slate. (See Fig. 1.)
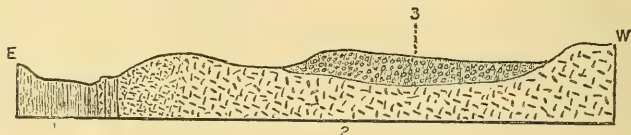
FIG. 1.—Relations of slate (1), felsite and associates (2), and conglomerate (3) at the inlet by Tan-y-pant, Llanberis.

It is true that my critics draw a fault somewhere about here, but it is not clear where they think it runs. It cannot be in the slate, as that would throw no light on the question ; it cannot be at

the junction, which they describe as a surface of original deposit:
it must be in the felsitic part, probably at some supposed junction of
felsitic grit with true felsite. Such a fault would have to rotate the
conglomerate and bring it out from between the felsitic grit and
felsite. Now, the rocks in this area are quite bare, and one can see
for certain that there is no fault; even the mass that discloses the
junction with the slate is continuous till it becomes a true felsite.
The only possible fault in the neighbourhood is on the other side of
the mass of purple slate between it and the next exposure of
conglomerate, that is, along the face of the cliff above and below
the road.[1]

The similar section described by Sir A. Geikie (E, p. 96) is
doubtless on the continuation of the line of junction seen below.
The purple slate[2] is there also said to be nearly vertically inter-
banded with felsitic material which passes towards the west into
a true felsite. Sir A. Geikie does not say exactly where this section
is, but describes it as separated from "the porphyry of the ridge"
by a "zone of conglomerate and grit," so it is most likely where
Miss Raisin has inserted felsite on her map. In my map, however,
it is included with the "Post-Llanberis," because on the upper
surface there are scattered here and there some pebbles of quartz,
so that it is covered, as it were, by a skin of conglomerate. Here
again, then, if the spot is rightly identified, the plane of junction
with the slates is nearly vertical, while that with the conglomerate
is horizontal.[3]

This inlet section is really an important one, as it is the only
place I know of, except in tunnels, where the felsite and any other
rock than the conglomerate can be seen in unbroken sequence.
What we see in such a case I regard as *one* irresistible argument for
the unconformity I postulate, and, so long as it holds, the question
whether the purple slate here is the workable slate or not is of
secondary importance, for if the conglomerate is unconformable it
may just as well extend over the workable slate as not. The rock
is like the workable slate, and like no rock out of that group; as
a fine-grained rock it cannot be a mere local deposit; and it is in
continuation with the worked slate which runs over the hill to the
south-west. My critics also recognize in it one of the characteristics
of parts of the workable slate series—the "interbanding of fine grit
and purple slate," which is quite a distinct thing from the "alter-
nation of hard grey slate, transversely cleaved, and coarse grit,"
characteristic of the Post-Llanberis group.

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[1] Professor Bonney and Miss Raisin also claim a fault on the other side of the
conglomerate, between it and the main mass of the felsite, but the junction may be
seen in a block near the water's edge; one is welded to the other.

[2] So gradual is the passage from one rock to the other that Sir A. Geikie considers
the parts of the slate nearest to the felsite to be only a cleaved portion of the latter.

[3] A similar argument is applicable to the tramway section on the opposite side of
the lake. The felsite there shown next the first conglomerate is followed beyond the
conglomerate (and a dyke) by nearly vertical slaty beds, but the summit of the felsite
crag shows a covering of conglomerate, indicated by the presence of quartz pebbles.
Here, however, the vertical succession is broken.

Next, they cannot believe that the conglomerate passes over to the other side of the purple slate, because the rock there found seems to them to be less squeezed, more purple, with a few additional varieties of pebbles, and thinner. These differences (excluding the first, which one cannot deal with seriously) are slight at the best, and just what we should expect in a shore deposit, the change in colour being related to its position over purple slate rather than over felsite.

Next, in relation to the synclinal in the railway cutting and my belief in its unconformity, Miss Raisin says that the purple slate " turns up again " on the south-east side of it, and thus behaves as the overlying strata do. But the phrase quoted is ambiguous; it may be intended as a colloquial expression for " occurs," or it may mean that the dip is changed. It is quite to be expected that slate would *occur* where she has marked it, and, indeed, I have it so in my note-book section, here copied (Fig. 2), though it is omitted in my general section of this cutting, but I could find no proof of dip in it, while in the nearest visible purple slate I noted a high dip to the E.S.E. as on the other side of the synclinal. But an unconformity or its
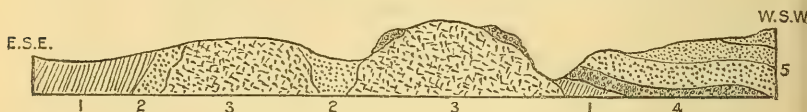
Fig. 2.—South-east end of the synclinal in the Llanberis railway cutting. (1) Purple slate, (2) green (St. Ann's ?) grit, (3) greenstone, (4) conglomerate, (5) grit.

absence cannot be proved in this sort of section; it is too obscure. Its only use is to show how far an unconformity, otherwise proved, extends over the underlying rocks. Still, what we see here is more favourable to an unconformity than the reverse. I pointed out that the conglomerate " mounts up over the back of the greenstone boss " and passes to the other side, as now shown in Fig. 2. This looks like a transgression over the outcrop of slate.[1]

I also described the conglomerate as leaving the felsite along the north-west boundary and disclosing between them a different succession. I briefly described the immediate successor of the felsite here as a hard purple slate, but Miss Raisin goes into details and records between the felsite and conglomerate a breccia, a pebbly grit, a banded grit and argillite (a greenstone), and a purple grit,— just what we might expect to follow the felsite in spots now further west, representing hollows on its surface at the time of their deposit.

[1] The following quotation from Professor Bonney's paper (C) will show that he at that time gave quite a different account of this section from mine and Miss Raisin's, and considered the conglomerates now distinguished as inseparable except as varieties. " The cutting . . . . passes into fine green grits or 'bastard slate,' beyond which we find a thick mass of interbedded conglomerate and similar grit, then another band of grit, followed by a band of small rolled fragments of felsite about as large as hemp-seed." It is plain that either what he here calls fine green grit or bastard slate is the same as that now called purple argillite, or he has missed the first conglomerate in the cutting, and takes the next band to be the " Cambrian " conglomerate, calling it " the finer variety," and saying that " with considerable variety of detail the general character of these is similar."

Their occurrence indicates a long interval between the outflow of the felsite and the deposit of the conglomerate, and this interval must include an unconformity, since the conglomerate comes back again and lies on the felsite in a very short distance. My critics try to account for these numerous intervening beds, each indicating some change of conditions on the same spot, by reminding us of the interchangeable deposits of grit and coarser material on the seashore. This I have already allowed for, having included with the conglomerate much that is only the red grit into which it passes in places.

In connection with the strata which overlie this conglomerate, I am charged by my critics with inaccuracy when I say, speaking of their lamination, that almost wherever seen these laminæ are horizontal. No doubt from its form this statement is liable to be taken to mean that the strata are almost always horizontal. That this is not the meaning might be inferred from the high dips shown in my section of the railway synclinal, which must necessarily be continued into the country behind. They are, in fact, seen, as stated by Miss Raisin, in many places. But the question is whether in places where the dips are high the laminæ can be seen. Possibly they can; I have, however, seldom found them, except where the strata are nearly horizontal, either in this district or higher up on the hill, or on Y Bigl, and even Miss Raisin only speaks here of high dipping "outcrops," but when elsewhere "lamination" is mentioned it is accompanied by the word "horizontal" (loc. cit. (K), p. 588).

These horizontal laminæ are for the most part only observable on the summits of elevations, such as the spots I named (10, 16, 18, on my map), the last one being both the highest and best; it is marked 666 on the 6 inch ordnance map. How such horizontal laminæ above are compatible with highly inclined outcrops below, is explained by the deposit of the strata on an undulating surface. Those lying in the hollows would be squeezed into synclinals under earth pressures, being nipped in between the older and harder rocks, while the higher ones might escape.[1] Thus the high dipping outcrops in the low ground are no arguments against the general horizontality of the strata, and therefore call for little notice. If Miss Raisin had given the direction of the dips she noticed we might find that their average was zero. I ought to remark, however, that my words "dip" and "horizontal" here have reference to the *apparent* dip in a direction parallel to the lake-shore. There may be also, and probably is, more or less of a dip towards the lake in the direction of the strike of the underlying slates.

We now pass to the strictures on my statement about the grounds of Glyn Padarn. They say it is not easy to recognize my "definite succession along an E.N.E. and W.S.W. line." Miss Raisin, however, has succeeded in doing it and in confirming my statement. But in quoting me my critics have omitted the words which I actually

[1] The manner of this was illustrated by a model at the reading of my paper.

italicized as containing the gist of the matter, that this line is the line of strike of the purple slates. Is it necessary to explain that if these surface beds are bands in the slate series, and we go along the line of strike, we must continue on the same bed, and not change again and again ? The definite succession is fatal to the hypothesis. It indicates a strike at right angles to the dominant strike of the district, which is only possible in superficial deposits. Even a fault cannot do much towards altering the strike, unless it be on a geotectonic scale.

The dips Miss Raisin records in some part of these grounds are of no consequence from this point of view, though *combined* they give a general "gentle dip towards the E.N.E.," and separately they indicate a slight synclinal arrangement. But in the centre of the grounds, standing with one's back to the road and looking along the strike of the slates of the country as shown in the neighbouring quarry, we see the crag shown in Fig. 3. It illustrates at the same time the

Fig. 3.—Low crag in the Glyn Padarn grounds, looking W.S.W.

perpendicularity of the strike of the beds (whatever be their dip) to that of the slates, and my description of the alternations of transversely cleaved grey slate and coarse grit characteristic of the Post-Llanberis group. As noted above, a fault between this and the quarry would make little difference to the argument, but of such a fault there is absolutely no evidence, and in the absence of one the bottom beds of worked slate in the quarry, if continued on their rise, would run into this crag, or very near it. The transverse fault seen in the quarry has nothing to do with this, but lies beyond.

In the large exposed surface of conglomerate "beyond the wall" a band of purple slate most certainly lies with a very low dip upon

Fig. 4.—Mass of purple slate mud, overlying conglomerate outside the Glyn Padarn grounds, looking N.E.

it. This band is perhaps more probably a redeposited purple mud than a fragment. It is shown in Fig. 4. The conglomerate, *pace* Miss Raisin, does contain felsite pebbles, and in no way resembles the St. Ann's grit, or any grit interbanded with purple slate

elsewhere, for, as desired by my critics, good " distinctions between the various conglomerates and grits " have already been drawn, and in most cases, as here, can be easily recognized.

I regard all this as very strong evidence that there are unconformable deposits here, and cannot see how it can be affected either for good or ill by anything that may be seen in the railway cutting. Nevertheless it is satisfactory to show how the neighbouring exposures can be explained in relation to our conclusions. Thus on the north-west side of the grounds we find purple slate and ordinary St. Ann's grit coming on again at a higher surface-level. This I explain by the hypothesis of a fault which has let down the unconformable deposits to a lower level than they originally occupied. But to support this hypothesis we should be able to point out the fault and show that it lets down something—we cannot reasonably expect any particular kind of rock — on the S.E. side. Such a fault we can point to: see Fig. 5. This suggests at least, by the anticlinal

Fig. 5.—Fault seen in the Llanberis railway cutting, looking N.E. (1) Purple slate, (2) green slate, (3) slickensided fault, (4) conglomerate, (5) grit.

structure on the left, that it is a down-throw on the right, and, as it happens, on this side are rocks, conglomerate and grit, which, from what we have observed above, could easily be brought here by a slight fault.

In reference to this my critics say: " Mr. Blake speaks of it as a slight fault, but it is only so on his own hypothesis, and to argue from that statement is reasoning in a circle." But I have not argued from it at all. If I were to do so now it would be to say that the hypothesis, that this conglomerate has been let down from above by a slight fault and forms the continuation of similar rocks near at hand, is a less wild one than that which supposes it to be " faulted up from great depths," and so have no relation to the neighbouring conglomerates. This last hypothesis is not even suggested by anything that is seen on the ground.

Before leaving this district I should point out that the map of it given by my critics is inconsistent. They draw a fault by the Tan-y-pant inlet, and make the succession on the two sides of it different. On one side it is felsite, conglomerate, felsitic grit, grit with argillite; on the other, felsitic grit, purple slate, conglomerate, grit with argillite. These two successions cannot both be the true one.

The Tramway Section and Y Bigl.

I will not here, as I did at the reading of my paper, explain the corrections I have been led by additional observations to make in my own map, as they lead me further from my critics' views, but will confine myself to their statements.

We will commence with the tramway section. Of this Professor Bonney gave a diagram in C. He and Miss Raisin now give a second, and they say, " we adhere to our original diagram." If anyone will take the trouble to put these two diagrams (A and B) side by side and compare them, he will notice that (1) in A a fault is placed between the felsite and the conglomerate, in B it is shifted to the other side of the conglomerate; (2) in A a purple slate is repre- sented as occurring in the synclinal, in B there is none; (3) in A the middle conglomerate is undivided, in B it is divided into two; (4) in A the beds between the second and third conglomerate are called green slaty grit, in B they are quite differently described; (5) in A these beds are represented as forming an anticlinal, making the second and third conglomerates parts of the same bed, in B these beds are all made to dip towards the second conglomerate, making the third a distinct and lower bed. When, then, the authors claim that they adhere to the original diagram, and add, " but would shift the anticlinal so as to fall nearly on the third conglomerate," they might as well have said, " but change it altogether."

I do not complain of a change of views, if frankly acknowledged, but in this case I fear it is a change for the worse, for it lands them in many difficulties. *The* Cambrian conglomerate has gone by the board, and they have become quite lavish of their successive con- glomerates. They have already claimed one below that on the summit of Moel Tryfaen, and one above that next the felsite by the Llyn Padarn inlet, and here there must be a fourth unless they can account for the change of material lying between the supposed two on one side of the lake, and the two on the other. This material in one case is felsitic grit and purple slate, and in the other felsitic grit of a different kind and " rainspot breccia." Next they have to account for the absence of the second conglomerate on the north-west side of the banded-slate synclinal, and to this end have to introduce a new hypothetical fault for which there is no independent evidence, but rather the reverse. Then they have to deny the identity of the very similar conglomerates in the two crags almost facing each other on the slopes of Y Bigl, on the sole ground that one of them contains additional varieties of pebble. At the same time they identify one of these, on the west of Moel Goronwy, with a totally different felsitic breccia, containing none of the great pebbles, on the east side. They have to make two conglomerates along the west side of that hill, where they acknowledge not to have examined the ground, and where there is certainly only one; and they draw the second con- glomerate in a straight band right over the high ground, thereby representing it as vertical, though in the tramway section they state that it has a moderate dip.

There is, however, direct evidence that these second and third conglomerates are parts of one and the same sheet, for one can be traced round on the slopes above the section, passing across about the level of the lower road, with a very narrow interval of grass, into the other. This, while it negatives the new section, does not prove an unconformity; for if, as Professor Bonney originally

represented, there were an anticlinal here, the junction would
naturally take place over its crest; but of such an anticlinal no one,
from Sir A. Ramsay onwards, has ever been able to find a trace, and
it is now abandoned even by Professor Bonney and his coadjutor.
From these considerations and others to follow I hold that an
unconformity is the only alternative left, whatever may be the
teaching of Professor Green's section.

This section, seen on the tramway, has been differently inter-
preted by my critics and myself. If my opponents' reading
of it be correct, I should say with one of them that the
unconformity was only locally absent; if mine be correct, it will
afford only confirmatory evidence, valuable, no doubt, but not
essential. My critics, however, try to give it an unmerited
importance. They "are told," they say, "that here the hypothesis
can be brought to a direct test." They were certainly never told so
by me. No hypothesis can become a conclusion without being
subject to many tests, and a single section, with the possibility of
a local absence of unconformity, is not suitable for a "final appeal."

To me the evidence of this section is clear enough, but Sir A.
Ramsay, Sir A. Geikie, and Miss Raisin are all against me, and
I have only the support of Professor Green,[1] a good stratigraphist.
With regard to this support, it is not fair of my critics to say
that "the only line which might be supposed, and has been
supposed by Professor Green, to mark it [the unconformity] is not
shown by Mr. Blake," when I distinctly said that "his description
is so wonderfully true to nature that I could only quote him
verbatim," including, of course, his diagrams. My general diagram
was intended only to illustrate my view of the general relations,
just as was Professor Bonney's.

I do not think the line which those who see conformity here have
noticed some way down in the breccias is really a line of bedding.
I can see there no change of material, but of course I may be wrong.
But if so, there still remains the cleavage. Now cleavage, as Dr.
Hicks pointed out, had already been produced in the district before
the conglomerate, containing cleaved pebbles, was formed. Nor do
I see how the angular fragments in the underlying breccia could
have been turned round, thereby shortening the horizontal dimension
of the rock, after the conglomerate was there, and yet leave an
undulating, closely-welded line between the two rocks, seeing that
the conglomerate has not been shortened, and the line of junction
is, at least in places, perpendicular to the cleavage. Hence, whether
from bedding or cleavage, I think the breccia fragments were
made vertical before the deposit of the conglomerate.

Again, my critics say that "the 'nearly horizontal line' does
not exist." As to this, it must be remembered that for two rocks to
be conformable they must be conformable everywhere, but to be
unconformable they need only be unconformable anywhere. It is
thus quite enough for the purpose that my critics themselves

[1] Professor Hughes and Dr. Hicks *accepted* the unconformity, but I do not know
that they have personally observed it.

draw a festoon on the boundary, part of which must of course be actually horizontal. It was, in fact, from this more horizontal portion of the boundary that I was judging when I wrote. But if the amount of dip be in question, none of the drawings yet given of the section are accurate enough. The two rocks are broken up by a number of transverse joints, along which slips appear to have taken place, producing a step-like series of festoons (see Fig. 6). If these were restored, the slope would not appear so great.
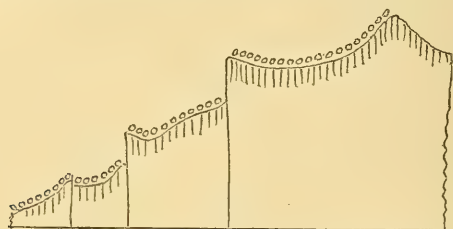
Fig. 6.—Junction of conglomerate and breccia in the tramway cutting, Llyn Padarn, looking N.E.

My critics further state that " the unconformity is quite disproved by the finer matrix graduating from one [the breccia] into the other [the conglomerate]." In a hand-specimen the line is sharp, and the two matrices are differently coloured. In the field the joint face of one is smooth, being along a cleavage plane ; of the other, rough, where the cleavage almost ceases. But a similarity of matrix is to be expected when one rock is derived from the other. This is perhaps the last district where such a similarity should be used as an argument. for here we have the well-known example of even a crystalline felsite yielding to the succeeding conglomerate a matrix which can be scarcely distinguished from the original rock. When the original is clastic we may well expect the derived matrix to be absolutely indistinguishable. The fallacy, too, of this argument has been already demonstrated. On this ground the conglomerate overlying the " granitoidite " at Twt Hill was positively asserted to belong to the same series, but it was afterwards acknowledged to be of a totally different age and unconformable.

I do not know that this section is worth all this labouring to prove its teachings. I am only forced to it by the dogmatic tone adopted by my opponents. I should rather gather from the conflict of opinion here how very useless a single section may be to carry conviction as to the structure of a country ; and in this case the further evidence enables us to dispense with it altogether.

There is, indeed, in this district a discriminating test as to the truth of my reading or of that of my critics, which may be applied again and again in many places and in many ways. Immediately to the north-west of Green's section lies a synclinal of pale banded slates and grits, towards which, according to my opponents, the conglomerate is dipping, and which they take to overlie it. That is,

the slates are *above* the conglomerate. According to my reading, the conglomerate is unconformable over them. That is, the slates are *below* the conglomerate. Here, then, is a clear issue. As to this, my opponents state as "further proof" of their view, that "the grits continue the succession above the conglomerate," and "rain-spot breccia [i.e. rock like the underlying breccia at Green's section] recurs above the supposed unconformity." Now, if the authors could point to any clear section in which a rock undoubtedly belonging to the banded-slate series, whether a grit, a breccia, or a slate, can be seen overlying Green's conglomerate in regular sequence, it would be fatal to my account of the rocks. This ought not to be a difficult matter, somewhere along the line of junction depicted on their map, but they do not point to any such section ; they use the ambiguous phrase "continue the succession." If they cannot do so, but only *assume* that the "grit" and "rain-spot breccia," from their position to the north-west, i.e. in the direction of the supposed dip, of the conglomerate, must lie above it, the circularity of their "proof" leaves nothing to be desired.

On the other hand, I have searched in vain for such a section, but have only found patches of conglomerate overlying slates, as figured by Professor Green, not only immediately above his section but also to the north-west of it. The ground about here, however, is low and hummocky, and does not yield good sections. Further up the hill it is more hopeful. Above the Fachwen road the junction runs obliquely up the hill, making a large angle with its former direction. According to my opponents' explanation, it is the lower beds here that form the higher ground, which they account for by giving the synclinal axis a dip towards the lake.[1] Along the line of junction here there are some clear sections which are so fatal to my critics' views that I am sure Miss Raisin cannot have seen them, as she could never have suppressed them if she had, especially as I alluded to them in my former paper. They are shown in Fig. 7. They are found a little to the north-east of the spot where I marked + on my map. The first is near to the angle of a wall, where it curves round as shown on the 6 inch ordnance map. They cannot be missed, and they speak for themselves. The drawings represent nearly vertical faces, and the sides of the crags show that the conglomerate is not carried down behind the slate. The underlying slates are continuous as far as can be seen down to the tramway, and the conglomerate is of the same type as all three in that section. Other similar sections continue the line till we are removed only by a narrow valley from the continuation of the conglomerate adjoining the felsite, the only visible rock intervening being a boss of greenstone. I claim that the test proves my reading to be right.[2]

[1] They do not explain how they get the synclinal down again into the further valley consistently with their mapping of the beds ; nor do they account for the enormous expansion of the strata between the conglomerate and slate compared with the tramway. Y Bigl summit is also represented as on slates, and not on laminated grits, but this may be an unintentional error.

[2] It is also in accordance with Sir A. Ramsay's section.

In my paper I said that these conglomerates crossed the hill horizontally, and at this statement my assailants make themselves merry. No doubt it would have been more correct to say that they form a slight synclinal, as indicated on Sir A. Ramsay's figure in his
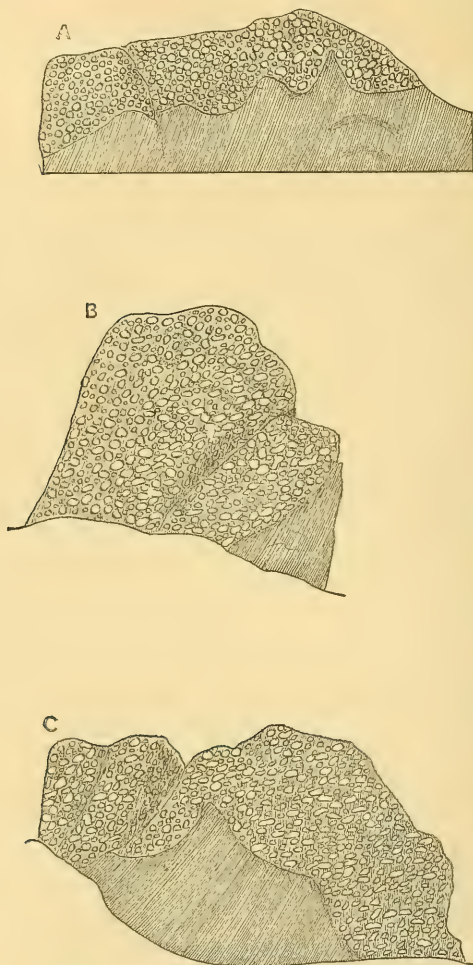
Fig. 7.—Sections on Y Bigl showing conglomerate lying on banded slate.   A, B, C are in order from east to west.

memoir; but the dips Miss Raisin quotes have nothing to do with the matter. If my assailants will look at my former fig. 3 and my present Fig. 7 they will see that there are all varieties of dip to choose from, from 90° downwards, but then they have overlooked

my words, "eliminating contortions." If I spread out a fan on a table it may be said to lie horizontally upon it, yet all its parts will be highly inclined, and even the horizon itself on a stormy day at sea has not a single level spot upon it. In such a squeezed district as Y Bigl it is not by local dips in individual sections, but by the position of corresponding outcrops, that we must judge of the lie of the stratum as a whole.

The Microscopic Evidence.

But what does the microscopic evidence amount to ? That some of the minuter fragments (for they require the microscope to see most of them) are derived from the same kind of rocks, whether they be found in Cambrian or Post-Llanberis strata. These rocks are for the most part of a common kind, with no particular character to render identity certain, but we will grant they are the same. At that early epoch there was not much choice of materials to derive a fragment from, and any of them must have come either from Cambrian rocks themselves or from the Pre-Cambrian of the neighbourhood. In the wearing down of the Cambrian strata to make the conglomerates, the elements of the coarser rocks in them would yield smaller elements to the succeeding rocks, and these would be found in the matrix. But the character of the later rock would be shown by the larger fragments it contains. The coarser Post-Llanberis rocks are always thus distinguishable. The rederivation of some parts of the conglomerates is interestingly shown at Moel Tryfaen, where one of the pebbles is itself conglomeratic.

It is not the fragments that are identical in the two series that present any difficulty, but rather the origin of those larger stones whose home we can find neither in Cambrian nor Pre-Cambrian rocks, but which closely resemble rocks of Post-Llanberis age. Some of these perhaps might be matched approximately in Anglesey, but they seem too large to have come so far. I think it not at all an unreasonable hope that we may some day find a fossiliferous pebble. I much regret that my opponents in this matter should have taken up the other side of the question, for, if they had sought to do so, there is no one more likely to be able to tell us whence the large pebbles may have come. In such an investigation the microscope would be doing its proper work ; but it cannot prove by the similarity of small fragments the continuity of the deposits containing them, any more than it can disprove by the difference of the fragments the identity of two conglomerates, as has been already shown in the case of Twt Hill and Careg Goch. The worker with the microscope must not forget that in geology he is the servant of the stratigraphist, for until he knows the conditions of occurrence of his rocks his account of them has no *geological* value. It is therefore quite beyond his province to attempt to prove microscopically such a stratigraphical conclusion as the non-existence of an unconformity. The attempt in the present instance is founded on the assumption that rocks formed when " the same rocks were undergoing denudation " must belong to the same

series, and cannot be divided by an unconformity. That this assumption is unwarranted has again and again been proved. The break at the base of the Llandovery alluded to by our authors is, both in Shropshire and at Llandovery, between rocks of very similar character; and such is the case, it is generally stated, between the upper and lower parts of the Old Red Sandstone in Herefordshire, and between the Elgin and the Old Red Sandstone in Scotland. In most of these cases the separation is effected by the aid of the fossils, but in the present case stratigraphy has to do the work alone, and it is perfectly capable of doing it.

I trust that in the above remarks I may in no case have made a statement without at the same time indicating plainly how it may be checked, nor quoted my own opinion without giving any reasons for it, both of which procedures I hold to be inconsistent with scientific argument.

NOTICES OF MEMOIRS.

I.—Herstellung von Diamanten in Silikaten, entsprechend dem natürlichen Vorkommen in Kaplande. Vortrag gehalten im Verein zur Beförderung des Gewerbfleisses am 7 Februar, 1898, von I. Friedländer. (Berlin, 1898.)

(Artificial Production of Diamond in Silicates, corresponding to the Actual Mode of Occurrence in South Africa.)

IN the recent diamond-making experiments of M. Moissan, fused iron rich in carbon was allowed to cool in such a way that the separation of the excess of carbon took place under pressure, and it was thought that a high pressure was necessary to the success which had been attained. It is now known that the necessary pressure is not very high, for microscopic diamonds have been found as normal constituents of ordinary cast iron. In South Africa no iron is present in the metallic state in the diamond-bearing rock, although it is largely present as a chemical constituent of the stony matter. Hence, in regarding Moissan's method as being possibly identical with the one by which the South African diamonds had been formed, it was necessary to surmise that the crystals, after formation in the molten iron at some great depth below the earth's surface, had floated into the molten silicate-material above. It was, however, soon pointed out that the diamond-bearing rock, if in a state of fusion at small pressure, dissolves any diamonds contained in it.

Dr. Friedländer fused a small piece of olivine, a centimetre in diameter, by means of a gas-blowpipe, kept the upper portion in the molten state for some time by playing upon it with the flame, and stirred it with a little rod of graphite. After solidification the silicate was found to contain a vast number of microscopic crystals, but only in the part which had been in contact with the carbon. These Dr. Friedländer has subjected to a careful examination. They are octahedral or tetrahedral in form, are unattacked by hydrofluoric and sulphuric acids, have a high refractive index, sink slowly in

methylene-iodide, burn away when heated in a current of oxygen, and are unaltered if heated in a current of carbonic acid : the stony matter containing them scratches corundum. Hence Dr. Friedländer infers that they are diamond, and that the South African diamond may have been actually formed, as already suggested, by the action of a molten silicate, such as olivine, on graphite : carbonaceous shales are interrupted by the diamond-bearing rock, and numerous fragments of the shale, much altered, are found enclosed in the rock itself. The paper is illustrated with seven micro-photographs.

II.—Note on the Occurrence of Diatomaceous Earth at the Warrumbungle Mountains. New South Wales. By Professor T. W. Edgeworth David, B.A., F.G.S. Proc. Linn. Soc. New South Wales, 1896, pt. 2, pp. 261–268, pls. xv–xvii.

Diatomaceous Earth Deposits of New South Wales. By G. W. Card, F.G.S., and W. S. Dun. Records Geol. Surv. New South Wales, vol. v, pt. 3, 1897, pp. 128–148, pls. xii–xv.

DEPOSITS of Diatomaceous Earth occur not infrequently in Victoria and Queensland as well as in New South Wales, but so far there is no record of them in South Australia or in Western Australia. They are widely distributed in the older colony of New South Wales, for deposits are known at Cooma, about 260 miles to the south of Sydney ; at Bathurst and the Mundooran district, 250 miles to the west ; and also in the Warrumbungle Mountains, the Richmond River district, and at Barraba, from 300 to 350 miles to the north of Sydney.

At Cooma the deposit is over 20 feet in thickness ; it lies in a hollow partly inclosed by hills of basalt, and is now only covered by surface soil. In the Warrumbungle Mountains there is a bed of diatomaceous earth 3 ft. 9 in. in thickness, interstratified in trachytic rocks, which are regarded by Professor David as of early Eocene or late Cretaceous age. In the Richmond River district the earth is found in depressions of scoriaceous basalt, and is overlaid by beds of the same material. At Barraba the diatom bed is eight feet in thickness, with a single intermediate band of coarse sand two inches in thickness ; beneath it are mudstones and lava fragments imbedded in diatomaceous material, and it is overlaid by a flow of basalt considered by Mr. E. F. Pittman to be of Miocene age. This covering of basalt is now the summit of an elevated tableland.

In these various deposits there is a very close resemblance in the character of the diatomaceous earth, which is a light, whitish, powdery material, typically similar to that known from other parts of the world. In some instances the siliceous constituents have been partially dissolved, and now form bands and nodular masses of hard, homogeneous, colloid silica. Chemical analyses show from 81 to 97 per cent. of silica, with, as a rule, small amounts of ferric oxide, alumina, and carbonates of lime and magnesia.

Microscopic examination shows, further, a very singular uniformity in the diatoms composing these different deposits in New South

Wales, for they consist almost exclusively of two or three varieties of the genus *Melosira*, and, rarely, a few examples of *Navicula*. With the diatoms there is also a small proportion of acerate spicules of fresh-water sponges. The markings of the diatoms are as perfectly preserved as in recent forms. Detrital materials are absent in the beds, but in a few instances impressions of leaves of plants have been noticed. All the deposits are distinctly of fresh-water origin, and probably of Tertiary age. Professor David considers that the constant association of volcanic rocks with the diatomaceous beds is not accidental, as probably hot springs, and the lavas also, furnished supplies of silica to the lakes in which the diatoms lived. It is evident that the preservation of these beds is in many instances due to being overlaid by basaltic and trachytic lavas.

The diatomaceous deposits in Queensland, like those of New South Wales, mainly consist of *Melosira*, but in those of Victoria the variety of diatoms is considerably greater, and fourteen genera have been enumerated in some of the fresh-water beds.

G. J. H.

REVIEWS.

I.—Fossil Plants. For Students of Botany and Geology. By A. C. Seward, M.A., F.G.S. Vol. I. 8vo; pp. xviii, 452, with 111 illustrations. (Cambridge: Messrs. C. J. Clay & Sons, 1898. Price 12s.)

PALÆOBOTANY is no new creation of the *fin du siècle*, although, indeed, the subject has undergone considerable modification with the advance of botanical knowledge, more especially since it has been so largely assisted by the advances made in histological research.

We cannot but recall with gratitude the labours of such men as Sternberg, A. Brongniart, Lindley and Hutton, Göppert, Bowerbank, Schimper, Hooker, Williamson, Carruthers, De Saporta, Grand'Eury, and many others, who have paved the way for the botanist of to-day who desires to take up the study of Fossil Plants.

The author of the present volume is already favourably known as filling the office of Lecturer in Botany in the University of Cambridge, and has been a worker for the last ten years at palæobotany, one of his early papers having appeared in this Magazine for 1888 (p. 289); he is also the author of two volumes of a " Catalogue of Mesozoic Plants in the British Museum" (1894–5), and of several other papers of importance communicated to the Geological Society and elsewhere.

He tells us that "The subject of Palæobotany does not readily lend itself to adequate treatment in a work intended for both geological and botanical students. The botanist and geologist are not always acquainted with each other's subject in a sufficient degree to appreciate the significance of palæobotany in its several points of contact with geology and recent botany. . . . . It needs but

a slight acquaintance with geology," he thinks "for a botanist to estimate the value of the most important applications of palæobotany ; on the other hand, the bearing of fossil plants on the problems of phylogeny and descent cannot be adequately understood without a fairly intimate knowledge of recent botany." "The student of elementary geology is not, as a rule, required to concern himself with vegetable palæontology, beyond a general acquaintance with such facts as are to be found in geological textbooks. The advanced student will necessarily find in these pages much with which he is already familiar ; but this is to some extent unavoidable in a book which is written with the dual object of appealing to botanists and geologists."

While we cordially admit that "a fairly intimate knowledge of recent botany" is needful, if one proposes to take up such difficult questions as "the bearing of fossil plants on the problems of phylogeny and descent," yet, on the other hand, the recent botanist who takes up the study of fossil plants with only "a slight acquaintance with geology" is quite as likely to come to grief. Indeed, the botanist who ventures into the domain of palæobotany must be well-equipped with geological, mineralogical, and chemical knowledge, if he would attempt to interpret correctly the many structural and stratigraphical problems which lie before him at the very threshold of his investigation.

The first chapter is devoted to a historical sketch showing the dawn and development of geological ideas, more particularly those relating to fossil plant-remains ; and the gradual evolution of accurate and intelligent observation which superseded the theorists of the last century. In the second the author treats of the relation of palæobotany to botany and geology. Here one naturally finds the methods of using fossils by the stratigraphical geologist, solely interested in determining the relative age of fossil-bearing rocks, contrasted with the intelligent study of fossils by the zoologist and the botanist, anxious to inquire into questions of biological interest which centre round the relics of ancient faunas and floras.

Alas ! how few zoologists really interest themselves in fossil remains of extinct animals, seeing neither form nor comeliness, nor anything to desire in them ! Indeed, our author admits that " the botanist, whose observations and researches have not extended beyond the limits of existing plants, sees in the vast majority of fossil forms merely imperfect specimens, which it is impossible to determine with any degree of scientific accuracy " ! " He prefers to wait for perfect materials ; or, in other words, he decides that fossils must be regarded as outside the range of taxonomic botany."

This has been really the attitude of both zoologists and botanists with regard to palæontology until within the last twenty years. Now all is changed, and the geologist is told by the biologist that in the future he need not concern himself with fossil organic remains ; they will be taken over into abler hands than his own and properly dealt with. We are heartily glad to hear that this is to be so ; but where, we venture to ask, would our science have been

during the past fifty years if we had not maintained a school of
palæontologists, who have kept alive an interest in fossil remains,
and who have been content to study and describe, to the best of
their ability, even the imperfect specimens which were obtained,
without waiting for the perfect materials which were not attainable?

Referring to the dual aspect of palæontology, as treated of by
the biologist and the geologist, Mr. Seward appropriately quotes
Humboldt, who fifty years ago wrote : " The analytical study of
primitive animal and vegetable life has taken a double direction.
The one is purely morphological, and embraces especially the natural
history and physiology of organisms, filling up chasms in the series
of still living species by the fossil structures of the primitive world.
The second is more specially geognostic, considering fossil remains
in their relations to the superposition and relative age of the
sedimentary formations."   To this we might now add that the
one furnishes a guide to the past history and records the modifi-
cations which the *ancestors* of still living forms have undergone ;
the other shows us the life-range of each form in time and often
its former distribution over the earth as well.

On the subject of " Fossil Plants and Distribution " we
cordially agree with the author.   " The present distribution of
plants and animals represents one chapter in the history of life on
the earth ; and to understand or appreciate the facts which it
records we have to look back through such pages as have been
deciphered in the earlier chapters of the volume. . . . . In
the case of particular genera the study of the distribution of the
former species, both in time and space, that is geologically and
geographically, points to rational explanations of, or gives added
significance to, the facts of present-day distribution.   That isolated
conifer, *Ginkgo biloba*, L., now restricted to Japan and China, was
in former times abundant in Europe and in other parts of the world.
It is clearly an exceedingly ancient type, isolated not only in
geographical distribution but in botanical affinities, which has
reached the last stage in its natural life.   The mammoth trees of
California (*Sequoia sempervirens* and *S. gigantea*) afford other
examples of a parallel case." [1]

The author takes us through a chapter on Geological History
showing how strata have been built up ; and then one on the
preservation of plants as fossils.   Both these subjects are carefully
illustrated, and the student ought to be able to grasp some very good
and clear notions on these subjects as he reads this part of the book.

A tougher chapter follows (v) " On the Difficulties and Sources
of Error in the Determination of Fossil Plants," all of which is
excellent reading ; but the student working at the present day with
the vast added lights invented for him in the past thirty or forty
years, need not, like the Pharisee of old, thank God for his
more exalted position to-day, nor forget entirely that but for the

[1] See the eloquent address by Professor Asa Gray to the American Association :
Silliman's Amer. Journal, October, 1872, p. 282.

labours of past generations of workers, he and his Professors also might be priggishly discoursing with Dr. John Woodward on the exact time of year when the Deluge took place ; or discover with Dr. Scheuchzer, of Zurich, in a giant fossil salamander from Oeningen, the image of "*Homo diluvii testis.*"

Under the subject of Nomenclature and the Rule of Priority, Mr. Seward writes : "Some writers would have us conform in all cases to this rule of priority, which they consistently adhere to apart from all considerations of convenience or long-established custom. . . . . A name may have been in use for, say, eighty years, and has become perfectly familiar as the recognized designation of a particular fossil ; it is discovered, however, that an older name was proposed for the same species ninety years ago, and therefore, according to the priority rule, we must accustom ourselves to a new name in place of one which is *thoroughly established by long usage.*" In all this, and much more under this head, we are heartily in accord with the author, and would go so far as to follow the example of Pope Gregory in the "Ingoldsby Penance," and say—

> "Go fetch me a book ! go fetch me a bell
> As big as a dustman's ! and a candle as well :
> I'll send him—where, good manners won't let me tell ! "

In Part II, Systematic, the author begins with the simplest type of very minute organisms, the THALLOPHYTA, as *Perediniales* (small single-celled organisms) ; he then treats of Coccospheres and Rhabdospheres. *Peredinium* was described by Ehrenberg in 1836 from Cretaceous beds in Saxony, while the others occur in the English Chalk and Lias, and all have been found nearly everywhere in sea-water. Other microscopic bodies are also noticed by the author, as the Chroococcaceæ, *Girvanella, Zonatrichites* ; *Schizomycetes* (*Bacilli*) ; Algæ. Among these last, the student is warned against the many *spurious* fossil organisms pointed out by Williamson, Nathorst, and others, which simulate plant-remains. Then follow accounts of true fossil Algæ and of objects simulating Algæ. To these succeed recent and fossil Diatoms ; Chlorophyceæ, Siphoneæ, and Confervoideæ ; Rhodophyceæ ; Phæophyceæ ; Myxomycetes ; Fungi. Most of these forms are much too obscure, and involve problems far too difficult for the elementary student to attack. In the Characeæ we begin to reach forms which even the young student of palæobotany may readily recognize and appreciate, occurring as they do in the Jurassic and Wealden, and in many of the Tertiaries of England and France.

Thence we pass on to the second half of the book, viz., the Mosses, the Equisetales or Equisetaceæ, with chapters on *Calamites* and *Sphenophyllum.* Here structures of stems, roots, foliage, the spore-cones and spores of these plants, give abundant subjects for illustration, and we should have been glad if more could have been given had space permitted. A list of authors and their works referred to in the text and an index usefully and appropriately end this volume.

As higher forms are reached no doubt the subject-matter will increase in interest. The author publishes in his preface the names of many people who have helped him in his work, but to none is he more indebted than to Mrs. Seward, " who has drawn by far the greater number of the illustrations," and we may add *very well done indeed* ! In Volume II the author promises us that the systematic treatment of plants will be concluded, and the last chapters will be devoted to such subjects as geological floras, plants as rock-builders, fossil plants and evolution, and other general questions connected with palæobotany.

In conclusion, we cannot part from Mr. Seward without expressing our conviction that the volume before us will prove a most acceptable addition to the Biological Series of Cambridge Natural Science Manuals issued by Messrs. C. J. Clay & Sons from the University Press.

II.—A New Geological Map of England and Wales, reduced from the Ordnance and Geological Surveys, and published with Government Authority under the direction of Sir Archibald Geikie, D.C.L., LL.D., F.R.S. With Descriptive Text. By John Bartholomew & Co. Mounted on cloth and in case, 12*s*. 6*d*. ; on cloth with rollers and varnished, 17*s*. 6*d*. (Edinburgh, 1897.)

THIS map is on a scale of an inch to ten miles, and is slightly larger than Ramsay's hand-coloured map published by Stanford. The colour-printing adopted by Bartholomew is excellent, but the tints are not quite so effective as those laid down by hand on the older map, and this is noticeable more especially as regards the Cretaceous and Tertiary strata. The colours, however, are clear and transparent, the topography is accurate, and the railways are shown up to date, including nearly the whole of the Great Central Railway, which is not yet open to the public. Those parts of Scotland, Ireland, and France which are included in the map are coloured geologically, and there are four longitudinal sections to depict the structure of the country from Holyhead to Beachy Head, from Denbigh to Saltfleet, from the Solway Firth to Flamborough Head, and across the Isle of Wight. The map is also accompanied by 28 pages of explanatory notes, which give a concise account of the strata. Future work will no doubt introduce some detail into the large area of "Lower Silurian" rocks in Central and South Wales, and also into the Devonian rocks. We note that the Plymouth limestone is coloured blue, but the Torquay and Brixham limestones are not so distinguished. We observe that the colour adopted for Triassic marls is not at first sight readily to be distinguished from that of the Permian marls and sandstones; but there is much yet to be done in discriminating Permian and Trias in the field in the Midland and Northern Counties. The Rhætic beds are indicated in places where they have been mapped by the Geological Survey, but, as

remarked in the text, "this group of strata runs with singular persistence throughout England and Wales."

The price of this map is 12s. 6d., and as it is unquestionably the best geological map of England and Wales which can be conveniently carried in the pocket, it should meet with a cordial welcome from all interested in the physical structure of our country.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—March 9, 1898.—W. Whitaker, B.A., F.R.S., President, in the Chair.

Professor J. W. Judd exhibited, on behalf of the Coral Reef Committee of the Royal Society, the lowest core (698 feet) from the boring at Funafuti (Ellice Islands), and drew attention to the remarkable changes exhibited by the rocks obtained at this depth. The core from this boring (a mass of material more than a ton in weight) had been sent to this country by Professor Edgeworth David, and was now being submitted to careful study. The last 20 or 30 feet of the boring was carried on in a rock which was of a very soft character, and highly but minutely crystalline. Microscopic examination shows that the rock is almost completely converted into a mass of very small rhombohedra, the organic structures being nearly obliterated; while a preliminary chemical examination seems to indicate that magnesia has been introduced into the rock to a considerable extent. The complete study, microscopical and chemical, of all the stages of the change which has taken place in this rock— a study which will be undertaken by Mr. C. G. Cullis—promises to throw much light on processes of rock-formation of very great interest to the geologist.

The following communications were read :—

1. "Note on Clipperton Atoll." By Rear-Admiral Sir W. J. Wharton, K.C.B., F.R.S., Hydrographer to the Admiralty. (Communicated by Sir Archibald Geikie, D.Sc., F.R.S., F.G.S.)

This atoll, 600 miles from North America, in lat. 10° 17′ N., long. 109° 13′ W., possesses a lagoon which is now completely cut off from the sea. In this is a perfectly round hole where soundings of 20 fathoms or more are reported, on the authority of Mr. Arundel, and even deeper ones on that of the captain of a merchant-vessel. On the coral ring there rises a mass of modified trachyte, the subject of the following communication, about 60 feet in height. The great depth of the lagoon and the rock-mass on the ring are not compatible with the origin of the reef by subsidence or outward growth; and the possible hypothesis is put forth that this reef had grown on the lip of a volcanic crater, or on an island, such as Krakatao, in which the interior has been enlarged and deepened by volcanic explosion.

2. " A Phosphatized Trachyte from Clipperton Atoll." By
J. J. H. Teall, Esq., M.A., F.R.S., V.P.G.S.

Specimens from the projecting rock described in the preceding
communication are dark brown, white, or cream-coloured. The
brown specimens are trachytes, composed of glassy phenocrysts of
sanidine set in a groundmass of microlitic felspars with brown inter-
stitial matter. The light-coloured rocks are more or less altered
trachytes, in some of which the glassy phenocrysts of sanidine may
still be recognized. Analyses of several specimens show that the
rocks all contain varying amounts of phosphoric acid, as indicated
by the following table :—

	I.		II.		III.
	per cent.		per cent.		per cent.
SiO_2	54·0	...	43·7	...	2·8
P_2O_5	8·4	...	17·0	...	38·5
Loss on ignition ...	3·1	...	12·3	...	23·0

The last specimen consists of 95 per cent. of hydrated phosphate
of alumina, with some iron, having thus a composition allied to the
so-called redonite from Redonda in the West Indies. The progressive
alteration affects first the groundmass, then the microlitic felspars,
and lastly the porphyritic crystals of sanidine ; and it is probable
that the change has been effected by solutions of alkaline phosphate
and other compounds derived from the droppings of sea-birds.
A somewhat similar phosphate, shipped from Connétable Island off
French Guiana, is referred to on the authority of Mr. Player.

3. " The Pliocene Deposits of the East of England.—Part I. The
Lenham Beds and the Coralline Crag." By F. W. Harmer, Esq,,
F.G.S.

From the discussion of lists of fossils, a large number of sections,
and a series of borings, the author endeavours to establish the
following propositions :—

I. With regard to the Lenham Beds :

(*a*) That they are older than the Coralline Crag, thirteen out of
sixty-seven mollusca found in them being characteristic Miocene or
Italian Lower Pliocene forms unknown or very rare in the latter
formation.

(*b*) These beds had probably been upheaved, consolidated, and
exposed to denudation before the deposition of the Coralline Crag,
and may have been, as formerly suggested by Professor E. Ray
Lankester, the source from which the " boxstones " found at the
base of the Suffolk Crag have been derived. These boxstones
contain a fauna, not identical with, but of the same general
character as that of Lenham.

(*c*) In the interval between the deposition of the Lenham Beds
and the Coralline Crag the sea retired to the north, in consequence
of the upheaval of the southern part of the area, as it did in
Belgium towards the close of the Diestien period.

(*d*) The Lenham Beds are most nearly, though not exactly,
represented by the Zone à *Terebratula grandis* of Belgium, and

possibly by some fossiliferous deposits recently discovered at Waenrode, near Diest, the Coralline Crag corresponding very closely with the Belgian Zone à *Isocardia cor.*

II. With regard to the Coralline Crag :

(*a*) That the junction of the Crag with the London Clay dips to the N.N.E.

(*b*) That no satisfactory evidence, either stratigraphical or palæontological, is forthcoming to show that any divisions to be observed in this formation at Sutton are persistent at other localities, and that species which have been tabulated as characteristic of certain horizons are found also in other parts of the Coralline Crag, and often in the Red Crag as well.

(*c*) That there is no evidence of any great subsidence, of deep-sea conditions, of great changes of climate, or of the operation of floating ice during the period. The climate was warmer than that of Britain at the present day, more nearly approaching that of the Mediterranean or the Azores.

(*d*) That, so far from it being possible to separate this Crag into eight zones, the twofold division hitherto adopted, into shelly incoherent sands and indurated rock, can no longer be maintained, the latter being merely an altered condition of the former, as proved by the discovery of a section showing the two types passing laterally into each other.

(*e*) That, with the exception of the base, this Crag forms a consistent and continuous whole, accumulated under similar conditions, namely, in the form of submarine banks, piled up by currents in sheltered situations like that known as the Turbot Bank off the Antrim Coast and those at the south of the Isle of Man, where Professor Herdman's " neritic " deposits occur.

(*f*) That the German Ocean was less open to the north during the Coralline Crag period than at present, but that it was connected with the Atlantic by a channel over some part of the southern counties of England.

III. With regard to the Red Crag :

That it forms, with the exception of the Chillesford Beds and " the unfossiliferous sands of the Crag," a continuous sequence of deposits arranged horizontally, and not vertically. It was a marginal accumulation of a sea slowly retreating to the north and east, as shown by the gradually increasing number of northern mollusca met with in this direction.

II.—March 23, 1898. — W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read :—

1. "The Eocene Deposits of Devon." By Clement Reid, Esq., F.L.S., F.G.S. (Communicated by permission of the Director-General of H.M. Geological Survey.)

A re-examination of the area around Bovey has led the author to think that Mr. Starkie Gardner is probably right in referring the

supposed Miocene strata to the Bagshot period. Lithologically, as well as botanically, the deposits in Devon and Dorset agree closely. The gravelly deposits beneath the Bovey pipeclays are also shown to belong to the same period, and not to be of Cretaceous date. This correction has already been applied by Mr. H. B. Woodward to a large part of the area. The plateau gravels capping Haldon are also considered to belong to the Bagshot period, for they correspond closely with the Bagshot gravels of Dorset to the east, and of the Bovey Basin to the west, and possess peculiarities which distinguish them from any Pleistocene Drift.

2. " On an Outlier of Cenomanian and Turonian near Honiton, with a Note on *Holaster altus*, Ag." By A. J. Jukes-Browne, Esq., B.A., F.G.S. (Communicated by permission of the Director-General of H.M. Geological Survey.)

Although an outlying patch of Chalk in the parish of Widworthy was mentioned by Fitton and marked on De la Beche's map, it has not yet been described. The tract is about $4\frac{1}{2}$ miles south-west of Membury, $3\frac{1}{2}$ miles east of Honiton, and about 7 miles from the coast at Beer Head.

The quarries at Sutton are almost entirely obscured by vegetation, but the following approximate section was obtained from a mason who formerly worked in them :—

			feet.
	7. Flint-rubble		4 to 6
[Zone of *T. gracilis*.]	6. Soft white Chalk		10 to 30
[Zone of *Rh. Cuvieri*.]	5. Hard Chalk		About 20
	4. Freestone		,, 5
	3. Soft Chalk with green grains		,, 5
	2. Hard cockly Chalk		,, 2
	1. " Grizzle " (a hard calcareous sandstone).		

The Freestone, used locally for building, is evidently identical with the Beer Stone.

Another small outlier of Turonian Chalk occurs at Wilmington, resting on hard quartziferous limestone with glauconitic grains, which yielded fossils indicating its equivalence with the uppermost Cenomanian beds of the coast-section. Below this come other sandstones, sometimes containing lumps of " grizzle," giving a total thickness of 40 or 42 feet to these beds on the whole—a much greater thickness than is ever attained on the coast. A list of fossils is appended to the paper, and the author discusses the affinities of *Holaster altus*, throwing out the suggestion that there is a gradation from *H. Bischoffi* through *H. altus* to *H. subglobosus*.

3. " Cone-in-Cone : Additional Facts from Various Countries." By W. S. Gresley, Esq., F.G.S.

Examples of flinty stone in the " fire-clay series " of the Ashby coalfield exhibit " areas of conic structure, lying unconformably." In the same stratum of shale are large masses of the same flinty rock, more or less coated with conic structures, which appear to have been formed out of layers of shale and ironstone. The

bending-up of the shale above the nodules and down below them, the close but unconformable covering of Permian breccia, and the staining of the whole section suggests, if indeed it does not demonstrate, to the author that the growth of the cone-in-cone took place subsequently to the deposit of the Permian breccia. Several American and other examples are described, and a series of conclusions are appended to the paper.

III.—April 6, 1898.—W. Whitaker, B.A., F.R.S., President, in the Chair.

Professor T. Rupert Jones exhibited and commented upon a series of large stone implements, sent to England by Mr. Sidney Ryan, from the tin-bearing gravels of the Embabaan in Swaziland (South Africa). They consist of fine-grained quartzite, chert, lydite, siliceous schist, and quartzites composed of breccia and grit-stones, one of the latter mylonized. He also exhibited some corresponding rock-specimens from the neighbouring Ingewenyaberg, with a map and section prepared by Mr. S. Ryan. Some similar implements from the same district, lent by Mr. Nicol Brown, F.G.S., and some analogous implements of rough quartzite, from Somaliland, lent by the Rev. R. A. Bullen, F.G.S., were also exhibited.

Professor H. G. Seeley exhibited the humerus of a Plesiosaurian in which the substance of the bone was almost entirely replaced by opal. He explained that the fossil was from the opal-mines of New South Wales. Externally there is no indication of its internal condition as a pseudomorph, and it had been broken to ascertain its commercial value as opal. It is translucent; of a bluish tint, with a slight red fire. So far as he was aware, it was the only example of a fossil bone in this condition; and he was indebted to Messrs. Hasluck, the opal merchants, for the opportunity of placing the specimen before the Fellows.

The following communications were read:—

1. "On some Palæolithic Implements from the Plateau-Gravels, and their Evidence concerning ' Eolithic' Man." By W. Cunnington, Esq., F.G.S.

Although at first inclined to believe that the chipping on the "Eoliths" of the plateau-gravels was the work of man, the author has been led to recant this opinion by the detailed study of specimens lent or given to him by Mr. B. Harrison. His reasons are mainly based on the facts that the chipping is of different dates, even upon the same specimen, and that it was produced after the specimens were embedded in the gravel.

A further series of specimens, which, although not found actually *in situ* in the gravels, present undoubted evidence that they came from these, are considered by the author to be of Palæolithic type. One of them appeared to have gone through the following stages:— first it was fashioned by man into a Palæolithic implement; then it

was abraded, broken. and chipped along one edge in the same fashion as the alleged " Eolithic " working ; finally it was stained, marked with glacial striæ, and covered with a thin layer of white silica.

This implement appears to prove that Palæolithic man lived on the Kentish plateau before or during the deposit of the plateau-gravels, and that the " Eolithic " chipping is not the work of man.

2. " On the Grouping of some Divisions of Jurassic Time."   By S. S. Buckman, Esq., F.G.S.

The author argues for an arrangement in the division of Jurassic time based upon the zoological phenomena of the Ammonite-fauna. He considers that such time-divisions should be related to the duration of Ammonite families.   He divides the Jurassic Period into two epochs—the Eojurassic and the Neojurassic : the former the time when the Ammonite families of the Arietidæ and their close ally the Hildoceratidæ were dominant ; the latter commencing just upon the extinction of these families, and being the time when the Stepheoceratidæ held chief sway.

The epochs are subdivided into ages, and the ages, again, are divided into hemeræ—a hemera being the chronological unit.   Reasons are given for the different subdivisions, and for commencing the Eojurassic Period with the *rotiformis*-hemera.

The Eojurassic Period it is proposed to divide into four ages—the Sinemurian, the Pliensbachian, the Toarcian, and the Aalenian.

During the Sinemurian age, whereof the zoological phenomenon is the acme and paracme of the Arietidæ, was deposited a part of the Lower Lias, beginning with the zone of *Ammonites Bucklandi* and ending with that of *A. oxynotus*.   This age is divided into the following seven hemeræ, stated in ascending order : *rotiformis, Gmuendensis, Birchi, Turneri, obtusi, stellaris, oxynoti.*

During the Pliensbachian age, marked by the dominance of Deroceratidæ and Amaltheidæ, was laid down the rest of the Lower and almost all the Middle Lias.   It includes seven hemeræ, namely : *raricostati, armati, Jamesoni, Valdani, striati, margaritati, spinati.*

During the Toarcian age, when the *Dumortieriæ* and a part of the Hildoceratidæ were prominent, the following strata accumulated : a small part of the Middle and the whole of the Upper Lias, the Cotteswold Sands, the Midford Sands, and a portion of the Yeovil Sands.   There are ten hemeræ : *acuti, falciferi, bifrontis, Lilliæ, variabilis, striatuli, Struckmanni, dispansi, Dumortieriæ, Moorei.*

During the Aalenian age, when there was a preponderance of another portion of the Hildoceratidæ which may be known as the *Ludwigia*-group, and of *Hammatoceras*, the rest of the Yeovil Sands and a part of the Inferior Oolite were the accumulated deposits.   This age is divided into the following six hemeræ : *Aalensis, opaliniformis, scissi, Murchisonæ, Bradfordensis, concavi.*

Part of the Neojurassic division is separated into two ages. During the first, the zoological phenomenon is the acme and

paracme of *Sonnininæ*; during the second, the predominance of *Parkinsoniæ.*

The paper contains a hemeral timetable of the Eojurassic Period and part of the Neojurassic, a genealogical table of Ammonite development during the same and a previous portion of time, notes on certain generic names, and a list of the Ammonite genera referred to.

CORRESPONDENCE.

A MECHANICAL THEORY OF THE DIVINING-ROD.

THE review in *Nature* (1897, pp. 568, 569) of a publication relating to the "divining-rod," recalls to my mind a purely mechanical theory of that rod, which was given me years ago by a friend.

This theory has been repeatedly tested by me and shown to be correct in the presence of my classes. The process is exceedingly simple. Take any forked twig of a reasonably tough fibre in the clenched hands with the palms upward. The ends of the limbs forming the twig fork should enter the closed fists on the exterior side of each fist, i.e. on the two sides of the clenched hands furthest from each other.

When a twig is grasped in this position it will remain stationary if held loosely, or with only a moderately firm grasp; but the moment the grasp is tightened, the pressure on the branches will force the end of the twig to bend downwards. The harder the grip the more it must curve.

The curvature of the twig is mechanically caused by the pressure of the hands forcing the limbs to assume a bent and twisted position; or the force that causes the forked limb to turn downwards is furnished by muscles of the hands, and not from any other cause.

The whole secret of the "divining-rod" seems to reside in its position in the hands of the operator, and in his voluntarily or involuntarily increasing the closeness of his grasp on the two ends of the branches forming the fork.

If the above conditions are fulfilled the twig will always bend downwards—water or no water, mineral or no mineral; anyone can be an operator, and any material can be used for the instrument, provided the limbs forming the fork are sufficiently tough and flexible.

It can be easily understood how an ignorant operator may deceive himself, and be perfectly honest in supposing that some occult force, and not his hands, causes the fork to curve downwards.

M. E. WADSWORTH.

Michigan College of Mines, Houghton, Michigan.

PLACOPARIA FROM THE SKIDDAW SLATES.

Sir,—As supplementary to the note published by Miss G. L. Elles in the March number of this Magazine (p. 141) recording the occurrence of *Placoparia* in the Skiddaw Slates, it may be of interest to mention that one of the three specimens in the Woodwardian Museum was correctly named and labelled as long ago as the year 1890, when it was collected by Mr. H. Kynaston, M.A., F.G.S., at Outerside during Professor Hughes' geological excursion to the Lake District. The second specimen, which was obtained at the same time and locality, was identified by me in 1895, when I was rearranging the collection, and was duly entered with the other in my manuscript catalogue of the fossils of the Skiddaw Slates in the Woodwardian Museum. The third specimen, as Miss Elles has mentioned, comes from Ellergill, and is a recent gift from Professor H. A. Nicholson, F.R.S.

F. R. Cowper Reed.

Woodwardian Museum, Cambridge.
 April, 1898.

MISCELLANEOUS.

New Geological Survey Maps.—In our January number, p. 48, attention was drawn to the issue of several sheets of the General Geological Map of England and Wales (scale an inch to four miles), published by the Geological Survey. The fifteen sheets of the colour-printed edition have now all been issued; and (with the exception of the title-sheet, price 2s.) the price of each sheet is 2s. 6d. The total cost of the map is therefore £1 17s. It is to be hoped that some of the one-inch Geological Survey maps, such as that of "London and its Environs," which in the hand-coloured form costs no less than 30s., or that of the Isle of Wight, price 8s. 6d., may ere long be issued in the cheaper form.

Geological Survey.—The vacancy caused by the retirement of Mr. George Sharman, senior Palæontologist on the Geological Survey, has been filled by the appointment of Mr. F. L. Kitchin, M.A., Ph.D., as Assistant Palæontologist, under Mr. E. T. Newton, F.R.S., Palæontologist.

A Liner in a Duststorm.—The Castle Line mail steamer "Roslin Castle" arrived at Plymouth on February 22 more than two days later than usual, and Captain Travers reported an extraordinary experience. He stated that on Monday, February 14, the vessel met what appeared to be a dense fog, but it proved to be a sandstorm, the air being permeated with red sand from the Sahara Desert for over 900 miles. During this time the sun and stars were obscured, and no observations were possible until after Madeira was reached.—*Daily Mail.*

1 a

1 b

2 a

2 b

3 b

3 a

4 a

4 b × 2

4 c

5 a × 2

6 × 3

5 b × 4

7 × 2
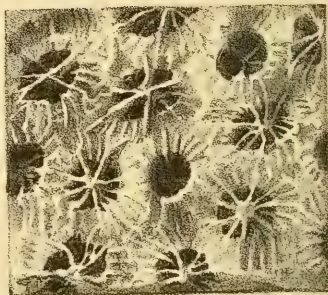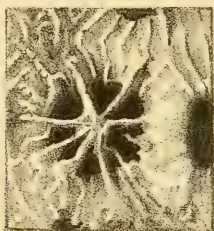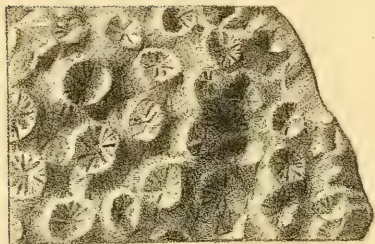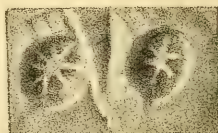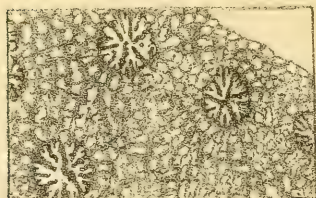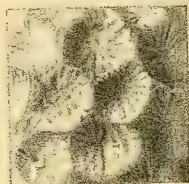
E. Drake del. et lith.

West, Newman imp.

Egyptian Corals.

1a × ⅔

1b × 2

1c × 3

2 × 2

3 × 3

6 × 2

4 × 3

5 × 2

E. Drake del. et lith.

Egyptian Corals.

ORIGINAL ARTICLES.

I.—A Collection of Egyptian Fossil Madreporaria.

By J. W. Gregory, D.Sc., F.G.S.

(PLATES VIII AND IX.)

THE collection of fossils belonging to the Geological Survey of Egypt which has been sent to England for description by Capt. H. G. Lyons, R.E., contains a series of forty specimens of corals, including representatives of nine genera and eleven species. Of the latter two are new.

The horizons represented are as follows :—

Pleistocene : Raised coral reefs at Jebel Zait.

Middle Miocene—Helvetian : Camps 8 and 20 between Cairo and Suez ; near Jebel Attaka, Jebel Owebid, etc.

Upper Eocene : Fayum, in Lake Birket-el-Qurun.

Lower Eocene—Libyan : Dungul Wells and near Silsila, Upper Egypt.

Turonian : Abu Roasch, west of Gizeh.

A record of a species of *Fungia* from the Pleistocene deposits, based on some specimens in the British Museum collection, is included in the present paper.

The principal works on the Egyptian coral-faunas are the following :—

C. G. Ehrenberg. "Beiträge zur physiologischen Kenntniss der Corallenthiere im Allgemeinen, und besonders des rothen Meeres, nebst einem Versuche zur physiologischen Systematik derselben": Abh. k. Akad. Wiss. Berlin f. 1832 (1834), pp. 225–380.

C. B. Klunzinger. "Die Korallthiere des rothen Meeres," pts. ii and iii. Berlin, 1879.

Joh. Felix. "Korallen aus ägyptischen Tertiärbildungen": Zeit. deut. geol. Ges., vol. xxxvi (1884), pp. 415–453, pls. iii–v.

E. Pratz. "Eocäne Korallen aus der lybischen Wüste und Aegypten": Beitr. Geol. Pal. libysch. Wüste, pt. ii (1883), pp. 219–238, pl. xxxv.

Th. Fuchs. "Beiträge zur Kenntniss der Miocänfauna Aegyptens und der libyschen Wüste": Beitr. Geol. Pal. libysch. Wüste, pt. ii (1883), pp. 18–66, pls. vi–xxii.

K. Mayer-Eymar. "Die Versteinerungen der tertiären Schichten von der westlichen Insel im Birket-el-Qurûn See": ibid., pt. ii (1883), pp. 67–78, pl. xxiii.

I. PLEISTOCENE.

Genus SYMPHYLLIA (Edwards & Haime), 1848.

SYMPHYLLIA ERYTHRACEA? (Klunzinger), 1879.

Isophyllia erythracea? Klunzinger, 1879: "Korallthiere roth. Meer.," pt. III, Die Steinkorallen, (II) Asträaceen und Fungiaceen, p. 10, pl. i, fig. 10; pl. ix, fig. 9.

DISTRIBUTION.—Recent: Red Sea (Klunzinger). Pleistocene: Raised reef at Jebel Zait; Coll. Geol. Surv. Egypt, No. 632.

REMARKS.—The collection includes a fossil which is probably the cast of a massive *Symphyllia*, and agrees more closely in general appearance with *Symphyllia erythracea* than with any other species. The specimen is not in a condition for positive determination. Walther[1] has figured a coral from the raised reefs of Jebel Hamman Musa on the coast of the Gulf of Suez, opposite the locality whence the Egyptian Survey specimen was obtained, which probably also belongs to this species.

Pourtalès[2] and Duncan[3] have both urged that *Isophyllia* and *Symphyllia* should be merged, a proposal with which I agree: this species is therefore included in *Symphyllia*, as that name has three years' priority.

Genus ORBICELLA, Dana, 1848.

ORBICELLA FORSKALI (Edwards & Haime), 1849.

Astræa Forskaliana, Edwards & Haime, 1849, "Mon. Astr.," No. 4, pt. 3: Ann. Sci. nat., Zool., ser. 3, vol. xii, p. 100.

? *Favia tubulifera*, pars, Klunzinger, 1879: op. cit., p. 28, pl. x, fig. 2 (*non* pl. iii, fig. 6).

Orbicella mammillosa, Klunzinger, 1879: ibid., p. 49, pl. v, fig. 5; pl. x, fig. 10.

DISTRIBUTION.—Recent: Red Sea. Pleistocene: Low-level reefs of Jebel Zait, Egypt; Coll. Geol. Surv. Egypt, No. 22. High-level reefs (150 metres), near Jebel Zait; Coll. Geol. Surv. Egypt, No. 373.

The collection of Pleistocene corals from the shores of the Gulf of Suez includes four specimens of *Orbicella*, which I refer to

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[1] J. Walther, "Die Korallenriffe der Sinaihalbinsel": Abh. k. sächs. Ges. Wiss., vol. xxiv (1888), pl. v, fig. 9.

[2] L. F. de Pourtalès, "Deep-Sea Corals": Ill. Cat. Mus. Comp. Zool., No. iv (1871), p. 70.

[3] P. M. Duncan, "Revision of Madreporaria": Journ. Linn. Soc., Zool., vol. xviii (1884), p. 91.

Orbicella Forskali (Ed. & H.). This determination, I feel sure, is not free from doubt, as I have not been able to see specimens of the four following recent "species"—*Orbicella Forskali* (Ed. & H.), *O. laxa*, Klnz., *O. mammillosa*, Klnz., and *Favia tubulosa*, Klnz.

The specimens agree in every essential character with the original diagnosis of *Orbicella Forskali*. That coral was then said to have septa belonging to the fourth cycle, which was not, however, stated to be complete. The four fossil specimens have three complete cycles of septa and representatives of the fourth. The only difference between the corals and the original description of *O. Forskali* is, that the columella is more strongly developed, which, however, is not an important character in *Orbicella*. But in the "Histoire Naturelle des Coralliaires," Milne Edwards and Haime put *Orbicella Forskali* into the group of species having four complete cycles. This was probably an error, and possibly a mere accident. Klunzinger had not seen specimens of the species, but he accepted the presence of four complete cycles from Milne Edwards and Haime's action in 1857, and founded for an allied coral with the fourth cycle incomplete the species *O. mammillosa*.

The coral, however, among Klunzinger's series with which these Pleistocene specimens most closely agree is *Favia tubulifera*, Klnz. Klunzinger gave two figures of this species, pl. iii, fig. 6, and pl. x, fig. 2, the characters of which do not seem to me quite consistent. The former is a true *Favia* : the corallites are irregular, triangular or elongated, and in one case, at least, is clearly undergoing fission. But the latter specimen (pl. x, fig. 2) shows only the characters of *Orbicella* ; that may be due to the fact that the specimen figured is small ; but as far as that figure goes the specimen appears to be specifically identical with *Orbicella Forskali*.

Faurot[1] has recorded this species from the Pleistocene deposits of the southern end of the Red Sea in the Gulf of Tadjura.

Favia denticulata (Ell. & Sol.) has corallites somewhat of the same type as regards numbers of septa, development of columella, and size ; but the calice is very much deeper, and the septa thinner and more equal in size.

Genus FUNGIA, Lamarck, 1801.

FUNGIA PATELLA (Ell. & Sol.), 1786.

Var. LOBULATA, Klunzinger, 1879.[2]

The British Museum collection includes three small specimens (R. 1,308) of *Fungia* from the Egyptian Pleistocenes, which may be conveniently recorded here. The specimens are young, having the following dimensions :—

	Height.			Diameter.
(a)	12 mm.	...	...	30 by 35 mm.
(b)	9 mm.	...	...	30 by 33 mm.
(c)	7 mm.	...	...	33 by 37 mm.

[1] L. Faurot, "Une Mission dans la Mer Rouge (Île de Kamarane) et dans le Golfe d'Aden (Aden et Golfe de Tadjoura)" : Arch. Zool. Exper., ser. 2, vol. vi, p. 121.

[2] Klunzinger, op. cit., p. 62, pl. vii, fig. 4 ; pl. viii, fig. 2.

The form varies considerably: the base is concave in *a*, but convex in *b*, and flat in *c*; the shape of *a* is somewhat reniform, but *b* and *c* have irregular marginal lobes.

The specimens present remarkable resemblances to *F. repanda*, Dana,[1] with which they agree in general form, in the depression round the corallum, half-way between the centre and margin, in the small number and thickness of the septa, and in the proportions of the calicular fossa; but the under surface is not coarsely papillose, and the septal teeth are not turned backwards (see Pl. IX, Fig. 5), though this character may have been destroyed by weathering.

The resemblance to *F. repanda* necessitates a comparison of these corals with *F. scruposa*, Klnz.,[2] which agrees with these specimens in the prominence of the expanded inner ends of the septa; but that species, like *F. repanda*, differs by the characters of the costæ, which are coarsely and abundantly dentate. *F. valida*, Verr.,[3] which Klunzinger has figured from the Red Sea, agrees in its septal characters, but differs by the great inequality of the costæ.

Klunzinger has doubtfully included Verrill's *F. Haimei*[4] as a synonym of his *F. patella* var. *lobulata*. But Verrill states that *F. Haimei* differs from *F. discus* by having on its nearly equal costæ numerous sharp curved spines, instead of irregularly scattered obtuse spines. In this respect the three Egyptian specimens differ from *F. Haimei*, as they have low, blunt, scattered spines on the costæ (Pl. IX, Fig. 5). Their general characters, however, agree so closely with those of *F. patella* that they may be safely included in that species as members of the variety *lobulata*.

II. MIOCENE.

Genus STYLOPHORA, Schweigger, 1819.

STYLOPHORA ASYMMETRICA, nov.

DIAGNOSIS.

Corallum massive, flat-topped, growing in successive horizontal laminæ. The upper surface is ornamented by the long, sharp, well-raised septo-costæ.

Corallites very large, separated by exothecal areas slightly narrower than the diameter of the corallites.

Calices rarely deep; usually small and raised above the general surface of the corallum. The calices rest on the flat-topped columella, and are bounded laterally by the highly raised, exsert septa.

Septa irregular in development. There are typically six large, thick primary septa fused to the columella, and six short secondary septa, of which the inner margin is free. But this diagrammatic

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[1] Dana, "Zooph. Explor. Exped. Wilkes," vol. viii (1848), p. 295, pl. xix, figs. 1–3.
[2] Klunzinger, op. cit., p. 63, pl. vii, fig. 2; pl. viii, fig. 1.
[3] Verrill, "List of Polyps": Bull. Mus. Comp. Zool., vol. i (1864), p. 51.
[4] Verrill, op. cit., p. 51.

arrangement is seldom seen. There are usually three primary septa on one side and four or five on the other; the septa are rarely bilaterally symmetrical, and the arrangement is heptameral or octameral, rather than hexameral. Primary septa highly exsert.

Columella, massive, flat-topped.

DIMENSIONS.

Horizontal laminæ	...	...	...	5 in 12 mm.
Average diameter of corallite	...	...		6·5 mm.
Average distance of calicinal centres	...	...		11 mm.

DISTRIBUTION.—Middle Miocene—Helvetian: Egypt, east side of Wadi Jiaffra, north-east of Caravanserai No. 8, on road from Cairo to Suez; Coll. Geol. Surv. Egypt, No. 644.

DESCRIPTION OF FIGURES.—Pl. VIII, Fig. 4*a*, part of upper surface of a corallum, nat. size; Fig. 4*c*, side view of the same specimen, showing lamellar growth, nat. size; Fig. 4*b*, one corallite, × 2 diam.

AFFINITIES.—In Duncan's diagnosis of *Stylophora* he states that "the calices are rather deep," as is the case in the type species, *S. digitata* (Pall.), and the characteristic forms of the genus. The two corallites of *S. similis* (May.-Eym.) figured as Pl. VIII, Fig. 6, are typical forms of the Eocene group of *Stylophoræ*, which agree closely with the recent species. Another series of species is, however, included in the genus which have larger corallites and raised, exsert septa. *S. asymmetrica* is the extreme form of this group, and I felt at first that it ought to be placed in a new genus. But the essential characters are those of the true *Stylophora*; the difference is due to the much greater size of the corallites, and to the fact that the calice appears superficial, as it is usually raised on the exsert septa. But the calice is really deep, as it occupies a depression surrounded by the raised septa; and in some corallites the septa end below the surface of the corallum.

The nearest ally of this species is probably *S. macrotheca*, Ach.,[1] in which, however, the corallites are much smaller, the distance between the calicinal centres being only from 2·5 to 3 mm., so that they are about a quarter of the size of those of *S. asymmetrica*.

Another coral which presents some striking resemblances is *S. subreticulata*, Reuss,[2] a well-known Helvetian species from the Oberer Tegel of Grund. The Egyptian coral differs, however, by the greater size of the corallites, by the greater prominence of the secondary septa, and by the asymmetry of the septa. The costæ occur, moreover, as raised lines, whereas in *S. subreticulata* the exotheca is ornamented by radial series of coarse granules.

From the typical Oligocene set of species, e.g., *S. distans* (Leym.),[3]

[1] A. d'Achiardi, "Cor. Eoc. Fruili," pt. iii: Atti Soc. tosc. Sci. nat., vol. i (1875), p. 178, pl. xiv, fig. 2.
[2] A. E. von Reuss, "Foss. Kor. öster.-ung. Mioc.": Denk. Akad. Wiss. Wien, vol. xxxi (1871), p. 250, pl. v, fig. 10; pl. vii, fig. 1; pl. xiii, fig. 5. The secondary septa are shown only in pl. vii, fig. 1*b*.
[3] A. Leymerie, "Mém. Terr. à Nummul. Corbières": Mém. Soc. géol. France, ser. 2, vol. i (1844), p. 358, pl. xiii, fig. 6. Also Von Reuss, "Pal. Stud. ält. Tert. Alpen": Denk. Akad. Wiss. Wien, vol. xxviii (1868), p. 24, pl. ix, fig. 2.

S. conferta, Reuss,[1] *S. tuberosa* (Cat.),[2] *S. annulata*, Reuss,[3] and
S. pulcherrima, Ach.,[4] this new species may be easily distinguished,
as they have plain inter-calicular areas, and the calices surrounded
by a small raised rim.   *S. confusa*, Dunc.,[5] from the Gaj Series
(Miocene) of Sind, differs by its very crowded corallites.

Genus ORBICELLA, Dana, 1848.

ORBICELLA SCHWEINFURTHI (Felix), 1884.

Heliastræa Schweinfurthi, Felix, 1884, "Kor. ägypt. Tert.": Zeit.
    deut. geol. Ges., vol. xxxvi, p. 449, pl. v, fig. 5.

DISTRIBUTION.— Middle Miocene — Helvetian : Wadi Ramlieh
(Felix) ; near north side of Jebel Attaka, near Suez ; Coll. Geol.
Surv. Egypt, Nos. 997 and 999.

FIGURE.—Pl. IX, Fig. 3, part of a horizontal section, × 3 diam.

AFFINITIES.—One of the four specimens of this coral resembles
Orbicella Guettardi (Defr.),[6] and may represent the fossil recorded
from Egypt by Fuchs [7] as *Heliastræa* cf. *Rochettana*.   It is certainly
very similar to the figures of that species given by D'Achiardi.[8]
Felix's species is an ally of *O. Defrancei* (Ed. & H.),[9] but the
calices are deeper.

Genus PLESIASTRÆA, Edwards & Haime, 1848.

PLESIASTRÆA MICROCALYX (Felix), 1884.

Heliastræa microcalyx, Felix, 1884 : op. cit., p. 450, pl. v, fig. 4.

DISTRIBUTION. — Middle Miocene — Helvetian : Wadi Ramlieh
(Felix).   Between lat. 30° 16′ 40″ and 30° 15′ 50″, and long.
31° 54′ 40″ and 32° 2′ 10″ ; Coll. Geol. Surv. Egypt, No. 814.

DESCRIPTION OF FIGURES.— Pl. VIII, Fig. 5*a*, part of upper
surface of an encrusting corallum, × 2 diam. ; Fig. 5*b*, horizontal
section across the same specimen, × 4 diam.

AFFINITIES.—This coral agrees exactly in external form with
Felix's figure, so that I feel no doubt as to their specific identity.
The coral has not the external aspect of an *Orbicella*, and I was

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[1] Von Reuss, ibid., p. 25, pl. ix, figs. 3–6.
[2] T. A. Catullo, " Terr. Sedim. Sup. Venezie " (1856), p. 63, pl. xiv, fig. 3 ;
and Von Reuss, op. cit., p. 46, pl. ix, fig. 7.
[3] Von Reuss, " Foram. Anth. Bry. Oberburg " : Denk. Akad. Wiss. Wien,
vol. xxiii (1864), p. 12, pl. ii, figs. 1–3.
[4] A. d'Achiardi, " Cor. Eoc. Fruili," pt. iii : Atti Soc. tosc. Sci. nat., vol. i
(1875), p. 176, pl. xiii, figs. 1–11.   P. M. Duncan, " Foss. Cor. Sind " : Pal.
Indica, ser. xiv, pt. 1 (1880), p. 73, pl. xv, figs. 12, 13.
[5] Duncan, ibid., p. 83, pl. xxiii, fig. 7.
[6] Vide Michelin, " Icon. Zooph." (1842), p. 58, pl. xii, fig. 3.
[7] Th. Fuchs, " Beitr. Kenntn. Mioc. fauna Aegypt." : Beitr. Geol. libysch.
Wüste, vol. iii (1883), p. 65.
[8] A. d'Achiardi, " Studio Comp. Cor. Terr. terz. Piem. e Alpi Venete " : Annali
Univ. Pisa, vol. x (1868), p. 14, pl. i, figs. 12, 13.
[9] Vide Von Reuss, " Foss. Kor. öster.-ung. Mioc." : Denk. Akad. Wiss. Wien,
vol. xxxi (1871), p. 239, pl. ix, fig. 3 ; pl. x, fig. 1.

not surprised that a microscopic section showed the presence of pali, and accordingly necessitated the transference of the species to *Plesiastræa*. The figure of the section also illustrates the nature of the exotheca.

The species is very closely allied to *Plesiastræa Romettensis*, Seg.[1]

Genus SOLENASTRÆA, Edwards & Haime, 1848.

SOLENASTRÆA TURONENSIS (Michelin), 1847.

Astræa Turonensis, Michelin, 1847 : " Icon. Zooph.," p. 312, pl. lxxv, figs. 1, 2.

Solenastræa Turonensis, Edwards & Haime, 1857 : " Hist. nat. Cor.," vol. ii, p. 498.

DISTRIBUTION. — Miocene — Helvetian : Turin, Touraine, etc. ; Egypt—Jebel Geneffe, near Suez (*fide* Fuchs) ; Camp No. 20, between Cairo and Suez ; Coll. Geol. Surv. Egypt, Nos. 356, 372 ; and Jebel Owebid, No. 971.

DESCRIPTION OF FIGURE. — Pl. IX, Fig. 4, horizontal section across some corallites, × 3 diam.

REMARKS.—The collection includes a series of massive specimens of a coral, which has the long, narrow, crowded corallites of typical *Solenastræ*. It is only exceptionally that any septa are preserved, a fact which suggests their possible cribriform nature. That the septa are not cribriform may be proved by lateral examination of the septa, which, however, is seldom possible. It is shown by the section on Pl. IX, Fig. 4. The figure does not show the intense secondary mineralogical changes that have occurred in the substance of the corallum.

The coral has all the specific characters of *Solenastræa Turonensis* (Mich.). Locard[2] has described a nearly allied Corsican coral as *Solenastræa Peroni*, which is said to differ from *S. Turonensis* by the smaller size of the corallites (diameter 1·5 mm. instead of 2 mm.) and the less developed columella. The former difference is slight, and the latter may be an accident of preservation, as in *Cyphastræa* septa and columella are so easily removed ; while Klunzinger's figures of the Red Sea species shows that the columella varies greatly in different corallites of the same corallum. Thus, his figure[3] of *C. chalcidicum*, Forsk., has no trace of columella in many corallites, whereas it is fairly well developed in a few. The Egyptian specimens agree with the typical forms of *S. Turonensis* in the diameter of the corallites and with *S. Peroni* in the development of the columella.

[1] G. Seguenza, " Cor. foss. terz. Messina," pt. ii : Mem. R. Accad. Sci. Torino, ser. 2, vol. xxi (1864), p. 111, pl. xiii, fig. 3. For better figures see Von Reuss, " Foss. Kor. öster.-ung. Mioc." : Denk. Akad. Wiss. Wien, vol. xxxi (1871), p. 244, pl. xviii, fig. 2.
[2] A. Locard, " Descr. Faune Terr. Tert. Moy. Corse " (1877), p. 219, pl. vii, figs. 5–7.
[3] C. B. Klunzinger, op. cit., pt. ii (1879), pl. v, fig. 8.

Among recent Red Sea species it is most allied to *C. chalcidicum*, Forsk., which Klunzinger's figures [1] do not show to have cribriform septa.

S. Turonensis has been doubtfully recorded in the Egyptian Miocene by Fuchs.[2]

GENUS INDET.

The collection includes two blocks of a Miocene coral (Coll. Geol. Surv. Egypt, No. 998), which are the internal casts of a large flat-topped massive corallum. They are labelled *Isastræa*, but are insufficiently preserved for identification. The corallites are circular, separated by exotheca, the walls appear to have been solid, the septa are long and thin, and there is no columella. This series of characters suggest the genus *Aræcis*. The specimens were collected at lat. 30° 12′ 20″, long. 32° 24′ 30″.

III. EOCENE.

Genus CŒLOSMILIA, Edwards & Haime, 1850.

Cœlosmilia Milneri, nov.

Diagnosis.

Corallum free, tapering below to a sharp point; laterally compressed, so that the transverse section is elliptical. The axis is straight or slightly curved.

Calice shallow.

Septa very jagged; five complete cycles, the members of which are very unequal in size; the primary and secondary septa are thick near the periphery; septa of higher orders thin and short. Septa slightly exsert.

Axial space very large.

Epitheca irregular; when present it consists of a thin layer, horizontally wrinkled.

Dimensions.

	mm.		mm.		mm.		mm.
Height　　... ...	16	...	13	...	17·5	...	29
Diameter : major ...	18	...	14·5	...	14·5	...	14
Diameter : minor ...	13	...	10·5	...	11	...	11·5

Distribution. — Lower Eocene—Libyan Series : Dungul Wells (lat. 23° 30′, long. 31° 21′), Upper Egypt ; Coll. Geol. Surv. Egypt, No. 265.

Description of Figures.— Pl. VIII, Figs. 1, 2, and 3, three specimens seen from the side (Figs. 1*a*, 2*a*, and 3*a*) and in transverse section (Figs. 1*b*, 2*b*, and 3*b*) ; nat. size.

Affinities.—The simple corallum, the absence of endotheca, of pali, and of columella, the large axial space, the broad interseptal loculi, and jagged septa, are the characters which together

[1] C. B. Klunzinger, op. cit., pt. ii (1879), p. 53, pl. v, fig. 8 ; pl. x, fig. 11.
[2] Fuchs, op. cit., p. 64.

necessitate the reference of this species to the genus *Cœlosmilia*. The only other genus that needs consideration is *Smilotrochus*, which has simpler and more crowded septa and narrower inter-septal loculi.

The nearest allied species is *Cœlosmilia Faujasi* (Ed. & H.),[1] from the Maastrichtian of Ciply, which has a peduncle, although, as the authors of the species remark, the coral probably becomes free when mature. But the Belgian coral is much taller, and narrower; the height is 40 mm. and its diameter 20 mm., whereas the Egyptian species is smaller, lower, and proportionately broader.

Cœlosmilia elliptica, Reuss,[2] from the Oligocene of Castelgomberto, is also an allied form, but has longer, more equal septa, and a small axial space. It is also pedunculate. Another similar species was described as *Smilotrochus cristatus*, Felix,[3] from San Giovanni Harione, but in that species also the septa are less unequal, those of the last orders being much longer than in *Cœlosmilia Milneri*.

The species is named after the distinguished former Financial Adviser to the Khedive, by whose management of the Egyptian finances the Geological Survey of the country has been rendered possible.

Genus STYLOPHORA, Schweigger, 1819.

STYLOPHORA SIMILIS (Mayer-Eymar), 1883.

Astrohelia similis, Mayer-Eymar, 1883, " Verst. tert. Birket - el - Qurûn ": Beitr. libysch. Wüste, vol. i, pt. 2, p. 73, pl. xxiii, fig. 2.

DISTRIBUTION.—Upper Eocene: Fayum, in Lake Birket-el-Qurun (Mayer-Eymar), and Coll. Geol. Surv. Egypt, No. 619.

DESCRIPTION OF FIGURE.—Pl. VIII, Fig. 6, two corallites showing the columella, × 3 diam.

AFFINITIES.— The occurrence of a well-developed columella in this coral is alone sufficient to necessitate its removal from *Astrohelia*. The species is a member of Duncan's alliance the Stylophoroida, and of the genus *Stylophora*, of which its nearest ally is perhaps *S. distans* (Leym.).[4] Comparison of the figure here given of two corallites with Leymerie's figures of *S. distans* shows the resemblance between them; the corallum in the latter is granulate, but so it may also have been in the Egyptian species. The specimens are not well preserved, having been polished and worn by sand erosion. Professor Mayer-Eymar's figures do not show the columella, which is not often seen in the five specimens in the Geological Survey Collection. Two

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[1] *Parasmilia Faujasi*, Edwards & Haime, " Mon. Astr." : Ann. Sci. nat., Zool., ser. 3, vol. x (1849), p. 245. Edwards & Haime, " Hist. nat. Cor.," vol. ii, p. 177.
[2] A. E. von Reuss, " Pal. Stud. ält. Tert. Alpen " : Denk. Akad. Wiss. Wien, vol. xxviii (1868), p. 140, pl. i, fig. 5.
[3] J. Felix, " Krit. Stud. tert. Kor. Vicentin " : Zeit. deut. geol. Gesell., vol. xxxvii (1884), p. 382, pl. xvii, figs. 1–3.
[4] A. Leymerie, " Mém. Terr. à Nummul. Corbières " : Mém. Soc. géol. France, ser. 2, vol. i (1844), p. 358, pl. xiii, fig. 6.

corallites with the columella are shown on Pl. VIII, Fig. 6. The corallum occurs in cylindrical or flat branches.

Genus LITHARÆA, Edwards & Haime, 1849.

LITHARÆA EPITHECATA, Duncan, 1880.[1]

DISTRIBUTION.—*Cardita Beaumonti* Series : Sind. Lower Eocene —Libyan Series : a little south of Silsila, on the Nile (lat. 20° 40′), Upper Egypt ; Coll. Geol. Surv. Egypt, Nos. 165, 176, 183 ; Dungul Wells (lat. 23° 30′, long. 31° 20′), Upper Egypt ; same coll., No. 306.

DESCRIPTION OF FIGURES.—Pl. VIII, Fig. 7, part of the surface of a young corallum with deep calices (No. 183), × 2 diam. ; Pl. IX, Fig. 6, part of a hemispherical corallum (No. 306), × 2 diam.

REMARKS.—The coral is represented in the Egyptian collection by two forms—one with a low, flat, broad corallum, like the type of the species ; and the other, hemispherical, like Duncan's var. *hemispherica*. I do not see how these Egyptian corals can be specifically separated from the Sind specimens, and so describe them as a geographical variety.

Litharæa epithecata is closely allied to *L. rudis*, Reuss,[2] but the septa are stouter and stronger than in that Oligocene form, which has been recorded by Felix from the Wadi Ramlieh in Egypt.

IV. CRETACEOUS.[3]

Genus PHYLLOCŒNIA, Edwards & Haime, 1848.

PHYLLOCŒNIA TOUCASI, De Fromentel, 1884.

"Pal. Franç. Terr. Cret.," Zooph., p. 549, pl. cliii.

Var. ÆGYPTIACA.

CHARACTERS.—This coral differs from the typical form of the species by the smaller size of the corallites, which are, moreover, somewhat more crowded. In other respects the corallum agrees precisely with the specimen figured by De Fromentel : the costæ are not always alternately unequal, but then they do not appear to be so in the original figure.

DIMENSIONS.

	Type.	Var. *Ægyptiaca.*
Height of corallum	—	42 mm.
Diameter of corallum	—	61 × 87 mm.
Average diameter of corallite ...	8 mm.	4–5 mm.
Average distance of calicinal centres	10 mm.	5–6 mm.
Septa	3 complete cycles.	3 complete cycles.

[1] " Foss. Cor. Sind " : Pal. Indica, ser. xiv, pt. 1, p. 23, pl. ii.
[2] Von Reuss, " Pal. Stud. ält. Tert. Alpen " : Denk. Akad. Wiss. Wien, vol. xxix (1869), p. 251, pl. xxvii, fig. 2.
[3] A description of the Cretaceous rocks of Abu Roasch, with a diagrammatic map of the fault system in the district, has been given by J. Walther, " L'Apparition de la Craie aux Environs des Pyramides " : Bull. Inst. Egypt, ser. 2, No. 8 (1887), pp. 3–13 ; 2 pls.

DISTRIBUTION.— Turonian: Bausset, France (De Fromentel); Abu Roasch, Egypt (Brit. Mus. Coll., R. 336, and Coll. Geol. Surv. Egypt, No. 53).

FIGURES.—Pl. IX, Fig. 1*a*, corallum from above, $\frac{2}{3}$ nat. size; Fig. 1*b*, part of upper surface of corallum, × 2 diam.; Fig. 1*c*, some corallites seen in horizontal section, × 3 diam. Fig. 2, part of horizontal section across another specimen, × 2 diam.

REMARKS.—The specimen used as the type of this variety was presented to the British Museum by W. M. Newton, Esq. It is well preserved, and shows the upper surface of the corallum. A weathered specimen sent by the Egyptian Geological Survey proves to be the same species; the external surface has been destroyed, and only transverse sections show sufficient of the septa for determination.

DESCRIPTION OF PLATE VIII.

FIGS. 1–3. *Cœlosmilia Milneri*, nov. Libyan Series. Three specimens seen from the side (Figs. 1*a*, 2*a*, and 3*a*) and in transverse section (Figs. 1*b*, 2*b*, and 3*b*); nat. size. Coll. Geol. Surv. Egypt, No. 265.

FIG. 4. *Stylophora asymmetrica*, nov. Helvetian: east side of Wadi Jiaffra, on road from Cairo to Suez; Coll. Geol. Surv. Egypt, No. 644. Fig. 4*a*, part of upper surface of corallum, nat. size; Fig. 4*c*, view of vertical section across the same specimen, nat. size; Fig. 4*b*, one corallite of the same specimen, seen from above, × 2 diam.

FIG. 5. *Plesiastræa microcalyx* (Felix). Helvetian: Coll. Geol. Surv. Egypt, No. 814. Fig. 5*a*, part of upper surface of corallum, × 2 diam.; Fig. 5*b*, part of a horizontal section across the same specimen, × 4 diam.

FIG. 6. *Stylophora similis* (Mayer-Eymar). Upper Eocene: Fayum; Coll. Geol. Surv. Egypt, No. 619. × 3 diam.

FIG. 7. *Litharæa epithecata*, Dunc. Libyan Series: Coll. Geol. Surv. Egypt, No. 183. Part of surface of a young corallum, showing deep calices, × 2 diam.

DESCRIPTION OF PLATE IX.

FIGS. 1 and 2. *Phyllocœnia Toucasi*, De From., var. *Ægyptiaca*, nov. var. Turonian: Abu Roasch, near Gizeh. Fig. 1*a*, upper view of the corallum in the British Museum (R. 3,436), $\frac{2}{3}$ nat. size; Fig. 1*b*, part of the upper surface of the same, × 2 diam.; Fig. 1*c*, a horizontal section across the same, × 3 diam. Fig. 2, part of a horizontal section across a specimen in the Coll. Geol. Surv. Egypt, No. 53; × 2 diam.

FIG. 3. *Orbicella Schweinfurthi* (Felix). Helvetian: Coll. Geol. Surv. Egypt, No. 997. Part of a horizontal section, × 3 diam.

FIG. 4. *Solenastræa Turonensis* (Mich.). Helvetian: Coll. Geol. Surv. Egypt, No. 356. Part of horizontal section across several corallites, × 3 diam.

FIG. 5. *Fungia patella* (Ell. & Sol.), var. *lobulata*, Klnz. Pleistocene: Egypt. Coll. Brit. Mus., No. R. 1,308: a view of part of the base, showing the scar of the anthoagathus and the low obtuse spines on the costæ, × 2 diam.

FIG. 6. *Litharæa epithecata*, Dunc. Libyan Series: Coll. Geol. Surv. Egypt, No. 306. Part of the surface of a hemispherical corallum, × 2 diam.

II. — On Meshwork-structures observable in Microscopic Sections of Rocks.

By Grenville A. J. Cole, M.R.I.A., F.G.S.,
Professor of Geology in the Royal College of Science for Ireland.

THIS note deals with a very simple matter, which is perhaps familiar to many workers with the microscope. I believe, however, that it is not referred to in ordinary text-books, and a word or two in reference to it may be useful.

From time to time, meshwork-structures have been described, either in the felted groundmasses of igneous rocks or in the products of the decay of ferromagnesian minerals; and it is frequently remarked that a rectangular arrangement of the constituents of the mesh is clearly brought out when the section is examined between crossed nicols.

One of the most beautiful experiments to illustrate the separation of materials in a crystalline form from a state of fusion is to receive a drop of " candle-grease " from an ordinary commercial candle upon a microscopic slip. Place a circular cover-glass upon it, heat until the material is well fused, and lay it beneath a power magnifying some 100 diameters and between crossed nicols. If the instrument has been previously focussed for a glass slip of the right thickness, no stage of the process of crystallisation will be lost. At first, as cooling proceeds, tiny specks emerge from the dark ground, like stars in an evolving universe. Gradually a delicate meshwork of fine and somewhat wavy rods spreads inwards from the cooling outer circle of the cover-glass. These rods rapidly thicken, while their interstices finally become filled up. But the meshwork effect is still perceptible, and a rectangular arrangement of the crossing fibres is strikingly apparent.

On repetition of the experiment, it may appear surprising that the rectangular mesh extends regularly across the slide, as if some polarity existed between the minute crosses of which it is composed. On still further repetition, it will be plain that the two series of fibres always lie at 45° to the diagonals of the crossed nicols.

On rotating the stage, the meshwork does not rotate; that is, new fibres come into the positions of the former ones, and therefore into the same positions of prominence between crossed nicols.

The secret is, of course, that the crystals of stearic acid are in these positions in a state of maximum illumination, while those lying in other positions have a much feebler effect upon the eye, or may even be totally extinguished. Even if the crystals of such an aggregate have oblique extinction, in every radiating or hap-hazard group there are likely to be four crystals which are at 45° to their positions of extinction; these will impress themselves upon the eye, and a cross will be the result, though its components will not have their longer axes at 45° to the diagonals of the nicols. The effect is far more noticeable where, owing to the thickness of the section, or to the strength of the double refraction of the material, the interference-colours are of a high order. I have seen no more striking example than in a schist with irregularly scattered plates

of muscovite, which I recently received for examination from the Geological Survey of the United Kingdom. The cross-sections of the mica, coloured in pinks and greens between crossed nicols, stand out in two distinct series perpendicular to one another, so as to suggest a remarkable double foliation. On rotation of the stage, however, all chance of misconception was removed.

It would be unwise to suggest that this or that rectangular mesh, described by various authors, may be a structure visible only between crossed nicols, and with no existence in reality. But it is easy to extend the observation to the mesh-structure of decomposing olivine, and to dispose of some of the difficulties as to the presence or absence of rectangularly arranged fibres in particular examples. I am indebted to Miss C. A. Raisin, B.Sc., for the loan of several sections of serpentine from the Rauenthal, for comparison with other serpentines in my own collection; and the former have proved of special service. While fully agreeing with Miss Raisin [1] and Professor Bonney [2] as to the former existence of olivine in the Rauenthal rock, I would not lay great stress upon the rectangular appearances seen in the meshwork of this or other serpentines.[3] Where the mesh-structure is on a coarser scale, or on using a higher power, rectangular mesh-structures are rarely seen, since the eye does not readily take in the requisite number of illuminated bars at the same time; where, however, the structure is finer—i.e., where the original cracks of the olivine were closer together—a rectangular effect is readily produced, by the prominence of the doubly re-fracting decomposition-products lying along those cracks or portions of cracks that happen to be perpendicular to one another.

I cannot help thinking that von Drasche's [4] "deutliches quad-ratisches Netzwerk" in some parts of the "serpentine-like rock" of Windisch-Matrey may have been quite local, or even due to accidents of observation, especially as the author states that the fibres in most parts of the rock intersect at very various angles. The rectangular effect is well shown in his plate, fig. 2; and prominence was given to a similar arrangement by Hussak [5] during his investigation of the antigorite-serpentine of Sprechenstein, near Sterzing in Tyrol. This rock was photographed by Cohen [6] in the same year, from one of Hussak's specimens, between crossed nicols, and the figure is still better known from its occurrence in Rosenbusch's "Massige Gesteine." In his description of the plate, Rosenbusch uses for the arrangement the term "Balkenstructur," which is adopted also by Zirkel.[7] Cathrein [8] also comments on

[1] "The Nature and Origin of the Rauenthal Serpentine": Quart. Journ. Geol. Soc., vol. liii (1897), p. 255.

[2] "Note on Specimens of the Rauenthal Serpentine": GEOL. MAG., 1887, p. 68.

[3] See Miss Raisin, op. cit., p. 263.

[4] "Ueber Serpentine und serpentinähnliche Gesteine," Tscherm. Mitth., 1871, p. 5 (Jahrb. d. kk. geol. Reichsanstalt, Bd. xxi).

[5] "Ueber einige alpine Serpentine," Tscherm. Mitth., 1883, p. 70.

[6] "Sammlung von Mikrophotographien," pl. lxv.

[7] "Lehrbuch d. Petrographie," 2te. Auflage, Bd. iii (1894), p. 384.

[8] "Beiträge zur Petrogr. Tirols": Neues Jahrb. für Min., 1887, Bd. i, p. 152.

a "Balkennetz," and agrees with Hussak on its significance in indicating the pyroxenic origin of certain serpentines. F. Becke,[1] as is now well known, has diminished the importance of Hussak's suggestion by indicating similar structures in an antigorite-serpentine derived from a true olivine-rock; and he regards the antigorite plates as developed along the cleavages of the original olivine grains. This is the view taken by Miss Raisin in dealing with the rectangular structures of serpentine; while Professor Bonney, with much probability, regards the irregularity of the mesh-structure ordinarily seen as due to the imperfect character of the cleavages in olivine. In 1891 I wrote[2]: "These needles, picked out by the use of the polariscope, are so frequently at or nearly at right angles to one another as to suggest their development along the cleavage-planes of the mineral that has been pseudomorphosed. It is often stated that the serpentine in such cases has been derived from pyroxene; but the structure is extremely common in company with others referred as certainly to olivine." Becke's paper on the Stubachthal has fully confirmed the latter statement; but my present note is intended to suggest that a true rectangular meshwork, continuous throughout the whole of an olivine grain, is not so frequent an occurrence as might at first appear. In the first place, the more brightly illuminated part of the cross-section of a curving "antigorite" or other plate may catch the eye and give a fictitious appearance of regularity. In the second place, a second rectangular meshwork may sometimes appear during rotation within the grain that is being observed, the former one being now extinguished; and we thus see that several systems of cracks, with corresponding alteration-films, occur, and that these cracks are picked out in pairs by the use of polarised light. No one can deny that olivine is often broken up into approximately rectangular blocks, even in the fresh state; for the larger crystals observable in many basalts show this character when examined with the lens. Consequently, a rudely rectangular structure is common in the products of alteration. But I believe that its regularity is easily liable to be exaggerated; and the same consideration becomes far more important when extended to sections of metamorphic rocks, containing tufted chlorites, micas, and so forth, lying in all directions through the mass.

In conclusion, the reality of the optical effect above described cannot be more happily demonstrated than in the *photographs* accompanying Mr. Arnold-Bemrose's paper[3] "On a Quartz-Rock in the Carboniferous Limestone of Derbyshire." The irregularly-lying quartz needles have been photographed in section between crossed nicols; and a rectangular effect, which is just apparent in fig. 2, becomes markedly so in the more fine-grained material shown in fig. 3.

[1] "Olivinfels und Antigorit-Serpentin aus dem Stubachthal," Tscherm. Mitth., Bd. xiv (1895), p. 275.

[2] "Aids in Practical Geology," p. 164. The objects here called "needles" are the cross-sections of the little plates developed along the cracks.

[3] Quart. Journ. Geol. Soc., vol. liv (1898), pl. xii.

III.—A Numerical Scale of Texture for Rocks.

By H. Stanley Jevons, B.A.

WHEN reading through descriptions of hand-specimens of igneous rocks I have often found a difficulty in forming an exact mental picture of the appearance of the rocks because of the very meagre information usually given as to the coarseness or fineness of their texture. The following simple method would, I believe, to a great extent obviate the difficulty now experienced in giving such information.

Since the degree of texture of a rock depends on the average volume of its constituent crystals, the theoretically correct method of expressing it is by stating the latter in some standard measure. The determination of this average volume is, however, practically impossible, so we fall back on the next best method for its expression, that of measuring the average area of the individual crystals exposed on any surface of the rock. One way of doing this is by counting the number of crystals in a given area, but it is a very cumbrous process even with the best appliances I could devise. The method to be described consists in directly measuring the length of a number of crystals and calculating their average length. Its fundamental idea is the average area of the crystals, but this is expressed by means of their average linear dimensions, so that the figures, though originally lengths of crystals, are primarily symbols for their areas, a fact which it is important to bear in mind when a crystal of irregular outline is being measured. They are thus not proportional to the areas they represent, but to their square roots. As it is desirable to have a conventional usage on such points, I have chosen the length as the dimension for measurement, though theoretically any other would have done, and the millimetre as the unit in which it is expressed, because of its convenient size. As the same unit will probably be used by all, it will be unnecessary to mention it each time, 3, for instance, being understood to mean 3 mm.

The only apparatus required is a small scale, preferably of ivory, about eight centimetres long, divided into millimetres throughout and into half-millimetres for two centimetres from both ends.[1] To measure the degree of texture with this, one first studies the surface of the hand-specimen, fixing with the eye on several crystals which appear to be of about the average size, and then one measures these to the number of about a dozen, taking the average. If the crystals are oblong the diagonal should be measured, if oval the greatest diameter (when lath-shaped the fact must be mentioned); but if they are very ragged one must simply measure the conspicuous parts, for it is the size of these, after all, which gives the rock its appearance of a coarse or fine texture. Some examples later on will perhaps render these directions clearer. The size of the individual crystals is fairly constant in some rocks, but in most the majority of the crystals will be of about the same size, while the rest will vary

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[1] Such a scale may be had of Messrs. Stanley & Son, Great Turnstile, London.

between certain higher and lower limits.   In this latter case a state-
ment of the general average size will still give a very good idea of
the appearance of the rock, but for the sake of accuracy it would be
well also to state the limits. As examples I may quote the following
readings I have taken from various hand-specimens : Carrock Fell
gabbro, 8 ; minette from Sale Fell, 1·5 ; Shap granite, 3 to 4, with
porphyritic crystals, 25 ; Buttermere granophyre, 2 ; the tonalite of
Monte Tonale, 4 ; a granite from Ben Nevis, 2·5, with interstitial
matter about 0·3, and porphyritic crystals up to 7.

The principle and method are equally applicable to microcrystalline
rocks if one uses a micrometer scale in the microscope and reads
the lengths of the average crystals in fractions of a millimetre.   For
instance, a specimen of the nosean-phonolite of the Wolf Rock,
Plymouth, is in texture 0·084 ; with porphyritic crystals, 1·0.
Perhaps it may be interesting by way of illustration to give the
measurements by which the size of the porphyritic crystals was
determined in this case.   They are 23, 32, 60, 26, 40, 80, 40, 40,
28, 90, 40 and 60, mean 47. Since twelve divisions of the scale equal
·254 mm., the average length of the crystals measured is ·996, say
1 mm. That there is a considerable difference between the maximum
and minimum lengths must be admitted (a rather greater one here
than usual, I think), but still there is a general average size, which
the eye can get hold of and distinguish easily from one a little
higher or a little lower.   As another example I may mention
a biotite-olivine-dolerite from Kintellan, Argyleshire, which is in
the groundmass ·89 ; porphyritic constituents 2·03.

The following measurements which I have made of some of the
figures in Teall's " British Petrography " may be of service as a kind
of criterion by which any person may see whether he is measuring
in the way I have explained.   The results quoted are the direct
measurements, as I have not troubled to reduce for the magnification.
Plate xxv, fig. 2, and pl. xxvii, fig. 1, are both easy to measure, and
give 15 and 16 respectively.   Pl. viii, fig. 1 is not so easy, because
many of the crystals are very ragged, but if each large patch of
viridite be taken as representing one crystal we get the figure 14,
or taking the magnetite separately (at 8), we have for the remainder
16.   As an instance of how to measure a ragged crystal I will take
the brown hornblende in the lower half of the figure.   From the
bottom right-hand corner to the rounded top I make it 21, and
I neglect the ragged tail which projects upwards on the right.
This procedure may seem arbitrary, but it is really necessary,
because otherwise such crystals would receive a value out of all
proportion with their area, the quantity I have already shown that
we are really endeavouring to express.   In the case of ragged
crystals, therefore, discretion must be used to give a number which
would probably represent the linear dimensions of a crystal of the
same area but of regular outline.

In pl. xii, fig. 2, the constituents must be mentioned separately,
thus—porphyritic crystals (only one in the figure), 23 ; lath-shaped
felspars, 8 ; augites, 3·5 ; iron-ores, 1.   One of the most difficult is

pl. xix, fig. 1, whose structure is that shown macroscopically by many gabbros. It is impossible in this case to separate out a number of individual crystals and measure them, so one must scan the picture until one has an idea of the average apparent size of the crystals, fix upon two or three well-defined ones which seem to express this, and measure them. The crystals I fixed upon when measuring this figure were a plagioclase just above the centre, marked " 10 " in the key, and a pyroxene to the low left, marked " 7." These measure 19 and 14 respectively in greatest diameter, so that one might quote 16 or 17 as a rough average value. It must always be understood that with a rock of this structure the number given does not represent an actual measurement of crystals, but is only a measure of the general impression the eye forms of its texture, so that it cannot be very definite.

The ophitic structure usually involves the quotation of at least three numbers, for the ophitic plates, the included granules, and the interstitial matter respectively.

With regard to the time taken by these measurements, I may say that a hand-specimen takes me about three minutes and a slide about five. The most encouraging feature in the method is that the eye can at a glance distinguish between rocks, say, of texture 1·5 and 2, though by the method now in use one could only describe them both as medium-grained. I think it very likely that a little practice will enable one to give roughly the degree of texture of a rock without any measurement at all, as, for instance, to say, " Texture granitic, from 2 to 2·5," almost at a glance, though it would of course usually be desirable to check the statement by measurement. It is almost needless to add that the method is applicable to sedimentary rocks equally with those of igneous origin.

In conclusion, I may say that several of my friends, among them Professor Bonney and Miss Raisin, have kindly measured some specimens which I placed before them. The coarse-grained rocks presented some difficulties, which led to their not giving quite concordant figures on the first attempt, but the results were on the whole distinctly encouraging, especially among the finer-grained rocks. I venture, therefore, to bring this idea before the notice of petrologists, because, although it does not entirely do away with the personal element in the description of the texture of rocks, it has at least the merit of greatly reducing it, and of so rendering comparable the descriptions of different authors.

IV.—The Surface Geology of the North of Europe, as illustrated by the Åsar or Ösar of Scandinavia and Finland.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.
(*Concluded from the May Number, page* 206.)

LET us next turn to the postulated subglacial rivers. How can we conceive of tunnels of ice 100 miles long running in one direction, 300 feet high, and only 20 or 30 paces wide? The difficulty about the provenance of the stones, again, is equally great

or even greater, and more insurmountable in such a case than it
would be in the case already cited.

Those parts of Sweden whence the stones in question were derived
are so comparatively low that we cannot conceive an ice-sheet
existing on the scale postulated by the glacialists which did not at
the same time bury all such rocky surfaces fathoms deep under ice.
We have already, in many ways, criticized the transcendental notion
involved in so-called "ground moraines," and the mechanical pro-
cess which the wilder American geologists euphoniously describe
as "*plucking.*" "Plucking" is the process by which ice, under
a pressure of many tons to the square inch and moving so slowly
that the movement would be virtually inappreciable in the nether
layers of the ice-sheet, is supposed to have had the capacity of
breaking up its own bed and performing feats of quite superlative
dentistry. This view, which I believe to be utterly fantastic, and
which has never been supported by any mechanical argument or by
anything better than an *obiter dictum,* is the only refuge for the
believers in ground moraines as the explanation of the Swedish
åsar.   But this plucking proceeding is not all that is required.
Granting that we may indulge ourselves in a *plucking* theory, in
order to pluck up stones the ice must be in contact with its stony
bed, and we altogether fail even to understand the process when the
ice is separated from its bed by a padding of sand or gravel or
boulders.   Can it continue to " pluck " through this intervening
cushion, and if so, how is it to continue doing so when the sub-
glacial deposit becomes 40 or 50 or a 100 yards thick ?   If we
discard the plucking process as ridiculous, whither is the glacialist
to turn ?

When a stream began to flow underneath an ice-sheet, how could
it possibly obtain materials from any other source to pile up a mound
a hundred miles long, of uniform height, and rising a hundred yards
above the level of the bed of the ice-sheet itself ? It could not derive
them from the rocks underlying its own bed, for these would be
protected from denudation by the sand and gravel and stones already
there.   Suppose it were possible to get the stones (stones formed of
the hardest crystalline rock), how could it roll them into absolutely
rounded and curved forms ?   On such a bed basalt and gneiss are
not easily worn into these shapes by being rolled over beds of sand
and clay containing a sprinkling of stones. If it were strong enough
to roll them and toss them about, the subglacial stream must have
been a torrential river, and if so, as we have said, it must have
scoured out the sand and brickearth completely, instead of leaving
them mixed heterogeneously with the great boulders.

I have referred to the difficulty of assigning continuous mounds
of the same general height and breadth, and extending over great
distances, to the handiwork of rivers, whose beds naturally and
necessarily grow wider as they march from their source to their
outfall ; but in the case of the Scandinavian åsar the subglacial
theory presents an additional difficulty. According to the glacialists,
the Scandinavian ice-sheet extended to the Carpathians and to

Central Russia. How is it, then, that the åsar did not continue their strange march right away to these goals? Did the subglacial rivers stop short where the various Swedish åsar terminated their journey? If so, what became of their water? Was it frozen again? How was this? The further south we travel, the warmer must the climate have been under the same conditions, and consequently the more water must have flowed from the ice-sheet. Its drains, the subglacial rivers, must therefore have increased in volume instead of dying out, and surely when they reached the flat country of Poland and Russia must have become more and more liable to deposit materials in their beds. How is it, then, that the åsar do not continue their march to Cracow? But apart from all this, let me repeat a question I have already asked, and which presents itself to a traveller who has crossed the country in a very grotesque fashion. I wonder if the champions of subglacial rivers as the depositors of the åsar have ever drawn a series of contour-lines, say from Dalecarlia to Silesia, and if so, how do they propose to explain the flow of any river, whether under an ice arch or not, along such a course, not only across the undulating surface of Sweden, but across the Baltic depression?

There remains another element which we have not yet considered, namely, the large, sometimes portentously large, angular and sub-angular blocks which occur in the surface layers of the åsar, and sometimes in large numbers on their backs, the ås near Gamla Upsala being a good example. Among the many boulders we noticed, there was one whose cubical contents must have been 36 yards. Similar subangular and angular blocks have occurred in the deposit containing marine shells at Upsala. How are we to explain these blocks and their occurrence where they are found, by any kind of fluvial action? Rivers must become desperate torrents, such as occur sometimes in the ravines of the Caucasus and the Western Himalayahs, to move such stones at all, and how could they be deposited by rivers in the midst of stratified sands with marine shells, and on the tops of the åsar? How comes it they are not found at the bottom, where the cannon-shot gravel so often occurs? When it is said they were transported by ice-rafts, how could they get on to the backs of the ice-rafts? If frozen to their under surface, the difficulty is still greater, for torrential rivers do not freeze into solid masses, nor does their ice-covering become attached to boulders which may be lying on their beds. So far as I know, rivers in Scandinavia do not now carry about and deposit such stones, except when there may be an occasional collapse in their banks; and if the glacial rivers derived them from dis-integrated banks, it only removes the difficulty of their explanation one step further back. But those who appeal to ice in this fashion forget the relative age generally assigned to the surface beds of the åsar. The great majority of geologists are emphatic about the surface beds of the åsar containing marine shells being Post-Glacial. If so, then we have a double crux, for not only have we to explain the existence of gigantic erratics far away from their parent beds,

but to explain them and their portage when anything but a glacial climate is testified to by the mollusca occurring with them.   It seems, therefore, impossible to appeal to ordinary rivers in order to explain these angular blocks ; much more so is it difficult to account for their portage by subglacial or supraglacial rivers.   In neither case do such rivers carry ice-rafts.   Nor can we see how ice-rafts could arise in either of them.   Ice-rafts are the broken pieces of ice which once covered subaerial rivers.   The only ice which covers subglacial rivers is the tunnel of ice through which they flow, while supraglacial rivers do not freeze on their surface, but cease to exist entirely in winter, for they are the result of the melting of the surface of the glaciers and nothing more.

In every way we view the fluviatile theory of the origin of the åsar it seems to collapse when analyzed, and if I could be astonished at anything which the glacial geologists choose to formulate I should be greatly surprised at its continued existence in their textbooks.   The time is assuredly coming when the reputations which have been built up on such science will as assuredly collapse.   No wonder a desperate struggle is made to maintain them in some quarters, and a portentous silence prevails in others.   Putting aside the fluviatile theory, whither are we to turn for an explanation of the åsar but to the primitive theory of all ; the one which commended itself to the earliest Swedish geologists, namely, that they are in some way or other the result of the action of the sea during a period of submergence.   Thus Swedenborg urges that the existence of a former widespread ocean is proved by the mixture of substances in the åsar of sand and gravel, of clay, and large masses of rock and boulders.   He urges further that the polished and triturated appearance of the stones in them was the work of the sea, and the slope of the ridges he thinks proves that they were thrown up by the sea into great accumulations, and so formed into lengthened ridges.   He argues that the fact of the ridges running north and south shows that the same winds prevailed in Diluvian times as do now, and he appeals to the principle of hydraulics to show that the sea could have done this kind of work. Robert, writing as far back as 1836, says : " Les collines de sable du N., ou ôsars comme on les appelle vulgairement, ont été formées au sein des eaux de la mer par l'effet des courants, phénomène encore en action."   The sea in its normal attitude was appealed to to explain the åsar by two other acute, later writers, namely, Ch. Martins and Robert Chambers.   The former, an extreme champion of the Glacial theory, says : " The åsar form one of the numerous proofs of the immersion and emergence of the Scandinavian surface. . . . . The åsar were the work of the sea during the time of the Scandinavian immersion.   They are veritable dunes (the *Revler* of the Jutland coast), with a cross-bedding in their stratification, formed by the waves which traversed these ramparts and there deposited the pebbles and sand which it had removed from the bottom of the sea.   The pebbles in the åsar are never striated.   If they ever had any striæ these have been

removed by their being rubbed down by the sea," etc. (Bull. Geol. Soc. France, 1846, p. 97.) R. Chambers, writing in 1850, after speaking of the angular drift of Sweden as the result of glacial action, continues: "This rubbish has afterwards been under the sea, which, detaching certain portions, has worked the stones into round forms, separated the sand and clay, and left the whole in a new arrangement, namely, that of terraces with long branching ridges or banks." These ridges he connects with the Irish eskers and the Scotch kames, but says they are specially characteristic of Sweden, where they extend for hundreds of miles without any regard to the interruption of lakes or rivers, sometimes thirty, sometimes fifty, and occasionally not much less than a hundred feet in height above the base; and he attributes them to the agitations of a sea which had succeeded to the reign of the glacial influence. ("Tracings in the North of Europe," p. 238, etc.) Erdmann, writing in 1868, accepts the conclusions of Martins and Chambers, and speaks of the åsar as "d'anciennes jetées litorales accumulées et remaniées par la mer" ("Exposé," etc., p. 42). This view is a good deal more rational than that which attributes the åsar to the operation of rivers, subglacial or otherwise.

We can hardly account for the formation of the boulders which make up so large a portion of the åsar except by the intervention of the sea. These boulders are, so far as my experience goes, quite different to river shingle. Their enormous and portentous number, their widespread distribution, the very hard crystalline rocks out of which they have been rolled and fashioned, all testify in a most effective manner to the operations of a turbulent sea on a shallow bottom acting upon the débris of crystalline rocks, and acting for a long time. They bespeak, in fact, a period of long depression. They seem to me to be the complementary phenomenon to the polished and rounded surfaces of Scandinavia, to have been fashioned at the same time, and to have been, in fact, the main instruments in the hands of the sea in rounding and polishing these surfaces, being themselves rounded in the process. They present as few traces of ice-action as cannonballs or Beecham's pills do.

Secondly, the sands which form the so-called sand åsar, and form also conspicuous beds in other åsar which are nearly always, if not always, stratified and false-bedded, seem to me to be marine sands, and nothing else. I cannot in any way distinguish them from well-known barren marine sands elsewhere, and notably those of Dalecarlia, which occur there sometimes as åsar and sometimes as thick and well-stratified beds covering a wide extent of country. These widespread stratified sands of Dalecarlia and their lessons were especially noted by Murchison. "In approaching Hedmora," he says, "or ascending to that town, which lies about 150 or 200 feet above the River Dal Elf, the whole tract is one of undulating hilly sands . . . . resembling the bottom of a former sea. . . . . In approaching Sater these sands, constituting linear åsar here and there united by cross bands or bars, are covered by worn boulders and gravel, and further on the åsar are entirely composed of water-worn

boulders. . . . . The river banks at Sater, as at numberless places on the Dal Elf, consist of mounds of finely laminated sandy loam." (Q.J.G.S., iii, 372.) Murchison goes on to describe the sometimes finely laminated sands which are seen in following the Dal Elf through the fertile tracts of Gustafsland (id., p. 373). I have recently been spending some days in this same district, and have been deeply impressed by the same facts, and notably as they occur about Leksand and thence to Insjon.

A third notable testimony to the marine origin of the åsar is the presence in several cases in their upper layers of marine molluscs like those now living in the Baltic. At Upsala I collected numerous specimens of *Tellina Balthica, Cardium edule, Littorina litorea*, and *Mytilus edulis*. The last-named were much decayed and reduced to fragments. They still retained their colour, which gave a purple tinge to the clayey bed in which they lie.

This kind of evidence is a very potent support to the view that the åsar are, in fact, of submarine origin, and witness, as so many other facts in Scandinavia do, a recent submergence of a large part of the country. It is, nevertheless, clear that when we examine other features of the åsar we cannot attribute them to the ordinary operations of the ocean, and I confess I cannot see in them, as some others have done, a kind of sea-beaches or dunes. Their shape, their internal structure, the alignment of the stones in them ; the fact that they consist of a number of parallel ramparts ; the further fact that their main trunks have a number of branches ; their occurrence at all levels from 2,000 feet downwards ; their running up and down hill and being distributed entirely independently of the contours of the country ; their sometimes occurring athwart each other and sometimes as cross pieces joining two separate åsars ; the rounded and elliptical forms they assume when their continuity is broken : all these facts seem to be at issue with their having been beaches.

On the other hand, the sea in its normal moods does not diversify its actual bed with such ramparts as these. The sea in its normal action is a great leveller and smoother of its beds into soft and curving outlines, and does not lay down upon it a succession of ramparts with steep sides and running for scores of miles in direct lines. Nevertheless, it is from the operations of the sea, not in its normal but in its abnormal moods, that the only explanation of the åsar which fits in with the facts is derivable, and has long ago been derived. Playfair has a pregnant passage on this subject written long ago. " Sandbanks," he says, " such as abound in the German Ocean, to whatever they owe their origin, are certainly modified, and their form determined, by the tides and currents. Without the operation of these last, banks of loose sand and mud could hardly preserve their form and remain intersected by many narrow channels. The formation of the banks on the coast of Holland, and even of the Dogger Bank itself, has been ascribed to the meeting of tides, by which a state of tranquillity is produced in the waters, and in consequence a more copious deposition of their mud. Even the great Bank of Newfoundland seems to be

determined in its extent by the action of the Gulf Stream. In the
north-east the current which sets out of the Baltic has evidently
determined the shape of the sandbanks opposite to the coast of
Norway, and produced a circular sweep in them, of which it is im-
possible to mistake the cause." (Playfair's "Illustrations," pp. 417–8.)
So much for an old master, who was also a champion of Huttonian
methods in geology. In more recent times the same lesson has
been well and continually pressed by Mr. Kinahan in regard to the
Irish eskers, which are really small forms of åsar. I will quote
a passage or two, which I cannot improve upon. He says : "The
eskers are modifications of the banks and shoals which accumulated
at the colliding and dividing of the 'flow' tide currents of the
esker sea, similar to those that are found in the seas round Great
Britain and Ireland at the present day. In the Irish Sea, in the
vicinity of the Isle of Man, there is a meeting of the north and
south 'flow' tide waves or a 'head of the tide.' Here the tidal
currents meet and neutralize one another in one place, forming
a mass of currentless water that simply 'rises' and 'falls' and
deposits there silt and other materials. The other heads of the tide
in these seas are south and east of England—in the Straits of Dover
and between Norfolk and Holland. But in these places there are
different results, as the currents collide and pass one another for
greater or less distances, and at their edges, or the junction of the
different currents, long banks of gravel and shingle accumulate.
It is also found that long banks of gravel and shingle may form at
the dividing or splitting up of the 'flow' tide current. This is
exemplified off the south-east coast of Ireland. From Greenore
Point a main current runs northward up the Irish Sea, while
secondary currents branch off into Wexford Bay ; and at the
junction of these currents with the main current there are long
banks between Greenore and Wicklow Heads." Again, he says :
At the half tide or "awash" portions of banks, and in other
shallow places where two currents collide, there are esker-like
ridges ; as St. Patrick's Bridge between Kilmore and the Saltees,
county of Wexford, and on the Dogger Bank, off the mouth of
Wexford Harbour. *No action but marine at the present day forms
ridges at all like the eskers.* ("Geology of Ireland," pp. 225–230.)

The åsar are, in fact, very large and glorified eskers. The shape
of the åsar, and their occurring in a parallel series of mounds, point
to a further fact, namely, that the moving mass of water must have
been separated into a number of more or less parallel currents, at
whose colliding edges the long banks were accumulated. This
feature is also at once explained when we examine the contour of the
country, and it has been pointed out by Murchison with his usual
insight, and been apparently overlooked by his successors. He
points out how the åsar in the neighbourhood of Upsala have long
ridges of granitic rock running parallel to them, and he says they
appear to have here assumed their linear direction in consequence
of the rocky elevations on their flanks. The prevalent linear or

north-and-south direction of these masses has necessarily been determined by the chief physical features of Sweden, which consist of frequent alternations of ridges of crystalline rocks and longitudinal depressions.

Murchison further points out how, when we get away from these controlling ridges of rock, the åsar depart from their typical form. Thus, he says, in the tract between Danemora and the little seaport of Kakholm, the åsar, consisting of true rolled and sandy detritus, are frequently arranged in circular heaps of about 100 paces in diameter, each capped by coarse angular blocks. "Now, the water-worn materials are, it will be observed, thus circularly grouped on the lowest elevations in the midst of small plains or flats, from one to two and three miles wide, *which are devoid of those distinct longitudinal encasing ridges of granitic rocks whereby the osar have usually obtained their prevailing long and ridge-like character.*"

In other cases, again, the åsar simulate the ordinary "crag and tail" formation, which, as Sefstrom urged, was the case in Sweden with most of the smaller ones. A well-known instance is that at Kinnekulle, on Lake Wenern, which I have lately examined, and where a train of sand and boulders, after the fashion of an ås, is most clearly, as Brongniart urged, the result of some watery current speeding over the land and leaving a train of débris behind it on meeting with an obstacle.

All the facts, therefore, seem to concur in claiming as the efficient cause of the Swedish åsar great masses of water, sometimes rushing in a series of more or less parallel currents, colliding and elbowing each other and dropping their burden along their edges, and sometimes coalescing into a more or less continuous flood. The abnormal size, the great length and height, and the portentous masses of materials comprised in these mounds, and especially the great size of their contained boulders, necessitate our postulating that the rush of waters must have been on a corresponding scale.

There still remains the question as to whether the åsar were the result of the diurnal (tidal) operations of a turbulent ocean or the rapid and sudden action of a great and cataclysmic rush of water, such as we have on other grounds postulated. In regard to this question, they present some features which seem to me to be conclusive.

In the first place, if they had been the result of the diurnal action of the sea, their internal structure would have been uniform. Instead of this we find that, while the great mass of the materials in most of them is arranged in heterogeneous fashion, being formed of a medley of different-sized boulders, their upper layers consist of stratified sands, finely levigated and laminated clays and brick-earths, mixed with light shells, or they are formed entirely of sands marked by violent cross-bedding, pointing very clearly to a great flood which threw down the great mass of its burden regardless of its gravity, and ended up, as floods always do, by depositing over the previous load the finer contents which it held in suspension in laminæ and layers. The very fact of the great mass of the substance of the coarse åsar being heterogeneous and

unarranged shows that if thrown down by water it could not have been by a succession of efforts, which would have laid down stratified beds, but by one impulse of a most powerful and portentous character.

This is again testified to by another fact, which I have not seen noticed, but to which I can vouch for from personal observation. When a section occurs in an ås and the section has been slightly weathered by the wind, it will be seen that in many cases, where the materials are fine, and consist of sand or clay or fine pebbles, and lines of stratification and laminæ occur in them, that these lines resemble those to which I have called attention occurring in the cliffs at Cromer. They form perfectly continuous lines of curvature extending from the top to the bottom of the deposit, showing that the whole deposit has been the result of one impulse, and not of many. This was especially beautifully visible in an open section I noticed close to Omberg, in West Gothland, which I recently visited. This lamination is a great deal commoner in the ås than is generally supposed. It often requires the face of the section to be slightly wind-weathered before it is disclosed, and I am convinced that it will be found pretty nearly everywhere when no large boulders occur. Wherever the rush of water was sufficiently great to carry with it the large stones, then, it would seem, it laid down its load heterogeneously. Where the rush was less marked, and the water could only carry lighter materials, these lines of stratification were developed.

The most striking and conclusive proof, however, that these gigantic ramparts were thrown down by some rapid and portentous movement of water rather than by exceptional tidal action, is the fact so much overlooked by those who have written on the åsar, namely, their running up and down hill without consideration for the lines of drainage, and this, too, in their line of march. No tide, no race, no movement of water of a torrential character, such as we know it, in any of the oceans or seas of the world, would drive along such a great mass of water in a number of parallel currents, keeping the same lines of movement athwart hill and dale, and lay down enormous masses of heavy unsorted stones in gigantic ridges.

To do this the water must have been not only enormous in quantity, but the impulse which drove it must also have been of quite a cataclysmic character. We can compare it only with the great waves of translation which followed the earthquake of Lisbon, or those which followed great earthquakes in Java some years ago, and of which another example occurred in Japan quite recently. These are the models and types to which we must turn in explaining the åsar and other phenomena of the Drift. We have only to multiply the potency of the cause and the problem is explained, and this, as we have seen, the critical examination of the facts enables us to do. The sudden upheaval and breakage of the solid strata in Central Sweden over several degrees of latitude underneath a widespread sea—this is what the facts compel us to accept, and this is sufficient to solve our difficulty.

To conclude, therefore. The present evidence of the åsar seems to me to completely support the view urged in previous papers from other facts and premises, namely, that Scandinavia was recently very largely submerged by the sea, which covered it for a long time, which smoothed and rounded its surface, and which rounded and smoothed its myriads of boulders ; and that this sea was eventually drained and discharged by some rapid and sudden upheaval of its bed, causing a perhaps unprecedented diluvial movement. It was this rapid movement of a vast rushing sea, driven from its bed by the upheaval of that bed, which, as we saw in a former paper, accounted for many of the facts in the recent geology of Scandinavia. It alone, it seems to me, accounts for the various features presented by the Scandinavian åsar, and which bear no trace of any kind which can justify us in calling in ice in any shape to explain them.

V.—Woodwardian Museum Notes.

A Carboniferous Brachiopod (*Eumetria* ? *serpentina*, De Kon.) new to Britain.

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

IN rearranging the Carboniferous fossils in the Woodwardian Museum, I met with a specimen labelled *Athyris*, n.sp., which reminded me of the form described by De Koninck [1] as *Terebratula serpentina*. On careful examination I am convinced that it belongs to this species, and the following is a description of our specimen :— Shell subovate, terebratuliform, widest at about one-third its length from its anterior edge. Valves moderately convex, slightly flattened anteriorly, and devoid of sinus and fold ; margin entire and regular. Ventral valve a little less deep than dorsal valve, and furnished with a slightly recurved beak truncated by a large circular foramen, bordered in front by a pair of deltidial plates. Surface of both valves ornamented with straight, radiating, very faint ribs, 60 to 70 in number, arranged in a regular close series separated by weak narrow furrows. Some of the ribs bifurcate at about half their length, and those near the hinge-line curve gently backwards. Shell substance finely punctate. Concentric striæ of growth are distinct on both valves. Length, 25 mm. ; breadth, 22 mm. ; dorsi-ventral diameter, 12 mm.

Our specimen was found by Mr. E. B. Tawney in the Lower Limestone Shale of Clifton, Gloucestershire, and the Tournai beds in which the Belgian specimens occur appear to be on the same stratigraphical horizon. The faunas of the Lower Limestone Shale of Britain and of the calcareous slates of Tournai are in many respects closely similar. De Koninck [2] in 1887 placed this species in the genus *Acambona* of White,[3] but the latter, in his original definition of this genus, gave the absence of a foramen in the ventral valve as a distinctive feature. Since

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[1] " Descr. des anim. foss. qui se trouvent dans le terr. carb. de la Belgique" (1843), p. 291, pl. xix, fig. 8.

[2] " Fauna du Calc. carb. de la Belgique" (1887), vol. iv, pp. 96, 97, pl. xxii, figs. 25–31.

[3] Proc. Boston Soc. Nat. Hist., vol. ix (1862), p. 27, figs. 1, 2.

De Koninck figures and describes a foramen in the Belgian examples
(with which ours agrees), Hall [1] is inclined to consider this species
as congeneric with *Eumetria vera* (Hall) from the Kaskasia Limestone
of the Lower Carboniferous Series of America. But until we know
the internal structure of the species, we cannot positively decide to
what genus it should be assigned. Waagen [2] has suggested that it
may belong to his genus *Uncinella*, from the Productus Beds of the
Salt Range of India. In the description of *Retzia* ? *carbonaria* (Dav.)
from the Lower Carboniferous Shales of Skrinkle, Pembrokeshire,
Davidson [3] mentions *Terebratula serpentina*, but *Retzia* ? *carbonaria* is
held by Hall [4] to belong to the distinct genus *Hustedia*.

VI.—Note on a large Boulder at Wimpole Hall, Cambs.

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

ABOUT five-and-twenty years ago a large boulder, lying in the
garden of Wimpole Hall, near Royston, was pointed out to the
Rev. Osmond Fisher by the Lady Hardwicke of that period, and
she informed him that it had been brought from near Old North
Road Station when the hill there was lowered. As its dimensions
and nature had not been determined, Mr. Fisher invited me to
accompany him to Wimpole on April 22nd in order to examine it,
having previously obtained permission from the present owner of
the property, Lord Robartes. After a brief search the boulder was
discovered lying about 30 yards north-west of the conservatory
and almost concealed under a dense growth of ivy. It measures
approximately 8 ft. 10 in. in length, 4 ft. in height, and 1 ft. 8 in. in
breadth, and consists of a greenish-grey tough sandstone. Mr. Fisher
determined its S.G. to be 1·91 and its weight to amount to 3 tons 2 cwt.
Lithologically the rock is precisely similar to portions of the Spilsby
Sandstone of Lincolnshire, and a specimen in the Woodwardian
Museum from near Claxby is indistinguishable from it. By good
luck a small Ammonite occurred in a fragment chipped off by the
Rev. E. Conybeare, who met us at Wimpole; and Mr. G. C. Crick,
of the British Museum, who has kindly examined it for us, writes
that it is "not referable to any species which has hitherto been
recorded from Great Britain," but that it "is closely related to
Olcostephanus (*Craspedites*) *subditus* (Trautschold), which has been
recorded from the Spilsby Sandstone of Lincolnshire (Pavlow and
Lamplugh, 'Argiles de Speeton,' etc., p. 116, pl. xiii (vi),
figs. 5*a*, *b*, *c*)."

The occurrence of many boulders in the Cambridgeshire Boulder-
clay from northern sources has been noticed by many observers, and
possibly some of the sandstones which are frequently found in it
may come from the Lower Greensand beds of Lincolnshire, but,
as far as I am aware, no block of such a size from these beds,
bearing such a definite proof of its origin, has ever before been

[1] "Palæont. New York," vol. viii, Brachiopoda, ii (1894), pp. 118, 119, pl. li.
[2] "Palæont. Ind.," ser. xiii, Salt Range Fossils, vol. i (1883), p. 495.
[3] "Brit. Foss. Brach.," vol. ii, p. 219, pl. li, fig. 3.
[4] Op. cit., p. 122.

discovered in our area. The outcrop of its parent-bed is about 50 miles distant in a straight line from Old North Road Station. The Boulder-clay, where it was found, is said by Professor Bonney (" Camb. Geol.," p. 49) to be 160 feet thick, as seen in the cutting and well.

From the presence in the Cambridgeshire Boulder-clay of fragments of the Red Chalk and Carstone, and from the general invasion of the outcrops of beds to the south by the materials of beds to the north or north-east, it has been inferred that the direction of movement of the agent of transportation was towards the south ; and the occurrence of this boulder of Spilsby Sandstone is strongly in favour of this view. But in spite of this evidence for its support it cannot be said that this theory is completely satisfactory, for it fails to explain the reason of the extremely miscellaneous character of the majority of the non-local rocks in the Boulder-clay, and the distribution of the deposit in relation to the configuration of the country, whether we consider the transporting agent to have been land-ice, icebergs, or an ice-foot.

NOTICES OF MEMOIRS.

Facts and Arguments in favour of an Antarctic Expedition.

IN advocating " The Scientific Advantages of an Antarctic Expedition " before the Royal Society in February last,[1] Dr. John Murray, F.R.S. (now Sir John Murray, K.C.B., F.R.S.), said :—

" From a scientific point of view the advantages to be derived from a well-equipped and well-directed expedition to the Antarctic would, at the present time, be manifold. Every department of natural knowledge would be enriched by systematic observations as to the order in which phenomena coexist and follow each other, in regions of the earth's surface about which we know very little or are wholly ignorant. It is one of the great objects of science to collect observations of the kind here indicated, and it may be safely said that without them we can never arrive at a right understanding of the phenomena by which we are surrounded, even in the habitable parts of the globe.

" Before considering the various orders of phenomena concerning which fuller information is urgently desired, it may be well to point out a fundamental topographical difference between the Arctic and Antarctic. In the northern hemisphere there is a polar sea almost completely surrounded by continental land, and continental conditions for the most part prevail. In the southern hemisphere, on the other hand, there is almost certainly a continent at the South Pole, which is completely surrounded by the ocean, and, in those latitudes, the most simple and extended oceanic conditions on the surface of the globe are encountered."

The author then proceeds to discuss the Meteorology.

[1] Proceedings of the Royal Society, vol. lxii, No. 387, pp. 424–451, Feb. 24, 1898.

" One of the most remarkable features in the meteorology of the globe is the low atmospheric pressure at all seasons in the southern hemisphere south of latitude 45° S., with the accompanying strong westerly and north-westerly winds, large rain and snow fall, all round the South Polar regions. The mean pressure seems to be less than 29 inches, which is much lower than in similar latitudes in the northern hemisphere. Some meteorologists hold that this vast cyclonic system and low-pressure area continues south as far as the pole, the more southerly parts being traversed by secondary cyclones. There are, however, many indications that the extreme South Polar area is occupied by a vast anticyclone, out of which winds blow towards the girdle of low pressure outside the ice-bound region. In support of this view it is pointed out that Ross's barometric observations indicate a gradual rise in the pressure south of the latitude of 75° S., and all Antarctic voyagers agree that when near the ice the majority of the winds are from the south and south-east, and bring clear weather with fall of temperature, while northerly winds bring thick fogs with rise of temperature.

        ✳   ✳   ✳   ✳   ✳   ✳   ✳

" There would appear, then, to be good reasons for believing that the region of the South Pole is covered by what may be regarded practically as a great permanent anticyclone with a much wider extension in winter than in summer. It is most likely that the prevailing winds blow out from the pole all the year round towards the surrounding sea, as in the case of Greenland, but, unlike Greenland, this area is probably seldom traversed by cyclonic disturbances.

" But what has been stated only shows how little real knowledge we possess concerning the atmospheric conditions of high southern latitudes. It is certain, however, that even two years' systematic observations within these regions would be of the utmost value for the future of meteorological science."

Referring to the Antarctic ice, Dr. Murray said :—

" From many points of view it would be important to learn something about the condition and distribution of Antarctic sea-ice during the winter months, and especially about the position and motion of the huge table-shaped icebergs at this and other seasons of the year. These flat-topped icebergs, with a thickness of 1,200 or 1,500 feet, with their stratification and their perpendicular cliffs, which rise 150 or 200 feet above and sink 1,100 or 1,400 feet below the level of the sea, form the most striking peculiarity of the Antarctic Ocean. Their form and structure seem clearly to indicate that they were formed on an extended land surface, and have been pushed out over low-lying coasts into the sea.

" Ross sailed for 300 miles along the face of a great ice-barrier from 150 to 200 feet in height, off which he obtained depths of 1,800 and 2,400 feet. This was evidently the sea-front of a great creeping glacier or ice-cap just then in the condition to give birth to the table-shaped icebergs, miles in length, which have been described by every Antarctic voyager.

"All Antarctic land is not, however, surrounded by such in-accessible cliffs of ice, for along the seaward faces of the great mountain ranges of Victoria Land the ice and snow which descend to the sea apparently form cliffs not higher than 10 to 20 feet, and in 1895 Kristensen and Borchgrevink landed at Cape Adare on a pebbly beach, occupied by a penguin rookery, without encountering any land-ice descending to the sea. Where a penguin rookery is situated, we may be quite sure that there is occasionally open water for a considerable portion of the year, and that consequently landing might be effected without much difficulty or delay, and further that a party, once landed, might with safety winter at such a spot, where the penguins would furnish an abundant supply of food and fuel. A properly equipped party of observers situated at a point like this on the Antarctic continent for one or two winters might carry out a most valuable series of scientific observations, make successful excursions towards the interior and bring back valuable information as to the probable thickness of the ice-cap, its temperature at different levels, its rate of accumulation, and its motions, con-cerning all which points there is much difference of opinion among scientific men."

We come then to the question—" Is there an Antarctic continent ? It has already been stated that the form and structure of the Antarctic icebergs indicate that they were built up on, and had flowed over, an extended land surface. As these bergs are floated to the north and broken up in warmer latitudes they distribute over the floor of the ocean a large quantity of glaciated rock fragments and land detritus. These materials were dredged up by the 'Challenger' in considerable quantity, and they show that the rocks over which the Antarctic land-ice moved were gneisses, granites, mica-schists, quartziferous diorites, grained quartzites, sandstones, limestones, and shales. These lithological types are distinctly indicative of continental land, and there can be no doubt about their having been transported from land situated towards the South Pole. D'Urville describes rocky islets off Adélie Land composed of granite and gneiss. Wilkes found on an iceberg, near the same place, boulders of red sandstone and basalt. Borchgrevink and Bull have brought back fragments of mica-schists and other continental rocks from Cape Adare. Dr. Donald brought back from Joinville Island a piece of red jasper or chert containing Radiolaria and sponge spicules. Captain Larsen brought from Seymour Island pieces of fossil coniferous wood, and also fossil shells of *Cucullæa, Cytherea, Cyprina, Teredo,* and *Natica,* having a close resemblance to species known to occur in Lower Tertiary beds in Britain and Patagonia. These fossil remains indicate in these areas a much warmer climate in past times. We are thus in possession of abundant indications that there is a wide extent of continental land within the ice-bound regions of the southern hemisphere.

" It is not likely that any living land-fauna will be discovered on the Antarctic continent away from the penguin rookeries. Still, an Antarctic expedition will certainly throw much light on many

geological problems. Fossil finds in high latitudes are always of special importance. The pieces of fossil wood from Seymour Island can hardly be the only relics of plant life that are likely to be met with in Tertiary and even older systems within the Antarctic. Tertiary, Mesozoic, and Palæozoic forms are tolerably well developed in the Arctic regions, and the occurrence of like forms in the Antarctic regions might be expected to suggest much as to former geographical changes, such as the extension of Antarctica towards the north, and its connection with, or isolation from, the northern continents, and also as to former climatic changes, such as the presence in Pre-Tertiary times of a uniform temperature in the waters of the ocean all over the surface of the globe."

After pointing out the importance of magnetic and pendulum observations, geodetic measurements, tides, and currents, the author referred to the depth of the Antarctic Ocean.

" In regard to the depth of the ocean immediately surrounding the Antarctic continent we have at present very meagre information, and one of the objects of an Antarctic expedition would be to supplement our knowledge by an extensive series of soundings in all directions throughout the Antarctic and Southern Oceans. It would in this way be possible, after a careful consideration of the depths and marine deposits, to trace out approximately the outlines of the Antarctic continent. At the present time we know that Ross obtained depths of 100 to 500 fathoms all over the great bank extending to the east of Victoria Land, and somewhat similar depths have been obtained extending for some distance to the east of Joinville Island. Wilkes sounded in depths of 500 and 800 fathoms about 20 or 30 miles off Adélie Land. The depths found by the 'Challenger' in the neighbourhood of the Antarctic circle were from 1,300 to 1,800 fathoms, and further north the 'Challenger' soundings ranged from 1,260 to 2,600 fathoms. To the south-west of South Georgia, Ross paid out 4,000 fathoms of line without reaching bottom. In the charts of depth which I have constructed I have always placed a deep sea in this position, for it appears to me that Ross, who knew very well how to take soundings, was not likely to have been mistaken in work of this kind.

"The few indications which we thus possess of the depth of the ocean in this part of the world seem to show that there is a gradual shoaling of the ocean from very deep water towards the Antarctic continent, and, so far as we yet know, either from soundings or temperature observations, there are no basins cut off from general oceanic circulation by barriers or ridges, similar to those found towards the Arctic."

Dr. Murray next spoke of the deposits of the Antarctic Ocean.

"The deposits which have been obtained close to the Antarctic continent consist of blue mud, containing glauconite, made up for the most part of detrital matters brought down from the land, but containing a considerable admixture of the remains of pelagic and other organisms. Further to the north there is a very pure diatom ooze, containing a considerable quantity of detrital matter from

icebergs, and a few pelagic foraminifera. This deposit appears to form a zone right round the earth in these latitudes. Still further to the north the deposits pass in deep water, either into a Globigerina ooze, or into a red clay with manganese nodules, sharks' teeth, ear-bones of whales, and the other materials characteristic of that deep-sea deposit. Since these views, however, as to the distribution of deep-sea deposits throughout these high southern latitudes, are founded upon relatively few samples, it cannot be doubted that further samples from different depths in the unexplored regions would yield most interesting information."

The subject of temperature of the Antarctic Ocean was then discussed.

"The mean daily temperature of the surface waters of the Antarctic, as recorded by Ross, to the south of latitude 63° S. in the summer months, varies from 27·3° to 33·6°, and the mean of all his observations is 29·85°. As already stated, his mean for the air during the same period is somewhat lower, being 28·74°. In fact, all observations seem to show that the surface water is warmer than the air during the summer months.

"The 'Challenger' observations of temperature beneath the surface indicate the presence of a stratum of colder water wedged between warmer water at the surface and warm water at the bottom. This wedge-shaped stratum of cold water extends through about 12° of latitude, the thin end terminating about latitude 53° S., its temperature varying from 28° at the southern thick end to 32·5° at the northern thin end, while the temperature of the overlying water ranges from 29° in the south to 38° in the north, and that of the underlying water from 32° to 35°. This must be regarded as the distribution of temperature only during the summer, for it is improbable that during the winter months there is a warmer surface layer.

"In the greater depths of the Antarctic, as far south as the Antarctic circle, the temperature of the water varies between 32° and 35° F., and is not, therefore, very different from the temperature of the deepest bottom water of the tropical regions of the ocean. The presence of this relatively warm water in the deeper parts of the Antarctic Ocean may be explained by a consideration of general oceanic circulation. The warm tropical waters which are driven southwards along the eastern coasts of South America, Africa, and Australia, into the great all-encircling Southern Ocean, there become cooled as they are driven to the east by the strong westerly winds. These waters, on account of their high salinity, can suffer much dilution with Antarctic water, and still be denser than water from these higher latitudes at the same temperature. Here the density observations and the sea-water gases indicate that the cold water found at the greater depths of the ocean probably leaves the surface and sinks towards the bottom in the Southern Ocean, between the latitudes of 45° and 56° S. These deeper, but not necessarily bottom, layers are then drawn slowly northwards towards the tropics, to supply the deficiencies there

produced by evaporation and southward-flowing surface-currents, and these deeper layers of relatively warm water appear likewise to be slowly drawn southwards to the Antarctic area to supply the place of the ice-cold currents of surface water drifted to the north. This warm underlying water is evidently a potent factor in the melting and destruction of the huge table-topped icebergs of the southern hemisphere. While these views as to circulation appear to be well established, still a fuller examination of these waters is most desirable at different seasons of the year, with improved thermometers and sounding machines. Indeed, all deep-sea apparatus has been so much improved as a result of the 'Challenger' explorations, that the labour of taking specific gravity and all other oceanographical observations has been very much lessened."

In speaking of the pelagic life of the Antarctic Ocean, the author mentioned that "In the surface waters of the Antarctic there is a great abundance of diatoms and other marine algæ. These floating banks or meadows form primarily not only the food of pelagic animals, but also the food of the abundant deep-sea life which covers the floor of the ocean in these South Polar regions. Pelagic animals, such as copepods, amphipods, molluscs, and other marine organisms, are also very abundant, although species are fewer than in tropical waters. Some of these animals seem to be nearly, if not quite, identical with those found in high northern latitudes, and they have not been met with in the intervening tropical zones. The numerous species of shelled Pteropods, Foraminifera, Coccoliths, and Rhabdoliths, which exist in the tropical surface waters, gradually disappear as we approach the Antarctic circle, where the shelled Pteropods are represented by a small *Limacina*, and the Foraminifera by only two species of *Globigerina*, which are apparently identical with those in the Arctic Ocean. A peculiarity of the tow-net gatherings made by the 'Challenger' Expedition in high southern latitudes, is the great rarity or absence of the pelagic larvæ of benthonic organisms, and in this respect they agree with similar collections from the cold waters of the Arctic seas. The absence of these larvæ from polar waters may be accounted for by the mode of development of benthonic organisms to be referred to presently. It must be remembered that many of these pelagic organisms pass most of their lives in water of a temperature below 32° F., and it would be most interesting to learn more about their reproduction and general life-history."

As to the benthos life of the Antarctic Ocean, Dr. Murray said :—

" At present we have no information as to the shallow-water fauna of the Antarctic continent ; but, judging from what we do know of the off-lying Antarctic islands, there are relatively few species in the shallow waters in depths less than 25 fathoms. On the other hand, life in the deeper waters appears to be exceptionally abundant. The total number of species of Metazoa collected by the 'Challenger' at Kerguelen in depths less than 50 fathoms was about 130, and the number of additional species known from other sources from the shallow waters of the same island is 112, making altogether 242

species, or thirty species less than the number obtained in eight deep hauls with the trawl and dredge in the Kerguelen region of the Southern Ocean, in depths exceeding 1,260 fathoms, in which eight hauls 272 species were obtained. Observations in other regions of the Great Southern Ocean, where there is a low mean annual temperature, also show that the marine fauna around the land in high southern latitudes appears to be very poor in species down to a depth of 25 fathoms, when compared with the number of species present at the mud-line about 100 fathoms, or even at depths of about two miles.

" In 1841 Sir James Clark Ross dredged off the Antarctic continent species which he recognized as the same as he had been in the habit of taking in equally high Northern latitudes, and he suggested that they might have passed from one pole to the other by way of the cold water of the deep sea. Subsequent researches show that, as with pelagic organisms, many of the bottom-living species are identical with, or closely allied to, those of the Arctic regions, and are not represented in the inter- mediate tropical areas. For instance, the most striking character of the shore-fish fauna of the Southern Ocean is the reappearance of types inhabiting the corresponding latitudes of the northern hemisphere, and not found in the intervening tropical zone. This interruption of continuity in the distribution of shore-fishes is exemplified by species as well as genera, and Dr. Günther enumerates eleven species and twenty-nine genera as illustrating this method of distribution.   The genus by which the family Berycidæ is repre- sented in the Southern Temperate Zone (*Trachichthys*) is much more nearly allied to the northern than to the tropical genera. ' As in the Northern Temperate Zone, so in the Southern . . . . the variety of forms is much less than between the tropics. This is especially apparent on comparing the number of species constituting a genus. In this zone, genera composed of more than ten species are the exception, the majority having only from one to five.' . . . . ' *Polyprion* is one of those extraordinary instances in which a very specialized form occurs at almost opposite points of the globe, without having left a trace of its previous existence in, or of its passage through, the intermediate space.'

"Speaking of the shore-fishes of the Antarctic Ocean, Günther says : ' The general character of the fauna of Magelhæn's Straits and Kerguelen's Land is extremely similar to that of Iceland and Greenland.   As in the Arctic fauna, Chondropterygians are scarce, and represented by *Acanthias vulgaris* and species of *Raja* . . . . As to Acanthopterygians, Cataphracti and Scorpænidæ are repre- sented as in the Arctic fauna, two of the genera (*Sebastes* and *Agonus*) being identical.   The Cottidæ are replaced by six genera of Trachinidæ, remarkably similar in form to Arctic types . . . . Gadoid fishes reappear, but are less developed ; as usual, they are accompanied by *Myxine*. The reappearance of so specialized a genus as *Lycodes* is most remarkable.' [1]

[1] Günther, " Study of Fishes," pp. 282–290 ; Edinburgh, 1880.

" These statements with reference to shore-fishes might, with some modifications, be repeated concerning the distribution and character of all classes of marine invertebrates in high northern and high southern latitudes. The 'Challenger' researches show that nearly 250 species taken in high southern latitudes occur also in the northern hemisphere, but are not recorded from the tropical zone. Fifty-four species of seaweeds have also been recorded as showing a similar distribution.[1] Bipolarity in the distribution of marine organisms is a fact, however much naturalists may differ as to its extent and the way in which it has originated.

" All those animals which secrete large quantities of carbonate of lime greatly predominate in the tropics, such as Corals, Decapod Crustacea, Lamellibranchs, and Gasteropods. On the other hand, those animals in which there is a feeble development of carbonate of lime structures predominate in cold polar waters, such as Hydroida, Holothurioidea, Annelida, Amphipoda, Isopoda, and Tunicata. This difference is in direct relation with the temperature of the water in which these organisms live, a much more rapid and abundant precipitate of carbonate of lime being thrown down in warm than in cold water by ammonium carbonate, one of the waste products of organic activity.

" In the Southern and Sub-Antarctic Ocean a large proportion of the Echinoderms develop their young after a fashion which precludes the possibility of a pelagic larval stage. The young are reared within or upon the body of the parent, and have a kind of commensal connection with her till they are large enough to take care of themselves. A similar method of direct development has been observed in eight or nine species of Echinoderms from the cold waters of the northern hemisphere. On the other hand, in temperate and tropical regions the development of a free-swimming larva is so entirely the rule that it is usually described as the normal habit of the Echinodermata. This similarity in the mode of development between Arctic and Antarctic Echinoderms (and the contrast to what takes place in the tropics) holds good also in other classes of Invertebrates, and probably accounts for the absence of free-swimming larvæ of benthonic animals in the surface gatherings in Arctic and Antarctic waters.

" What is urgently required with reference to the biological problems here indicated is a fuller knowledge of the facts, and it cannot be doubted that an Antarctic expedition would bring back collections and observations of the greatest interest to all naturalists and physiologists, and without such information it is impossible to discuss with success the present distribution of organisms over the surface of the globe, or to form a true conception of the antecedent conditions by which that distribution has been brought about."

Dr. Murray concluded his paper as follows :—

" There are many directions in which an Antarctic Expedition would carry out important observations besides those already touched

[1] Murray and Barton, " Phycological Memoirs of the British Museum," part iii ; London, 1895.

on in the foregoing statement. From the purely exploratory point of view much might be urged in favour of an Antarctic Expedition at an early date; for the further progress of scientific geography it is essential to have a more exact knowledge of the topography of the Antarctic regions. This would enable a more just conception of the volume relations of land and sea to be formed, and in connection with pendulum observations some hints as to the density of the sub-oceanic crust and the depth of ice and snow on the Antarctic continent might be obtained. In case the above sketch may possibly have created the impression that we really know a great deal about the Antarctic regions, it is necessary to restate that all the general conclusions that have been indicated are largely hypothetical, and to again urge the necessity for a wider and more solid base for generalizations. The results of a successful Antarctic Expedition would mark a great advance in the philosophy—apart from the mere facts—of terrestrial science.

"No thinking person doubts that the Antarctic will be explored. The only questions are: when? and by whom? I should like to see the work undertaken at once, and by the British Navy. I should like to see a sum of £150,000 inserted in the estimates for the purpose. The Government may have sufficient grounds for declining to send forth such an expedition at the present time, but that is no reason why the scientific men of the country should not urge that the exploration of the Antarctic would lead to important additions to knowledge, and that, in the interests of science among English-speaking peoples, the United Kingdom should take not only a large but a leading part in any such exploration."

The Duke of Argyll, Sir J. D. Hooker, Dr. Nansen, Dr. G. Neumayer, Sir Clements Markham, Dr. Alexander Buchan, Sir A. Geikie, Dr. Sclater, Professor D'Arcy Thompson, Admiral Sir W. J. L. Wharton, and others, took part in the discussion which followed.

REVIEWS.

Wachsmuth and Springer's Monograph on Crinoids.

The North American Crinoidea Camerata. By Charles Wachsmuth and Frank Springer. Mem. Mus. Comp. Zool. Harvard, vols. xx and xxi, containing 838 pp. and 83 plates. (Cambridge, U.S.A., May, 1897).

First Notice.

IN the last letter that he wrote me, Charles Wachsmuth repeated a wish already expressed by word of mouth, namely, that in some English publication I should review this grand monograph, then in active preparation. Although, through the kindness of Mr. Alexander Agassiz and Mr. Frank Springer, a copy has been in my hands for a twelvemonth, yet the wish of my departed friend is still unfulfilled. The reasons for delay have been two. The first is the size and importance of the work, coupled with my desire to do it justice. What has taken twenty years to write cannot be digested

and criticized at a week's notice. The second reason is the large amount of personal controversy and criticism of my own writings. Of this so much was made in certain premature reviews published in America, that I could not, at an earlier date, have avoided some remarks in self-defence; and I was unwilling to attack one whose mouth had so recently been sealed by death. The time has at last arrived when I can venture on a satisfactory appreciation of this work, and when argument may meet argument without suspicion of personal bitterness. Therefore, with the kind permission of the Editor of the Geological Magazine, I propose to deal, in a series of notices, with the several sections of the book, directing special attention to facts or opinions first published therein.

The perusal and reperusal of this work has brought to light a few errors. The correction of these, as the pages are passed in review, will, I trust, be ascribed less to a love of censoriousness than to a desire to increase the usefulness of a book that must be the standard of reference for many years to come. Several of these errors are by no means peculiar to Messrs. Wachsmuth and Springer, and it was hardly in their power to discover them.

This memoir consists of three parts :—Introductory, dealing with the history of our knowledge and with terminology; Morphological, dealing with the elements of the crinoid skeleton, and with such internal organs as leave traces in the fossils; Systematic, first dealing with the classification of the Crinoidea, and then describing the North American genera and species referred by the authors to their Order Camerata. Eight plates and a few text-figures elucidate the morphological questions discussed, while seventy-five illustrate the descriptions.

The drawings have been made in pencil by C. R. Keyes, J. L. Ridgway, and A. M. Westergren, and have been reproduced by the Heliotype Printing Co., Boston. There are also a few drawings by G. Liljevall. This mode of illustration is the most satisfactory for palæontological work when fine detail is to be shown. Its peculiar difficulties have been overcome, so far as is possible, by the attention of Mr. Westergren. Many of the figures are admirable examples of draughtsmanship; whether they are correct cannot be decided (except in a case to which I shall recur) without comparison with the specimens figured. A thoughtless habit of praising scientific illustrations because they look pretty has made the reputation of many a careless draughtsman. The magnification of the figures should have been stated in all cases where they are not of natural size, not merely in some cases. Information is given as to the collections in which the figured specimens are, but the original locality of each specimen is not indicated. The type-specimens are distinguished, but nothing tells us that several other specimens have been already figured elsewhere. In a few instances it is hard to see how the information that is given can be correct. It is, for example, impossible that figs. 2*a* and 2*b* on pl. xv should represent, as they are said to do, the ventral and dorsal aspects of " the same specimen " of *Gilbertsocrinus dispansus*; even more does this apply

to figs. 2*c* and 2*d*. I would also suggest that figs. 5 and 7 of pl. v
are incorrectly described ; if they really are in the position stated,
then they show a variation of fundamental structure, remarkable not
merely in itself but also from the fact that it is not alluded to in
the text.   While grateful for the numerous figures, so admirably
illustrative of specific form, one could have wished to see more
drawings of detail on an enlarged scale. The pores of *Batocrinus*,
to instance a structure much discussed by our authors, are nowhere
adequately figured. Similarly, the representations of the assumed
slits or pores in the anal sac of the Fistulate Inadunata are not
enough magnified to form evidence worth opposing to the numerous
enlarged and detailed figures already published by me as proof that
these supposed slits are nothing but deep folds. It is a great boon
to have gathered in one volume such charming and, no doubt,
trustworthy figures of nearly all the species of North American
Camerata ; but it may be suggested to future workers that the
time has gone by for nothing but pictures of specimens, however
exquisite. We want accurate drawings of structure and variations
of structure, represented in the most intelligible manner possible.
Apparently it is thought undignified or inartistic to put reference
letters on the plates illustrating a book of this importance.   Such,
at any rate, is the custom, with the result that it is often hard to
follow descriptions of structure.   When an exact drawing of an
obscure specimen is given, and in many cases most rightly given,
let us at least have an explanatory diagram.   Too many of our
scientific " ships " are spoiled for want of this " ha'porth of tar " ;
though this is not always the author's fault.   One feature of Messrs.
Wachsmuth and Springer's plates is the consistency of orientation :
" in illustrating the plates of the calyx, the dorsal view is figured
with the anal interradius *up*, and the ventral view with the anal side
down. Right and left remain the same in both cases." This example
should always be followed ; and when a specimen is drawn from the
side its orientation should invariably be stated.

Let us turn now to the text.   The Historical Introduction is
of value chiefly for its account of discovery and work in North
America.   Fourteen hundred crinoid species from that country are
now described, but in 1858 only seventy had been defined.   In that
year remarkable finds were made, and the now famous localities of
Burlington, Crawfordsville, Keokuk, and Louisville yielded hundreds
of perfect specimens.   Troost had already reported, though not
published, 86 new species and 16 new genera from Tennessee, but
Burlington furnished over 300 species, a greater number than those
hitherto known from the whole world.   Crinoid-collecting became
the rage, while " men of science, anxious to publish the new forms,
and fearing they might be preceded by competitors, brought out
preliminary descriptions to secure priority for their species.   These
descriptions, in many cases, were so indefinite that the identification
of the species was almost impossible, and this created considerable
annoyance and labour to later writers."   It is to be feared that the
creation of annoyance in this manner has not yet ceased, and that it

is by no means the prerogative of writers on crinoids. Many
descriptions issued forty years ago as "preliminary" remain uncom-
pleted to this day. It is pleasant to find that the earlier English
authors are not accused of similar bad faith; at the same time, "their
descriptions in many cases are so primitive that neither genera
nor species can be identified."

The account of the American localities for fossil crinoids, given in
this part of the work, is interesting and useful enough to indicate
the value there would be in a complete list of such localities with the
geological horizon as now ascertained. If the names of the chief
collectors could be added, as here, and also a list of the chief species
from each locality, so much the better. There are in the Old World,
and doubtless in the New, numerous ancient collections of North
American crinoids, with somewhat imperfect labels bearing names,
both of locality and horizon, which it is hard to identify with names on
modern maps or in modern manuals of geology. Nor would it be
only on such obscurities that the table we desire would throw light.
If drawn up by a competent authority, such as Mr. Springer, it would
advance the study of distribution in space and time, an accurate
knowledge of which is so necessary to the zoological evolutionist.
In this research no help is to be despised. As our authors say
in a passage that comes with great weight from practical collectors
and palæontologists:

"The trouble is that all our generalizations are necessarily based
upon the Crinoids as they are represented *in our museums*, and not
upon the Crinoids as they actually existed in geological time, which
is a very different thing. It is like trying to reconstruct a book
from detached fragments of the chapters, some of them written in
hieroglyphics for whose decipherment the key has not yet been
found. We are accustomed to speak of the imperfection of the
geological record, but it is doubtful if in our practical studies we
always bear in mind what this really means. . . . . How much
do we actually know of the life represented in the rocks accessible to
us? Nearly all the known Silurian Crinoids come from the out-
croppings of the strata at two localities in Europe, and three or four
in America. The Devonian exposures producing well preserved
specimens are even more limited. The Lower Carboniferous
collections are better and more widely distributed, but are in-
significant after all. Take the Burlington and Keokuk limestones,
which in a few localities have produced more Crinoids in number and
species than any other formation. They consist of several hundred
feet of strata almost entirely composed of the comminuted remains of
countless myriads of Crinoids—fragments which are worthless to the
Palæontologist. It is only rarely that a thin layer is found in which
the calcareous skeletons are preserved well enough for study;—little
basins of limited extent, in which, during a period of temporarily
quiet waters, the Crinoids lived, died, and were imbedded at sufficient
depths to escape the destructive effects of shore action. If the
collector happens to be present when one of these colonies is un-
covered by the quarrymen, the specimens may be rescued for the

benefit of Science.   But it is an even chance that they will be buried in the debris of the quarry, broken up for ballast, or walled up in the foundation of a building, and thus be lost again.   Out of the thousands of square miles in which these rocks lie nearest the surface, all the collections that have ever been made represent only the imperfect gleanings of not more than a few acres.   If it be supposed that we get, even in this way, a fair representation of the crinoidal life of that period, the answer is that almost every new discovery of 'nests' or 'colonies' of good specimens brings to light new forms, and that species or genera hitherto very rare are often suddenly found within a limited space quite abundantly.   In the Upper Coal Measures, to judge from our books and museums, one would suppose that Crinoids were well-nigh extinct.   Scarcely a dozen species are known, and most of them only by their lower calyx plates.   Yet there are many beds in this formation which extend over hundreds of thousands of square miles from the Missouri Valley far into the Rocky Mountains and tilted up along their flanks, which are completely filled with fragments of Crinoids.   Suddenly the collectors at Kansas City, who have studied these rocks for years, discover an abundant deposit of well preserved specimens in a shale so soft that a few minutes' rain dissolves them into unrecognizable fragments."   (pp. 167–8.)

The historical account of the European literature will no doubt be of use to American workers, but it would have been of more value to them, and to all of us, had Messrs. Wachsmuth and Springer been in a position to verify their references and quotations instead of copying from De Koninck and W. B. Carpenter.   The writings of Agricola and Rosinus may not be accessible to workers in Iowa or New Mexico, but no specialist on Crinoidea can be forgiven for misrepresenting J. S. Miller and Johannes Müller, as do our authors. Let me substantiate this criticism in detail.

Agricola, we are told (p. 11), applied the name "*Encrinus* to the calyx of *Encrinus liliiformis*, at that time the only Crinoid in which a crown had been found in connection with the stem."   This is the intensification of an error already bad enough.   It was Harenberg who, in 1729, thus misapplied Agricola's term *Encrinus*, which originally bore the same relation to *Pentacrinus* as *Entrochus* bore to *Trochites*, i.e. *Encrinus* meant a series of star-shaped columnals. What Agricola and the rest really did say is set forth in my recent paper, "*Pentacrinus* : a name and its history" (*Natural Science*, vol. xii, pp. 245–256).

The next paragraph says that " Rosinus . . . . was the first writer to show that the Crinoids were not plants, as before then generally supposed, but were closely related to the Asterids." Rosinus was a writer of much merit, but the date of his " De Stellis Marinis quondam nunc Fossilibus Disquisitio " was 1719, whereas Llhuyd had published even more correct views in his " Lithophylacii Britannici Ichnographia," issued at London and Leipzig in 1699 (see *Natural Science*, loc. cit., also vol. xii, pp. 292 and 431). Wachsmuth and Springer's error, copied from De Koninck, was long ago corrected by W. B. Carpenter.

Guettard next receives some praise that is far too faint. The name "Palmier marin" was not his invention; the animal to which it was applied has been more correctly known as *Pentacrinus asteria* than as *P. caput-medusæ*; there are three misprints in the reference to his paper.

Blumenbach (the date of whose "Handbuch der Naturgeschichte," Ed. 1, is 1779, not 1780) obtains "the credit of having been the first writer who ranked them [crinoids] with the Asteroids and Ophiurids among the order 'Vermes crustacei,' which corresponds approximately to our present Echinoderms." He may have been the first *post-Linnæan* writer to do this; but he was only following Llhuyd in both arrangement and terminology. Moreover, in the edition of the "Handbuch" cited by our authors, Blumenbach referred the Echinoderms to 'Cartilaginea,' associating the crinoids with various Hydrozoa. It was not until 1788 that he placed them under 'Crustacea.'

J. S. Miller's definition of a crinoid is turned into nonsense on p. 12. Miller wrote as follows, but Wachsmuth and Springer have quoted only the italicized words: "*An animal with a round, oval, or angular column, composed of numerous articulating joints*, supporting at its summit a series of plates or joints *forming a cup-like body containing the viscera, from whose upper rim proceed five articulated* arms, dividing into tentaculated *fingers*, more or less numerous, surrounding the aperture of the mouth, situated in the centre of a plated integument, which extends over the abdominal cavity, and is capable of being contracted into a conic or proboscal shape." The omissions can scarcely be intentional.

On p. 14 "Heisinger (1837)" no doubt refers to Hisinger's "Lethæa suecica," which was published in that year, and not to Heusinger, who also was an early writer on crinoids.

On the same page it is said that Joh. Müller's paper "Ueber den Bau des Pentacrinus caput-medusæ" appeared in 1840. The first part of it was read in that year, but none was published till 1843. In this paper Müller wrote as an anatomist rather than as a systematist, and it is not easy to understand what his precise views as to the classification may have been. Probably he wrote thus of set purpose, recognizing that the time for a formal classification of crinoids had not arrived, and intending only to give names to certain plans of structure. Nevertheless, my interpretation of Müller is so different from that of Messrs. Wachsmuth and Springer that I can only suppose they have not referred to the original paper, incredible though such an inference may seem. "Müller," they write, "divided the Crinoids into three great groups: the '*Crinoidea Articulata*,' the '*Crinoidea Tessellata*,' and the '*Crinoidea Costata*.'" And again: "The Tessellata were subdivided by Müller into two groups: Crinoidea *with arms*, and Crinoidea *without arms*. To the former he referred all true Crinoids and the Cystid genus *Caryocrinus*. . . . . The *armless* Crinoids comprise the 'Pentremites' (Blastoidea) and 'Sphæronites' (Cystidea)."

Instead of criticizing these statements in detail I will contrast

with them my interpretation of Müller's intentions. Müller's
'Crinoidea' included all Pelmatozoa then known. His first
division was into those with arms and those without, the former
group being the 'Crinoidea brachiata' of writers who preferred
a Latin terminology, and the latter including ' Pentremites ' and
' Sphæronites.' Among crinoids with arms, the stalked forms
were always distinguished from the unstalked ; but it is not clear
that Müller intended this as a prime classificatory division, although
the point should not be omitted from any account of his views. Apart
from this he noted, not three, but five divisions in the Crinoidea
brachiata, viz. : (1) the Articulata, both stalked, as Pentacrinidæ, and
unstalked, as Antedonidæ ; (2) the Tessellata, both stalked, as most
Palæozoic crinoids, and unstalked, as *Marsupites* ; (3) the Costata,
unstalked only, and not to be described as a " great group," since it
included only the small genus *Saccocoma* ; (4) the Testacea, erected
for the reception of *Haplocrinus mespiliformis*, and defined thus : cup
and tegmen form a firm, connected test, with five ambulacra running
up to the mouth ; (5) *Holopus*, " eine ganz eigenthümliche Abthei-
lung der festsitzenden Crinoiden " (p. 210), with sessile cup and,
apparently, no anus (p. 229). " The stalked crinoids without arms,"
writes Müller (p. 229), " form two Families. Both are most
probably [unlike the Tessellata] provided with distinct mouth and
anus." The first Family is further distinguished from Tessellata
by having a star-shaped arrangement of ambulacra on the ventral
surface of the calyx : " these are the Pentremites." The second
Family, which may be described in Müller's words as " Die
Tessellata dieser Abtheilung, ohne Stern von Tentakelfelder," are
the Sphæronites " with their genera as established by Mr. von
Buch (1840)." It was probably this phrase " Die Tessellata
dieser Abtheilung " that led Messrs. Wachsmuth and Springer
to suppose that Müller really meant to class the Cystidea in the
Tessellata ; surely he merely meant to imply that they followed
in this one respect the 'tessellate' type of structure. In any case
the phrase shows that he did not place the Blastoidea with the
Tessellata ; in fact, on the previous page he compares them, much
in the same way, with the Testacea.

It results from the above that the statement on p. 23, that Zittel in
1879 followed Müller in his classification, is also incorrect. For
Zittel really did divide the Crinoidea brachiata, or Eucrinoidea as he
called them, into three suborders, merging *Holopus* and the Testacea
in the Articulata.

I do not know what is meant by " Roemer's classical memoir on
the Cystidea," but everybody knows his memoir on the Blastoidea,
and knows that it was published in 1851, not in 1855 as would
follow from the remarks on p. 17 of the present monograph. The
reference to Pictet's Paléontologie on the same page should not be
" Tom. v " but " 2e edition, tom. iv.''

The account of the successive classifications proposed by
Wachsmuth and Springer themselves is clear, and will be
welcomed by many who have not mastered all the previous

writings of these authors. But in the account of P. H. Carpenter's views is a curious omission. The division of the Crinoidea by Wachsmuth and Springer into Palæocrinoidea and Stomatocrinoidea was accepted by Carpenter and Etheridge, jun., in 1881 (Ann. Mag. Nat. Hist., [5,] vii, 281–298) ; the latter authors, however, laid more stress on the asymmetry of the posterior interradius in Palæocrinoidea than on the condition of the tegmen, and therefore suggested the names Irregularia and Regularia.

It is personally gratifying to gather from this history that the first rejection of the division into Palæocrinoidea and Neocrinoidea must have been independently and synchronously published by these eminent American authorities and by myself (February, 1889) ; further, that in applying the logical consequences of the tegminal structure of *Taxocrinus* to all Crinoidea, I actually preceded them by half a year (April, 1890). No one will suffer from the absence of all allusion to this in the present monograph, which certainly does not err in the direction of underestimating any contributions that I have so far been able to make to our knowledge of the Crinoidea.

Such errors as have been pointed out do not materially detract from the value of the monograph, and we can readily forgive a few such slips when we remember the age and ill-health with which the senior author had to struggle, and the constant pressure of other occupation that must have made his colleague's revision of the proofs a task of no ordinary difficulty. These circumstances will, I hope, always be borne in mind by any who read the present or future chapters of this review. F. A. BATHER.

(*To be continued.*)

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—April 20, 1898.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read :—

1. " Note on an Ebbing and Flowing Well, at Newton Nottage (Glamorganshire)." By H. G. Madan, Esq., M.A., F.C.S. (Communicated by A. Strahan, Esq., M.A., F.G.S.)

This well lies in a direct line drawn north and south from the church of Newton Nottage to the sea, about 80 yards south of the church and 500 yards from the sea. Sand-hills about 20 or 30 feet high lie between it and the sea. A range of Carboniferous Limestone cliffs runs east and west to the north of the church, while the same formation crops out in the sea at half-tide level. Between the two there is a band of Keuper conglomerate covered in one place at least by 7 feet of brown loamy clay with pebbles. At the shore-junction of conglomerate and limestone numerous springs occur, and it is in the conglomerate that the well is sunk, its bottom being 8 feet above ordnance datum.

A series of about forty observations made at intervals of an hour (and in many cases at the intermediate half-hours) during three

consecutive days, enables the author to construct a curve showing the relationship existing between the rise and fall of the tide on the coast and that of the water in the well. The result is to establish the existence of a wave in the well of the same frequency as the tidal wave, but delayed, or with an establishment of, three hours (*plus* or *minus* a few minutes).

The analyses of water taken from the well at its highest and lowest show no difference, so that no sea-water enters the well directly. On the other hand, the slight brackishness of the water appears to prove the diffusion of a small amount of salt water into the well.

2. " *Petalocrinus.*"   By F. A. Bather, Esq., M.A., F.G.S.

Certain curious fan-like objects, obviously echinodermal, have for a long time been preserved in the Riks-Museum at Stockholm, but their significance was first definitely ascertained when similar fossils were found in Iowa, and brought to England by Mrs. Davidson. The latter were described by Mr. Stuart Weller in a paper entitled " *Petalocrinus mirabilis* (n.sp.), and a New American Fauna "; and the former, with fresh material obtained by Mr. Weller from various American localities, are the subject of the present communication.

The Silurian crinoid genus *Petalocrinus,* Weller, is discussed, on the evidence of all the original material from Iowa and of the further material above mentioned. The replacement of the original material of the Iowan fossils by silica has taken place only in certain parts, forming a number of siliceous boxes, as it were, which are either hollow or more or less filled with chalcedony or crypto-crystalline silica. They are therefore neither casts nor impressions, and details of structure are frequently destroyed.

Petalocrinus is shown to have a dicyclic base—not monocyclic, as originally described. The structure of the tegmen is shown to be that of the Cyathocrinoidea. The arm-fans characteristic of the genus are proved to have been formed by fusion of the branches of an arm of Cyathocrinid type. In them, description is given for the first time of axial canals, covering-plates, the articular facet, and various minor structures. The species *P. major,* Weller, is shown to be an *Omphyma* ; but *P. mirabilis,* Weller, the genotype, is re-described, and with it five new species—two from Iowa ; three, as well as a possible mutation of one of them, from Gotland. A family Petalocrinidæ, descended from the Cyathocrinidæ, probably by way of *Arachnocrinus,* is founded for the reception of this genus.

3. "On the Origin of the Auriferous Conglomerates of the Gold Coast Colony (West Africa)."   By Thomas B. F. Sam, Esq., C.E. (Communicated by J. Logan Lobley, Esq., F.G.S.)

This paper gives an account of a recent journey from Adjah Bippo to the Ankobra Junction in the Gold Coast Colony. A range of clay-slate hills is succeeded for six miles by flat ground in which diorite was found, and that by a lofty hill in which clay-slate dipping east occurs. The Teberibie range with reefs of conglomerate, and a second range with similar reefs, were crossed.

Gold-bearing alluvia are briefly described, and the gold is supposed to have come from the hills. The Adjah Bippo, Takwa, and Teberibie formations are considered to be part of a syncline. Some conclusions are drawn as to the method of formation and probable auriferous character of the rocks.

II.—May 4, 1898.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read :—

1. "The Carboniferous Limestone of the Country around Llandudno." By G. H. Morton, Esq., F.G.S.

Llandudno is so well known and frequently visited, that the Carboniferous Limestone and the subdivisions into which it is divided by clear lithological characters may be more easily examined there than at any other similar locality. The subdivisions of "Lower Brown," "Middle White," and "Upper Grey," along the broad belt of limestone from Llanymynech to Prestatyn, and around the Vale of Clwyd, Abergele, and Llandulas, have been so frequently described in the Proceedings of the Liverpool Geological Society that it is unnecessary to give any general description of them. At Llandudno the precipitous Great Orme's Head presents fine sections of the Carboniferous Limestone and the subdivisions referred to, and may be easily examined (with the aid of the appended geological map), in a continuous series of cliffs, ridges, and quarries. The entire succession is, however, not perfect, for the highest beds of the "Upper Grey Limestone" have been denuded, and at the Little Orme's Head the subdivision is altogether absent.

Copper-lodes on the Great Orme's Head appear to have been worked by the Romans, and again in recent years until abandoned fully thirty years ago. Some of the lodes are faults, but little can be ascertained about them now, and only two or three are faults with any appreciable amount of dislocation. It is to the undulation of the limestone that the ever-varying dip of the beds is attributed.

Numerous fossils occur in the "Upper Grey Limestone," and a few are peculiar to the subdivision and the locality, but of these only a single specimen of each has been found. *Productus margaritaceus* is abundant, though only an occasional species in other localities, and not found at a lower horizon anywhere else in North Wales. Other species, such as *Orthis Michelini*, formerly supposed to be peculiar to the "Upper Grey Limestone," have been found at the base of the "Middle White Limestone," at the Flagstaff Quarry on the Marine Drive, near the Happy Valley.

The dolomitization of the Carboniferous Limestone is remarkable, and almost peculiar to that around Llandudno, though it also occurs at Penmon in Anglesey. The "Lower Brown Limestone" has been almost entirely converted into dolomite, and portions of the overlying subdivisions. The filling of the faults has often been changed into dolomite, and the alteration of the Limestone has generally been very capricious : the author's opinion being that the change took place after the dislocation of the strata in post-Triassic times.

To illustrate Miss G. L. Elles's paper on the Graptolite-Fauna of the Skiddaw Slates.

LAKE DISTRICT.	S. WALES.	S. SCOTLAND.	CANADA.	SWEDEN (SCANIA), AFTER TULLBERG.
(Borrowdale Volcanic Series.)				
Upper Skiddaw Slates.	? Llandeilo.			Higher Zones of Dicellograptus-shales.
(a) Milburn Beds.				Zone (n) Glossograptus.
(b) Ellergill Beds, with Diplograptus.	Llanvirn.	? Lower parts of Barr Series.		Zone (o) D. geminus.
				Lower part of Dicellograptus-Skiffer.
Middle Skiddaw Slates.				Zone of Phyllograptus cf. typus (Hall).
(a) Upper Tetragraptus-beds.	Upper Arenig.			
(b) Dichograptus-beds.	Middle Arenig.	Benmane Shales.	Quebec Group.	Orthoceras-limestone.
(c) Lower Tetragraptus-beds.	Lower Arenig.			Tetragraptus-beds.
				Phyllograptus-Skiffer.
Lower Skiddaw Slates.				
(a) Bryograptus-beds.	Tremadoc.			Ceratopyge-beds.
(b) ?	? Lingula-flags.			

Table showing the relationships of the divisions of the Skiddaw Slates with the other rocks of these areas.

2. "The Graptolite-Fauna of the Skiddaw Slates." By Miss G. L. Elles. (Communicated by J. E. Marr, Esq., M.A., F.R.S., F.G.S.)

This paper deals not only with the collections of the author, but with the Dover Collection and others preserved in the Woodwardian Museum, with the collections of Professor H. A. Nicholson, Mr. Postlethwaite, and that of the Keswick Museum of Natural History. An account of the literature, both stratigraphical and palæontological, of the Skiddaw Slates is given, followed by a list of all the graptolites known from the beds. This list comprises 22 genera and 59 species.

In the ensuing description all the known genera and species are noted, and corrections and additions made to existing knowledge concerning the diagnosis, structure, and development of many of them.

The following seven species, new to this country—*Bryograptus ramosus* (Brög.), *Clonograptus tenellus* (Linn.), *Trochograptus diffusus* (Holm), *Pterograptus* (Holm) sp., *Didymograptus gracilis* (Törnq.), *Azygograptus suecicus* (Mbg.), *Diplograptus appendiculatus* (Törnq. MS.)—and ten new species and varieties are described.

A table showing the distribution of the Skiddaw graptolites in the Arenig rocks of Great Britain, in the *Phyllograptus*-Skiffer, etc., of Sweden, and the Quebec Group of Canada is given, and the accompanying (contracted) table (p. 286) expresses the relationships of the divisions of the Skiddaw Slates with the rocks of these areas.

In conclusion, the author is struck with the remarkable resemblances existing between the species of various genera; these can be so easily explained by supposing that the forms in question are the results of development along certain lines, that she offers the suggestion that this is their real origin. In dealing with the phylogeny, she divides these graptolites into two groups—

(1) Those derived from a *Bryograptus*-form.
(2) Those derived from a *Clonograptus*-form.

To the first group belong 15 named graptolites from the Skiddaw Slates and 4 species from other localities; and to the second 12 Skiddaw species and 2 others.

CORRESPONDENCE.

THE LLANBERIS UNCONFORMITY.

Sɪʀ,—As my name has figured much in your pages for the last two months permit me to say that I have no intention of replying to Mr. Blake's "Revindication of the Llanberis Unconformity." My chief reasons for adopting this course are: (1) It would be necessary for me to investigate on the ground all statements which rest only on his authority, because hitherto I have so often found that what he deems facts appear to me to be fancies. For this task I have now no time, being tied much more closely to London than was formerly the case, so that my short vacations are devoted to work which offers greater attractions. (2) Controversy with

Mr. Blake is endless. What is one year "a crucial test" and "a decisive proof" is thrown overboard in another as absolutely unimportant, nay, as a good riddance (compare Q.J.G.S., 1888, p. 284, with id., 1892, p. 244, and this Magazine, 1891, p. 487). It is like seeking to tie down Proteus. Prove him wrong, that point is dropped and another is started: " Primo avulso non deficit alter Plumbeus." I will therefore merely say that some of the slips or changes of opinion, which he attributes to me, exist only in his own imagination, and that in regard to one or two points where I have altered my mind (and have never made any secret of it as he seems to insinuate) I am not ashamed to draw fresh inferences when new facts have been discovered. Thus I have had to unlearn much that I was taught in my younger days about crystalline and metamorphic rocks by those to whom I looked up. So I am content (as I believe Miss Raisin is) to leave Mr. Blake apparently in possession of the field, unless it should happen that some former pupil, anxious to flesh a maiden sword, should crave for a subject, in which case I promise to recommend to him the "Revindication of the Llanberis Unconformity."   T. G. BONNEY.

UNIVERSITY COLLEGE, LONDON.
    May, 1898.

OBITUARY.

EDWARD WILSON, F.G.S.—We have just received (May 23rd) the sad intelligence of the loss of our highly esteemed fellow-worker in Geology, Edward Wilson, F.G.S., for fourteen years the untiring Curator of the Bristol Museum, whose published papers have appeared in the Quarterly Journal of the Geological Society, the GEOLOGICAL MAGAZINE, and other periodicals. In 1888 he received the award of the Murchison Fund from the Council of the Geological Society (of which Society he had been elected a Fellow in 1872). Mr. Wilson's published papers date back for thirty years, and deal with the Red Marls, the Keuper and Bunter Beds, the Rhætic, and Lias. He has also published papers upon the Liassic Gasteropoda, etc. At the time of his death he was investigating the Uphill Cave Deposits, near Weston-super-Mare. He passed away, after three weeks illness, on May 21st, 1898, in his 49th year.

MISCELLANEOUS.

GEOLOGICAL SURVEY APPOINTMENTS.—The vacancy caused by the resignation of Mr. W. W. Watts has been filled by the appointment of Mr. W. Pollard, M.A., D.Sc., who joins as an Assistant Geologist in the Petrographical Department; and that caused by the retirement of Mr. De Rance has been filled by Mr. C. B. Wedd, B.A., as Assistant Geologist. In Ireland, the petrographical work will be carried on by Mr. H. J. Seymour, B.A., who succeeds as Assistant Geologist to the post left vacant by the resignation of Professor Sollas.
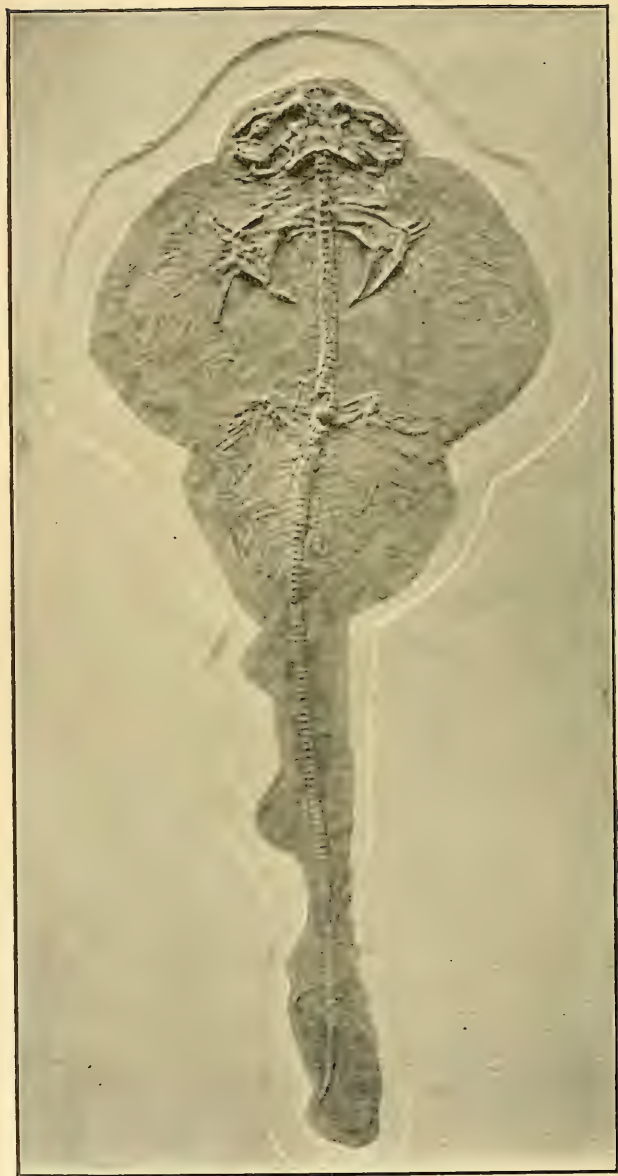
Squatina acanthoderma, O. Fraas, 1854.
Lithographic Stone: Nusplingen, Würtemberg.

ORIGINAL ARTICLES.

I.—Preliminary Note on a New Specimen of *Squatina* from the Lithographic Stone of Nusplingen, Würtemberg.

By Arthur Smith Woodward, F.L.S., F.G.S.

PLATE X.

SEVERAL specimens of extinct species of the angel-fish or monk-fish (*Squatina*) are already known from the Lithographic Stone (Lower Kimmeridgian) of Bavaria, Würtemberg, and France; and some of these are in an admirable state of preservation. Two forms are clearly distinguishable—the one a small fish not more than 0·15 m. in length, with a dense armour of rounded dermal tubercles on the anterior border of the head and each of the paired fins, and upon the lateral aspect of the tail;[1] the other a comparatively large fish, attaining a length of at least a metre, without any similar development of the dermal tubercles, either in the regions mentioned or on any other part of the body.

An imperfect example of the latter fish from Eichstädt, Bavaria, was originally described by Münster[2] under the name of *Thaumas alifer*, and subsequently referred by Giebel[3] to the existing genus *Squatina*. Some years afterwards a finer specimen, either of the same or a closely allied species, from Nusplingen, Würtemberg, was described in detail by Fraas[4] under the name of *Squatina acanthoderma*. In 1859 the specific identity of this fish with the Eichstädt fossil was first maintained by Von Meyer;[5] and still more recently the same opinion was expressed by Von Zittel,[6] who briefly described and figured a nearly complete example from Eichstädt more than a metre in length. Quite lately an equally fine specimen has been obtained by Mr. B. Stürtz from the classical quarry at Nusplingen; and it is thus possible now to compare complete examples of the fish from the Bavarian and Würtemberg localities.

[1] *Squatina speciosa*, H. von Meyer: Palæontographica, vol. vii (1859), p. 4, pl. i, fig. 2.

[2] Münster, "Beitr. Petrefakt.," pt. v (1842), p. 62, pl. vii, fig. 1.

[3] Giebel, "Fauna der Vorwelt—Fische" (1847), p. 298.

[4] O. Fraas, Zeitschr. deutsch. geol. Ges., vol. vi (1854), p. 782, pls. xxvii–xxix.

[5] H. von Meyer, Palæontogr., vol. vii (1859), p. 3.

[6] K. A. von Zittel, "Handbuch der Palaeontologie," vol. iii (1887), p. 92, fig. 105.

The new specimen from Nusplingen has been acquired by the British Museum, and is shown of about one-eighth the natural size in the accompanying photograph (Plate X). It measures 1·12 m. in total length, and is exposed from the dorsal aspect, exhibiting the complete outline of the fish, with all the fins. The tail is observed to occupy about one-half the total length of the fish; and the maximum width across the pectoral fins is somewhat less than half this length. The cranium and cartilages of the jaws, so far as they can be distinguished, are essentially identical with those of the recent *Squatina*; but the dentition is unfortunately not displayed.
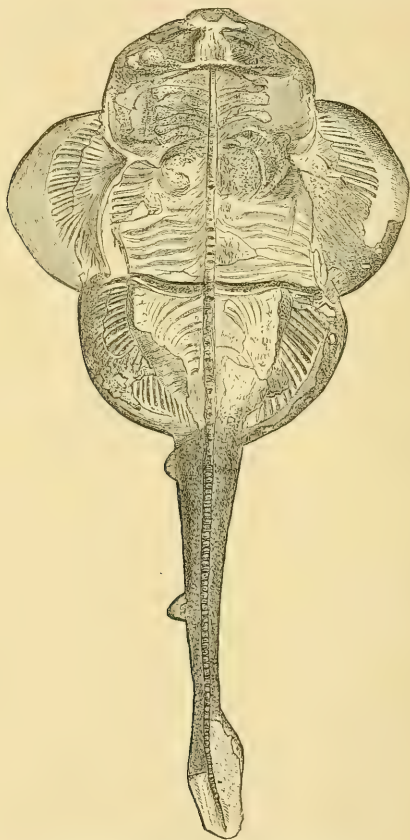
Fig. 1.—*Squatina alifera* (Münster).
Lithographic Stone (Lower Kimmeridgian): Eichstädt, Bavaria.
(From Von Zittel's "Handbuch.") One-tenth nat. size.

The vertebral column is complete, comprising about 150 well-calcified centra; and there are traces of the slender abdominal ribs in the region of the pelvis, while some of the laminar neural spines are seen both at the base of the tail and near its extremity within

the caudal fin. The characteristic pectoral arch and three basal cartilages are well preserved, especially on the right side; but the radial cartilages of the great pectoral fin are scattered and only imperfectly shown—indeed, partly destroyed. The imperfect pelvic cartilage lies beneath the thirtieth and thirty-first vertebral centra, where there is a slight displacement of the column; and the cartilages of both pelvic fins are somewhat scattered, though the long and slender basipterygium is distinct and in position on the right side. The anterior dorsal fin arises quite at the base of the tail, and is apparently similar in size to the posterior dorsal, which is separated from it by a space not exceeding the length of its base of insertion. The caudal fin is rather large, its extent considerably exceeding one-third the length of the tail. The trunk and fins are completely covered with very fine shagreen, which is apparently not enlarged or modified into spinous tubercles on any region.

On comparing this new fossil with the type-specimen of *Squatina acanthoderma*, of which there is a good plaster cast in the British Museum, it will be observed to agree precisely in the proportions of all the parts preserved. On the other hand, judging from the figure of the Eichstädt fish published by Von Zittel (Fig. 1), there seem to be several important differences between the latter and the new specimen from Nusplingen. For example, the Eichstädt fossil is represented as having a larger and broader head, relatively smaller pectoral fins, and much smaller and more widely separated median fins. These differences may, of course, be partially explained by imperfections in preservation, and differences in the mode of crushing; but it is obvious that the specific identity of *Squatina acanthoderma* from Nusplingen and *Squatina alifera* from Eichstädt is by no means established.

II.—On some Triassic (?) Estheriæ from the Red Beds or Cimorron Series of Kansas.

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

PROFESSOR CHARLES S. PROSSER, Geological Department, Union College, Schenectady, N.Y., having sent me some specimens of *Estheria* found in the Red Beds or Cimorron Series of Kansas, with the request that I would determine the species, my notes on them are here offered to the Geological Magazine, in which other fossil *Estheriæ* from North America have been illustrated and described.

Professor Prosser has treated of "The Cimorron Series or the Red Beds" at pp. 75–95 of "The University Geological Survey of Kansas," vol. ii, 1897; and in the "Kansas University Quarterly," vol. vi, No. 4, October, 1897, p. 151, Professor Prosser, in giving an account of the Red Beds or Cimorron Series, states that Mr. C. N. Gould had lately found a number of invertebrate fossils (presumably the *Estheria* under notice) in a soft red sandstone not more than 100 feet above the base of the Red Beds or Cimorron

Series, eight miles west and three miles south of Hunnewell, Sumner County, Kansas.

Two of the longer and one of the shorter forms are here figured.
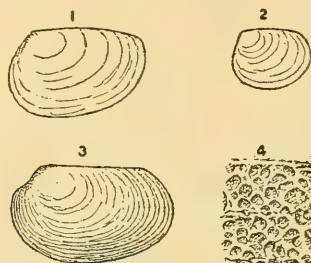
Fig. 1.—Oblique-oblong, deeper in front than behind; umbo forward and rather prominent; dorsal margin nearly straight or very slightly convex; ventral margin elliptically curved, full in the anterior region. Measures 4·5 mm. in length, and 2·5 mm. in height. Magn. 4 diam.

Fig. 2.—Smaller form, subquadrate, rounded behind, subtruncate in front, probably a young condition. It measures 2·5 by 2·0 mm. Magn. 4 diam.

Fig. 3.—The interior of the mould or hollow cast of a larger and more oblong variety. Magn. 4 diam.

Fig. 4.—Irregular and variable siliceous deposit among the sand-grains. Magn. 30 diam.

Among the specimens some have the following different measurements, but all appear to belong to one species: 5 × 3 mm.; 4·5 × 2·5 mm.; 4 × 3 mm.; 4 × 2·5 mm.; 2·5 × 2 mm.

Of the published forms the one that approaches most nearly this *Estheria* from the Red Beds of Kansas is shown by fig. 1, pl. ii, "Monograph Foss. Estheriæ," Pal. Soc., 1862, and described at p. 57, etc. This measures 5·5 by 3·6 mm., and is rather higher in the posterior region than the sketch, Fig. 1, here given.

The smaller form (Fig. 2) has an analogue as to shape in fig. 4 (5·3 by 4·0 mm.), and as to shape and size in fig. 14 (2·5 by 1·8 mm.); also in the somewhat similar young, sexual, or varietal forms of other species.

We may also compare the larger of the first two sketches with Fig. 3, Pl. XI, Geol. Mag., Dec. IV, Vol. IV (1897), described at p. 290 (*Estheria Mawsoni*, from the Cretaceous strata of Brazil); but here the antero-ventral region is too prominent. Its interstitial ornament is of a *bar* pattern, of which we have no indication in the Kansas specimens. It measures 5·3 by 3·6 mm.

The figs. 26 and 27 of pl. iii, "Monogr. Foss. Esth." (about 5·3 mm. in length), approach in shape, and they exhibit good examples of the prominent umbo; but their interstitial ornament is bar-like.

Estheria Lewisii, J., from Bucks Co., Pennsylvania (Geol. Mag., Dec. III, Vol. VII, 1890, p. 385, Pl. XII, Figs. 3a, b), measures 5 by 3 mm., and is too broadly and fully curved on the ventral margin, and too high in the posterior region, to match the Kansas form.
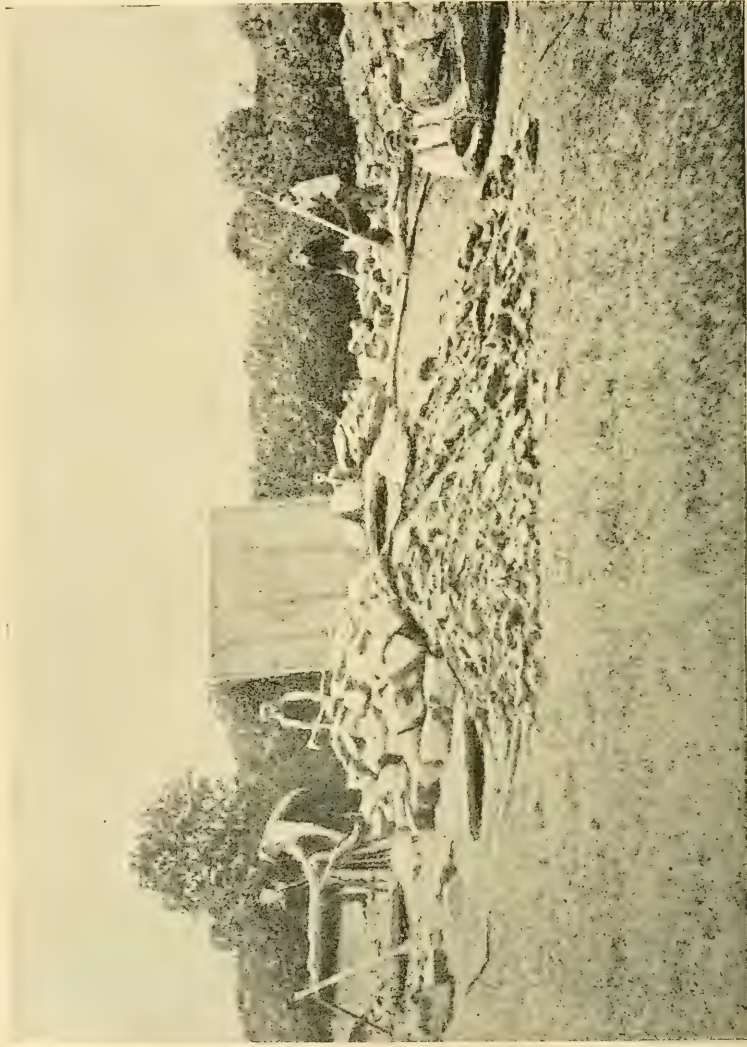
Modern "Dene Hole" Makers working in the "Purbecks" of Brightling, Sussex.

The picture shows four pits in all stages of the working and completion.

Estheria Hindei, J., from Phœnixville, Pennsylvania (GEOL. MAG., Dec. III, Vol. VIII, 1891, p. 51, Pl. IX, Figs. 5–8), measures 7 by 4·5 mm., and is nearly oblong, that is, higher anteriorly; and although much like the Kansas *Estheria*, its relative size, small umbo, and boldness of the concentric striæ are distinctions; and there is no trace of its bar ornament in the other form.

Imbedded in a coarse sandstone, the Kansas *Estheriæ* are too badly preserved to exhibit their interstitial sculpture. Their concentric lines of growth are recognizable (Fig. 3), but nothing else satisfactorily. There is a delicate, siliceous, irregularly reticulate, white infiltration among the grains of quartz (Fig. 4), which gives in the hollow casts a false appearance of ornament, especially where the concentric lines are present; but it cannot be so regarded at all.

The relative specific value of the North-American *Estheriæ* and portions of their ornament, figured in the "Monogr. Foss. Estheriæ," 1862, has been estimated by me in the GEOL. MAG., 1890, p. 386, and 1891, p. 51.

The conclusion arrived at is, that the *Estheriæ* from the Red Beds (or Cimorron Series) of Kansas and Oklahoma should be registered the same as the Triassic *Estheria minuta* (Alberti). If, however, the interstitial ornament is found well preserved, it may prove the species to be different.

III.—ANCIENT AND MODERN "DENE HOLES" AND THEIR MAKERS.

By CHARLES DAWSON, F.S.A., F.G.S.

(PLATES XI AND XII.)

THE name "Dene Holes" has been locally given to certain ancient artificial caverns usually found excavated in the Chalk of Essex and Kent. They have deep vertical entrances by shafts, being of varying depth, but the caverns themselves all bear a general similitude in design. They have been chiefly explored in the counties of Essex and Kent, although they undoubtedly exist in many other counties.[1]

In places where the chalk stratum is overlain by some other deposit, the latter has been cut through by a shaft and the chambers have been formed in the solid chalk below, leaving as a rule only sufficient chalk between the cavity and the superincumbent strata to ensure the stability of the roof.

No spoil heaps of chalk are found near them on the surface, showing that the chalk taken out has been disposed of, and unfortunately nothing has been discovered within the chambers which gives any decisive clue to their age, origin, or use, although from objects discovered many are thus proved to have been in existence for some centuries.

It has been surmised by some that they have been used as habitations, but there is not the slightest internal evidence of this.

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[1] The writer and Mr. John Lewis, C.E., F.S.A., descended two very fine ones at Brighton, Sussex. One of these was incomplete with respect to depth. In the floor were excavated two or three steps. The workmen seemed to have been excavating the chalk laterally from these steps and thus lowering the floor.

Others imagine that they were hiding-places or stores for crops, but both these latter suggestions, in absence of direct evidence, are rendered unlikely by the size, depth, and number of the pits, and their close proximity to one another. They differ very much from those much smaller beehive-shaped excavations discovered in Portland and which, with probability, may be considered to represent a type of the true silos or grain-pits of ancient writers.[1]   The dene holes ere of very considerable size and would have held an enormous amount of grain or fodder, and this notwithstanding that their normal size may have been slightly exaggerated by falls of blocks of chalk from the roof and sides.   Judging from the wonderful stability of the shafts in many cases, the formation of these particular pits may have extended over some years, perhaps by intermittent excavation until the chambers got too large to be conveniently worked.   With respect to similar classes of these excavations existing elsewhere, the stability of the rock and subsoil does not seem to have admitted of this intermittent working.

To those people who have made a study of these excavations[2] the chief points which present themselves as requiring elucidation are as follows :—

If these pits are merely chalk-pits (which theory is the natural presumption which first occurs to the mind)—

1. Why are they frequently clustered together ; and although they are dug so close to one another yet they are never intentionally connected ?

2. Why are they all constructed on the same general design and seemingly elaborate ground plan ?

3. And why were they dug for chalk when chalk itself occurs on the surface less than a mile away ?

It will be the object of this paper to answer the above questions by simple comparison of the so-called " dene holes " with excavations of exactly similar character and design, which have been worked for centuries, and which are still being worked in England.

In the centre of East Sussex, in a very old-world neighbourhood, many miles away from any railway station, there is exposed a series of rocks known as the " Purbeck Beds," being the lowest beds exposed in the South-East of England.   This strip of ancient strata, as it shows itself, is about $8\frac{1}{2}$ miles long by 1 mile in width. Here and there beds of limestone called " the Greys " and " the Blues " are to be discovered, sometimes cropping out and sometimes occurring within a short distance of the surface.   Up to the middle of the present century, and doubtless for centuries past, this stone has been quarried to be burnt for lime, and proved to make a cement of exceptional hydraulic properties.

For many years past the quarrying of the limestone has been given up ; but the stone is now being excavated for " road-metal," and thus used for many miles around.

[1] See Mr. T. V. Holmes' paper in the Essex Field Club Transactions, 1887, p. 253.

[2] See Essex Field Club Reports, especially Mr. T. V. Holmes' paper, vol. 1887 ; also Mr. Miller Christy's paper in the *Reliquary*, April, 1895.

The whole of this area is covered with countless thousands of pits resembling the dene holes of Essex and Kent. They represent, in fact, the result of the usual method of procuring the limestone wherever the stone is quarried from a depth below the surface of the ground. The workmen, who with their forefathers have been accustomed to this industry all their lives, perform the work with wonderful celerity. The stratum of stone having been ascertained to exist near the surface, a well about three to four feet in diameter is commenced in certain blue and brown shales, and usually reaches the limestone within 40 feet (sometimes 50 or 55 feet) from the surface. The cavity above the stone is then belled out on all sides to a diameter varying with the stability· of the strata. Sometimes the cavity is 15 or 16 feet in diameter, sometimes considerably more. The stone is then removed, and four small arched lateral chambers are dug at four equidistant points in the side of the bell-shaped cavity so as to extract as much stone as the pitman dare without endangering his life. Three men are employed in and about the hole when in full working order. The stone is hauled up by one of the men on the surface by means of a windlass of very primitive description and a handle of a curved peculiar shape which is characteristic. Sometimes there is a handle each end of the windlass where the work is heavy.
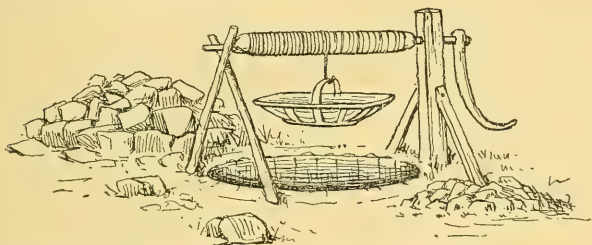
Stone Pit-mouth, showing primitive Windlass and " Trug-Basket."

To the cord is attached a Sussex "trug-basket," in which the smaller fragments of the stone are hauled up; the larger pieces are tied by the cord and hauled separately. The writer made the usual descent into the pit, which is performed by placing the toe on the hook of the cord and holding the rope above, the windlass being carefully unwound by the man at the surface. With a frayed rope not an inch in diameter this may seem dangerous; but few accidents have been known to occur.

While the last pieces of stone are being removed from the pit one of the men commences another shaft about six yards away, so that it may be well forward by the time the other work is completed. Sufficient room is scrupulously left to prevent one chamber encroaching too near to the other, and it is therefore necessary to adopt some regularity in their design. And so the operation is repeated over and over again without any variation of importance.

When asked why they do not run galleries and mine the stone with timbered and propped sides, they say that the way they do it occupies less time, is least expensive, and that they work always in the same general design because they know, by experience, that it is a safe one. Indeed, the whole operation of digging a well and getting out the stone is only a matter of a few days; and they then fill one pit with the débris from another. Their rule of thumb formula as to whether a shaft will pay is : " A foot of dirt to an inch of stone = that pays." The deepest bed of limestone at Worge Farm and Perch Hill Farm, Brightling, is three feet thick; it however runs as thick as four feet in other places. The price of the stone is 4s. per yard, and the men have to pay 1s. 9d. per yard as a royalty to the landlord (1s. 6d.) and tenant (3d.). The workmen clear about 2s. 6d. to 3s. per day. The stone is carted a radius of five miles over hilly country.

The limestone has, however, a bad trick of "thinning out" very rapidly within a short distance, which cannot be discovered from the surface; and partly for this reason, and partly for the economy of the surface space, the pits usually occur in clusters (occasionally one may see these pits at work while another gang are quarrying the stone on the surface where it crops out about 200 yards away). On all sides one may see circular depressions caused by subsidences of the old pits having been insufficiently filled up. Besides these "bell pits" which I have mentioned I should point out that in ages past this system of working was the common one among the ironworkers of Sussex for procuring the iron stone or ore in the "Wadhurst Clay" and the "Fairlight Clays"[1] ("Hastings Wealden Beds"). Large numbers of these pits remain in the woods, but on the pastures and arable fields they are usually less traceable. Waste pits do not occur in connection with these "myne pits," because the lime and marl obtained in digging them was used as a flux for smelting the iron and top as a dressing in cultivation.[2] The chambers are very rarely connected by levels. As these pits occur in association with slag heaps containing Roman remains it is probable that the method of mining is at least as old as the period of the Roman occupation of Britain. The well-known passage from Pliny (the Elder, A.D. 23–79) concerning this class of excavation may refer to these iron mines. In describing the early process of "marling," he says : " Another kind of white chalk is 'Argentaria,'[3] which is brought from a depth of a hundred feet, the pits usually made narrow at the mouth, internally *as in metal mines the vein spreading out* (or widening, 'spatiante vena').[4] They

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[1] Near Crowborough Warren New Water Mill.

[2] Beside the writer's own authority on the subject may be quoted Mr. William Topley's memoir on the Weald Geological Survey: see titles " Iron Works " and " Lime."

[3] Argentaria (whitening), so called (as we learn from another passage in Pliny) because of the brightness it imparted to silver when rubbed with it (see book 35, chap. lviii, Pliny's " Natural History ").

[4] This passage has been misquoted by modern writers as " the veins running about."

use this chiefly in Britain." (Pliny's Natural History, book 17, chap. viii.)

In some parts of Hertfordshire and Bedfordshire[1] similar pits are still sunk through superincumbent strata for obtaining a chalk dressing, and these pits are of similar character to the " dene holes," and probably many other counties have examples of the working. I do not here propose to say much about the modern Hertfordshire and other recorded chalk pits or wells which belong to this class, but it may be interesting to give a description of these pits of Hertfordshire and Kent, as they were in full working order more than a century ago. They are described by the chief agricultural writers of that time, who wrote perfectly independently and innocently of dene-hole controversies !

I will commence first with Mr. Walker's Report on the Agriculture of Hertfordshire (reprinted by the Board of Trade, 1804; see p. 158), and who appears to have made notes in 1794. He says (see title *Chalk*) : " The prevailing practice of sinking pits for the purpose of chalking the surrounding land, enables me to remark in general that the basis of the soil in Hertfordshire will be found to consist of a deep bed of chalk ; the superstructure, an irregular indenture of chalk and earth pillars ; the earth pillars broadest at top, and narrowing as they descend, the chalk pillars broadest at the bottom, rising conically, and narrowing as they ascend to the surface. The chalk pillars frequently ascend to the surface and form part of the staple, and the whole extent of the apex is visible in ploughed lands. The earth pillars have been found to descend fifty feet and upwards, to the no small mortification of the chalk-pit diggers, who are frequently obliged to abandon a pit which they sunk in an earth pillar to the depth of twenty feet and upwards, and sink in a fresh pit with better hopes of success.

"This general rule, however, admits of many exceptions ; the chalk in several parts of the county is covered for many acres together with a great depth of earth, which often renders the question of a chalk basis uncertain, and the downs skirting the county towards Cambridgeshire are for the most part a continued bed of hurlock or bastard chalk covered with a very thin staple."

Our author then proceeds to give a description of the working of these pits.

" The undermentioned method is pursued in chalking land, and the persons employed therein follow it as a trade. A spot is fixed upon nearly centrical to about six acres of land to be chalked. Here a pit, about four feet diameter, is sunk to the chalk, if found within twenty feet from the surface ; if not, the sinkers, considering that they are on an earth pillar, fill up the pit, and sink in fresh places till their labour is attended with better success."

He mentions a very curious circumstance which reminds us of the wattled covers to the shafts of the subterranean dwellings

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[1] Mackery End Farm, Harpenden ; Hyde Farm, near Luton ; New Mill End Farm, near Luton ; and many others.

"BELL PITS" at BRIGHTLING (Sussex)

Ground Plan of a Group

Perpendicular Section

SHAFT

PURBECK STRATA

Lateral chamber

STONE BAND

Ancient Kent Denehole

Ground plan.

CHALK

Ancient Essex Denehole

Ground plan

THANET SAND
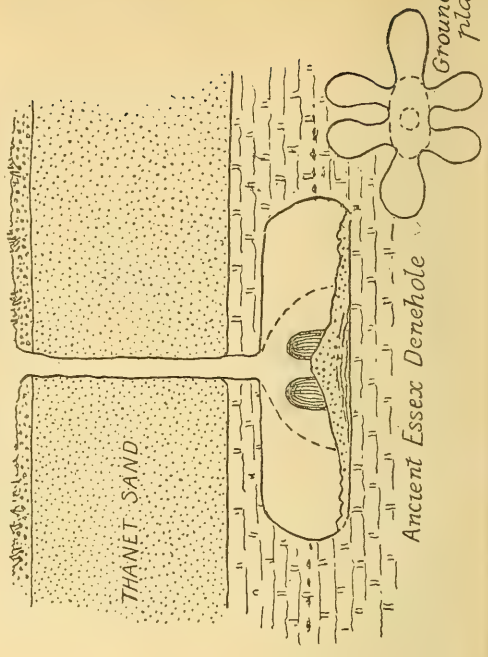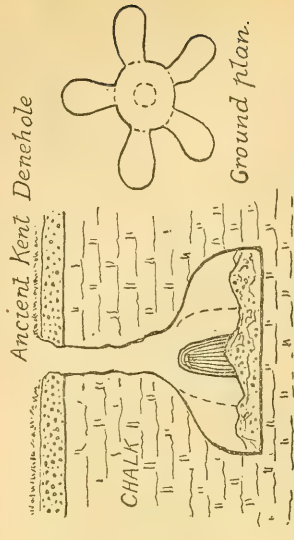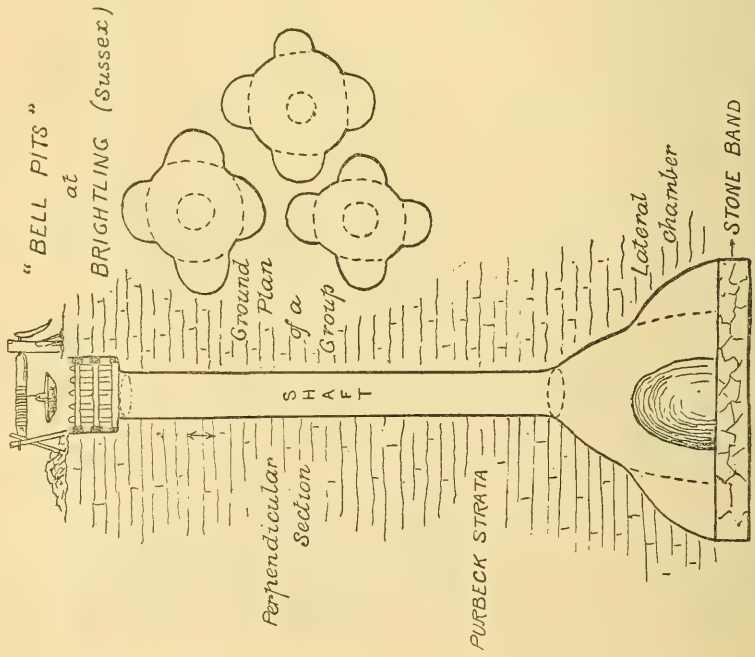
described by Dr. Blackmore and Mr. E. T. Stevens,[1] at Highfield, near Salisbury;[2] namely :—

" The pit from the surface to the chalk is kept from falling in by a kind of basket-work made with hazel, or willow rods and brushwood, cut green, and manufactured with the small boughs and leaves remaining thereon to make the basket-work closer. The earth and chalk are raised from the pit by a ' Jack rowl ' on a frame, generally of very simple and rude construction. To one end of the rowl is fixed a cart-wheel which answers the double purpose of a fly and a stop; an inch rope of sufficient length is wound round the rowl, to one end of which is affixed a weight which nearly counterbalances the empty bucket fastened to the other end. This apology for an *axis in peritrochio,* two wheel-barrows, a spade, a shovel, and a pickaxe are all the necessary implements in the trade of a company of chalk-diggers, generally three in number. The pitman digs the chalk and fills the basket, and his companions alternately wind it up and wheel its contents upon the land. When the basket is wound up to the top of the pit, to stop its descent till emptied, the point of a wooden peg of sufficient length and strength is thrust by the perpendicular spoke in the wheel into a hole made in the adjoining upright or standard of the frame to receive it.

" The pit is sunk from twenty to thirty feet deep and then chambered at the bottom, that is, the pitman digs or cuts out the chalk horizontally in three separate directions, the horizontal apertures being of a sufficient height and width to admit of the pitman working in them with ease and safety."

The comparatively small expense of carrying out this mode of chalking is given by the same writer.

" One pit will chalk six acres, laying sixty loads on an acre. If more be laid on, and to the full extent of chalking, viz. 100 loads, then a proportionate less extent of land than six acres is chalked from one pit. Eighteen barrowfuls make a load, and the usual price for chalking is 7*d.* per load, all expenses included, therefore the expense of chalking at sixty loads per acre is £1 15*s.,* and at 100 ditto £2 18*s.* 4*d.*

" As the chalk is considered to be better the deeper it lies, and the top chalk, particularly if it lies within three or four feet of the surface, very indifferent, and only fit for lime or to be laid on the roads, gateways, etc., the chalkers must be directed to lay by the chalk for the first three or four feet in depth, to be applied to the above purpose. If it be not wanted for those uses it is again thrown into the pit. When filled up, Mr. Walker also observes that the flints must be picked out from the chalk before it is carried on to the land, for if the pit-makers are not narrowly watched they will chalk with both." [3]

[1] See Report on the Blackmore Museum, pt. ii, p. 152.
[2] The interior of these dwellings as described are perfectly distinct in form from the so-called " dene holes."
[3] The flints are sometimes found squared, and are used to line the mouth of the well. In the two Brighton ones the upper or bad chalk had been similarly used.

I have taken the opinion of an analyst on the question of chalk quarries from a depth being better than that obtained from near the surface.   Mr. S. A. Woodhead, B.Sc., public analyst for Sussex, says :—

" *Calcium carbonate* (chalk) is insoluble in water, but if the water is charged with carbon dioxide the calcium carbonate then becomes soluble, because it is changed into the bicarbonate.   From this it is seen that the carbonate may be changed to the bicarbonate, and this bicarbonate is soluble in water.

" If the calcium bicarbonate comes in contact with ordinary lime and water it becomes changed into the carbonate of lime, which, being insoluble in water, is deposited in the same condition as it was taken up, i.e. as calcium carbonate (chalk).

" Below, one gets a more soluble form of chalk, by reason of the precipitation above-mentioned, which, when laid on land containing organic matter, unites with nitric acid found in the soil and forms calcium nitrate (nitrate of lime), which is an actual plant food."

Mr. Walker quotes instances of practical experience in chalking. Mr. W. J. Malden, Principal of the East Sussex Agricultural College, in support of this view says :—" Farmers throughout the Chalk areas invariably lay aside the first few feet in digging a chalk-pit, as common experience has shown that this chalk exercises no beneficial effect, whereas much good is done by that obtained by that lower down."

" Mr. Byde (Ware Park) pays for winding it up in buckets 7$d.$ a load of twenty-four bushels, and 8$d.$ a foot for the shaft till the chalk is found ; the men barrow it on to the land at the distance of twenty poles for 8$d.$, *but then they open a fresh shaft every forty yards.*   They have 2$d.$ in the shilling for beer, and for filling it into carts and spreading it 4$d.$ a load more.

" Forty loads are the common quantities per acre.   He finds fifteen loads of chalk per acre *repeated once in ten or twenty years* much better than a large quantity at once."

He sums up the reasons why these pits were used in preference to open workings which, by the distance away, would necessitate the use of horses and carts.

He concludes: " Upon the whole, I must observe that this husbandry, which is general throughout the county, has considerable merit ; but the great singularity is the long-established practice of drawing up by shafts and barrowing it on to the land.   Those who have been accustomed to the marle carts of Norfolk and Suffolk know what severe work to the teams that business always proves and what a most heavy expense attends it.   Horses of great value are often lamed or destroyed, and the purchase of carts and harness, with the wear and tear of both, form very heavy articles. *The Hertfordshire custom is therefore much to be preferred.*

" Two or three pounds per acre could be easily afforded by men who could not set any regular clay carts at work for want of a scale of business proportioned to such teams, etc."

Surprise has been expressed among those who have dug trenches

on the surface near the Essex dene holes that no fragments of chalk
have been discovered by them, and this has been looked upon
by some as evidence that the excavators of these pits, desiring
secrecy, distributed the spoil over a wide area.   The following
passages from the *Complete Farmer*, 1807, describing this class
of chalk-pit, may have a direct bearing on the above subject :—

" In making use of it (the chalk) it should be broken as small
as possible.   It should be dug near the end of autumn and laid
on immediately.   At that season the air is generally moist ; the
moisture will be absorbed by the chalk ; this will occasion it to
swell and break into pieces, and if frost comes on it will accelerate
the business.   It should in no case be ploughed in till its parts are
properly separated and 'reduced to crumbs,' and then it should be
completely harrowed in and mixed with the soil."

Mr. Bannister also says, when land is dressed with chalk, pulveri-
zation is the chief aim to secure the full virtue of this manure.

It may seem an extraordinary thing that the practice of chalking
from deep wells, like those in Essex, should have ceased entirely
and their origin forgotten in that county.   At all events, although
it seems that these chalk wells were dug in the adjoining counties,
we find that in Essex, at the end of the last century, chalk was
brought from Maldon, where it was landed in barges loaded from
the chalk cliffs of Kent.   It cost 10s. a load at Maldon, and was
then carted several miles into the country to manure the land.

Mr. John Bannister, of Horton Kirby,[1] Kent, writing in 1799 of
the practice of chalking, observes that " there are two methods
of obtaining chalk ; the first is, by uncallowing a piece of ground
and making it convenient for a pit, where carts may be drawn into
it and there filled.   This (open working) is on a presumption that
the chalk lies near the surface and that the pit is within a *small*
distance of the field on which the manure is to be laid."

The other method is to sink pits in the field where chalk is
intended to be laid as manure, *and which, he says, in his opinion,*
" is far preferable to that of drawing it in carts as before mentioned."
" In this case a number of pits are to be sunk according to the
extent of the field.   These pits are to be made in the form and
circumference of a well with an apparatus at the top and a bucket
to draw up the chalk.   The people who undertake the business,
having been brought up to it from the cradle, perform it with great
facility, and without timidity, though attended with much danger.
A person is employed at the top to draw up the contents of the pit,
shoot the chalk into the cart, and wheel the same on to the land.

" When the labourer has arrived at the chalk, which takes up
a longer or less distance of time, according to the depth at which it
lies, and has dug some little time therein, in perpendicular form
wherein he began the pit, he proceeds to form apertures in different
horizontal directions ; so that where the chalk is good, and the pit
stands firm, large tracts of ground are undermined for this purpose."

[1] See his " Notes on Agriculture," chap. xviii, title ' Chalk Manure.'

The Editor of the *Complete Farmer* says : " Obstacles to the work sometimes fall out from the light contexture of the soil, which does not unfrequently give way to the destruction of the chalk drawer. To the farmer it may be of consequence to consider the nature of his land ere he embarks on the scheme of husbandry ; as, if from the circumstances above mentioned, he may have reason to think his pit will not stand firm, it would be a matter of prudence to desist from any further thoughts of sinking a perpendicular pit, and change the mode of operation by bringing his chalk from an uncallowed pit or (open working), but where it can be obtained at a moderate expense, and with a tolerable certainty of success, *the preceding method is certainly the most eligible.*"

The writer does not wish to occupy more space by " hammering a driven nail." It must surely be apparent to all those of logical mind who have read and explored both sides of the question that no mystery exists with respect to the " dene holes " in Essex. The whole class of these excavations have their origin and inception of design in the very ancient custom of " bell pit " mining. It might be argued, not unfairly, that the same system of working, identical in general design, may have been made use of for other purposes than for chalk quarries merely ; that is, assuming that further evidence exists of their having been so used, which, however, remains to be discovered with respect to the Essex " dene holes."

The writer thinks we may safely say that where such collateral evidence does *not* exist, and pits of this description are discovered from which the chalk has been removed and carried away, that the balance of probability in favour of their having been merely chalk-pits is overwhelming.

DESCRIPTION OF PLATE XI.

Modern Dene Holes and their makers at work in the " Purbecks " of Brightling, Sussex. Picture shows four pits in all stages of working and completion.

IV.—On a New Species of Brachyurous Crustacean from the Chert Beds (Upper Greensand), Baycliffe, near Maiden Bradley, Wilts.

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

HAVING, in March last, received from Mr. Jukes-Browne, F.G.S., of the Geological Survey, a small carapace of a crab obtained by Mr. J. Scanes, of The School House, Maiden Bradley, from a quarry in the Chert Beds of Baycliffe, near Maiden Bradley, Wilts, I endeavoured to identify it with some species of Cretaceous *Necrocarcinus* already described, but without success. I am therefore reluctantly compelled to refer it to a new species. The specimen is rather imperfect, which renders the task of determining its characters the more unsatisfactory.

The carapace appears to have been nearly equilateral (31 mm. long and 30 mm. broad) ; the right side is, however, imperfect, and the edge of the posterior border is also wanting. The surface is tumid,

and the centre is divided by a mesial furrow, and transversely by a well-marked cross-furrow ending in a notch upon the lateral border (*a, a*). The metagastric lobe is marked by two triangular-shaped swellings on either side of the mesial furrow, with their convex borders directed outwards and their points downwards; at the point of each swelling is a round pore, one being placed on either side of the mesial line: a transverse furrow divides the metagastric swelling from two others, marking the urogastric prominence. These have an indented, V-shaped furrow dividing them in the centre. Behind the gastric region is a lesser single median prominence marking the cardiac region, having two small subcentral puncta on it. On either side, occupying about one-third of the breadth of the lateral border of the carapace, is placed the branchial region. This is marked by a reniform swelling, and is divided from the hepatic region on the latero-anterior margin by a deep rounded notch (*a, a*), and by the great median transverse furrow which here crosses the carapace from side to side. The hepatic region is smooth and not elevated; the margin is marked by a single spine on the latero-anterior border, indicating the outer angle of the orbit. The rostrum is blunt and has a broad furrow down the centre, dividing the frontal region into two raised prominences.

The general surface of the carapace is smooth and devoid of tubercles and rugosities, and it is not quite certain in its present state of mineralization whether the outer layer may not have been removed. In any case, the divisions of the carapace are so distinct as to render it capable of determination, and in its present condition this form of *Necrocarcinus* may conveniently bear the trivial name of *N. glaber.*

Necrocarcinus glaber, sp. nov.   Twice nat. size.
From the Greensand Chert Beds, Baycliffe, near Maiden Bradley, Wilts.

Since the above was written Mr. Scanes has sent up another broken specimen, identical with the above, and in the same condition, so that we may justly conclude that they show the actual surface of the carapace. Mr. Scanes has kindly presented the specimen here figured to the British Museum (Natural History), to be preserved in the Geological Department.

V.—An exposure of Quartzite and Syenitic Rock
near Martley, Worcestershire.

By Charles St. Arnaud Coles.

THE section in which these rocks are exposed is seen in a field
at a distance of about a quarter of a mile from the village of
Martley and due north of Berrow Hill Farm.   Here is a small
excavation for roadstone, but it does not appear to have been
worked lately. Both the quartzite and syenitic rock are exposed,
the latter being very decomposed. The relations of the rocks to one
another appear to be as follows (see Figure) :—Below, at A, the
quartzite is seen to stand out conspicuously. Round this, as at B,
is a thin layer of powdery rotten rock, differing but little from the
rest of the decomposed syenite, forming a crust at C, but evidently
marking the junction of the quartzite and syenite ; the latter being
at D and E sufficiently undecomposed to allow of its being sliced.
Above comes a loose breccia consisting of fragments of these rocks,
but this is evidently surface soil.
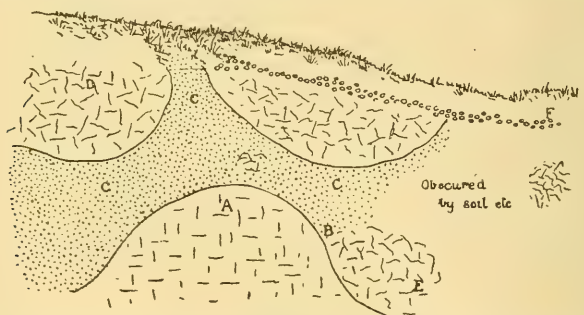
Syenitic Rock-exposure, near Martley, Worcestershire.
Diagrammatic section brought to one plane. A = Quartzite ; B, C = Decomposed
Syenite, that at C forming a slope ; D, E = Undecomposed Syenite ; F = surface soil.

This section appears to correspond in position with that noticed
by Professor Phillips ("On the Malvern and Abberley Hills," p. 8).
However, no quartzite is mentioned by him, and the Old Red,
Coal-measures, and Trias figured by him are not now visible.   It
seems probable, therefore, that the old excavation has been filled in,
and that the present one has been worked to a greater depth, owing,
most likely, to the discovery of the hard quartzite. A careful
examination of the two rocks shows that their apparent relation,
as mentioned above, in all probability is not the real one.

The syenitic rock, as has been mentioned, is very decomposed, but
two specimens have been sliced. The structure is holocrystalline.
Green mica and a felspar are the most prominent minerals,
but there is also a little quartz. The felspar occurs in large,
irregular, and fractured crystals, but is so kaolinized as to make
it impossible to state with certainty whether it is plagioclase or
orthoclase, but probably both are present. The mica is also much

decomposed and is partly replaced by chlorites and iron oxides; some of the latter mineral is, however, probably original, and appears to be titaniferous. The least altered biotite crystals form irregular wisps between those of the felspar. In this slice but little quartz is visible. There are also a few crystalline grains of a colourless silicate, with low polarization tints, one of which gives straight extinction. Possibly the mineral is zoisite. A second slice shows a larger quantity of quartz in the form of composite grains, probably due to fracture. Felspar and mica are present, as in the last slice, with the addition of a little hæmatite and one or two zircons. The rock is therefore a quartziferous mica-syenite or possibly diorite.

The rock obviously resembles the Malvern syenite. The similarity between the two has been noticed by Professor Phillips, and later by the Rev. W. S. Symonds ("Records of the Rocks," p. 37). Both these authors regard the rock at Martley as Malvernian in age; the former stating emphatically that it is not intrusive, and, in addition, that it differs from all other intrusive rocks in the neighbourhood. This syenite, so far as he could see, did not seem to have produced any alteration on the adjacent rocks.

The underlying quartzite exhibits a somewhat granular and saccharoidal structure. One specimen shows slickensides, another a very distinct and well-rounded pebble. On microscopic examination we find that the rock consists almost wholly of rounded grains of quartz, with a few fragments of decomposed felspar. One or two grains show a composite structure, as if derived from a schist. There are also clots of iron-oxide scattered about the slice. With crossed nicols each quartz grain is seen to be surrounded with a thin zone, evidently a secondary deposit. No strain shadows are visible, but dislocations are seen in parts of the field, and near them the grains are slightly crushed.

A second slice presents a very similar structure, but with a finer texture; the component grains not being so well rounded as in the last specimen. It shows no distinct signs of crushing, but is traversed by minute veins of quartz which occupy cracks.

The rock is therefore a quartzite with well-rounded grains, and is remarkably free from earthy matter. It is identical in every respect with that of the Lickey, and most probably belongs to the same geological age.

NOTICES OF MEMOIRS.

THE GEOLOGICAL SURVEY OF GREAT BRITAIN AND IRELAND.

[Having, through the kindness of Sir A. Geikie, been favoured with an early copy of the Summary of Progress of the Geological Survey for the past year, and finding it to contain matter of much general interest to geologists, we are glad to give it a special notice in our present number.—EDITOR.]

SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY FOR 1897.
By Sir A. GEIKIE, D.Sc., D.C.L., LL.D., F.R.S., F.G.S., Director-
General. 8vo; pp. 176. (London: Eyre & Spottiswoode, 1898.
Price 1s.)

INTRODUCTION.

AS no official publication up to the present time has given an
account of the origin, history, organization, methods, and aims
of the Geological Survey of the United Kingdom, advantage is
taken of the opportunity offered by the preparation of the present
Summary of Progress to prefix an Introductory Section, in which
these particulars may be specially set forth.

The objects for which the Geological Survey is carried on are
of a twofold character, scientific and practical. It is charged
with the preparation of a detailed map of the United Kingdom,
in which the geological structure of every district is worked out,
the boundaries and limits of the various rocks and superficial
deposits are traced, and the outcrop of each important seam or vein
is represented. Such a map forms the basis for an exact knowledge
of the geology of the country, and is thus of fundamental value
in the interests of pure science. It is also intimately connected
with many of the most important questions of every-day life. Thus,
by discriminating and delineating the different kinds of superficial
deposits and subsoils, the map provides a basis for the solution of
some of the chief problems in agriculture. It affords information
which is absolutely necessary in questions of water-supply, drainage,
and other sanitary matters. It supplies data required by the engineer
in constructing roads and railways, by the architect in providing
materials for new buildings, by the mining surveyor in determining
the position of new pits and mines.

Besides preparing the map, the Geological Survey constructs
detailed sections explanatory of the geological structure of the
country; also memoirs descriptive of the geology of the districts
represented on the sheets of the map, and larger monographs
illustrative of the various geological formations of Britain. It
collects specimens of the minerals, rocks, and fossils of each of
the three kingdoms, arranges and describes them, and displays
them to the public in the Museums in London, Edinburgh, and
Dublin.

Besides its contributions to the progress of geology as a science,
the Survey from the very beginning of its existence has kept in
view the general utility of its operations. It has been constantly
called upon by the various public Departments to furnish information
in regard to the practical application of geology. The general
public, also, has continually sought assistance of a similar kind.
Each of the three offices in London, Edinburgh, and Dublin has
become a centre of reference for information and advice on questions
in which a knowledge of the geology of the country is requisite.

The following introductory pages contain (1) a brief narrative
of the origin and progress of the Geological Survey and of the

Museum of Practical Geology, up to the present time; (2) a description of the various kinds of work carried on by the Survey in the field, in the office, and in the museum, with an account of the publications, issued and in preparation, by the establishment.

I. THE ORIGIN AND HISTORY OF THE SURVEY AND MUSEUM.

The Geological Survey of the United Kingdom and the Museum of Practical Geology, Jermyn Street, owe their origin to Henry Thomas De la Beche—one of the most illustrious geologists of this century. After various geological researches prosecuted early in life on the Continent and in the South of England, he eventually undertook a more detailed examination of the rocks of Devon and Cornwall. Supplying himself with the maps of the Ordnance Survey, on the scale of one inch to a mile, he began to map the geological structure of that part of the country. This labour was carried on with his own hands and at his own charges. As it advanced, he was led to perceive that it might possess great public importance in regard to the development of the mineral resources of the kingdom. An accurate delineation of the courses of the mineral veins, coal-seams, and other useful substances contained among the rocks beneath the surface, and of the bearings of the faults that dislocate and shift them, could hardly fail to prove of much practical value as well as of scientific interest. After he had made some progress with his self-imposed task, De la Beche was induced to apply to the Government of the day for recognition and assistance. The Ordnance Survey, indeed, under the enlightened supervision of Colonel Colby, had already encouraged the surveyors of its staff to keep a record of their observations respecting the relations between variations in the topography of the land and changes in the characters of the rocks underneath. In this manner the geology of the district around Ludlow, together with that of the Forest of Dean and the central parts of Herefordshire, had been with more or less precision traced upon the Ordnance sheets.[1] De la Beche represented to the authorities that the work on which he was engaged would be much more efficiently carried out if it were conjoined with that of the general trigonometrical survey of the whole country, which was then in progress. His views were eventually approved of, and in the year 1832 he was appointed by the Board of Ordnance to affix geological colours to the maps of Devonshire, with portions of Somerset, Dorset, and Cornwall. By the Spring of 1834 he was able to publish four sheets of the geological map of the county of Devon, whereon the general geological structure was depicted with a minuteness and beauty of execution such as had not before been equalled. Three additional sheets of the Ordnance Survey were completed by the end of that year, while another was nearly finished.[2]

This rapid progress and the obvious advantages to be derived from the maps led to a more definite recognition of De la Beche's

[1] Proc. Geol. Soc., vol. i, p. 447.
[2] Op. cit., vol. ii, p. 154.

labours. In the Spring of 1835 the Master-General and Board of
Ordnance consulted the Professors of Geology in the Universities of
Oxford and Cambridge (Buckland and Sedgwick) and the President
of the Geological Society (Lyell), as to the expediency of combining
a geological examination of the English counties with the geographical
survey then in progress. Supported by the strongly expressed
approval of these distinguished men, the Treasury agreed to place
on the estimates a grant " to defray the additional expense which
will be incurred in colouring geologically the Ordnance county
maps." [1]   As the sum thus granted amounted to only £300 a year,
most of the expense of the mapping still fell upon De la Beche him-
self. He also undertook the lion's share of the field-surveys, though
he had the occasional assistance of some of the Ordnance surveyors
who possessed geological experience. But he had gained the first
and fundamental object which he had in view. His enterprise was
officially recognized as a national Geological Survey, of which he
himself became Director.

But De la Beche's bold and far-seeing mind had conceived
a much more extensive scheme than the preparation of a geological
map, and as soon as he felt himself secure in his first step he
proceeded to take the next. In the Summer of 1835 he submitted
to the Government a proposal that the exceptional opportunities
enjoyed by himself and his staff to collect specimens illustrative of
the applications of geology to the useful purposes of life should
be taken advantage of, and that such collections, displaying the
mineral resources of the country, should be placed in a room or
rooms under the Board of Public Works. His plans being
eventually accepted, rooms were assigned to him for the accommo-
dation of the Survey collections in Craig's Court, Charing Cross, and
he was asked to carry out his scheme under the control of the Office
of Woods and Forests. Besides the extensive series of specimens
gathered together during the mapping of Devon and Cornwall, there
was another large assemblage of samples of British building-stones
which had been collected by the Commission (whereof De la Beche
was a member) appointed to inquire into the most suitable materials
for rebuilding the new Palace of Westminster after the burning
of the old Houses of Parliament in 1834. The specimens thus
accumulated were arranged by De la Beche with reference to
the instruction of the public, in illustration of the mineral resources
of the country. Materials for making roads, for the construction of
public works or buildings, for useful or ornamental purposes in the
arts, for the preparation of metals, were grouped in such a way and
with such explanatory labels, maps, models, diagrams, and sections,
as to convey a large amount of useful information in the most
compact and accessible form. In this manner the Museum of
Practical Geology took its rise. The collections were in fair
working order by the year 1839, though not ready to be opened
to the public for two years later. De la Beche was appointed

[1] Proc. Geol. Soc., vol. ii, p. 358.

Director, an office which for some years he filled gratuitously. The infant museum was in charge of the Office of Woods and Forests, but the Geological Survey still remained under the Board of Ordnance.[1]

A further part of the Director's wide-reaching scheme was soon put into execution in the premises at Craig's Court. He had planned that besides obtaining information from specimens, models, diagrams, and maps, the public should be enabled at a moderate cost to procure analyses of rocks, minerals, and soils from the establishment under his control. He was authorized to fit up a laboratory and to appoint as Curator of the Museum one of the ablest analytical chemists of his time, Richard Phillips. He likewise procured the sanction of the Office of Woods for the institution of lectures, having for their object the illustration of the applications of geology and of its associated sciences to the useful purposes of life. Owing to the want of a suitable theatre and other appliances the design of providing lectures could not be carried into execution for twelve years. But eventually in the Autumn of 1851, when the building in Jermyn Street was inaugurated, De la Beche's scheme was carried out by the opening of the School of Mines.[2]

There was one further department which owes its foundation to the indomitable energy of De la Beche. In 1838 the British Association had memorialized the Government to take steps to collect and preserve all plans recording the mining operations of the United Kingdom, inasmuch as great loss of life and destruction of property had arisen from the want of the proper preservation of such documents. The Director of the Geological Survey was accordingly authorized to form a Mining Record Office as part of his establishment at Craig's Court. This new undertaking started in 1840, under the charge of T. B. Jordan, who was succeeded in 1845 by Robert Hunt. A large series of mining plans was gradually accumulated, and a yearly volume was issued embodying the statistics of the mineral industries of the United Kingdom. These statistics were obtained from the information voluntarily supplied by the proprietors, lessees, and others. Eventually, however, an Act of Parliament compelled the mine-owners to furnish the statistics to the Inspectors of Mines, who published them in their Report to the Home Office. As it thus became unnecessary that two similar returns should be published, and as it seemed desirable that the work of the Mining Record Office should be brought into closer relations with the Inspectors of Mines,

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[1] Account of the Museum of Economic Geology, by T. Sopwith, 1843 ; Buckland, Proc. Geol. Soc., vol. iii, pp. 211, 221 ; Life of A. C. Ramsay, p. 39.

[2] The School of Mines continued to form part of the Jermyn Street establishment for more than twenty years. The progress of scientific education in that interval, however, demanded more space for practical instruction than the building could supply. Accordingly, in 1872, the departments of chemistry, physics, and biology were transferred to more commodious quarters erected by the Science and Art Department at South Kensington, and the other departments were similarly transferred as space could be provided for them. The last Professor at Jermyn Street was the late Warington W. Smyth, on whose death, in 1890, the mining instruction was also removed to South Kensington.

that office was in the year 1883 transferred to the Home Office, under which the Inspectors serve.

We may now trace briefly the progress of the Geological Survey from its commencement to the present time. As above stated, it was begun as a private enterprise by De la Beche previous to the year 1832, and was first established as a branch of the Ordnance Survey in 1835. Ten years afterwards, in 1845, the staff was considerably increased, and the Survey was transferred from the Board of Ordnance to the "Office of Woods and Works," so that the whole of the geological organization, including the Survey, Museum, and Mining Record Office, was thus united in one Government Department, under De la Beche as Director-General. The Survey, which had hitherto been that of Great Britain, now became that of the United Kingdom. The staff in England and Wales was placed under A. C. Ramsay, as Director for Great Britain, while a small force was placed in Ireland, in charge of Henry James, R.E.

The Great Exhibition of 1851 led to the establishment in 1853 of a Department of Science and Art, under the Board of Trade, to which the Jermyn Street organization was transferred. In 1856 this Department was placed under the control of the Lords of the Committee of Privy Council on Education, and this arrangement has continued up to the present time.

By the time the Geological Survey was transferred in 1854 to the Science and Art Department, great progress had been made in the mapping of England and Ireland. The survey of the whole of Wales had been completed and published, and the field-work was advancing eastwards into the central counties of England. In Ireland, the maps of the counties of Dublin, Kildare, Wicklow, Carlow, Wexford, Kilkenny, Waterford, and almost all Cork had been completed, and the field-work was being pushed into King's County and Queen's County, and across Kerry and Limerick. In the same year, 1854, the operations of the Survey were extended into Scotland, where A. C. Ramsay broke ground in East Lothian.

Up to this time the field-work of the staff in England and Wales had been conducted upon the basis of the Ordnance maps on the scale of one inch to a mile, no larger scale being available. In Ireland, however, maps on the scale of six inches to a mile had been published by the Ordnance Survey, and these from the beginning were adopted as the groundwork of the Geological Survey. Maps on this larger scale were available also in Scotland, and were from the first made use of for geological purposes. As the Geological Survey advanced northwards in England, it found the six northern counties mapped on the six-inch scale, and at once adopted this larger scale as the basis of the field-work.

As the great advantages of the use of the larger scale came to be recognized in practice, it was found that the superficial accumulations could be expressed on this scale without unduly interfering with the delineation of the structure of the rocks underneath. At the same time, increased attention was now being paid to the drifts which had been so long neglected. Their paramount

importance in relation to soils had long been recognized, but their great geological interest as records of the Glacial Period was more gradually perceived. As the possession of a detailed topographical map now enabled the surveyors to trace the superficial accumulations with a precision quite unattainable on the old one-inch sheets, it was determined to delineate the distribution of these surface-deposits at the same time that the boundaries of the underlying rocks were being followed. Hence in the six northern counties of England, Scotland, and thenceforth everywhere in Ireland, the drifts were distinguished and expressed upon the six-inch maps.

The great practical and scientific advantages of carefully mapping the superficial deposits on a large scale were amply shown by the experience of a few years. It was found, however, that the tracing of the distribution of the various kinds of Drift greatly increased the amount of labour entailed in the preparation of the general map of the country, thus necessarily diminishing the area surveyed each year and reducing the rate of progress of the Survey. At last, in 1867, a great increase was made in the strength of the staff, which was also reorganized with a view to greater efficiency. A distinct branch of the service was established for Scotland under a separate Director (A. Geikie), the English branch remaining under the supervision of A. C. Ramsay, and the Irish under J. B. Jukes, while Sir R. I. Murchison, who had succeeded De la Beche in 1855, continued Director-General of the whole.

At this important epoch in the history of its organization, the Survey of England and Wales had completed and published the maps of the country as far north as a line drawn from Liverpool to Selby, and as far east as Retford, Melton Mowbray, Market Harborough, Huntingdon, London, Chatham, and Folkestone. Considerable progress had been made with the mapping of the north of Lancashire and Westmoreland, and a portion of the great Northumberland Coalfield had been surveyed. In Ireland the maps of the larger half of the island had been published, and the field-work had been pushed northwards to a line drawn from Castlebar to Drogheda. In Scotland, where the staff had always been disproportionately small, the maps of the basin of the Forth had been completed from the north of Fife to Berwick-on-Tweed. The backward state of the Ordnance Survey had necessitated the transference of the staff to the west side of the country, where six-inch maps were available, and some progress had been made with the examination of the south of Ayrshire.

The whole energy of the staff was now directed to the completion, as quickly as possible, of the one-inch map of each of the three kingdoms. That of England and Wales was finished in 1883, and that of Ireland in 1887. The completion of these maps liberated some of the officers in England and in Ireland, who were accordingly transferred to the Scottish staff. As the Survey of Scotland was commenced long after that of the sister kingdoms, and was carried on for many years by a staff of only two surveyors, it is not yet completed. At the present time the unsurveyed portions of the

country include the central mountains of Sutherland and Ross, with most of Inverness-shire, the western parts of Argyllshire, and most of the Western Isles.

When the one-inch map of England was completed, most of the staff was detailed for the purpose of mapping the superficial deposits in the southern half of the kingdom, and thus providing materials for a complete agronomic map of the whole of Britain. An opportunity has at the same time been afforded to revise the published maps and bring them up to date. The nature and extent of this revision will be more particularly noticed in subsequent pages. When the one-inch map of Ireland was finished the staff was reduced, partly by transference to Scotland and partly by retirement, only such a number of officers being retained as might suffice for the necessary revisions which the progress of time requires. To these revisions also fuller reference will be made in the sequel.

II. The Work of the Geological Survey.

The combined scientific and practical objects which De la Beche set before himself as his great aim at the first institution of the Geological Survey, have ever since been kept steadily in view. To this day the development of the mineral fields of the country by means of accurate maps, the collection of data for the guidance of those in search of water-supply, the accumulation of information required for the purposes of agriculture, engineering, road-making, architecture— these and many other applications of geology to the arts, manufactures, and practical affairs of our social life continue to form a large part of the work of the Survey. But, as De la Beche and his early associates clearly recognized from the beginning, all such utilitarian uses of geology must be based on a thoroughly systematic examination of the geological structure of the country. So closely are pure science and industrial progress linked together, that at any moment what might be supposed to be a matter of merely theoretical import may be discovered to have a high practical significance and value. Hence the Geological Survey has been conducted as a strictly scientific investigation, and has thus been able to advance the interests of geological science. The geological structure of the British Isles has been traced out in greater detail than was before attempted in any country, and numerous additions have thereby been made to the general body of geological knowledge.

1. Field Work.[1]—The first and most important duty of the Survey is to map in detail the geological structure of the country. When this task was first undertaken by De la Beche the Ordnance Survey maps on the scale of one inch to a mile ($\frac{1}{63360}$) which had then been published for some of the southern counties of England, and which he used as the basis of his work, were imperfect and incorrect in their topography. They were among the first undertakings of the Ordnance Survey, before methods of surveying had

[1] Some portions of the following account of the work of the Geological Survey are taken from a paper communicated by the Director-General to the Federated Institution of Mining Engineers. See their Transactions, vol. v (1893), p. 142.

been brought to the perfection that has since been attained. The possession of a correct topographical map is absolutely necessary as the groundwork of a detailed and accurate geological survey. From the outset the Ordnance maps have afforded the topographical groundwork on which all the geological surveying has been carried on. For many years only the sheets of the general map on the one-inch scale were available, but when, in the progress of the Ordnance Survey, maps on larger scales were prepared, these, as already remarked, were employed for geological purposes.

All the mapping of the Geological Survey is now conducted upon the Ordnance maps on the scale of six inches to one mile ($\frac{1}{10560}$), as has been above remarked. These maps were not available in England and Wales until about two-thirds of the country had been surveyed geologically, and it was only in the six northern counties that they could be adopted. In Ireland, however, and in Scotland, where they were obtainable from the commencement of the geological operations, the whole of the work has been conducted upon them.

It is impossible to overestimate the gain, both in completeness and accuracy, from the substitution of a large-scale map in the general investigation of a complicated geological region. Not only is it then much easier to fix the position of geological boundaries, but an amount of detail may be inserted for which, though of great importance, no room can be found on the one-inch scale. The large map serves at once as a map and a notebook, and numerous detailed observations can be taken and recorded upon it at the localities at which they are made.

Occasionally, where the geological structure becomes excessively complicated, and requires to be mapped out in much detail, maps on the scale of 25 inches to a mile ($\frac{1}{2500}$) are made use of. Ultimately, however, all the work is reduced to the one-inch scale, this being the scale on which the general geological map of the United Kingdom is published.

Geologists had made considerable progress in the study of the solid rocks before much attention was paid to the looser superficial deposits. The Geological Survey in this respect followed the general rule, and for many years made no systematic attempt to represent the numerous and often complex accumulations of superficial materials. Some of these, indeed, were shown on the maps, such as tracts of blown sand and river-alluvium. But it must be remembered that in the south-western counties, where the Geological Survey began its work, superficial deposits are of such trifling extent and importance that they were not unnaturally ignored. Only after most of the southern half of England had been completed was it determined to map the surface-deposits with as much care and detail as had been expended on the older formations lying beneath them. It had been discovered that this course was necessary both on scientific and practical grounds. In the first place, these superficial accumulations contained the records of the later geological vicissitudes of Britain, and were beginning to reveal a story of the profoundest interest, inasmuch as it dovetailed with the history of the human

occupation of the country. In the second place, it was recognized that in many various ways these surface-deposits had a direct and vital influence upon the welfare of the population. In agriculture, in water-supply, in questions of drainage, and of the location of dwellings, it was seen that a knowledge of the soils and subsoils, and of the formations from which these are derived, was of the utmost practical importance. It was therefore determined that henceforth the Geological Survey should not only pourtray the lineaments of the solid earth, but trace out the drifts and other surface-deposits which, like a garment, overspread and conceal them. It was impossible at first to go back over the ground where the surface-geology had been omitted. But it was arranged that when the whole country had once been mapped those tracts should be re-examined wherein the superficial deposits had not been surveyed. And, in the meantime, over all new areas the survey was made complete by tracing out simultaneously both the surface-deposits and the older rocks below them.

The Drift Survey of Wales, and of those parts of England where the superficial deposits were not originally mapped, now occupies the time of a considerable part of the English staff. In Ireland, also, those tracts where the peat and some other superficial deposits were not delineated are now having this omission remedied. In Scotland the drifts are all mapped at the same time with the rest of the geology.

As an illustration of the detail into which the mapping in this department has been carried, it may be mentioned that under the single term " alluvium " we now discriminate and indicate by separate signs and colours a large number of distinct deposits. Thus, there is a group of fresh-water alluvia, beginning with the present flood-plains of the rivers and rising by successive terraces to the highest and oldest fluviatile platforms. Deposits of peat are separately traced, and tracts of blown sand are likewise mapped. Another series, consisting of marine alluvia, ranges in position and age from the mud of modern estuaries and the sands of flat shores exposed at low water, through a succession of storm-beaches and raised beaches, up to the highest and most ancient marine terraces 100 feet or more above the present level of the sea. Regarding the origin of some of the high-level gravels, there is still much uncertainty, but the Survey has taken the first necessary step for their ultimate explanation by carefully tracing their distribution on the ground.

But the most abundant and complex group of superficial deposits is that which may be classed under the old name of Glacial Drifts. These have been mapped by the Survey in detail, and much of the progress of glacial geology in this country has been due to the sedulous investigation thus required. The ice-striæ on the solid rocks have been observed over so much of the country, that maps may now be constructed to show both the march of the main ice-sheets and the positions of the later valley-glaciers. The various boulder-clays have been mapped, likewise the sands and gravels.

The survey of the superficial deposits thus combines a wealth of geological interest with a great deal of practical value. The geologist may find in it the solution of some problems and the presentation of many more; while the farmer, the water-engineer, the builder, the road-maker, and the sanitary inspector may each in turn gain practical information from it for his guidance.

For purposes of distinction, the mapping of the formations of every age that lie beneath the recent superficial deposits is known in the Survey by the somewhat unhappily selected epithet of the "solid geology." The object in this part of the field-work is to represent on the maps the exact area which every formation or group of rocks occupies at the surface, or immediately below the soil and drift, together with all indications that can be obtained of its structure, such as its variations of inclination, its changes of lithological character, and the dislocations by which its outcrop is affected. While the basis of the work is rigorously geological, facts having an industrial bearing, such as the presence of useful minerals, or the depth and variations in thickness of water-bearing strata, are observed and recorded.

In those districts of the country where the rocks have long been well known and where the geological structure is simple, the duties of the surveyor are comparatively light, though it often happens there that the simplicity of the "solid geology" is compensated for by a great complexity in the overlying "drifts." Where, on the other hand, the rocks are varied in character and complicated in structure, where they are partially hidden under superficial deposits, and where they rise into mountainous ground, difficult of access and hard to traverse, geological surveying becomes a most laborious occupation. In such a region as that of the North-West Highlands of Scotland, for example, where the physical impediments are great, where the ground is often both rugged and lofty, where the climate is wetter and more boisterous than almost anywhere else in Britain, and where the quarters to be had are often sorry enough and remote from the scene of work, the surveyor has need of all his enthusiasm to carry him bravely through these preliminary obstacles. But when he comes to unravel the structure of the rocks, he may find it to be sometimes almost incredibly complex. He has to climb the same cliff, scour the same crag, and trudge over the same moor again and again before he begins to perceive any solution to the problems he has to solve.

If the complicated "solid geology" of such a region is enough to tax to the utmost the capacity and energy of the geologist, his task is made still more difficult by the necessity of keeping his eye at the same time ever open to all the variations of the superficial deposits, which in these rugged tracts are often singularly intricate, though they may also be fascinatingly interesting. The ice-striæ on the rocks, the scratched stones high on the mountain-sides that mark where the till once lay, the varieties of boulder-clay, the sand and gravel eskers, the scattered erratic blocks and the detection of their probable sources of origin, the moraine-mounds fringing or

filling the bottom of the glens, the sheets of flow-peat and the ragged peaty mantle that hangs down from the cols and smoother ridges, the recent alluvia and the successive stream-terraces, the lines of raised beach and the estuarine silts—all these and more must be noted as the surveyor moves along, and must be duly chronicled on his map and among his notes.

It is obvious that the progress of the mapping in such ground cannot be rapid. If the work is worth doing at all, it should be well done, and if well done, it must be done slowly and carefully. It is evident also that the total area surveyed in a year, if given in square miles, affords no guidance whatever as to the amount of labour involved. There may be a hundredfold more exertion, physical and mental, required to complete a single square mile in some districts than to fill in twenty square miles in others. It is customary in the Survey to estimate not only the area annually mapped by each officer in square miles, but also the number of miles of boundary-line which he has traced. The ratio between these two figures affords some measure, though an imperfect one, of the comparative complexity or simplicity of the work. In simple ground a surveyor need have no difficulty in mapping from 70 to 100 square miles in a year, each square mile including from 3 to 6 linear miles of boundary. But in more mountainous and difficult districts it may be impossible to accomplish half of that amount of area. In these cases, however, the ratio between area and boundary-lines usually rises to a high proportion. Thus, in the Scottish Highlands the average number of linear miles of boundary-lines sometimes rises to as much as 17 miles in every square mile surveyed.

In mining districts an endeavour is made to express on the maps the positions of the outcrops of all seams and lodes, the line of every important fault and dyke, with the place of such faults at the surface, and where they cut different seams underground. The information necessary to record these data is mainly furnished by the owners and lessees of the mines and pits, who, as a rule, most generously give the Survey every assistance. Details as far as possible are inserted on the six-inch Ordnance sheets. Copies are taken of borings and pit sections, and notes are made regarding variations in the character of the seams or lodes from one part of a mineral field to another. At the same time, the district is surveyed in the usual way, and by exhausting the surface-evidence the surveyor is not infrequently able to supply important additional information beyond what can be obtained from the mining-plans.

It is the necessary fate of all geological maps to become anti-quated. For, in the first place, the science is continually advancing, and the systems of arrangement of the rocks of the earth's crust are undergoing constant improvement, so that the methods of mapping which satisfied all the requirements of science thirty years ago are found to be susceptible of modification now. In the second place, in the progress of civilization, new openings are continually being made in the ground: wells, roads, drains, railways, and

buildings are being constructed, whereby fresh light is obtained as to the rocks below. Geological lines which were traced with the imperfect evidence formerly available can thus be corrected, and new lines which perhaps were not originally suspected can be inserted. If this kind of obsoleteness overtakes geological maps even where only superficial openings are concerned, still more does it affect those which depict the structure of mineral-fields still actively worked. The geological maps of Devon, Cornwall, and South Wales, made some two generations ago by De la Beche and his associates, were for their time admirable in conception and excellent in execution. Nothing approaching to them in merit had then been produced in any part of the world. But the mineral industry of the country has not been standing still all these years. Enormous progress has been made in working the ores of the western counties, and in developing the great South Wales Coalfield. Yet most of the maps still remain as they were originally published, though their revision is now in progress.

It is absolutely necessary, if the value of the labour and expense bestowed on the Geological Survey of the United Kingdom is not to be impaired and lost, that the maps should be revised and brought up to date as frequently as may be required. The necessity for such revision has been pressed on the attention of Government by influential memorials from various districts of the country ; and, hitherto, as far as the other requirements of the Survey permit, these requests have been complied with. Thus, in consequence of an urgent representation from the proprietors and lessees of the coalfield of South Wales, and from others locally interested in the development of that region, steps were taken a few years ago to place there a staff of surveyors, and the revision of the ground is actively advancing. Already three sheets of the new series of Ordnance Maps of South Wales have been published, and one other is now in the hands of the engraver. The inhabitants of Cornwall, likewise, recently memorialized the Science and Art Department to undertake a revision of the geological maps of that county ; and, in response to their request, a beginning of the work has been started. The people of North Staffordshire, anxious for the proper development of their coalfield, made a representation that the time had come when a revision of the maps of their district was necessary, and this task has been undertaken by the Geological Survey. Other districts have sent in similar petitions for re-survey with which it has been hitherto impossible to comply, owing to the smallness of the staff. All these tracts of country were originally surveyed on the old and imperfect sheets of the one-inch Ordnance map. But the revisions are conducted on the modern six-inch scale, and the reductions are made upon the new series of one-inch sheets. There can be no doubt that all the other mineral-fields of the country require similar treatment.

The revision of that large part of England and Wales where the superficial deposits were not originally mapped, in order to complete the Drift survey of the whole country, is carried on upon the six-inch

maps. While this revision is in progress advantage is taken of the re-examination of the ground to make any needful additions or modifications in the " solid geology." The work is reduced from the large field-maps to the new series of the one-inch map. Geological maps on the six-inch scale were formerly published for the mineral-fields, but are now no longer engraved, though a large number of sheets of the coalfields are on sale. But manuscript copies of six-inch maps relating to any parts of the country of which the one-inch sheets are published, are supplied to the public at the cost of manual transcription.

While the field-work is in progress the surveyors collect, for the purposes of their maps and explanatory memoirs, such specimens of minerals, rocks, and fossils as may be found to require special examination. But a more systematic collection is carried out under their supervision by the collectors, for study by the petrographers and palæontologists and for exhibition in the museums. Each branch of the Survey has one or two collectors, who move from district to district as their services are required. When one of them begins work in any area, he is supplied with a map on which the field-officer who surveyed it has marked every locality that should be searched, and also with a list of these localities, giving local details as to the rocks to be specially searched or examined, and the kind of specimens to be looked for and collected. When necessary, the surveyor accompanies the collector to the ground and starts him on his duties. Every specimen which the collector sends up to the office has a number affixed to it, and is entered in the lists, which are also at the same time transmitted to headquarters. The specimens are then unpacked and treated by the palæontologists or petro-graphers, as the case may be. In this manner a remarkably complete illustration of the geology of the United Kingdom has been accumulated by the Survey, and it is constantly receiving additions and improvements. The chief series is deposited in the Museum of Practical Geology, London ; but the geology of Scotland is most fully represented in the Museum of Science and Art in Edinburgh, and that of Ireland in the corresponding Museum at Dublin.

(*To be continued.*)

REVIEWS.

I.—Wachsmuth and Springer's Monograph on Crinoids.[1]
Second Notice.

BEFORE entering on the discussion of morphological questions, the authors very properly define the terms they propose to use. Since all these terms will be familiar to those who have followed the papers of Messrs. Wachsmuth and Springer, P. H. Carpenter, and myself, only a few remarks are needed.

[1] The North American Crinoidea Camerata. By C. Wachsmuth and F. Springer. Mem. Mus. Comp. Zool. Harvard, vols. xx and xxi, containing 838 pp. and 83 plates. (Cambridge, U.S.A., May, 1897.) For First Notice, see June Number, p. 276.

It is stated on p. 32 that this terminology is the result of corre-
spondence with P. H. Carpenter, and that " Mr. F. A. Bather, in 1890,
also agreed to accept this terminology with very slight modifications,
and applied it practically in his earlier descriptions of British fossil
Crinoids, but renounced it in 1892, and proposed in its place a new
one." To remove the misapprehension to which such a presentment
of the case must give rise, it may be stated that the scheme of
terminology in question includes 86 terms ; of these I have formally
renounced seven, while I constantly use all the rest with perhaps
three exceptions, and five of the terms were actually proposed by me.
I am glad to be in better accord with the American authors than
they have been ware of.

The expressions ' stem-joints.' and ' arm-joints' are in common
use, no doubt ; but this extension of the word ' joint ' to the
segments separated by the joint, however admissible in the kitchen,
should not pass into scientific terminology, which should be, above
all things, precise and unambiguous. The arm-ossicles are now
generally called ' brachials ' ; the stem-ossicles may well be termed
' columnals,' and the cirrus-ossicles ' cirrals.' As a natural con-
sequence of this loose use of the word ' joint,' we find Messrs.
Wachsmuth and Springer applying the term ' syzygy ' to the
brachials united by a rigid suture, rather than to the suture itself.
Such a usage is common, but that it is incorrect and unscientific
I have already shown [1] to the satisfaction of several leading writers
on crinoids, and among them Mr. Springer. As noted on p. 81 of
the monograph, " the term ' syzygy ' has also been used by some
writers for the immovable union of the nodal stem-joints with those
next below them " ; and to this use Messrs. Wachsmuth and Springer
object. It is true that the word was not used in this sense by
Müller, who seems to have overlooked the structures in question, and
it is equally true that " radiated and dotted surfaces do not always
imply a ' syzygy ' " ; still, Müller's definition is phrased in quite
general terms and not necessarily restricted to brachials, so that in it
there is nothing inconsistent with the extension to columnals. Such
extension leads to no ambiguity and saves the invention of yet
another set of terms.[2]

The term ' centrodorsal' is a never-ending source of trouble.
Our authors naturally do not confuse it with the absurdly-named
' dorso-central,' but they apply it to "the plate within the infrabasal
ring of the Marsupitidae." Now ' centrodorsal ' is the name of
that element in the skeleton of an Antedonid which is composed
of the infrabasals and the proximal columnal or columnals fused
into a solid cirriferous ossicle. We do not know the true relation-
ships of the plate at the aboral pole of *Marsupites*, but we know
that it does not comprise infrabasals and does not bear cirri. For
this reason I have proposed for it and for the similar plates in
Uintacrinus and *Saccocoma* the non-committal term ' centrale.' [3]

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[1] " The term ' syzygy,' etc." : *Zool. Anzeiger*, xix, pp. 57–61, Feb. 3, 1896.
[2] See P. H. Carpenter, " ' Challenger ' Report on Stalked Crinoids," p. 4, 1884.
[3] " On *Uintacrinus* " : *Proc. Zool. Soc. London*, vol. for 1895, p. 997 ; 1896.

The columnal that remains throughout life at the proximal end of the stem in the Ichthyocrinidæ and their allies, as well as in the Apiocrinidæ and their allies, may also fuse with the infrabasals, but is in other respects hardly comparable with a true centro-dorsal, though often called by that name; it is therefore convenient to distinguish this as the ' proximale.'[1]

The tegmen, or ventral covering of the calyx, consists of orals, ambulacrals, and interambulacrals. Through some portion or other of the tegmen there are pores, which place the outer water in communication with the body-cavity, and so, indirectly, with the water-vascular system. In most recent crinoids these pores are scattered over the tegminal surface and penetrate the plates of which it is composed. According to the work before us (p. 35), " the perforated plates have received the name *an-ambulacrals*." This does not represent fairly the accepted use of the word 'anam-bulacral,' and is sure to perplex the beginner. The term was invented by Joh. Müller, who applied it primarily to the above-mentioned water-pores, to distinguish them from the ambulacral pores for tube-feet (podia). The term has, however, been extended not merely to the plates pierced by the pores, but to the remaining imperforate plates of the tegmen other than ambulacrals or covering-plates and adambulacrals or side-plates.[2] In fact, rightly or wrongly, 'anambulacral' is nowadays a synonym of the less ambiguous 'interambulacral,' and should either be dropped or redefined in the strict Müllerian sense. It cannot well be extended to all perforate plates, for some of these may be actual brachial elements.

The term 'adambulacral' has just been mentioned. Messrs. Wachsmuth and Springer write (p. 36): " The *ambulacral plates* consist of the *ad-ambulacral* or *side-pieces,* and the *covering plates,* or *Saumplättchen*; the former, when present, constitute the outer, the latter the inner rows of the plates." It seems to me more precise and more in accordance with the use in other Classes of the Echinoderma, to restrict the term 'ambulacralia' to the alternating covering-plates, and not to widen its connotation so as to include adambulacralia. It must be admitted, however, that it is often hard to distinguish side-plates from covering-plates, owing in some cases to the compound structure of the latter, in other cases to their partial or complete atrophy.

The use of the word 'ambulacra' also appears to me highly incorrect. " The *ambulacra*," we are told (pp. 35, 36), " diverge from the mouth to the tips of the rays, following the ventral furrows of arms and pinnules. When subtegminal, they enter the calyx by means of the *ambulacral* or *arm openings* at the upper edge of the dorsal cup ; when tegminal, they follow the surface of the disk. They contain the *food-groove,* the *ambulacral vessels,* the *ovarian tube,* and the *axial canal.* The *food-groove* forms the upper passage.

[1] First proposed in F. A. Bather, " Wachsmuth and Springer's Classification, etc." : *Natural Science,* xii, p. 341, May; 1898.

[2] P. H. Carpenter, " 'Challenger' Rep. Stalked Crinoids," p. 76, 1884.

It is followed in descending order by the *subtentacular* canal, the *genital* canal, and the *axial* canal." Now the majority of the structures herein mentioned have nothing to do with ambulacra, which are here, as in all Echinoderma, radial extensions from the circum-oral water-vessel, giving off lateral branches, the podia (tentacles of crinoids, tube-feet of sea-urchins). Each ambulacrum may be accompanied by radial extensions of other systems of the body— or it may not. In a crinoid the ambulacra pass to the tips of the arms, so also do the radial extensions of the superficial oral nervous system, the paired cords of the deeper oral nervous system, and the pseudhæmal canal, none of which structures are mentioned by Wachsmuth and Springer. Those that they do mention are not quite happily introduced, for there are two subtentacular canals, as well as another extension from the body-cavity, unpaired and lying dorsal to the genital canal. The genital canal contains the genital rachis, which may be an "ovarian tube" or may be of male nature. Finally, the reader must not infer, as he might easily do, from the above-quoted description, that the axial canal with its contained axial cord accompanies the ambulacrum in its tegminal or subtegminal passage towards the mouth; it separates from it immediately on reaching the walls of the calyx, and while the ambulacrum passes along the ventral surface, the axial cord passes down the dorsal walls to the aborally situate chambered organ. Of course Messrs. Wachsmuth and Springer knew the above facts long before I wrote a line on the crinoids; but it is just because of their learning and authority that these lapses and ambiguities are so misleading to the student, for whose benefit the chapter is intended.

To the paragraph defining the term 'perisomic plates' (foot of p. 36) I turned with interest, because in 1891 these same authors published an important paper on "The Perisomic Plates of the Crinoids," [1] which I have read and reread without discovering what they meant by 'perisomic' or why they used the word. Moreover, the term has been a rock of offence to others, notably Dr. Arnold Lang, as I ventured to point out in a review [2] of the section on echinoderms in his valuable text-book. It is doubtful whether we shall be greatly helped by the present definition: "The term *perisomic plates* is given to all plates which are originally developed from simple, cribriform films of limestone. They comprise the interradials and interaxillaries, the anals, and all ambulacral and interambulacral plates." Of course the definition would "comprise" a good many other plates, such as basals, radials, and orals, but it is still doubtful whether this is the intention of the authors. In some respects the definition approaches that of Wyville Thomson, who first used the term; but he did not include the radials in his

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[1] *Proc. Acad. Nat. Sci. Philadelphia*, vol. for 1890, pp. 345–392, pls. ix, x. Reviewed in GEOL. MAG., Dec. III, Vol. VIII, pp. 219–224, May, 1891.

[2] "The text-book writer among the echinoderms": *Natural Science*, vi, pp. 415–423, June, 1895.

" perisomatic system." W. B. Carpenter rightly attached " but little importance to the form of the reticulation as a differential character " ; he was " disposed to regard the perforation or non-perforation by the radiating extensions of the Crinoidal axis [axial nerve-cords] as quite sufficient in itself to differentiate the entire skeleton into two series of plates." [1]   To some extent this division corresponds with Wachsmuth and Springer's division into primary and secondary ; but since they include the ambulacrals among primary plates (p. 38), it is clear that their ' perisomic ' is not a synonym of their ' secondary.' Here, then, is a term used in a different sense by each writer in succession, apparently incapable of strict definition, and corresponding to no morphological idea.   Why can we not bury it for good and all ? This mighty monograph affords a fitting mausoleum.

In designating the different radii and interradii of the calyx, the anal interradius is of course ' posterior,' while the radius opposite is ' anterior ' ; in the natural position of the crinoid, the right and left sides correspond with the right and left of one observing the cup from its anal side.   The radii adjoining the posterior interradius are naturally designated ' right and left posterior,' while the interradii adjoining the anterior radius are the ' right and left anterior.'   I have called the radii next the anterior radius the ' right and left anterior ' ; and the interradii next the posterior interradius, the ' right and left posterior.'   Messrs. Wachsmuth and Springer would substitute the appellations ' right and left antero-lateral' and ' right and left postero-lateral ' [2] respectively.   My mode of expression may be a tiny trifle less precise, but it is open to no misconstruction, since in a five-rayed symmetry only one radius can possibly be meant by ' right anterior ' ; moreover, it is three syllables shorter.

So far, it will have been seen, I have no quarrel with the terminology adopted by Messrs. Wachsmuth and Springer ; I differ from them merely in the interpretation of a few of the terms, a matter in which their opinion (where it is a definitely stated opinion and not a loose mode of expression or a slip) is of at least as much value as mine.   We come now to a case in which, after much epistolary discussion with my departed friends Carpenter and Wachsmuth, I decided to adopt a different and entirely new set of terms.   This was in connection with the successive series of brachials.   It seemed to me, as also to Carpenter, that the expressions " brachials of the first, second, or third, etc., order," and even " primary, secondary, or tertiary, etc., brachials," were too long and cumbrous.   In their stead Carpenter proposed " costals, distichals, palmars, post-palmars, second post-palmars, third post-palmars, etc."   These were accepted by Wachsmuth and Springer, and originally by me also.   But I soon discovered that such an expression as " the third second post-palmar " was not merely cumbrous and inelegant, but also one involving (for me at least) a more serious effort of memory or of calculation than circumstances

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[1] " Researches on the Structure . . . . of *Antedon rosaceus* " : *Phil. Trans.*, 1866, p. 742.

[2] They have " antero-lateral " (p. 37), but it must be a misprint.

warranted. The terms were open to criticism on the following grounds: want of congruity *inter se*; previous uses of the word 'costal' in various other senses; difficulty of remembrance and of working, especially in the higher series; inadaptability to symbols, formulæ, and general statements. The truth of this criticism has never been contested, nor has any objection, other than on the ground of novelty, ever been raised to the series of terms and symbols proposed by me in their place, viz., Primibrachs (I Br), Secundibrachs (II Br), Tertibrachs (III Br), Quartibrachs (IV Br), and so on, along with which go the terms and symbols applied to the successive axillaries, Primaxil (I Ax), Secundaxil (II Ax), and so on. Had I confined myself to the above criticism, and to the proposal of this simple, congruous, easily remembered, and easily applied set of terms, it is probable that they would have met with more general acceptance than has been their lot. Unfortunately, I thought it necessary to draw attention to a morphological difficulty in the way of homologizing the series of a pinnulate arm with those of a non-pinnulate arm; and to avoid this I proposed, for pinnulate arms only, "a terminology congruous with the Müllerian term 'distichals,'" viz., monostichals, distichals, tetrastichals, octastichals, and so forth. To this latter terminology various objections either have been or might be raised. In the first place, the morphological difficulty, though still obvious to me, does not appear to present itself to Messrs. Wachsmuth and Springer. Secondly, the terms in their higher series, though rarely required, rapidly increase in cumbrousness. Thirdly, the branching of pinnulate arms is often so irregular as to falsify the terms, e.g., instead of their being four rami of the third order there may be only three, which therefore cannot correctly be called tetrastichals. Fourthly, the terms cannot be readily intelligible to the systematist, if he really is so devoid of classical culture and mathematical training as my critics maintain. For these reasons I do not propose to put into practice what has never been more than a suggestion. There are, I still believe, cases in which the distinction between pinnulate and non-pinnulate arms requires expression in the terminology and formulæ, and the term 'main-axil' is undoubtedly of great use. But for general purposes I, like Wachsmuth and Springer (p. 77), "see no good reason why the former terms [primibrachs, secundibrachs, etc.] could not be used for all Crinoids, pinnulate or non-pinnulate." It is greatly to be wished that all writers on crinoids should agree on this matter, and to that end I make this concession.

We turn now to the "Morphological Part."

This is almost confined to the morphology of the skeleton, and begins by dividing the skeletal elements into (*a*) primary and (*b*) secondary or supplementary, (*a*) being subdivided into (i) abactinal and (ii) actinal. These categories, established in the paper on "Perisomic Plates" above referred to, were explained to readers of the GEOLOGICAL MAGAZINE in the review of that paper (May, 1891); they are

based on sound developmental principles, and conduce to a clear understanding of the variations in skeletal structure presented by the several Orders and Families.

The account of the Stem (pp. 38–58) has much value, not merely as a summary of known facts, but as introducing new details, and for the first time using the variations of this organ as factors in the main scheme of classification. The authors believe that the Crinoidea may be divided into two groups in accordance with the growth of the stem. In one group new columnals are developed next the cup, so that the top columnal is always one of the latest formed, and continually moves from its proximal position as new columnals develop.   This group includes all genera which the authors assign to their Orders Inadunata and Camerata.   In the other group the top-columnal is not the latest formed, but is a persistent 'proximale' (*vide* p. 320).   This group includes the Ichthyocrinoidea of some previous classifications, the Apiocrinidæ, Bourgueticrinidæ (including *Rhizocrinus*), Ante-donidæ and similar forms, Eugeniacrinidæ, and Holopodidæ; it is named ' Articulata ' by Messrs. Wachsmuth and Springer, but, as I have elsewhere urged, Von Zittel's name of ' Flexibilia ' is free from the variety of meanings under which the word Articulata labours.   This grouping, according to stem-growth, is not made superior to the previously existing ordinal divisions; but so far as the definition of the Order Flexibilia is concerned, it affords a diagnostic character of importance.   The systematist, however, though he may welcome such an aid, is bound to criticize with care the evidence on which it is proposed.   In this case so slight is the attempt at proof that scepticism remains our only attitude.   A student seeking a subject of research could not do better than investigate this question thoroughly.

As for the stem generally, it is obvious that a digested body of information, with reference to its characters in genera and species, would be of the utmost value to the stratigrapher, who finds thousands of stem-fragments, at present indeterminable, to one determinable crown.   What are the prospects of our ever being able to determine genera and species from columnals alone?   Among genera common in Neozoic rocks there are *Rhizocrinus, Bourgueticrinus, Acrochordocrinus,* and the Pentacrinidæ, which are pretty readily determinable; while in the highly specialized Pentacrininæ, at all events, the details of the stem are often characteristic of species. It is less easy to separate the genera and species of Encrinidæ, Apiocrinidæ, and Eugeniacrinidæ on these characters, although a few are fairly distinct (e.g., *Traumatocrinus, Millericrinus horridus, M. Charpyi*).   Among Palæozoic genera the differentiation of the stem had as a rule not proceeded so far, but peculiar and characteristic structures are presented by *Barycrinus, Herpetocrinus,* the Platycrinidæ (*sens. str.*), *Crotalocrinus, Cupressocrinus,* and a few others.   The majority of Palæozoic columnals, however, are simply circular in section with their joint-surfaces marked by radiating striæ; such specimens are the terror of the palæontologist.   Nevertheless stem-characters, even in unpromising genera, deserve careful study.   In

Herpetocrinus they afford the only means by which species can be distinguished.

It is a remarkable fact that some genera and species which appear closely allied differ in the mode of growth of the stem. "The internodes of some species begin at quite a distance from the calyx, while others have no internodal joints at all." In the Ichthyocrinidæ the proximal region of the stem consists of low ossicles, with no internodals, varying from 20 to 50 but nearly constant in number in the same species. *Platycrinus* has no internodes, but *Marsupiocrinus* has them well defined. *Mespilocrinus* has no internodals. *Rhodocrinus* has "but a single ossicle to each internode." Two Gotland species of *Gissocrinus* (*G. typus* and *G. campanula*) are much alike, and often I was only able to distinguish specimens by the number of the internodals, a feature imperceptible to the unaided eye.

Further study of the mode of growth, of external ornament, of joint surfaces, of the shape of the axial canal, and of the relations of cirri, with the consistent tabulation of these characters, may some day enable us to draw up a key. The difficulties are two: the changes of character in the different regions of the same stem; and the extreme rarity of complete stems in association with crowns. Still the work has to be done, and the amount already accomplished by Messrs. Wachsmuth and Springer suggests that the task is no impossible one. Let the student enter the field to which they have pointed the way.

Further remarks on minor points suggest themselves.

"In a few Palæozoic Crinoids, the whole stem is divided longitudinally, its joints being either quinque- or tri-partite. The former is the case in *Ohiocrinus*, *Ectenocrinus*, *Barycrinus*, *Anomalocrinus*, and probably others; while a tripartite stem has been observed only in *Heterocrinus*" (p. 41). In this sentence the names *Ectenocrinus* and *Heterocrinus* should be interchanged. The words "probably others" understate the case, since a quinquepartite stem has already been described and figured for *Cleiocrinus*,[1] *Thenarocrinus*,[2] *Botryocrinus*,[2] *Mastigocrinus*,[2] *Streptocrinus*,[2] *Ottawacrinus*,[3] *Euspirocrinus*,[2 3] *Vasocrinus dilatatus*, *Calceocrinus pinnulatus*,[2] and *Rhodocrinus asperatus*,[1] while traces of similar sutures have been proved in *Herpetocrinus*.[2] Other examples of quinquepartite stems are known, but have not yet been referred to any genus. In short a large number, if not the majority, of Lower Palæozoic genera had the stem so divided. The character is obviously a primitive one, but its meaning need not again be discussed.[4]

Another sentence, suggesting that this section was written many years ago and has escaped revision, is the statement that "In the Cyathocrinidæ the structure at the lower part of the stem is only known in *Barycrinus*." I should not put *Barycrinus* in the Cyathocrinidæ myself; but if it is to go there, so also must *Botryocrinus*, *Mastigocrinus* (which, indeed, Wachsmuth considered "merely

[1] By E. Billings.   [2] By F. A. Bather.   [3] By W. R. Billings.
[4] See "Royal Natural History," vol. vi, pp. 296–7; Warne & Co., 1896.

a variety of *Cyathocrinus* "), and *Thenarocrinus*, in all of which the root was described and figured more than six years ago. The distal end of the stem is likewise known in *Gissocrinus*, *Euspirocrinus*, and *Bactrocrinus*, which also are placed in the Cyathocrinidæ on the authority of Wachsmuth and Springer in Eastman's adaptation of Von Zittel's "Palæontology."

This section contains numerous interesting observations on the cirri, chiefly of Palæozoic crinoids. These structures were no doubt less specialized in the older crinoids, especially in Camerata ; but this is no adequate reason for the suggestion that they should " receive a different appellation." Cirri seem to have originated as branchings of the distal end of the stem, radical cirri ; these branches subsequently appeared at higher levels, and became more definite in arrangement ; the cirri in older genera were often large and branched ; they became eventually small in comparison with the stem, unbranched, attached by more definite facets, and with greater activity of movement. But all these changes can be traced ; there is a regular evolution, comparable to the evolution of pinnules ; and as to the homology of the diverse forms, there can be no question.

Our authors hint that the cirri of Palæozoic crinoids may have opened out at their ends. " The finest hair-like branches which have come under our observation are perforated at their extremities." They seem to think that the canal of the cirrus may have admitted water to the axial canal of the stem ; they point also to the pores occasionally found in the distal region of the stem as serving the same function ; but they do not seem to have discovered the intimate connection of these pores with the cirri. A branch of the stem naturally contained branches of the axial blood-vessels and nerves ; these became the axial cords of the cirri. After atrophy of the cirri, there still remained the extensions of these soft parts through the wall of the stem, each such extension representing the former attachment of a cirrus. The cavities left by these in the dead stereom are the so-called 'pores'; their evolution may be traced in good specimens of the root of *Crotalocrinus* (Figs. I–IV), but they are not confined to that genus. The greater size of the stem-lumen in so many Palæozoic genera is explicable on the theory of the evolution of the stem as a plated evagination of perisome such as is seen in some Cystidea ; there is no need to suppose for it any particular function. Its gradual diminution in phylogeny is precisely paralleled by the evolution of the cephalopod siphuncle, which likewise began as a visceral cone. The idea that streams of sea-water passed in through the cirri, or pores, or grooved channels on the under surface of the root, and bathed the folded inner walls of the axial canal as though these were gills, does not seem consistent with the general scheme of crinoid morphology and physiology. It is about as happy as Miller and Gurley's theory that " the mucous or fluid substance, that contained the material for the base, passed through the columnar canal into the pores of the base and was deposited in a softer state than it afterward assumed." We may, however, suppose that these passages

served the double purpose of transmitting nutrient fluid to the mesoderm cells depositing the outer layers of stereom, as the stem and root grew wider by concentric accretion, and of aerating the same fluid by bringing it near the oxygenated sea-water.
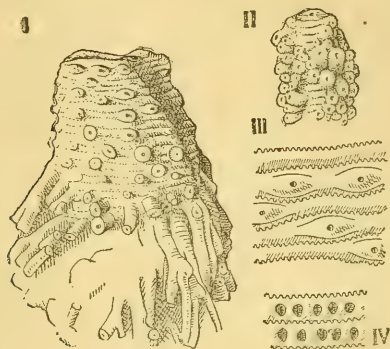
THE DEVELOPMENT OF 'PORES' FROM CIRRI.

I.—*Crotalocrinus*; portion of Root, with branching cirri below, and attachments of cirri in upper part. These latter show the axial canal that passes from the main axial canal of the stem, through the thickness of the columnals, to each cirrus, and continues to the end of the cirrus. Specimen from Silurian of Gotland. British Museum, regd. E 1,273. Nat. size.

II.—*Cystocrinus tennesseensis*; part of stem, showing stumpy aborted cirri, with axial canals opening at their ends. Niagara group, W. Tennessee. Brit. Mus., regd. E 53 (*a*). Nat. size.

III.—*Crotalocrinus*; part of stem, showing crenulate sutures between columnals, and on the columnals the atrophied attachments of cirri; compare with the extreme upper part of Fig. I. Wenlock Limestone, Much Wenlock. Brit. Mus., regd. E 6,633. × 5 diam.

IV.—*Crotalocrinus*; part of stem, showing total disappearance of cirrus-attachment, and only the axial canals remaining as 'pores' piercing the columnals. Silurian, bed *f* of Lindström, near Pafvalds, Gotland. Brit. Mus., regd. E 6,139. × 5 diam.

It is not quite clear what importance Messrs. Wachsmuth and Springer attach to the conception of the dorso-central. It is not necessary to repeat the reasons why "the dorso-central, considered as a morphological element of the Echinoderm type, has got to go."[1] There remains, however, the question whether it can be considered an independent element of the Crinoid skeleton. Since the distal segment of the stem always remains distal, no fresh ossicles ever being developed between it and the sea-floor, it is clear that it is homologous in all crinoids. In *Antedon*, as we have long known, this distal element forms no part of the adult, but is left behind when the animal enters on its free-moving existence. This is also the case in the Pentacrininæ, and Messrs. Wachsmuth and Springer have collected evidence to show that the same phenomenon was

[1] "The text-book writer among the Echinoderms," *op. cit. antea.*

common in various Palæozoic genera. In Actinocrinidæ, Platy-
crinidæ, and other forms "the terminal part tapers rapidly to a
point, and cirri are given off from the sides." This end is "not
homologous with the part by which the young Crinoid had been
formerly attached, but is a product of later growth." But all this
has nothing to do with the character of the original distal end.
The term dorso-central was applied to the distal segment of the
stem in the larval *Antedon rosacea* (or *A. bifida*) because it was seen
to be a flat cribriform plate, whereas the penultimate segment was
an elongate columnal formed of fasciculate stereom. The necessity
for a distinct term depends on two considerations : (i) the
universality of the occurrence of such a plate ; (ii) the morphological
difference between cribriform and fasciculate stereom. As to (i),
Wachsmuth and Springer infer from the development of *Antedon* and
from palæontological evidence, " that the young Palæocrinoid in its
early life was attached by a dorso-central." But the palæontological
evidence adduced is of the slenderest description : " In only two
instances do we know that [adult] Palæozoic crinoids were attached
by what appears to have been originally a dorso-central plate :
in ' *Cheirocrinus*' *clarus*[1] and in *Eucalyptocrinus crassus*."[2] The
former instance shows an encrusting root with lobate edges ; the
latter shows a slight terminal swelling from which proceed numerous
branching, radical cirri. Our authors consider the lobations of
the former as ' budding cirri,' while, with reference to the well-
known roots of *Eucalyptocrinus*, they write : " These roots seem to
have been derived from a central disk (dorso-central), from which
the numerous branches were given off in a similar manner as the
immature cirri from the terminal plate of ' *Cheirocrinus*' *clarus*."
The only other instance of a terminal plate quoted by them is from
the Hudson River group of Cincinnati. Here " we occasionally find
crinoidal disks, attached to pieces of coral, which closely resemble
the dorso-central of *Antedon*. These disks have a pit or depression
at the middle of the upper face, sometimes enclosing a small stem
joint. They are irregularly round, and some of them have small
processes passing outward from the sides, which seem to represent
primitive cirri." Clearly these objects are of the same nature
as those from the Niagara group of New York, to which Hall gave
the name *Aspidocrinus*. It is conceivable that they are, or may be,
of the same nature as the terminal plate of *Antedon rosacea*. But
these three or four instances are scarcely evidence that all or even
the majority of Palæozoic crinoids were at one time of their lives
attached by a dorso-central. An encrusting root is not necessarily
the homologue of a single cribriform plate, as study of the root of
Apiocrinus will speedily reveal to anyone. Besides, admitting
the secondary nature of many branching or tapering roots, we have
no evidence that they were preceded by dorso-centrals. But,
turning to (ii), we ask whether there really is any difference

[1] N.Y. State Cab. Nat. Hist. ; Fifteenth Rep., Pl. i. Figs. 17 and 18."
[2] N.Y. State Mus. Nat. Hist. ; Twenty-eighth Rep., Pl. xvii, Fig. 5."

between the distal element named dorso-central and the other elements of the stem. W. B. Carpenter's refusal to recognize a morphological distinction between cribriform and fasciculate stereom has already been quoted. That there is no physiological distinction between these elements, in *Antedon* itself, is seen by reference to the figures of *A. Sarsi* published by M. Sars.[1] These show that any columnal could form encrusting or lobate extensions over adjacent objects. Except as a misleading and highly confusing appellation for the primitive distal columnal, there is therefore no virtue in the term ' dorso-central.'

This conclusion does not affect the main thesis of Wachsmuth and Springer, that the majority of Palæozoic crinoids were not permanently attached. " A permanent fixation of the Crinoids would perhaps restrict the geographical range of the species, whereas we know that some of them have a very wide range. A majority of the species from the Lower Burlington group at Burlington are found almost unaltered in the south-western part of New Mexico, and some in Arizona, and many species of the Keokuk group have been traced from Southern Iowa as far down as Alabama. And we find in Scotland and Eastern Russia, with but slight modifications, the same forms which flourished in the Mississippi Valley during the epoch of the Kaskaskia group " (p. 52).

The important question of the orientation of the stem is best dealt with in connection with the structure of the base of the cup, which will be discussed in the next Notice. F. A. BATHER.

(*To be continued.*)

II. — THE GEOLOGY OF THE COUNTRY AROUND BOGNOR. By CLEMENT REID, F.L.S., F.G.S. Memoirs of the Geological Survey. 8vo ; pp. iv, 12, with 14 illustrations. (London, 1897. Price 6*d.*)

THIS little memoir has been prepared to illustrate the New Series Map Sheet 332, embracing that part of the Sussex coastline which projects in Selsey Bill and includes the favourite seaside resorts of Bognor and Littlehampton. The most interesting features in the geology are in connection with the Bracklesham Beds, which being exposed only on the foreshore must be studied at low-water spring-tides ; then "one sees laid bare some of the finest exposures of fossiliferous strata visible in England." Several of the characteristic fossils are figured in this memoir, which should prove a useful guide to the student. The Pleistocene deposits with their far-travelled erratics also possess many points of interest on which Godwin-Austen very many years ago, and the author more recently, have thrown much light.

[1] " Mémoires . . . . des Crinoïdes vivants " : Progr. Univ. Norvège ; Christiania, 1868. See pl. v, figs. 9, 12, 13, 15.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—May 18, 1898. — W. Whitaker, B.A., F.R.S., President, in the Chair.   The following communications were read :—

1. " The Garnet-actinolite Schists on the Southern Side of the St. Gothard Pass."   By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

The author describes the field relations and the microscopic structures of a group of schists or gneisses characterized by the frequent presence of conspicuous garnets and actinolites, which are exposed on the southern slopes of the St. Gothard Pass and for some distance west and east, on the northern side of the Val Bedretto. These, called for purposes of reference the Tremola Schists, he has examined from time to time since 1878, the last occasion being the summer of 1897, when he was accompanied and aided by Mr. J. Parkinson, F.G.S.   These rocks in the field might be regarded as highly altered sedimentary strata (as the author once thought) or as a group of igneous rocks (originating possibly in magmatic differentiation) affected by fluxion-movements anterior to consolidation.   To the latter view he now inclines, but considers the schistosity and the peculiar minor structures to be the results of crushing (generally without marked shearing) followed by very considerable mineral reconstruction.   The garnets he holds to be anterior to this crushing, but the larger biotites and the conspicuous actinolites to be posterior to it.   These minerals, in his opinion, throw some light on processes of crystallization in rocks more or less pulverized, or, in other words, in the presence of various impediments.   He thinks it probable that the Tremola Schists assumed their present form prior to the great Tertiary earth-movements which gave rise to the existing Alpine chain.

2. " On the Metamorphism of a Series of Grits and Shales in Northern Anglesey."   By Charles Callaway, M.A., D.Sc., F.G.S.

These rocks occur in a patch about three miles square, situated south-west of Amlwch, and extending from Llanfechell and Rhosbeirio to the boundary fault near Melin Pant-y-gwydd, and from Mynydd Mechell to Bodewryd.   They dip to the north, and apparently form a series in the following ascending order :—(1) Highly quartzose and gritty rocks.   (2) A considerable admixture of softer beds (hypometamorphic shales).   (3) Predominating shaly strata with gritty seams in subordinate proportion.   The lower beds contain intercalated seams of well-foliated micaceous or chloritic schist, and in these lower beds the signs of compression and contortion are most marked.

A series of microscopic slides from Rhosbeirio, Llanfechell, Pant-y-glo, and intermediate localities links together the fragmental rocks with the true schists.   Grains of clastic quartz are replaced by " granular particles fitting into each other with foliate interlocking

margins"; when in contact "the grains are moulded into each other, and welded together"; but when "entirely immersed in a soft matrix of mica or chlorite," they "still retain their sharp outlines." In the "matrix" the chlorite and mica flakes are gradually enlarged.

While "mechanical force has been concerned in producing the more intense metamorphism of the lower part of the series," the author is "not disposed to advance this as the sole cause of the changes produced."

3. "On a Volcanic Series in the Malvern Hills, near the Herefordshire Beacon." By Henry Dyke Acland, F.G.S.

These are the rocks described briefly by Dr. Callaway and Mr. Rutley, and afterwards more fully by the late Professor A. H. Green. They consist of tuffs, rhyolites, andesites, and dolerites or basalts. The microscopic appearance of the rocks exposed in excavations for a new reservoir between Tinker's Hill and Broad Down indicates that they are much crushed ; indeed, the amount of infiltrated calcite often causes the rhyolites to assume the aspect of limestones. On Tinker's Hill there is less crushing. On Hangman's Hill there are rocks allied to epidosites.

It is suggested that the rocks may be the volcanic equivalents of the plutonic rocks of the Malvern axis faulted down and protected by the bend in the axis which occurs in the neighbourhood of the Herefordshire Beacon.

II.—June 8, 1898.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read :—

1. "On the Discovery of Natural Gas in East Sussex." By C. Dawson, F.G.S., F.S.A.

Inflammable natural gas was first recorded by Mr. H. Willett in his thirteenth quarterly report of the Subwealden Exploration. Another discovery was in a deep artesian boring in the stable-yard of the New Heathfield Hotel. In 1896, at a site about 100 yards distant from the last-mentioned locality, a boring was put down by the London, Brighton, and South Coast Railway Co., the details of which are given in the paper together with those of the earlier Heathfield boring. From this boring gas has been escaping for the last 18 months, with a pressure of not less than 15 lb. to the square inch, and at the rate of about $12\frac{1}{4}$ cubic feet per hour (with a pressure of 20 tenths maintained), although the tube is stopped up, and is partially filled with water.

Though deficient in illuminating quality, the gas burns well when mixed with air and gives a good bunsen-flame. The author considers that it is probably derived from the lower beds pierced, that is, the Purbeck strata, or by percolation from the still lower Kimeridge beds, which were not reached by the borings. The borings pierce the southern slope of the great anticline which runs from Fairlight into Mid-Sussex, and is joined at Heathfield by another considerable anticline running through Burwash.

2. "Note on Natural Gas at Heathfield Station (Sussex)." By
J. T. Hewitt, M.A., D.Sc., Ph.D.   (Communicated by the President.)

A sample of natural gas from a boring at Heathfield was taken in
December, 1897, analyzed with the following result :—

Methane	...	...	...	...	...	91·9
Hydrogen	...	...	...	...	...	7·2
Nitrogen	...	...	...	...	...	0·9

Oxygen, carbon dioxide, carbon monoxide, olefines, and hydrocarbon
vapours were altogether absent.

A specimen of a bed of lignite (dried at 110° Centigr.) was also
analyzed :—

				Total analysis.	Percentage of organic materials.
Carbon ...	...	...	...	9·43	51·87
Hydrogen	...	...	...	1·83	10·07
Nitrogen	...	...	...	0·68	3·74
Sulphur ...	...	...	...	1·27	6·99
Oxygen ...	...	...	...	4·97	27·33
Ash ...	...	...	...	81·82	...
				100·00	100·00

An analysis of the ash is also given in the paper.

3. "On some High-level Gravels in Berkshire and Oxfordshire."
By O. A. Shrubsole, F.G.S.

The high-level gravels are divided by the author as follows,
beginning with the oldest :—

    1. Pebble-gravel, composed very largely of flint or chert.
    2. The Goring Gap gravel.
    3. Quartzose gravel, with only a small proportion of flint-pebbles.
    4. Quartzite-gravel, with purple and brown quartzite-pebbles.
    5. Local flint-gravels.

The pebbly contents of these gravels are expressed in percentages.
The Pebble-gravel occurs on the higher plateaux of the Chiltern
Hills, and a suggestion is thrown out that it may possibly be
of Diestien age.   The Goring Gap gravels contain a large
proportion of subangular flint.   The Quartzose gravels are dis-
tinguished by a certain proportion of opaque and vitreous quartz-
pebbles and a small number of quartzite-pebbles, generally pale
in colour : a small flint-flake was found in them at Bowsey Hill ;
amongst the possible sources of the constituents of this bed, old
pebble-beds like those of Potton and Upware are mentioned.
The Quartzite-gravel is widespread, and is found at heights varying
from 294 to 544 feet.   There is a gravel-pit near Moreton-in-the-
Marsh, close to the source of the Evenlode, which shows an
exceptionally large proportion of quartzite-pebbles, both smaller and
larger than 6 inches in diameter.   Farther on, similar gravels may
be traced through Evesham, up the Salwarp valley, and into the
Lickey district ;   the   author   conjectures that the source of
the quartzite-pebbles may lie in the direction of Warwickshire
and the Midlands.   Small flint-flakes usually having one bulb

of percussion have been found in all the gravels except the oldest. The value of these flakes as evidence is disputed.

4. " The *Globigerina*-marls of Barbados." By G. F. Franks, F.G.S., and Prof. J. B. Harrison, M.A., F.G.S. With an Appendix on the Foraminifera by F. Chapman, F.R.M.S., A.L.S.

After a reference to previous publications on the island by one of the authors and Mr. Jukes-Browne, an account is given of the tectonic structure of Bissex Hill, on which the principal exposures of the *Globigerina*-marl occur. Five faults are described, four of which cut all the rocks, while the fifth disturbs the Scotland Beds and the Oceanic Series, but leaves the overlying *Globigerina*-marl undisturbed.

The general succession is as follows :—The Scotland Beds are overlain unconformably by the Oceanic Series, which shows the usual succession from chalks to calcareo-siliceous beds, and in places to the upper chalks, the overlying red clays being absent. Then follows unconformably a detrital bed of *Globigerina*-marl containing rolled pebbles of various parts of the Oceanic Series, especially the chalks, and inclusions of clay presumably from the Scotland Beds. The bed is followed by buff marls, granular in appearance, and this, again, by marls and limestone, in the upper part of which *Globigerinæ* die out and are replaced by *Amphistegina* and fragments of lamellibranch shells. The whole succession is about 90 feet in thickness, and the beds pass up into basement-reef rocks without coral, and coral-rock.

Somewhat similar rocks were met with in a shaft at Bowmanston, and they probably occur in other localities. The presence, succession, and relations of these rocks enable the authors to draw conclusions as to the history of the island.

In the Appendix a list of 146 species of foraminifera is given : 15 of these occur only in strata ranging from the Cretaceous to the Pliocene Period. The rocks bear some resemblance to the limestones and marls of Malta and to the *Globigerina*-beds of Trinidad ; the recent foraminifera indicate that the deposit was formed at a depth of about 1,000 fathoms and at some distance from land.

CORRESPONDENCE.

EBBING AND FLOWING WELLS.

Sir,—At the meeting of the Geological Society of London, on April 20th, 1898, were read notes on the ebbing and flowing well at Newton Nottage, Glamorganshire, by Mr. Madan, M.A., communicated by Mr. A. Strahan, M.A.

The well lies about 500 yards from the sea, with sandhills between, and in the neighbourhood of a range of Carboniferous Limestone, whilst the same formation crops out in the sea at half-tide level. At the shore junction of conglomerate and limestone numerous springs occur, and it is in this conglomerate that the well is sunk. After many observations, the author has constructed

a curve showing the relationship existing between the rise and fall of the tide and that of the water in the well. From the position of the well in question and its surroundings, possibly the ebbing and flowing of the tide may produce the ebb and flow of water in the well, but there are other ebbing and flowing wells so situate that tidal variation can have on them no influence. Some few years back I was staying at Buxton, and frequently walked to Castleton. By the side of the road I noticed an ebbing and flowing well, but the variations of condition did not assert themselves at stated or defined times; on the contrary, the changes were erratic. One thing is certain, tides could here have no effect, since, as the crow flies, the distance from the estuary of the Mersey, the nearest point to the sea, is upwards of forty miles. How, then, can these variable conditions be explained? On the spot I could collect no information. The theory I propounded was this. The district is Lower Carboniferous Limestone, and, taking into account the results of the chemical action of underground water, the internal composition of the rocks become altered, large quantities are carried away, with the result that subterranean tunnels and cavities are formed, and if in the upper parts of this mountain limestone a spring or springs exist, the overflow would find its way by tunnels into the eroded cavities, from which it might be syphoned to the well below, producing the changes which perplex the traveller.

Caverns are abundant in the Carboniferous limestones. There is the peak cavern at Castleton. The Victoria Cavern, at Settle, Yorkshire, contains forms which favour my theory, since it has deep shafts and caverns inclining inwards. There is also recorded a fissure communicating with a basin in the limestone at Windy Knoll, near Castleton.   T. E. KNIGHTLEY.

106, CANNON STREET, E.C.
    May 19*th*, 1898.

SACCAMMINA CARTERI AND *NODOSARIA FUSULINIFORMIS.*

SIR,—In consequence of the paper by Mr. F. Chapman, in the Annals and Magazine of Natural History for March, 1898, in which he so properly connects *Saccammina Carteri* with *Nodosaria fusuliniformis* of M'Coy, I have sought for the second type-specimen referred to by M'Coy. It has now been placed in the wall-case containing fossil Foraminifera in the Museum of Science and Art, Dublin. It fully justifies Mr. Chapman's published conclusions, which were based upon the Cambridge specimen. There seems no doubt that we must now accept *Saccammina fusuliniformis* as the name of this well-known species.   GRENVILLE A. J. COLE.

SCIENCE AND ART MUSEUM, KILDARE STREET, DUBLIN.
    May 21*st*, 1898.

BOULDERS OF SPILSBY SANDSTONE.

SIR,—In his interesting note on a boulder of Spilsby Sandstone, at Wimpole, in Cambridgeshire (GEOL. MAG., June, 1898, p. 267), Mr. Cowper Reed rightly observes that no block so large, and bearing such a definite proof of its origin, has previously been

discovered in the area. I may, however, recall attention to the Merton Boulder, which lies on the estate of Lord Walsingham, at Merton, in Norfolk. This boulder is regarded by Mr. Whitaker as Neocomian Sandstone, and it measures 12×5 feet, but being partly under water its thickness could not be ascertained. (See F. J. Bennett, "Geology of Attleborough, Watton, and Wymondham," Geol. Survey Memoir, p. 10.) A more particular account of the Spilsby Sandstone has been given by Mr. A. Strahan, who refers to its tendency to weather into a loose sand in which great blocks of the unweathered rock remain here and there. Hence during the Glacial Period a number of ready-made boulders could have been obtained from the formation. Such blocks have, indeed, been recorded from the Drift in various parts of Suffolk, and some of them have yielded Brachiopoda regarded as Neocomian by W. Keeping and Davidson. (See Strahan, in "Geology of the Country around Lincoln," p. 88.)

<div align="right">H. B. Woodward.</div>

THE LLANBERIS UNCONFORMITY.

Sir,—The courteous letter, which you publish from Professor Bonney in your June number, calls for only two remarks. (1) I am not aware that Professor Bonney has in any case tried to find out *for himself* whether any stratigraphical statement of mine is fact or fancy. (2) To have once silenced a gun is not to take the fort. How many of the ship's guns are still in action?

<div align="right">J. F. Blake.</div>

OBITUARY.

MELVILLE ATTWOOD, F.G.S.
<div align="center">Born July 31, 1812. Died April 23, 1898.</div>

Melville Attwood was born at Prescott Hall, Old Swinford, Worcestershire, on July 31, 1812, and educated at Mathew Gibson's Academy, Tranmere, Cheshire, and afterwards studied at the Chemical Laboratory of Messrs. Watson and Pim, of Liverpool.

When quite a young man he was sent out to the Gold and Diamond Mines in Brazil, where he remained some years; on his return to England he leased and worked the celebrated Old Ecton Copper Mine in Derbyshire, and was engaged in mining and metallurgical works in the North of England and Staffordshire, and in 1843 he gave zinc a commercial value by successfully rolling the first English spelter. On the 15th October, 1839, he married Jane Alice Forbes, the sister of the late Professor Edward Forbes and of David Forbes, F.R.S., but in 1852, his wife's health becoming critical, he disposed of his interests and sailed for California, hoping that the change might benefit her; at the same time he accepted the position of manager to the Agua Fria Gold Quartz Company (in California), and in 1853 constructed at Grass Valley the first gold-mill in that country, for which he received a vote of thanks and a medal from the State of California.

He invented many appliances for the extraction of gold, also scientific instruments, and the "Attwood amalgamator" has been in general use in California and elsewhere for more than forty years.

In 1859 he made the first assays and analyses of the ores from the celebrated Comstock Gold and Silver Vein; and it was through him that the great riches of the above vein were made known to the world.

For the last twenty-five years nearly all his spare moments were given to microscopic work; he prepared his own specimens, and he leaves behind him a most valuable collection of minerals and microscopic slides. He was an intimate and esteemed friend of the late Sir Warington Smyth, Dr. John Percy, John Arthur Phillips, F.R.S., and other well-known scientific men.

He was able to practise his profession of consulting mining engineer until within a few weeks of his death, which took place at Berkeley, near San Francisco, California, on April 23, 1898, in his eighty-sixth year. His practical experience in gold-mining extended for a period of seventy years, as he was in the Brazilian gold-mines before he reached the age of seventeen.

He was a Fellow of the Geological Society, a Member of the Academy of Sciences (California), California State Geological Society, and the San Francisco Microscopical Society. The members of the last-mentioned Society attended in a body the funeral on April 26, with numerous old-time friends.

His contributions to the California Mining Bureau and scientific papers and magazines were numerous. The following is a list of some of his principal writings :—

"On the Milling of Auriferous Vein Stones," August 1, 1878 : California State Geological Society.

"Mineralization of Gold," August 20, 1878 : California State Geological Society.

"On an Improved Form of Batéa," August 20, 1878 : California State Geological Society.

"Wall Rocks of the Bodie Auriferous Lodes," March 4, 1879 : California State Geological Society.

"Rough Notes on the Geology of Bodie, illustrating the two ages of Gold," June 13, 1881 : San Francisco Microscopical Society.

"On the Milling of Gold Quartz," August 20, 1881 : California State Geological Society.

"On the Milling of Gold Quartz," sequel to above paper, 1882 : California State Mining Bureau.

"A simple Working Test for determining the quantity of Gold mechanically combined with Auriferous Vein Matter " : California State Mining Bureau.

"Gongo Soco Mine," 1896 : San Francisco Microscopical Society.

"Macroscopical Examination," February 14, 1897 : San Francisco Call.

"Mineralogy," 1897 : San Francisco Microscopical Society.

GEORGE ATTWOOD.
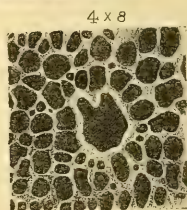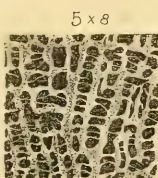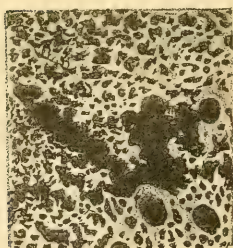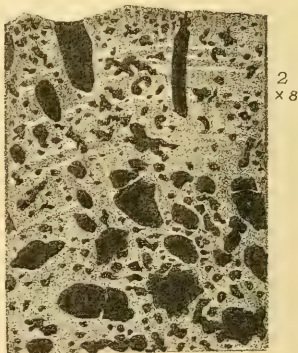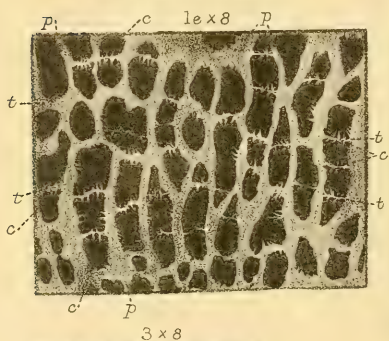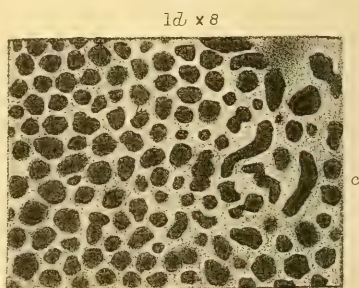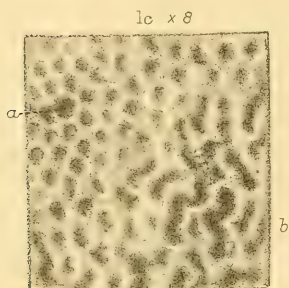
Egyptian Milleporoid Coral, &c.

ORIGINAL ARTICLES.

I.—*Millestroma*, a Cretaceous Milleporoid Coral from Egypt.

By J. W. Gregory, D.Sc., F.G.S., of the British Museum (Natural History).

(PLATE XIII.)

THE wide geographical distribution of the Milleporidæ is a clearer proof of the geological antiquity of the group than any evidence yielded by palæontology. For *Millepora* has no known Mesozoic or certain Lower Cainozoic representative, and is thus separated by a great gap from the Palæozoic Hydrocorallinæ, whence it is probably descended. But the Stromatoporoids disappear at the end of the Palæozoic, and I am not aware that any coral has been described which helps to connect that group and the Cainozoic Milleporids.

The question is complicated by the difficulty of distinguishing between the skeletons of those Bryozoa, Hydrozoa, and Anthozoa which consist of masses of parallel tubes.[1] In each of these groups there are genera in which the skeletal structures consist of bundles of long, narrow, cylindrical or prismatic tubes, which are of two sizes, and are divided into chambers by flat platforms or tabulæ. The problem how to determine to which group a particular fossil with these characters may belong has not yet been solved. This is not surprising since the same doubt also occurs respecting some living species. Thus, according to most authors, *Heteropora pelliculata*, Waters, is a Bryozoan; but according to Wentzel[2] it is a Favositid. In regard to the recent forms, even if we have no knowledge of the soft parts, we can get some light from the histological structure of the skeleton. But this clue is lost in the case of most of the fossils; for as a rule the calcareous skeleton is perforated by numerous pores and canals, so that it is open to attack by solvents; hence the hard tissues have generally been dissolved and redeposited in a crystalline form. During this process the

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[1] The difficulty presented by these multitubular fossils I have previously stated in the "Catalogue of the Jurassic Bryozoa" (Brit. Mus., 1896), pp. 3-6.

[2] J. Wentzel, "Zur Kenntniss der Zoantharia Tabulata": Denk. Akad. Wiss. Wien, vol. lxii (1895), p. 496. The species is referred to as *H. Neozelanica*.

intimate structure has been completely obliterated.   Accordingly it is often quite impossible to come to any final decision as to the affinity of such a fossil ; we have to be content with temporarily assigning it to one of the three groups, according to the balance of probabilities afforded by a series of characters, none of which are of absolute value.

The collection of Egyptian fossils recently sent for determination to the British Museum by Capt. H. G. Lyons, R.E., includes one interesting fossil which illustrates this difficulty.   It comes from the Turonian limestones of Abu Roasch, near Gizeh.   It consists of an irregularly ovoid mass, formed by a thick encrustation round a gastropod, probably a *Nerinæa*.[1]   A preliminary external examination left me quite in doubt whether the fossil was a Hydrocoralline, an Alcyonarian, or a Bryozoan allied to *Heteropora*.   Unfortunately a good deal of the interior of the coral has been silicified ; and in the siliceous layers (the dark band of Pl. XIII, Fig. 1*b*) the structure has been almost entirely obliterated.   Sufficient, however, is left to show that the fossil has the following characters :—

1. The skeleton, although apparently tubular, is really reticular, being composed of vertical pillars connected by intermediate plates.

2. The interspaces appear on the surface as a series of pores.

3. The pores lead down to interspaces which, owing to the connection of the pillars by more or less vertical laminæ, appear tubular.

4. The pores and apparent tubes are arranged quite irregularly, or in small cyclo-systems, or in linear series separated by branching, radial grooves.

5. The " tubes " are crossed by tabulæ.

6. The skeleton is traversed by short, broad, flexuous, horizontal canals.

The reticular skeleton and the canal system both preclude the reference of the fossil to the Bryozoa : this conclusion is supported by the cyclo-systems, which resemble those of the Cœlenterata rather than of the Bryozoa.   So the fossil is limited either to the Hydrozoa or Anthozoa.   It is unnecessary to refer to the characters which differentiate this fossil from most of the sub-divisions of the two groups.   If the fossil be an Anthozoan, it is clearly an Alcyonarian allied to *Heliopora* ; and if an Hydrozoan it is obviously one of the Hydrocorallinæ.   At first sight the specimen appears to resemble the Alcyonarians, owing to the compactness of its walls and the tubular structure of the whole colony.   There is none of the extremely loose, vesicular tissue and abundantly ramified, irregular canal system of such Hydrocorallines as *Millepora* and *Sporadipora*.   To illustrate the characters of two typical members of the Alcyonarian and Hydroid corals figures have been given on the plate of sections of *Heliopora* and *Sporadipora*.   Contrasting them we find the following differences :—

[1] *Nerinæa* has been recorded from this locality and horizon by Walther, "L'Apparition de la Craie aux environs de Pyramides" : Bull. Inst. Egypt, ser. 2, No. 8 (1888), pp. 6, 7.

	Sporadipora.	*Heliopora.*
Septa	No trace.	Rudimentary or clearly developed.
Micropores	Cyclo-systems.	Irregular.
Intermediate tissue between		
macropores	Spongy.	Tubular.
Canal system	Ramified, extensive.	Short and simple.

This set of characters is not at once decisive as to the affinities of the fossil; for, according to the two last, it more resembles the Alcyonarians, and, according to the two first, it is nearer to the Hydrozoa. But the two first characters appear to be by far the more important. *Heliopora, Heliolites,* and *Polytremacis* have all well-recognizable septa, and there is no cyclic arrangement of the micropores. In the Hydrozoa the absence of mesenteries leads to the complete absence of true septa, although in some cases the elongation of the micropores leads to the macropores being surrounded by radial laminæ; but these " pseudosepta " are external to the zooids, instead of a whole radial series being formed within a single zooid. The apparent compactness of the walls between the cavities in this fossil is probably exaggerated by the secondary changes: thus Fig. 1e shows that a series of small, dog-tooth like, crystals of calcite spring from the tabulæ and the walls. These crystals show that the whole skeletal tissue has been dissolved and redeposited. The definiteness of the walls is, therefore, not necessarily an original character. In fact, the apparently tubular structure of the " cœnenchyma " or intermediate tissue is misleading, for closer study (see Fig. 1e) shows that the skeleton is reticular and not really tubular. The vertical interspaces act as tubes, but these are formed by the growth of the vertical, trabicular pillars, and not by the calcification of a tubular membrane.

Hence even when compared with recent corals representing the two subclasses of Cœlenterata, there seems no doubt that the Egyptian fossil is a Hydrocoralline. And this view is established, almost conclusively, by a comparison with the Palæozoic forms. The general aspect of the fossil, with its massive, encrusting habit, its prominent blunt knobs, and its irregular, perforated surface, is strikingly stromatoporoid. Microscopic study of sections shows that in spite of the absence of the concentric lamination which is such a conspicuous feature in the Stromatoporidæ, the essential structure is the same.

The work of Professor Nicholson [1] has shown that the Stromatoporidæ may be divided into two groups, one of which presents points of resemblance to the Hydractinians, while the other reminds us rather of the structures found in the Milleporidæ. From the former section, including the Actinostromidæ and the Labechiidæ, this fossil differs by the presence of the functional zooidal tubes, a character which also serves to separate it from the Hydractinians. From the Stylasteridæ it differs by its massive habit, by the reticular structure of the cœnenchyma, and by the absence of the extensive

[1] H. A. Nicholson, " A Monograph of the British Stromatoporoids," pt. i (1886), p. 71.

canal system, which ramifies through the broad areas of porous, vesicular tissue that separates the gastrozooids. The massive growth, although a character of little importance, helps to separate the fossil from the Stylasteridæ. The only remaining available groups in which the fossil may find a home are the Milleporidæ and the milleporoid section of the Stromatoporidæ. To which of these it should be referred is not very easy to decide. If we abstract from Moseley's[1] diagnosis of the Milleporidæ all the characters which depend on the hard parts, we find that he states them as follows:—The cœnosteum is irregular, arborescent or incrusting; it is composed of a thin, superficial living layer, lying over dead, earlier-formed layers. The pores have no styles, and are divided into vertical series of chambers by tabulæ; the dactylozooids are usually irregularly arranged, but a circle of them may occur around a gastrozooid.

There is nothing in this series of characters to exclude the Egyptian fossil from the Milleporidæ. It differs, however, from *Millepora* in two ways: the pores are less unequal in size, and a transverse section shows none of the broad open cavities of the gastrozooids. In the second place, the walls around the interspaces in the corals are more compact and narrow. The specimen agrees more nearly with the milleporoid group of Stromatoporidæ owing to the presence of the long, vertical pillars, the linear series of pores, separated by branching grooves, and the more equal size of the pores. In the presence of occasional cyclo-systems it agrees, however, again with the Milleporidæ.

Among the Stromatoporidæ, it agrees most closely with the Idiostromidæ, and especially with the genus *Hermatostroma*, which has no axial tube, and in which we see the beginning of the reduction of the concentric, horizontal laminæ, that are so conspicuous in the typical Stromatoporoids.

I therefore regard the fossil as one of the missing links between the Palæozoic Milleporoid Stromatoporoids and the Cainozoic Milleporidæ, and therefore propose for it the name *Millestroma*. The species is named after the author whose work has placed our knowledge of the Palæozoic Hydrocorallines on a sound basis.

Family MILLESTROMIDÆ.

CHARACTERS.—Cœnosteum massive, encrusting. Definite zooidal tubes present. The cœnosteum is composed of reticular tissue with abundant tabulæ, but otherwise no well-developed horizontal laminæ. Micropores (dactylopores) usually irregular, linear, or in cyclo-systems. No principal axial tube.

Genus MILLESTROMA, nov.

DIAGNOSIS.—Cœnosteum massive; skeletal framework irregular, but forming a series of branching, anastomosing tubes. The horizontal or concentric laminæ are rudimentary, but tabulæ are

[1] H. N. Moseley, " Report on certain Hydroid, Alcyonarian, and Madreporarian Corals " : Rep. Chall. Exped., Zool., vol. ii, pt. 7, p. 92.

well developed. The pores are mostly irregular in distribution, but some occur in small cyclo-systems and others in linear series, separated by sinuous, branching depressions. Canals short and broad.

DISTRIBUTION.—Cretaceous : Egypt.

Millestroma Nicholsoni, nov.

DIAGNOSIS.— Cœnosteum ovoid, formed of a thick encrustation. The surface is marked in places by low humps and knobs ; otherwise it is smooth. Cyclo-systems widely scattered ; the macropore (gastropore) is not much greater than the micropores (dactylopores), of which there are usually six or seven in a system. The surface is also marked by irregular, sinuous, radial valleys ; on the ridges between them the pores are often linear in arrangement. Tabulæ abundant. The radial pillars are irregular in course.

DIMENSIONS.

Length of cœnosteum ...	...	...	...	...	83 mm.
Diameter of cœnosteum	...	...	...	...	40 mm.
Diameter of pores ...	...	...	...	...	about ·15 mm.

DISTRIBUTION.—Turonian : Abu Roasch, near Gizeh, Egypt ; Coll. Geol. Surv. Egypt, No. 51.

DESCRIPTION OF FIGURES.—Pl. XIII, Fig. 1*a*, half of the cœnosteum, nat. size, showing the knobbed surface (*a*) and the sinuous grooves (*b*); Fig. 1*b*, transverse section across the same specimen, nat. size, showing the gastropod which forms the nucleus of the cœnosteum ; Fig. 1*c*, part of the surface of the same specimen, × 8 diam., showing a cyclo-system at *a* and a weathered area at *b* ; Fig. 1*d*, part of a horizontal section across the same specimen, × 8 diam., showing the flexuous horizontal canals at *c* ; Fig. 1*e*, part of a vertical section across the same specimen, × 8 diam., showing the irregular pillars (*p*), the absence of concentric, horizontal laminæ, the abundant tabulæ (*t*), and the secondary crystals of calcite (*c*).

AFFINITIES.—This fossil most nearly resembles in its general characters the Stromatoporoid described by Nicholson as *Hermatostroma*.[1] With this genus it agrees in the presence of the horizontal flexuous tubes (cf. Nicholson, op. cit., pt. i, 1886, fig. 16, p. 106) ; in the presence of the branching and somewhat irregular vertical pillars (cf. Nicholson, op. cit., pt. i, p. 42, fig. 1, B, and pt. iv, pl. xxviii, fig. 9, with Pl. XIII, Fig. 1*e*); and with the linear series of pores, separated by irregular, somewhat radial grooves (cf. Nicholson, op. cit., pt. iv, pl. xxviii, fig. 13). *Hermatostroma*, however, has not the cyclo-systems shown on Pl. XIII, Fig. 1*c*; and *Millestroma* has not the well-developed concentric laminæ formed by horizontal " arms " from the vertical pillars. In both these respects the genus resembles *Millepora* more than the Stromatoporidæ. Cyclo-systems resembling those of this specimen are shown by Moseley in a specimen named *Millepora nodosa*. *Millestroma* is therefore an intermediate form between the Palæozoic and Cainozoic Milleporoid Hydrocorallinæ.

[1] H. A. Nicholson, " A Monograph of the British Stromatoporoids," pt. i (1886), p. 105.

EXPLANATION OF PLATE XIII.

Fig. 1. *Millestroma Nicholsoni*, nov. Turonian: Abu Roasch, Egypt. Fig. 1*a*, half of the cœnosteum, showing the knobbed surface (*a*) and the sinuous grooves (*b*); nat. size. Fig. 1*b*, transverse section across the same specimen, showing the gastropod which forms the nucleus of the cœnosteum; nat. size. Fig. 1*c*, part of the surface of the same specimen; × 8 diam. (*a*, cyclosystem; *b*, weathered part of the surface, showing reticular structure of the cœnosteum). Fig. 1*d*, part of a horizontal section across the same specimen; × 8 diam. (*c*, horizontal canals). Fig. 1*e*, part of a vertical section across the same specimen; × 8 diam. (*p*, pillars; *t*, tabulæ; *c*, calcite crystals).

Fig. 2. *Sporadipora dichotoma* (Mos.). Part of a transverse section through the margin of a cœnosteum, cutting the marginal zooids vertically; × 8 diam.

Fig. 3. Ditto, part of another section from the same, showing the central zooids cut transversely, and the extensive vesicular tissue; × 8 diam.

Fig. 4. *Heliopora cœrulœa* (Ell. & Sol.). Part of a transverse section across the central part of a corallum, showing a large gastropore; × 8 diam.

Fig. 5. *Hermatostroma episcopale*, Nich. Devonian: Devonshire. Part of a vertical section showing the pillars and tabulæ; × 8 diam. (After Nicholson.)

II.—Notes on the Correlation of the Lower Carboniferous Rocks of England and Scotland.

By William Gunn, F.G.S., of H.M. Geological Survey of Scotland.

THE substance of the following paper was given at a meeting of the Geological Society of Edinburgh on January 20th this year. Its object is to show that the group of Lower Scottish Limestones about Dunbar and round the Midlothian Coalfield does not represent any part of the Mountain Limestone of Yorkshire, but is the equivalent of the upper part of the Yoredale Series of Phillips, while the Edge Coals and Upper Limestones of Midlothian represent a series of beds which in Yorkshire and Northumberland lie above the true Yoredale Series of Phillips, and which were included by him in the Millstone Grit. It necessarily follows from this correlation that the lower part of Phillips' Yoredale Series, together with the Scar or Mountain Limestone of Yorkshire, are represented in Scotland by the Calciferous Sandstone Series, which is mainly a fresh-water deposit.

This correlation of the Lower Carboniferous rocks of the North of England with those of Scotland was determined in the year 1881, after an examination of parts of the coast of Haddingtonshire and Berwickshire in company with two of my colleagues, Mr. H. H. Howell, now Director of the Geological Survey, and the late Mr. W. Topley, who both accepted at the time the general views here stated. Mr. Topley thought them of so much importance that he wished to join with me in writing an elaborate paper on this correlation, and I drew up some notes on the subject, but for various reasons the paper was never completed or published. However, the principal results have been from time to time orally communicated to several of my colleagues.

To illustrate the paper four vertical sections are given representing the rocks below the Millstone Grit, each section being drawn to the scale of 600 feet to an inch. The most southerly of these gives the succession of beds from the top of Ingleborough down to the

basement conglomerate which rests unconformably on the highly inclined Silurian rocks. The lower part of the section is composed of a solid mass of limestone, 600 to 700 feet in thickness, while the upper part consists mainly of an alternating series of sandstones, shales, and limestones, to which Phillips gave the name of Yoredale Rocks, because he considered they were typically developed in Yoredale (Wensleydale). In this and the other sections the limestones are particularly marked, because it is by means of them principally that the rocks in different places are correlated. The Yoredale Series, then, in the Ingleborough section ranges from the Hardraw Limestone up to the highest limestone—the Main or Twelve-Fathom—but two of the limestones generally occurring elsewhere are wanting in this section, so that it is certainly not a typical one of the Yoredales. Above the Main Limestone here there occurs a thickness of 100 to 120 feet of shale, and the hill is capped by coarse Millstone Grit.

The Wensleydale section is mainly that proved in Keld Heads Mine between Leyburn and Redmire. It will be noticed at once that the Yoredale Limestones are here both thicker and more numerous than at Ingleborough. Four of the limestones are each about 60 feet in thickness, whereas only the Main Limestone on Ingleborough attained this thickness. The two additional limestones are the Underset and the thin limestone next below. It should be stated that the Underset is here abnormally thin, it being usually about twice the thickness given. The ' Fossil ' Lime, on the other hand, is usually only about one-half of the thickness here given, so it must be understood that the section does not stand for the whole of Wensleydale. The Main Limestone is often, perhaps generally, considerably more than 60 feet thick ; in fact, it obtained the name of ' Twelve-Fathom ' because it approximates to 72 feet in thickness. The upper part only of the Mountain Limestone is to be seen in Wensleydale, and its total thickness here is unknown, but it has already, as far as its upper members are concerned, begun to admit intercalations of sandstone and shale, and thus to approximate in character to the Yoredale Series above. In the dales to the north of Wensleydale somewhat similar sections may be obtained, and therefore it is unnecessary to give a detailed account of each. In the first valley, that of Swaledale, the section is very like that of Wensleydale, except that some of the limestones are thinner. In Teesdale we find that the Middle Limestone has separated into three limestones known as Scar, Cockleshell, and Singlepost Limestones, while nearly all the Yoredale Limestones, except the Main, are considerably thinner than in the dales farther south. Several comparatively thin limestones represent the upper part of the Great Scar Limestone of Ingleborough, while the lower part is a solid mass of about 200 feet in thickness, known locally as the Melmerby Scar Limestone. Below this is a variable but not thick mass of basement conglomerate, resting on the Silurian rocks which are exposed in the valley between the High Force and Caldron Snout. Not many miles to the west, in the Pennine escarpment, a thick series of sandstones occurs

below the Melmerby Scar Limestone, so it is evident that the floor on which the Carboniferous rocks were deposited was a very uneven one.

The section in Weardale is very similar to that in Teesdale, except that the Lower Carboniferous rocks are not reached.

When we reach Northumberland we find that the Mountain Limestone of Ingleborough is divided by intercalations of sandstone and shale so as to resemble in character the Yoredale Series above. This was long ago pointed out by Phillips, who says :—" The principal changes, as we proceed northward, appear to happen in the lower part of the limestone group, which loses its individuality, by admitting between its beds a constantly increasing quantity of mechanical admixtures, and at length becomes a subordinate feature in a country which has the characters of a coalfield." [1]   As we proceed from South to Mid-Northumberland, while the upper or Yoredale Limestones are generally persistent, the lower limestones representing the Great Scar gradually become thinner and less important, and in many cases disappear entirely, so that eventually we find that nearly all the important limestones are in the upper or Yoredale Series.   The work of my colleagues on the Geological Survey, as given in the published maps, is the authority for this part of Northumberland.

For Mid-Northumberland reference may be made to the admirable memoir by the late Mr. Hugh Miller on " The Geology of the Country around Otterburn and Elsdon " (1887), in which the announcement was made (see p. 5) of the identity of the Redesdale Limestone with the Dun Limestone of North Northumberland.   Mr. Miller and myself had many conferences on the correlation of the Lower Carboniferous rocks, and he entirely concurred in the main results embodied in this paper.   In this district the next limestone above the Redesdale is called the Fourlaws, and both these limestones traced into South Northumberland are found to lie far below the true Yoredale Limestones, and they therefore are portions of the Great Scar.

The North Northumberland section, somewhat generalized, is represented in the third column where the Dryburn Limestone is the uppermost of the Yoredales. Coals occur throughout the series down to the Fell Sandstones, but are omitted generally for the sake of clearness.   It will be seen that the principal limestones fall into two natural groups, in the upper of which the limestones are numerous and pretty frequent (down to the Oxford), while several hundred feet lower come the Woodend and the Dun Limestones. Below these is the group containing the Scremerston Coals, 800 to 900 feet thick, in which also limestones occur, but they are always thin (from 1 to 4 feet each), and are for the most part plant-limestones of an estuarine or fresh-water character.   Underlying the coals is a thick sandstone group—the Fell Sandstones—and at the bottom of the section is a portion of the Lower Carboniferous group called

[1] Manual of Geology, p. 165 (1855).

Tuedian Beds by the late Mr. Tate, of Alnwick, on account of their being characteristically developed along the Tweed. In 1856 Mr. Tate described these beds as consisting of grey, greenish, and lilac shales, sandstones, slaty sandstones sometimes calcareous, thin beds of argillaceous limestone and chert, and a few buff magnesian lime-stones. *Stigmaria ficoides, Lepidodendron,* coniferous trees, and other plants occur in some parts of the group, but there are no workable beds of coal. The fauna consists chiefly of fish-remains, Modiolæ, and Entomostraca. Generally fresh-water and lacustrine conditions are indicated.[1] The thickness of this series along the River Tweed from Carham to Berwick must be between 2,000 and 3,000 feet, and there is no doubt that it is the equivalent of the lower part of the Calciferous Sandstone of Scotland. Sedgwick seems to have been the first to point out the true position of these rocks in the Carboniferous formation in his address to the Geological Society in 1831; and in notes supplied by him for the third edition of De la Beche's Geological Manual he expresses the opinion that the Carboniferous Red Sandstone of the Tweed is superior to the Old Red Sandstone, and is about of the age of the Great Scar Limestone of Yorkshire and Cross Fell.[2] The natural inference from this would be that the limestones above the Scremerston Coals belong to the Yoredale Series, and it will be seen that this is so far true that *most* of the marine limestones belong to that series, viz. those from the Dryburn to the Oxford inclusive. This set of beds is thinner altogether here than in Wensleydale, but the difference is principally in the limestones, which in Wensleydale amount to about 300 feet, while in Northumberland they are not much more than half that thickness.

Among the sandstones and shales that come between the Oxford and the Woodend Limestones, occurs a marked band of oil shale which is very constant in North Northumberland. It contains remains of fishes, plants, and Ostracoda, and will be met with again in the Scottish section.

In the Northumberland section, No. 1 Limestone is the Dryburn Limestone of Lowick and the Ebb's Snook Limestone of Beadnell, and is called further south in Northumberland the Ten-Yard Lime-stone. It is the Main or Twelve-Fathom Limestone of Wensleydale and Swaledale, the Great Limestone of Teesdale and Weardale, and is the uppermost member of Phillips' Yoredale Series.

No. 2 Limestone is called at Lowick the Low Dean, and at Scremerston the Sandbanks Limestone, while generally in Mid-Northumberland it receives the name of the Eight-Yard Limestone. It is called in North-West Yorkshire the Underset Limestone, and in Teesdale and Weardale the Four-Fathom.

No. 3 Limestone is the Acre Limestone of Lowick, where it is also sometimes called the Dunstone (which name must not, however, be confounded with the Dun Limestone, the lowest of the marine

[1] Proc. Berwickshire Nat. Field Club, vol. iv, p. 151.
[2] De la Beche, Geological Manual, 1833, pp. 391, 392.

limestones). Further south it receives the name of the Six-Yard Stone, and in Weardale and Teesdale it is called the Three-Yard. It is the Little Limestone, 12 feet thick, in the Wensleydale section.

No. 4 Limestone is the Eelwell of Lowick and the Main Limestone of Beadnell and North Sunderland, and farther south in Northumberland it is called the Nine-Yard. In Weardale and Teesdale it is the Five-Yard. and in Swaledale it goes by the name of the Third Set of Lime. It is the ' Fossil ' Lime of Wensleydale.

Now it is these four limestones, with the intermediate strata, that form the group of limestones at Cat Craig, near Dunbar, which is the lower division of the Carboniferous Limestone Series of Scotland, and therefore these marine limestones of Scotland represent only the upper part of the Yoredale Series of Phillips.

The limestones numbered one to four have been traced almost continuously for nearly 100 miles, and we are certain of their identity, but the limestones below these have not been so traced, and there is some uncertainty about their exact equivalents. It seems most probable, however, that the six comparatively thin limestones, from 5 to 10 feet each, between the Eelwell and the Oxford, represent the Scar, Cockleshell, Singlepost, and Tynebottom Limestones of Weardale and Teesdale, and that the Oxford is on the horizon of the Hardraw Scar, or lowest bed of Phillips' Yoredale Series of Limestones. This much is certain, that the Woodend and the Dun Limestones are far below this horizon, and represent portions of the Mountain Limestone or Great Scar Limestone of Ingleborough. The Woodend is called in the Alnwick district the Hobberlaw Limestone, and in the Otterburn and Redesdale districts the Fourlaws Limestone, while the Dun is identical with the Redesdale Limestone. In Scotland generally these marine limestones below the Eelwell are represented by the estuarine Calciferous Sandstone Series. We have, however, a narrow strip of Lower Carboniferous rocks some six miles in length north of the Tweed, along the coast between Berwick and Burnmouth, and here most of the beds below the Eelwell can be observed, though the section near Berwick is a good deal faulted. Between the pier and the Fisherman's Haven the Eelwell, repeated by faults and folds, occurs four times over, the Oxford then is faulted against it, and in the area bounded by faults at the Bay of the Burgess' Cove occurs a set of beds of Tuedian-like aspect on the Oil Shale horizon. Northwards from this is a pretty continuous section from the thick sandstone above the Woodend Limestone down to the genuine Tuedians, which, with a steep reversed dip, are faulted against the Silurian rocks at Burnmouth. The Woodend and the Dun Limestones are thinner here than they are generally in Northumberland. The Dun or Lamberton Limestone may be followed along the coast for nearly three miles, and below it are found some at least of the Scremerston Coals, which were formerly worked at Lamberton, but were found to be poor and thin in comparison with the same seams south of the Tweed.

About 12 miles to the north-west, in a direct line from Burnmouth, Lower Carboniferous rocks are found on the coast of Berwickshire,

opposite Cockburnspath. We can recognize here in the white sandstones, interstratified with shales and with several thin and poor seams of coal, the representatives of the Scremerston Coal Series; the group of the Dun and Woodend Limestones is represented by a marine limestone in Cove Harbour, and in the next bay to the westward, immediately under the hamlet of Cove, occurs our well-marked band of oil shale. So far the section on this coast is very clear, but now the rocks which have been dipping steeply north or north-west flatten or undulate, though there seems to be a generally ascending series all along the coast to near Dunbar. Opposite Linkhead, 34 miles from Edinburgh, there is found an impure encrinital limestone, which seems most probably to represent the Oxford. Thus nearly all the lower limestones are dying out one after the other as we proceed westward, and at Skateraw most of the thin limestones between the Oxford and the Eelwell have disappeared, while at Cat Craig the lowest limestone is the Eelwell itself. My colleague Mr. Bennie, who has collected extensively both from the Acre Limestone of Lowick and from the second limestone (counting from below) at Cat Craig, has come independently to the conclusion that these limestones are the same, because they contain a similar assemblage of fossils. As all the rocks below the group of marine limestones at Dunbar have been classed as Calciferous Sandstones, it is now clear that the latter include representatives in time of the lower half of the Yoredale Rocks and the whole of the Mountain Limestone; and possibly the lowest part is older than the Scar Limestone of Ingleborough.

The upper part of the Scottish sectional column, viz. that called Carboniferous Limestone Series, is copied from that given by Mr. Howell on p. 73 of the Survey Memoir on the geology of the neighbourhood of Edinburgh, and it represents the Edge Coals of Midlothian Coalfield. Here we have a great development of coal-seams above the uppermost Yoredale Limestone, and higher up three thin marine limestones also accompanied by coal-seams. We have undoubtedly in Northumberland the equivalents of these upper limestones, also associated with workable coals, which, however, have been omitted from the Northumberland tables; lower down we have, close together, three or four coals which have been worked at Lickar, near Lowick; and elsewhere in Northumberland they are known as Little Limestone Coals. It seems pretty clear, then, that the Edge Coal Series of Midlothian is but an extraordinary development of these Lickar Coals. Even the total thickness of the beds in the Scottish section, some 1,300 feet from the lower limestones up to the Millstone Grit, can be matched in some parts of Northumberland. In Wensleydale this series is represented by a peculiar set of cherts, cherty limestones, etc., which cannot here be described, and on Ingleborough by a mass of shale. The term Yoredale was by the Geological Survey extended so as to include these beds, but they were classed by Phillips with the Millstone Grit, though sometimes he seems to have included a portion of them in his Yoredale Series.

It will thus appear how far from the truth was the old view that

COMPARATIVE SECTIONS OF ENGLISH AND SCOTTISH
LOWER CARBONIFEROUS ROCKS.
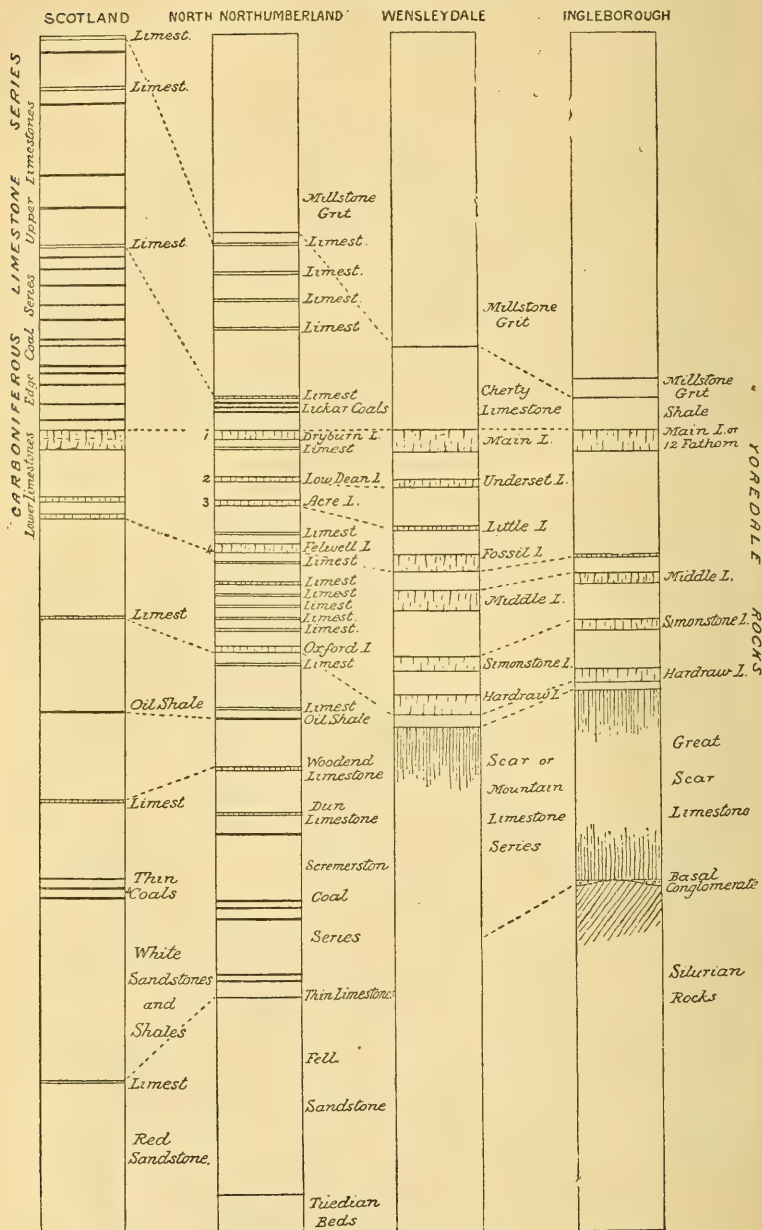
Corrigendum: for 'Felwell' (in middle of plate) read 'Eelwell.'

the Carboniferous Limestone Series of Scotland represents both the Yoredale Rocks and the Mountain Limestone of England, and that the Calciferous Sandstone is older than the Mountain Limestone. The newer reading, that the Scottish Limestone Series is the equivalent of the Yoredale Beds, and the Calciferous Sandstone of the Mountain Limestone, is a nearer approximation to the truth, but is still far from being correct, especially as it has been shown that the greater part of the Scottish Carboniferous Limestone Series, including the upper limestones and the whole of the Edge Coal Series, lies above the position of the Yoredale Beds of Phillips.

III.—The Solent River.

By the late Sir Joseph Prestwich, M.A., D.C.L., F.R.S.

(Communicated by Lady Prestwich.)

[The idea of a great river flowing through the Solent before the Isle of Wight was separated from Dorsetshire, was very clearly stated in 1862 by the Rev. W. Fox, who for many years was Curate of Brixton, in the Isle of Wight (*Geologist*, vol. v, p. 452). The subject was further dealt with two years later by Sir John Evans (Quart. Journ. Geol. Soc., vol. xx, p. 189), and subsequently by Mr. T. Codrington (ibid., vol. xxvi, pp. 541, 544). Sir John Evans has since entered more fully into the subject ("Ancient Stone Implements, etc., of Great Britain," and *Nature*, vol. xxvi, p. 532) ; and it was briefly discussed by Sir J. Prestwich in his paper on "The Raised Beaches and 'Head' or Rubble-drift of the South of England : their Relation to the Valley Drifts and to the Glacial Period; and on a late Post-Glacial Submergence" (Quart. Journ. Geol. Soc, vol. xlviii, p. 274).

The following article was marked by Sir J. Prestwich as "part of Submergence paper as first written but reserved for a separate paper."—H. B. W.]

AT Portsea Island a change takes place in the character of the drift, the 5 to 6 feet of gravelly clay forming the "Head" on the Old Beach to the east, being replaced on the same level by a bed of gravel, which, according to Mr. T. Codrington, attains a thickness of 27 feet, and still contains some boulders similar to those of Hayling Island, together with blocks of sarsenstone. To the west of Gosport the ground rises and the low cliffs of Stubbington and Hill Head are capped by 10 to 15 feet of gravel of a somewhat different character. No foreign boulders are to be seen in it, though I have found pebbles of quartzite derived apparently from the Triassic strata of Devonshire, as also some small subangular fragments of granite and other old rocks, large blocks of Tertiary Sandstone, and a few worn fragments of a fresh-water limestone[1] containing small *Lymneæ*. There are no shells either fluviatile or marine, and no beach underlies the gravel which rests directly on the Tertiary strata. It is intercalated with seams of sand and loam

[1] Derived from the opposite coast of the Isle of Wight.

roughly bedded, and contains flint implements.[1]   It is evident,
therefore, that we have here some important changes in physical
conditions, and that a considerable alteration in the characters of
the drift-beds likewise commences.   This has led to the belief that
the gravel on the coast from this point to Bournemouth and Poole
is the Alluvium of an old river, which, before the removal of the
Chalk ridge that extended across the bay of Christchurch, blocked
the rivers flowing southward, and diverted them into a main stream
flowing eastward, passing along the line of the present Solent and
debouching in the area now occupied by Spithead.

I cannot agree in this view, as it is wanting in proof, though as
the subject is a complicated one, and would take too much time to
discuss at length, I will merely touch upon some of the objections
which occur to me.   No one can doubt that the Chalk range of the
Isle of Wight was once continuous to the Dorset Coast in the Isle of
Purbeck, but it does not follow that it formed an impassable barrier
by which the drainage of the Frome, the Trent, the Stour, Avon, and
other rivers was stayed and made confluent, giving rise to the
" Ancient river Solent."

There is no reason why these separate rivers should not have held
on their southern course and passed through the barrier as the rivers
on the Sussex coast do at the present day.   To prove the contrary,
it must be shown that the gravel-beds in question are of fluviatile
origin, and that they contain the débris of rocks through which the
supposed river and its tributaries flowed, also that the levels are
such as would accord with the gradients of a river of that character.
An able exponent of the hypothesis admits that it is hard to
distinguish between the presumed fluviatile gravels and the older
probably marine gravels.[2]   First, as none of these gravels contain
either fresh-water or marine shells, the difficulty is easily understood.[3]
By itself this would not be a strong objection, as we all know how
frequently such organisms have been removed by the percolation of
the surface-waters, but taken in conjunction with others, it cannot
be neglected.   Secondly, the débris forming the gravel consists
almost entirely of materials derived from the high Chalk plateau to
the north of the coast-line.   Thirdly, there is no maintained fall of the
gravel from west to east.   The section given by Mr. Codrington[4]
along the coast for a distance of 10 miles between Poole and Barton
shows the following surface-heights :—West—126, 125, 117, 115,
121, 110, 120, 114, 117, 98, 126, and 114 feet—East; and so on to
95 feet near Lymington.   East of Lymington a lower plateau
commences, the level of which continues at heights varying from
35 to 40 feet to Hill Head and Stubbington.   So much for the
surface-levels.   Taking the levels at the base of the gravel, the

[1] Evans, Quart. Journ. Geol. Soc., vol. xx, p. 188.
[2] Evans, "Ancient Stone Implements," 1872, p. 609. [See also ed. 2, 1897,
pp. 688–696 ; also " Geology of Isle of Wight," ed. 2, p. 249, Geol. Survey ; and
C. Reid, " Geology of Bournemouth," 1898, pp. 10, 11, Geol. Survey.]
[3] The only fossil I have found in these gravels is a small indeterminable fragment
of bone in a pit near Poole Station.
[4] Quart. Journ. Geol. Soc., vol. xxvi, pl. xxxvii, fig. 2.

result is very similar. The top of the Eocene strata near Bournemouth is from 90 to 115 feet above the sea-level. It is about the same at High Cliff and Barton, and but little less near Lymington.

It is the same with the lower plateau, in which the surface of the Tertiary strata remains on a nearly uniform height above the sea-level for a distance of about 18 miles. Surely it is impossible to suppose that these levels can represent the gradients of a channel such as the supposed river must have had.

From Poole to Lymington, a distance of 20 miles, the gravel is nearly a dead level, and for the whole 35 miles to Stubbington there could only have been a fall of 60 to 70 feet. With these gradients, the transport of such a mass of débris as constitutes the gravel-beds would have been an impossibility; and equally unlikely would have been the sudden ending of the mass at Stubbington, and the escape of Hayling Island from the flood of this supposed river-gravel drift. Nor is the wear of the gravel as it must have been, had it been subjected to this long transport. In fact, there is no difference in the wear between the gravel in the neighbourhood of Bournemouth and that around Lymington—a condition equally inconsistent with the primary assumption.

It is, I think, more probable that the gravels on the Bournemouth and Barton coast represent a vast "head" derived from the high-level gravels further inland, for, like the latter, these coast gravels contain a considerable proportion of chert, ragstone, and ironstone fragments, derived originally from the Lower Greensand, and introduced thus indirectly into these lower-level gravels.

IV.—Further Investigations regarding the Submerged Terraces and River Valleys Bordering the British Isles.[1]

By Professor Edward Hull, LL.D., F.R.S., F.G.S.

I. *Introductory.*—The researches of previous investigators have had the result of showing that the platform on which are planted the British Isles and adjoining parts of the European continent was formerly connected by land with Iceland through the Shetland and Faeröe Islands, and this again with Greenland. This former connection is placed beyond doubt by the character of the fauna and flora. Dr. Wallace includes Iceland in his Palæarctic region, which embraces the British Isles and Europe;[2] and, as Professor Newton has shown, all the land mammalia, with only three exceptions, are European. The exceptions are those of Arctic habitats—the polar bear, the Arctic fox, and a mouse (*Mus Icelandicus*). Amongst the birds, the peculiar species are allied to those of Europe and the Faeröes. The botany and entomology of Iceland have been described in the Transactions of this Institute by the Rev. Dr. Walker, F.L.S.,[3] and his observations bear witness to the former

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[1] Read before the Victoria Institute, May 2nd, 1898. Published by permission of the Council of the Victoria Institute. The full paper, with map, will appear in the forthcoming volume of the Transactions for 1897–98.—E. H.

[2] "Geographical Distribution of Animals."

[3] Trans. Vict. Inst., vol. xxiv, p. 205.

land connection of Iceland with the British Isles. He remarks that "the first thing that strikes a visitor from the latter country is not the number of Arctic species, but the great abundance of plants that are very rare and local in Britain, such as *Saxifraga cæspitosa, Lichnis alpina,* and *Erigeron alpinum,* etc." The disappearance of the former glacial conditions from the British Isles and their continuance in Iceland account for the remarkable abundance of the plants referred to.

The very ample survey of the insects given by Dr. Walker leads him to the following conclusions :—

    1. The total absence of diurnal Lepidoptera.
    2.   ,,   ,,   Orthoptera.
    3. Neuroptera only represented by Phryganidæ.
    4. The most abundant tribes of insects in Iceland are moths and *Diptera.*

On the whole, the insect fauna, as well as the flora, of this island bear a remarkable affinity to those of Scotland.[1]

Now, we must not forget that this community of fauna and flora is characteristic of existing genera and species, and indicates a very recent physical, or land, continuity. It may date back, perhaps, as far as Pliocene times, passing into Recent, but not earlier; and if this be so, we have to consider to what extent the bed of the Atlantic Ocean requires to be raised in order to establish such a land connection, or in other words the amount of recent submergence which it has undergone; we have also to determine the tract of the ocean over which the continuity of land surface formerly existed.

The remarkable results established by American naturalists regarding the submerged terraces and river-valleys adjoining the American continent and prolonged into the North Atlantic, which have already been communicated to the Institute by Mr. Warren Upham,[2] and more recently by myself, have induced me to take up the investigation of the sub-oceanic region adjoining the British Isles with the aid of the Admiralty charts of soundings, which afford most ample materials for such investigation. The results, which appear to me of remarkable interest, I now venture to place before the Institute; from which it will be found that all tend to confirm the view of a very recent elevation of the British, and adjoining continental, areas to the extent of several thousand feet as compared with the level of the ocean surface at the present day.

II. *Land Connection with Iceland.* — An examination of the hydrographical charts shows that it would be necessary to raise the bed of the ocean to the extent of 1,320 feet (220 fathoms) in order to establish a land connection between the British Isles and Iceland. The actual amount of elevation was probably greater and may have reached about 6,000 feet. The evidence for this will be seen further on; and it corresponds very closely with the amount of elevation determined for the coast of North America by the

[1] Supra cit., p. 241.
[2] Trans. Vict. Inst., vol. xxix.

observers already referred to.[1] Indeed, all the evidence obtainable by soundings goes to show that the whole area of the North Atlantic has undergone stupendous changes of level in very recent times both as regards emergence and submergence.

III. *The British Platform.*—The submerged terrace on which the British Isles and adjoining portions of Europe are planted is generally known as " the 100-fathom platform." It is often represented on hydrographical charts, such as those of the late Professor Sir Wyville Thomson, by the 100-fathom contour taken from the Admiralty Chart.[2] But this strict adherence to the 100-fathom contour is misleading as regards the great physical features of the submerged lands; and the same observation applies to the other contours. These features undergo elevation and depression according to geographical position; and it is only by a close observance of the changes of depth, as indicated by the soundings, that the features themselves can be recognized and portrayed.[3]

Throughout a distance of 500 miles from the vicinity of Rockall on the north to the entrance of the Bay of Biscay, the British platform terminates seaward along the margin of a grand escarpment of 7,000 to 8,000 feet in height and remarkable for the steep descent of its flanks; in some cases precipitous. The edge of this escarpment is quite sharp, and well-defined by the sudden descent of the soundings; and at, or towards, its base it gives place to the abyssal plain with a very gentle descent towards the oceanic bottom. Off the coast of Scotland the escarpment is known as the Vidal Bank. Its upper margin very closely coincides with the 100-fathom line, but on tracing the margin southwards it is found to gradually become deeper, till opposite the entrance of the English Channel the margin nearly coincides with the 180–200 contours. The following sections taken at intervals from off the Hebrides to the coast of France, at the entrance to the Bay of Biscay, will illustrate this general statement.[4]

No. 1. Drawn through Rockall to the Isle of Mull, illustrates the form of the sea-bed near the head of the great bay which here penetrates northwards into the plateau, which stretches from Scotland by Rockall towards Iceland, on which the Faeröe Islands and Orkneys are also planted. The margin of the British platform is sharply defined by the 100-fathom contour at about 70 miles from Uinst, at which point the escarpment descends at a steep angle to the 1,000-fathom contour, where it gives place to the abyssal floor of the ocean, descending to a further depth of about 1,350 fathoms or 8,100 feet. The total height of the escarpment is here 7,500 feet approximately.

No. 2. Represents the outline of the sea bed west of County

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[1] I have given a short preliminary notice of the results of my examination of the Admiralty charts in *Nature*, March 24th, 1898.

[2] " The Depths of the Sea," pls. ii, iv, v (1873).

[3] The British platform is described by Professor Spencer, Geological Magazine, No. 403, p. 37 (1898).

[4] The sections here described are drawn on the plate which accompanies the original memoir in the Trans. Vict. Inst., vol. xxx, 1898.

Donegal, at Slieve Liag, which rises in a bold headland of nearly
2,000 feet from the ocean. Here the margin of the British platform
is still closely represented by the 100–120 fathom contour, and the
escarpment descends to the 1,000-fathom line, from which the floor
of the ocean gently descends to a depth of about 1,600 fathoms
or 9,600 feet ; the form and height of the escarpment are similar to
those of section vii, but somewhat steeper.

No. 3. This section is remarkable for two points : first, the width
of the British platform and the depth of its western margin below
the ocean surface. It is drawn from the coast of Clare, where
the cliffs of Mohir, formed of Carboniferous Sandstone, rise 400 feet
above the sea, along a series of soundings stretching due west for
a distance of 280 miles. The platform is here about 200 miles
across, and its western margin is indicated by the 200-fathom
contour very nearly ; that is, twice the depth of the margin opposite
Donegal and the Hebrides. The escarpment here, just west of the
"Porcupine Bank," is very bold and lofty ; descending abruptly
from the 200 to the 1,500 contours, being a total descent of about
7,800 feet. Directly north of the Porcupine Bank, the escarpment
is quite precipitous, as the two terminal contours (the upper and
lower) are in close proximity. With this tremendous descent
of over 7,000 feet, the escarpment stretches southward, till opposite
the south of Ireland it sweeps round eastward, producing a wide bay
about 200 miles across, and sloping upwards to the marginal line of
200 fathoms. Opposite this bay the floor of the ocean descends
to a depth of 2,500 fathoms (or 15,000 feet) within a distance of
200 miles.

No. 4. This section is drawn from the coast of Kerry in a south-
westerly direction, and is continued eastward over Carantual, the
highest mountain in Ireland, reaching a height of 3,400 feet above
the sea. The platform is here only 60 miles across, and the descent
from its margin is less precipitous than in the case of Sections 2
and 3. The depth of the margin is about 200 fathoms, and after the
initial steep descent to about 1,500 fathoms, the ocean bed gently
declines, till, at a distance of 170 miles from the margin, it reaches
a depth of 2,300 fathoms or 13,800 feet. This is the last of the
sections I have drawn, but if another were taken in a south-westerly
direction from Ushant, off the coast of France, it would show
a platform of 80 miles in breadth, breaking off at the 200-fathom
line in a sheer precipice of 5,000 feet just south of La Rochelle
Bank, which is situated at the edge of the platform itself.

We have now reached the southern limit of the region which
I have proposed to myself for investigation at the northern end
of the Bay of Biscay, but I do not doubt that the features here
described are continued still further south.[1] From what has been
stated it will be seen that throughout a line of coast of 600 or 700

[1] This statement I have since verified by an examination of the Admiralty chart
over the Bay of Biscay, which affords most interesting results, especially in the
determination of the channels of the rivers Loire and Adour traversing the platform,
and descending through deep cañons to the base of the great escarpment.—E. H.
(April, 1898).

miles we have a remarkably uniform succession of features, consisting of a gently sloping submerged terrace, stretching out from the coast to a variable distance, but which, on reaching a depth of 100 to 200 fathoms, breaks off in what would be a grand escarpment of 7,000 to 8,000 feet, if viewed from the outer ocean. Such regularity of features through so great a distance cannot be regarded as accidental; it points to uniformity of cause and mode of production. It is to a terrestrial surface we must have recourse for the explanation of the physical conditions here described. We are familiar with examples of plateaux bounded by escarpments leading down into plains both in the British Islands and in other countries. We have a familiar example in the Cotteswold Hills of Gloucester and Somerset; in the range of the Jura; in the range overlooking the Delta of the Nile above Cairo. All these terraced escarpments have been formed over the surface of emergent lands; they are absolutely terrestrial, not oceanic in their origin; and in ascribing a similar origin to those here under consideration, we are only drawing a logical deduction from the premises laid down. In a word, this grand terraced escarpment of the British Isles must have been formed during a period of emergence of the whole region to an extent of several thousand feet above the surface of the ocean, as it is at the present day. Professor James Geikie has recognized the generally abrupt descent of the continental plateau, but does not appear to have recognized that such features must have had a terrestrial origin.[1]

IV. *Submerged River Channels.*—The views I have just expressed receive remarkable confirmation from the existence of old river channels, which may be traced on the Admiralty charts by the soundings. It will be evident that during the period when the British platform was in the condition of a land surface, the rivers descending from the adjoining land, as well as the rain which fell upon its own surface, must have had outlets to the ocean towards the west; and we are, therefore, led to inquire, are such outlets, in the form of river channels, to be recognized by the soundings? I am able to give a very decisive answer in the affirmative to this question. Notwithstanding that the submerged lands around the British Isles have for thousands of years been covered by water, more or less loaded with sediment, and during the later glacial stages laden with icebergs and floes carrying stones and mud, two old river channels, at least, can be clearly traced—one draining the lands now occupied by the waters of the Irish Sea, and the other, by those of the English Channel. The courses of these old rivers are indicated by slightly irregular depressions in the soundings, varying in depth from 2 to 20 fathoms below the general levels adjoining, but they become remarkably accentuated on approaching the margin of the great escarpment, where they are converted into gorges or cañons bounded by precipitous walls of rock, and traceable down nearly to the base of the escarpment.

[1] Address to Geographical Section, Brit. Assoc., 1892: Proc. Roy. Geog. Soc., Sept., 1892, p. 639. The author, however, clearly describes the mode of formation by marine action on emergent lands of such plateaux as the British platform, p. 644.

V. *The English Channel River and the " Hurd Deep."* — The course of the river which drained the area of the English Channel can generally be traced by a curving line of depression from its source near the Straits of Dover to the margin of the great escarpment, where it cuts deeply into the rock in the form of a gorge or cañon.   Owing, probably, to silting up by sediment, the course is less evident than it would have been had no sediment been deposited.   But at one part of its course its position is still clearly defined on the chart for a distance of 70 miles under the name of the " Hurd Deep."   This is a nearly straight E. and W. gorge about 4 to 5 miles across, and at its deepest part 354 feet below the general floor of the sea bed.[1]   Here, we may suppose, the channel has been kept open and free from sediment, unlike the portions of the river valley above and below.   The cause of this dissimilarity of conditions is not far to seek.   On looking at the map it will be seen that the " Hurd Deep " lies in the narrowest part of the channel west of the Straits of Dover, between the Isle of Wight and Portland Bill on the north, and Cape de la Hague and Cape de Barfleur on the south.   Above and below this strait the channel broadens out to about twice its breadth between these points; hence the tidal currents have here extraordinary force and swiftness, owing to which the sediment, deposited above and below, appears to have been prevented from settling down and filling up the gorge of the old river.   The general outline, the direction and position of this remarkable rift, all point to the " Hurd Deep " as a river channel which has been cut down into the solid rock, and is bounded by steep, or precipitous, cliffs resembling on a small scale the American cañons.   The two submarine rivers here described must have exceeded in size any of our existing streams, and we may infer entered the ocean in a succession of grand cascades.[2]

VI. *Comparison with the American Submerged Platform.*—In my former paper[3] I described briefly the results arrived at by Professor Spencer and other American geologists regarding the " drowned " plains, escarpments, and river valleys lying outside the North American coast, and I showed that they consist (1) of the " Continental Shelf," stretching out into the Atlantic as far as the 100-fathom line, or thereabouts, when it breaks off along an escarpment, descending to a depth of 450 or 500 fathoms.   This escarpment is then succeeded by a second and more extensive terrace, known as " the Blake Plateau," which in turn terminates along a second grand escarpment descending to the abyssal depths of

[1] The deepest point shown by the soundings is 95 fathoms, while the bordering level of the sea bed is 36 fathoms.

[2] Man was not present to view the scene presented by the British Isles at this time ; but we may easily reproduce before our minds its grandeur as visible from the ocean at a distance of a few miles from the coast.   In front would rise the lofty terraced cliffs, several thousand feet in height, and stretching away to the north and south in bold headlands and wide bays till lost to sight in the distance ; while, planted on the nearly level terrace above, would be seen in the far distance the mountain heights robed in a white mantle of snow.

[3] " On Another Possible Cause of the Glacial Epoch " : Trans. Vict. Inst., 1898.

the ocean. It will be observed that as compared with the British subcoastal features there is a general resemblance, but with one important exception, namely, the absence of the representative of the " Blake Plateau." We may, without hesitation, recognize our British platform as the equivalent of the Continental Shelf; but, as I have already shown, the former terminates along the margin of one great escarpment descending to depths of nearly 10,000 feet. A solid escarpment of this kind indicates a slow continuous elevation, after the British platform had been planed down by wave action and subsequent depression after a lapse of time. On the coast of the American continent, however, there appears to have been an intermediate period representing a pause in the process of elevation and subsequent depression, during which the second shelf, or " Blake Plateau," was elaborated.

VII. *Geological Age of the Submerged Features.*—The formation of the British platform, like that of the American " Continental Shelf," may be referred back with confidence to the Mio-Pliocene period, and that of the grand escarpment to the succeeding early Pleistocene or Glacial stage. This view is in harmony with analogy and with what we know of the physical conditions of these periods. The Mio-Pliocene stage was one of great terrestrial changes of land and sea over the European and adjoining areas; but the climatic conditions were warm and genial, with a foretaste of more rigorous conditions towards the close. An elevation of 100 to 200 fathoms round our coasts would have been insufficient to have brought on glacial conditions, although undoubtedly tending in that direction in our more mountainous districts. But a further elevation to the extent of several thousand feet would undoubtedly bring about such conditions; and we are, therefore, justified in inferring a close relationship between this latter rise of the land with the adjoining oceanic bed and the incoming of those Arctic conditions which resulted in covering, not only our mountain heights but also the adjoining plains, with perennial snow and glaciers.

Having already in my former paper treated the subject of the origin of the Glacial period at some length, it is unnecessary that I should dwell upon it here, or explain how the great rise of the land would necessarily result in bringing about glacial conditions in the North Temperate zone, especially when combined with alterations in the temperature of the Gulf Stream. On these points the reader is referred to my former communication, and I shall only add here, that the conclusions which I ventured to enunciate on the basis of the statements of previous authors have been fully verified by my own study of the Admiralty charts, which I have here communicated to the Institute.[1]

[1] Professor T. McK. Hughes, in his interesting paper on " The Evidence of Later Movements of Elevation and Depression in the British Isles," read before the Institute in 1879, postulates a rise of the land to the extent of several thousand feet and infers the climatic changes which would thence result. I hope he will now concur with me that such a rise has actually taken place.—E. H.

NOTICES OF MEMOIRS.

The Geological Survey of Great Britain and Ireland.

Summary of Progress of the Geological Survey for 1897. By Sir A. Geikie, D.Sc., D.C.L., LL.D., F.R.S., F.G.S., Director-General. 8vo; pp. 176. (London : Eyre & Spottiswoode, 1898. Price 1s.)

(Continued from the July Number, p. 318.)

2. Preparation of Maps, Sections, and Memoirs.—The results obtained by the Geological Survey are made public in three forms : Maps, Sections, Memoirs and Annual Reports, to which may be added the arrangement of specimens in the three national museums, with their diagrams, handbooks, and other explanatory matter, and also the original papers, which, lying often beyond the scope of the Survey's publications, are prepared by members of the staff and, with the consent of the Director-General, are communicated by them to scientific societies and journals.

(a) *Maps.*—Experiments were tried some years ago as to the feasibility of producing the one-inch Geological Survey maps by colour-printing. But the scale of these maps is so large, the number of sheets so great, and the sale of many of them so comparatively small, that this method of reproduction has not yet been adopted. A large impression of each sheet would require to be printed off and a considerable stock would accumulate, so that any additions and alterations of the maps would be impracticable for many years. The original system of colouring by hand, which has up to the present time been retained, has this advantage, that by keeping the supply of copies of each sheet just sufficient to meet the demands of the public, any alteration of a map which from time to time may be found to be necessary, can be made without the loss involved in cancelling a large stock of copies.

Colour-printing may eventually be applied to the new series of one-inch maps. In the meantime it has been successfully tried in the case of a general map of England and Wales on the scale of four miles to an inch, to which reference will be made further on.

Some idea may be formed of the nature of the colouring work of the Survey maps, from the fact that upwards of 180 different tints and combinations are employed to denote the various kinds of rocks separately discriminated on them. It is difficult to find colours distinct from each other, yet harmonious, and that will not fade on exposure. To guard as far as possible against the risk of fading, every colour is also distinguished by its own symbol, which is legibly engraved where the colour occurs on the map.

Two editions of the one-inch map of England and Wales are issued for those districts of which the Drift survey has been completed, but where the drift covers small areas one edition is

found to be sufficient. One of these editions shows all the super-ficial deposits, and only the parts of the underlying formations as lie bare at the surface. The other edition presents the underlying formations as these would appear if the superficial accumulations could be stripped off. Each of these editions has its value for special purposes. In all questions of sanitation, water supply, agriculture, and building, it is obviously the "Drift" edition that should be consulted, while, on the other hand, where the informa-tion desired has reference to what lies deeper beneath the surface, as in the sinking of deep wells and mines, it is the "Solid" edition that will be most usually consulted. The difference between the two is merely one of colouring, for they are printed from the same copperplate, and as far as the engraving goes are exact duplicates.

The total number of six-inch maps published by the Geological Survey up to the present time is for England and Wales, 223 sheets; Scotland, 127 sheets; Ireland, 10 sheets. The number of one-inch whole-sheets and quarter-sheets (Old Series) for the whole of England and Wales amounts to 261; 238 of these are published only as "solid" maps; 95 are issued in two editions, "solid" and "drift"; of 23 only the "drift" edition is published. Of maps on the one-inch scale, belonging to the New Series, 15 sheets have been published, 11 of which are issued in two editions with and without drift. The number of sheets published of Scotland is 60, and of Ireland 205. The whole of Ireland has been completed and pub-lished. Every effort is now being made to complete at as early a date as possible the survey of Scotland, but the extraordinary complication of the geological structure of the Highlands, being far greater than was ever anticipated, renders the progress less rapid than was originally expected.

The desirability of having a general geological map of the country on a smaller scale than that of one-inch to a mile has long been recognized. When the mapping of England was completed, ad-vantage was taken of the existence of an index Ordnance Survey map on the scale of four miles to an inch ($\frac{1}{253440}$). This map, based on the old one-inch maps, had been laid aside incomplete by the Ordnance Survey, but it was likely to be so useful for geological purposes that at the request of the Director-General it was finished at Southampton. The work of the Geological Survey has been reduced upon this map, of which there are for England and Wales 15 sheets. The whole of these sheets have now been published in chromo-lithography, and when mounted in one sheet present at a glance a clear and vivid picture of the geological structure of the whole country. The price of each sheet is 2s. 6d., and the total cost of the map is £1 17s.

The value of reduced index-maps for geological purposes was recognized long ago by the preparation of a general map of Wales. When the Geological Survey of the Principality was finished the whole work was reduced to the scale of four miles to an inch and engraved in six sheets, which include parts of the West of England. This map has been on sale for many years.

(*b*) *Sections.*—The Vertical Sections are drawn usually on the
scale of 40 feet to an inch, and are prepared almost entirely to
illustrate the succession of strata in the coalfields. Each sheet
generally contains more than one section. The materials for the
plotting of these sections are sometimes obtained by actual measure-
ments taken by the surveyor himself, but more commonly are
supplied by the lessees or managers of the collieries. Sometimes
tables of comparative sections are given, in illustration of variations
in character and thickness between the seams of coal, ironstone, or
limestone in different parts of the same mineral field.

Occasionally, where a group of strata, though of little industrial
importance, possesses great geological interest, a vertical section of
it has been constructed and published in the same style as the
coalfield sections. In this way sections of the Jurassic rocks in
Eastern Yorkshire, of the Lower Lias and Rhætic rocks in the
West of England, of the Tertiary strata in the Isle of Wight, and of
the Purbeck group in Dorset have been issued.

Altogether 90 sheets of Vertical Sections have been published for
the three kingdoms.

The Horizontal Sections have been an important feature in the
work of the Geological Survey. De la Beche, recognizing the
practical disadvantages arising from the construction of sections
without any regard to the proportion between height and distance,
instituted the practice of drawing them on a true scale. He adopted
the scale of six inches to a mile, and invented a system of patterns
for the different kinds of rock, which, as he was himself an artist,
are appropriate and effective, for they represent in no small measure
the general structure of the rocks. The institution of such sections,
in lieu of the distorted diagrams too generally employed, was of
great service to the survey itself and also to the progress of geology;
for it served to correct the evil influences of distorted drawing, with
regard not only to geological structure but to the true forms of the
ground.

As an illustration of the character of these sections and their
usefulness in correcting popular misconceptions as to geological
structure and the form of the ground, reference may be made to that
which runs from Leicestershire to Brighton and passes through
London (Sheet 79). What is called the "London Basin" is by
many people regarded as a deep trough of clay, with the Chalk
rising steeply from under it both to the south and north, and we
may see this conception embodied in actual diagrams in textbooks
and elsewhere. But in reality both the London Clay and the Chalk
are so nearly flat that their inclination can hardly be detected except
by careful measurement. And the section, accurately plotted from
borings and well-sections, shows them apparently horizontal, though
on further inspection we find that their line of junction, which is
well above the datum-line at either end, lies several hundred feet
beneath it in the centre.

In all, 193 sheets of such sections for the United Kingdom have
been issued.

Besides the usual Horizontal Sections on the scale of six inches to a mile, occasional sections on a larger scale are prepared to illustrate the geological structure of particular localities. In this way the coastline of Cromer and Yarmouth has been represented in detail, and its numerous features of geological interest have been inserted so as to exhibit a kind of picture of the arrangement of the strata in these changing cliffs. Portions of the coastline of Dorset and of the Isle of Wight have been similarly treated.

(c) *Memoirs.*—It has for some years been customary to insert in the Annual Report of the Director-General of the Geological Survey (submitted to the Science and Art Department, and published in its Annual Report) a general statement of the nature and progress of the operations of the Survey for the year. This statement has at last become too voluminous to find a place in that Report. It is now given in the present publication, which is the first "Summary of Progress." It is intended hereafter to continue this series uniform with the Memoirs.

Obviously, in the course of a geological survey, a large amount of detailed information is collected which cannot find a place either on the Maps or the Sections. This material embraces much local detail, and a large body of evidence which is of importance in general geological inquiry. It can only be properly used by being arranged, condensed, and printed. The issue of Memoirs of its work has, therefore, been from the beginning one of the chief occupations of the Geological Survey of the United Kingdom. The form in which these publications have appeared has varied. De la Beche's plan was to publish volumes of General Memoirs, embracing descriptions of particular regions and also essays on special branches of geological inquiry. His own memoir on the geology of Cornwall, Devon, and West Somerset is an admirable example of his method, and has long taken its place among the classics of English geology. Edward Forbes' striking Essay on the "History of the British Flora and Fauna" and Ramsay's on the "Denudation of Wales" appeared in the first volume of these General Memoirs. There were practical difficulties, however, in the way of continuing these volumes when the staff increased, and the literary labour had to be shared by a number of observers, who were, in many cases, more ready to wield their hammers than their pens. When Murchison succeeded to the charge of the Survey, he sought to avoid these difficulties by instituting the practice of accompanying every sheet or quarter-sheet of the one-inch map with an explanatory pamphlet, giving the chief data on which the map had been constructed, with references to the best sections, lists of minerals, rocks, and fossils, and information as to the geological structure of the ground. These pamphlets, containing essential details only, were to be eventually condensed and collated by the Local Director, so as to form a generalized view of each important geological region. This scheme was well conceived, and with some modifications, rendered necessary by the progress of the Survey, has been continued. It is not always possible or desirable to prepare a separate explanation for each sheet or

quarter-sheet, for much reduplication of geological information would thereby be involved. Several quarter-sheets or sheets may be described together in a single Memoir.

Occasionally these Memoirs, when dealing with an important district, have been expanded beyond the limits of mere Sheet Explanations, and have taken the form of octavo volumes. Such, for instance, are the Memoirs on the Yorkshire Coalfield, on North Wales, on the geology of the Weald, on the geology of London, on the Isle of Wight, and on Cowal, Argyllshire.

The chief literary work on which the staff of the Survey is now engaged is the preparation of the General Memoirs to which the Sheet Explanations were designed to be preparatory. It appeared to the present Director-General that these Memoirs should consist of two series. In the first place, it is desirable that the local details which remain unpublished, or which have been scattered through separate Explanations, should be collected, condensed, and arranged so as to present a description of each important district of the country. As examples of this mode of treatment, the volumes on the Weald, London, and the Isle of Wight may be referred to. In the second place, it is obviously necessary, in the interests of geology, that the contributions made by the Survey to that science should be systematically set forth, and that a full account should be given of each of the geological formations of which the framework of the British Isles is built up. To carry out this requirement a stratigraphical rather than a geographical treatment is needful. A series of Monographs is demanded devoted to the description of the various rock-systems of the country, and brought up to the time of publication by giving not only what has been done by the Survey but an outline of the work of other observers.

The information obtained by the Survey in its progress is necessarily scattered through many maps, sections, and memoirs. The work of the service would be incomplete and difficult of consultation if it were left in this disseminated state. It needs to be gathered together, arranged, and put into connected form, so as to present an intelligible account of the geology and mineral products of these Islands. The task is a heavy one and cannot be speedily finished; but satisfactory progress is being made. A Monograph on the Pliocene deposits of England in one volume, and five volumes of another on the Jurassic rocks, have already been published; one on the Upper Cretaceous rocks is far advanced, and others are in preparation. Each Monograph will embrace one system or group of rocks, and may consist of one or more volumes according to the importance of the system and the area which it occupies in the country.

In the preparation of the memoirs, and for museum purposes, much assistance is now derived from photography. Several members of the staff have become expert photographers, and a large number of views of geological sections, coast-cliffs, and other natural or artificial exposures of rock have been taken. These serve as illustrations for the memoirs, and some of them are mounted to

accompany the specimens in the museums. It is in contemplation also to employ photography for duplication of the six-inch field-maps.

Besides the geological Memoirs, the Survey has published a series of Decades of British organic remains, with plates and descriptions, also Monographs of important genera or groups of fossils, including Professor Huxley's essays on *Pterygotus*, the Belemnitidæ, and the crocodiles of Elgin, and Mr. Newton's memoirs on Cretaceous fishes and Pliocene vertebrates.

3. PETROGRAPHICAL WORK.—In the earlier days of the Geological Survey each member of the staff determined for himself, by such tests as he could apply, the various rocks encountered by him in the field. Only in rare cases were chemical analyses made for him. The study of rocks had fallen into neglect in this country, being eclipsed by the greater attraction of the study of fossils. The introduction of the microscope into geological investigation has, however, changed this apathy into active interest. It is now recognized that apart from mere questions of nomenclature, rocks contain materials for the solution of some of the most important problems in physical geology. Accordingly, microscopic inquiry has in recent years been organized as one of the branches of the Geological Survey, and now affords constant and material aid in the progress of the mapping, three members of the staff being specially detailed for petrographical work in the office and in the field. Chemical analyses are likewise made, so as to afford all available information as to the composition of the mineral masses encountered in the field.

The original specimens from which the thin slides have been prepared are kept in cabinets, so that if any accident should befall a slide, a new slice can at once be cut. The mounted slides are arranged in separate cabinets. A large number of such slides has now been accumulated. From Scotland alone nearly 8,000 have been determined, and are ready for reference at any moment.

But besides assisting the field-work, the petrographers are engaged in determinations required for the arrangement of rock-specimens in the museums at Jermyn Street, Edinburgh, and Dublin. The collectors employed under the supervision of the surveying officers to make illustrative series of specimens of the rocks of each district, send these up to the office for examination and for insertion in the museum. In the course of the research thus imposed on them, the petrographers are from time to time enabled to make important original contributions to petrographical science. Moreover, by conferring in the field with the officers who are engaged in mapping, they are enabled to realize the nature of the problems to be dealt with by the surveyor, and the points on which petrographical assistance is needed. Their determinations are embodied in the Memoirs on the geology of the several districts.

4. PALÆONTOLOGICAL WORK.—In a country where the geological formations are to a large extent fossiliferous, it is necessary to pay close attention to the organic remains found in the rocks, to collect specimens of them, to determine these specifically, and to regulate thereby the geological boundary-lines upon the maps. The duty of

examining and reporting upon fossils collected by the Geological Survey is entrusted to the palæontologists, who occasionally visit the field, but are mainly engaged at the museum. With reference to the exigencies of field-work a somewhat similar system is followed with regard to fossil evidence as in the case of the petrography, though the same minute detail is not necessary. The officer, when in doubt about any species, the names of which are needful in separating formations and drawing their mutual boundary-lines, collects specimens of them and sends them up to the office for identification. They are compared by the palæontologist with published descriptions and named specimens, and a list of their specific names (as far as they can be made out) is supplied to the surveyor.

Besides such specimens as may require to be identified in the course of the mapping, full collections from the formations of each important district are made by the collectors under the guidance of the officers by whom the district has been surveyed. Every specimen is numbered and registered in the collector's book, so that its source and destination can at once be found. Lists of the fossils are drawn up by the palæontologists for insertion in the published Memoirs. A selection of the best specimens is placed in the cases, drawers, or cabinets of one or other of the three Museums. Fortunately in the case of the palæontologists also, though much of their work is necessarily of a routine official character, opportunities are afforded to them of making interesting and important additions to palæontological science. It was from this department of the Survey that Edward Forbes produced some of his best work, that Salter made his fame as a palæontologist, and that Professor Huxley enriched geological literature with his memoirs on Silurian Crustacea, Old Red Sandstone fishes, and Triassic reptiles. Within the last few years fresh distinction has been won by Mr. E. T. Newton, of the same department, from the investigation and restoration of a series of remarkable reptiles from the Elgin Sandstones.

5. The Museum of Practical Geology and the Geological Survey Collections in Edinburgh and Dublin.—For the complete illustration of the geology of a country it is necessary not only to construct geological maps and sections, and to publish printed descriptions, but also to collect and exhibit specimens of the minerals, rocks, and organic remains. Each branch of the Geological Survey has from the beginning kept in view the gathering of such specimens, and the galleries of the Museums in London, Edinburgh, and Dublin may be appealed to as evidence of the manner in which the duty has been discharged. The Museum in Jermyn Street is intended to be primarily illustrative of the minerals, rocks, and fossils of England and Wales, but as far as space will admit an endeavour is made to exhibit what is specially characteristic of the other two kingdoms. For more detailed illustrations of Scottish geology recourse must be had to the Museum at Edinburgh, and for those of Irish geology to the Museum at Dublin.

The Museum of Practical Geology, Jermyn Street, as its name denotes, was from the beginning intended to illustrate the applications of geology to the industries and arts of life, as well as the

more systematic treatment of the science. Its materials were meant
in the first place to be taken from the United Kingdom and to form
a collection in which the minerals, rocks, and fossils of this country
should be displayed to the public in connection with examples of
their economic uses. The cases of the Museum now contain an
extensive collection of the building and ornamental stones of the
British Isles, which has been largely made use of by architects,
builders, and others. The granites of Cornwall, Devon, Scotland,
and Ireland, the marbles of Derbyshire, Staffordshire, Devonshire,
Bristol, the Isle of Man, Ireland, and Scotland, are well represented,
together with many varieties of serpentine, limestone, dolomite,
sandstone, slate, etc. Materials required in the process of grinding
and polishing stones, and those illustrating the preparation of plaster
and cements, also find a place. One of the most complete parts of
the Museum is the great series of specimens illustrating the ores of
Great Britain and Ireland. There are likewise colonial and foreign
ores, and an important collection illustrating the metallurgy of the
metals. Perhaps the most attractive departments of the Museum
are the large horseshoe case, in which are placed examples of
minerals and their applications in the arts, and the extensive ceramic
collection, in which the connection between the raw material and
finished pottery is shown. The collection of British pottery was
one of the earliest formed, and is still, perhaps, the most illustrative
in the country. Models of geologically important districts and of
different mines are placed in the model rooms and in different parts
of the Museum. The Library contains a tolerably complete repre-
sentation of the literature of geology, British and foreign, and may
be consulted by persons engaged in geological research. Large
geological maps are arranged along the lower gallery of the Museum,
and can be drawn down and studied by visitors. An extensive
and valuable collection of photographs of geological sections and
landscapes in the British Isles has been deposited in the Museum
and is accessible to students. A microscope and a series of thin slices
of typical rocks have been placed in the library for consultation.

The portions of the Museum of Practical Geology most closely
connected with the work of the Geological Survey are the collections
of fossils, the series of rock-specimens, and the cases illustrating
geological processes and rock-structures.

The large series of fossils has been almost entirely obtained from
the rocks of the United Kingdom, and chiefly in the course of the
prosecution of the Survey. It has furnished the basis on which
the maps of the fossiliferous formations have been constructed.
Every important subdivision of the Palæozoic, Secondary, and
Tertiary systems is represented by a full series of its characteristic
fossils, gathered from the various districts in the British Isles
wherein it is developed. These are arranged and tabled in such
a way as to be readily accessible to the public. Those who wish to
follow out the palæontological details of the Survey maps and
memoirs, or to study general textbooks of the science, have thus
the fullest opportunities afforded to them.

The palæontologists with their assistants are continually engaged in arranging and revising the collections, and in adding fresh material received from the officers in the field, from donations, or from purchase.

The rock-collections have in recent years been greatly increased and entirely rearranged so as to bring them abreast of modern petrography. They include examples of rock-forming minerals, in illustration of the characters of the more important minerals that enter into the composition of rocks ; a series of typical rocks, named, classified, and so arranged close to the eye that the visitor may have no difficulty in observing their general external characters ; a section devoted to illustrations of various geological structures such as cleavage, jointing, foliation, plication, the structures of igneous rocks, the effects of contact-metamorphism, the markings made by glacier ice, and the results of weathering in different rocks. But the chief part of the collection is a series of British rocks arranged in stratigraphical order from the oldest gneisses up to the most recent shell-sand. Not only are the sedimentary rocks represented in this series, but a large suite of igneous rocks is included, so that the student of volcanic history may see samples of the lavas and tuffs which have been ejected at each of the periods of volcanic activity in the geological annals of Britain. Diagrams and maps are placed near the specimens to show the geology of the districts from which the latter were taken. Drawings are likewise given of the more important microscopic structures met with in rocks, and especially among those of Britain.

A series of handbooks and catalogues has been issued in explanation of the different parts of the Museum. Thus Mr. F. W. Rudler, the Curator, has prepared a general handbook to the whole contents of the building, and also one to the collection of British pottery and porcelain. There are, likewise, catalogues of fossils. A new guide to the rock-collections and another to the palæontological collections are now being prepared.

The Geological Survey collection, illustrative of the geology of Scotland, is arranged in the upper gallery of the west wing of the Museum of Science and Art, Edinburgh. It includes an extensive series of rocks grouped in petrographical order according to the respective counties from which they come, each specimen being traceable to its locality by a pin with its number fixed to the geological maps exhibited in the table-case below. There is, likewise, a large collection of fossils, mainly Scotch, arranged in stratigraphical order. A handbook to the whole collection prepared by Mr. J. G. Goodchild, the Curator, has been published.

The collections of the Irish branch of the Survey deposited in the Science and Art Museum, Dublin, are similarly arranged, and are illustrated by a handbook so full in its descriptions as to serve as a guide to the general geology of Ireland. This useful publication has been prepared by Messrs. A. McHenry and W. W. Watts.

REVIEWS.

I.—OUTLINES OF VERTEBRATE PALÆONTOLOGY FOR STUDENTS OF
  ZOOLOGY. By ARTHUR SMITH WOODWARD. 8vo; pp. xxiv, 470,
  with 228 illustrations in the text. (Cambridge : at the University
  Press, 1898. Price 14s.)

THE University Press has added another handsome, well-printed
  volume to the Cambridge Natural Science Manuals of the
Biological Series, and one which cannot fail to attract many readers
who are desirous to acquire the broad outlines of this branch of
biological inquiry. The subject of Palæontology has now become
so large and important that it is no longer possible to include both
Vertebrata and Invertebrata within the same cover, nor can any
one author be expected to attempt so herculean a task. Owen's
Palæontology (1860), one of the earliest, was written by Owen
and S. P. Woodward ; Nicholson's (1889) is by Nicholson and
Lydekker ; whilst K. A. von Zittel's Handbuch der Paläontologie
has many acknowledged authors of the different sections.

In the present volume we have the veritable *extractum carnis* of
many minds, which the Bibliography and the illustrations alike
attest, as spiritually present in the work ; giving, like the writings
of the Fathers, a higher value to the production.

This useful textbook is clearly the direct outcome of Mr. Arthur
Smith Woodward's earnest work during the past fifteen years in the
British Museum of Natural History, the strongest feature of which, and
that possessing also the greatest amount of original research by the
author, relates to the PISCES, and to their progenitors, the *Cyclostomi*
and *Ostracodermi*, here constituted into a distinct class, the so-called
AGNATHA, as pertaining to the direct ancestral line in the descent of
Fishes. These sections occupy 122 pages of the book, and have
no fewer than 80 illustrations after Lankester, Traquair, and the
author's own Catalogue of the Fossil Fishes in the British Museum.

The Batrachia, which term is here used to include the whole of
the Amphibia, are dealt with in 18 pages with 10 illustrations.
The Reptilia occupy 90 pages with 50 illustrations, and the Birds
are given 14 pages with 5 illustrations ; the three classes having
exactly the same number of pages allotted to them as the Fishes
and Agnatha. The remaining section is devoted to the Mammalia,
which has also the larger proportion of illustrations.

The work concludes with a valuable chapter on the geological
succession of the Vertebrate faunas, a copious bibliography, and an
excellent index.

Having said so much by way of prelude, we will now invite the
author to introduce his subject to the reader.

"The past history of the vertebrated animals, as revealed by
fossils, is not merely a subject of absorbing interest in itself; it is
also of prime importance in Biology from the possibilities it affords
for elucidating some of the most fundamental principles in the
evolution of life. Since these organisms represent the highest
phase of development to which the animal kingdom has attained,

they appear latest and become dominant latest in the geological series. The evolution of all, except perhaps the larger groups, is thus contemporaneous with the deposition of the series of rocks which yield the most numerous and satisfactory fossils. Moreover, the skeleton of the Vertebrata is more intimately related to the soft parts than that of any of the lower forms of life; hence the greater value of such remains as can be fossilized in determining the precise nature of the original animals to which they belonged."

" The order in which the various divisions of the Vertebrata appear in geological time, according to present knowledge, depends entirely upon their degree of specialization—the simplest first, the more complex afterwards. The earliest organisms, which seem to have possessed a notochord, occur in the Upper Silurian; and none of these ancient types hitherto discovered exhibit either a lower jaw or true paired limbs. Typical fishes appear first in the passage beds between the Upper Silurian and Lower Devonian, and become abundant in the latter formation. Batrachia begin to occur in the Lower Carboniferous, and are dominant in the Permian. Undoubted reptiles are found in the Lower Permian, but do not become dominant until the Triassic and Jurassic. Fragments either of mammals or of reptiles, which approach the latter extremely closely, are met with in the Triassic, and there are undoubted small mammals in the Jurassic; but these are insignificant before the Tertiary period. Birds occur first in the Upper Jurassic, but both on this horizon and in the Cretaceous they retain conspicuous characters of their ancestry which have subsequently disappeared; they seem to have become dominant contemporaneously with the mammals at the beginning of the Tertiary period.

" *Range in Time.*—Gradual evolution—whether in the form of progression, retrogression, or differentiation—is usually observable, even in the minor divisions, when their range can be traced through the geological formations; and characters change more or less slowly in proportion to their magnitude. In all satisfactorily known instances, an order exhibits a longer geological range than any of its contained families; its family-types persist for a longer time than any of the genera grouped under them; whilst the genera themselves remain for a more extended period than the species. A highly specialized member of any division is also more liable to early extinction than its more generalized congeners, probably from its less adaptability to changes in the environment. An illustrative case may be cited. The order Ungulata (hoofed-mammals) is known to range from the very earliest Eocene strata to the present day. The family Equidæ (horses), as commonly understood, arises in the Upper Miocene; the typical species of the surviving genus *Equus* appears first in the Lower Pliocene. One genus of this family (*Hipparion*), with highly complex teeth, was restricted in its range to the Upper Miocene and Lower Pliocene periods, while another (*Hippidum*), with much specialized nasal region, had only a brief existence in South America; whereas *Equus* itself, with more normal teeth and rostrum, has survived from the Lower

Pliocene to the present day. In like manner the highly specialized rhinoceros, *Elasmotherium* (Pleistocene of Russia), had a very limited range in time and space compared with its more ordinary allies.

"*Persistent Types.*—There are a few noteworthy exceptions to the common rule last mentioned, which still await explanation. These are generally referred to as 'persistent types.' There is one remarkable, highly specialized family of Crossopterygian fishes, the Cœlacanthidæ, ranging from the base of the Carboniferous to the top of the Cretaceous, with scarcely any modification which can be regarded even as denoting change in the genera representing it (see p. 78). The case of the Tapirs, ranging practically unaltered from the early Miocene to the present day, is also a striking illustration (p. 321).

"*Imperfection of the Geological Record.* — The difficulties in ascertaining and interpreting the facts of Palæontology are, of course, greatly enhanced by the imperfection of the geological record on which we depend. Every item of knowledge acquired may indeed be literally described as owing to a chapter of accidents. Firstly, the organism must find its way into water where sediment is being deposited, and there escape all the dangers of being eaten; or it must be accidentally entombed in blown sand or a volcanic accumulation on land. Secondly, this sediment, if it eventually happens to enter into the composition of a land area, must escape the all-prevalent denudation (or destruction and removal by atmospheric and aqueous agencies) continually in progress. Thirdly, the skeleton of the buried organism must resist the solvent action of any waters which may percolate through the rock. Lastly, man must accidentally excavate at the precise spot where entombment took place, and someone must be at hand capable of appreciating the fossil and preserving it for study when discovered. Having due regard to the doctrine of Chances, the palæontologist will thus not be surprised to learn, for example, that the Lower Devonian chordate animal *Palæospondylus*, the unique representative of its group at present known, has hitherto been found only in one stratum of flagstone a few inches thick in one quarry in Caithness (see p. 3); that *Archæopteryx*, perhaps the most precious of Jurassic vertebrates, is known only by two specimens and a feather from the Lithographic Stone quarries of Bavaria, which have been worked from time immemorial (see p. 232); and that the sole known evidence of a Pleistocene monkey in Britain is a detached molar tooth from one of the brickfields near Grays, Essex. Furthermore, it must be remembered that in every region the series of strata contains only a very discontinuous record of its successive faunas and floras. When a region is a land area, as a rule, no deposit capable of preservation for long periods can accumulate, and the characters of its life can only be inferred from fossils which have been entombed in sediments apparently of the period in question elsewhere. When the region happens to be covered with comparatively deep water, the sediments will contain scarcely any but aquatic organisms, rarely yielding a trace of the life on the nearest land.

" *Definite Direction of Evolution.*—Under such circumstances it can be readily understood, that the time has not yet arrived for deducing general laws from the data of Palæontology. In fact, our knowledge of the evolution even of the Vertebrata is most casual and fragmentary in character. Nevertheless, sufficient is known to indicate that changes in the vertebrate skeleton have taken place in a certain definite and irreversible order ; and the relative age of two skeletons of the same type of animal of widely different periods can readily be determined at a glance by an expert. For example, among the early Palæozoic fishes there are many heavily-armoured forms with very little ossification in the endoskeleton and only incipient vertebral centra. The endoskeleton does not begin to ossify to any noteworthy extent until the exoskeleton atrophies ; eventually at a later period the bony endoskeleton is the all-important part of the framework. Now, it so happens that in certain Mesozoic Pycnodont fishes (*Mesturus*) and the Tertiary coffer-fishes (Ostraciontidæ) the rigid dermal armour is again acquired ; but it is apparently contrary to law for the endoskeleton to revert to its primitive state, as observed in the Palæozoic fishes just mentioned ; the parts of the axial skeleton simply become rigidly fixed, and are nearly as well ossified as in their unarmoured contemporaries and relatives. When the vertebral centra have once become fully formed, indeed, they never degenerate to allow the unconstricted notochord to persist again. To take another example, the lobate fins with endoskeletal supports in the earliest fishes always appear to tend towards atrophy, while the dermal rays surrounding them become stouter ; and when the endoskeletal base of the fin has been reduced to one small row of elements, these never multiply again ; even the lobe of the great pectoral fin of the modern angler-fish (*Lophius*) is formed solely by the elongation of two of these little elements. The same phenomenon is observed among mammals ; the number of digits may be reduced even to one, but when any reduction has taken place the original pentadactylism is never restored. Finally, in the case of all vertebrates, the teeth tend to degenerate ; first the supply of successional teeth is stopped, then the one ' permanent' set disappears ; and when either of these phases of degeneration is accomplished, the original state is never recovered.

" *Specialization.*—It is thus evident that among animals there are certain definite and irreversible lines of progression, and other equally definite and irreversible lines of degeneration. At the same time the Palæontology of the Vertebrata shows most clearly that, on the whole, the evolution of these organisms has proceeded from the general to the special, while in every successive period of the earth's history some group has risen to a higher position in the zoological scale than any previously attained.

" *Expression Points.*—All known facts appear to suggest that the processes of evolution have not operated in a gradual and uniform manner, but that there has been a certain amount of rhythm in the course. A dominant old race at the beginning of its greatest vigour seems to give origin to a new type showing some fundamental

change; this advanced form then seems to be driven from all the areas where the dominant ancestral race reigns supreme, and evolution in the latter becomes comparatively insignificant. Meanwhile the banished type has acquired great developmental energy, and finally it spreads over every habitable region, replacing the effete race which originally produced it. Another 'expression point' (to use Cope's apt term) is thus reached, and the phenomenon is repeated. The Actinopterygian fishes furnish an interesting illustration. The earliest known member of this order (*Cheirolepis*) appears as an insignificant item in the Lower Devonian fauna, where Crossopterygian and Dipnoan fishes are dominant. When the latter begin to decline in the Lower Carboniferous, the suborder to which *Cheirolepis* belongs (Chondrostei) suddenly appears in overwhelming variety. By the period of the Upper Permian another fundamental advance has taken place—the Protospondyli have arisen; but only a solitary genus is observed among the hosts of the dominant race. In the Trias the new type becomes supreme, and at the same time the next higher suborder, that of the Isospondyli, begins to appear. This lingers on in the midst of the dominant Protospondyli during the Jurassic period, and then in the Cretaceous this and still higher suborders suddenly replace the earlier types and inaugurate a race which has subsequently changed only to an insignificant extent. The Mammalia afford another illustration of the same phenomenon. The reptilian class shows the closest approximation to that of the Mammalia at the dawn of the Mesozoic epoch, when it is just beginning to replace the older Batrachia. In rocks of this age, on all four continents— Europe, Asia, Africa, and America—there are numerous remains of the mammal-like Anomodontia (as they are termed, p. 144). Afterwards not a trace of these 'missing links' is known; and with the exception of the insignificant small jaws of possible Prototheria and Metatheria in the Jurassic and Cretaceous of England and North America, mammals do not appear either in Europe, Africa, or North or South America until the base of the Eocene, when they suddenly became dominant and are already differentiated.

"*Parallelism in Evolution.*— As nothing is yet known of the supposed refuges to which the incipient new races have betaken themselves to differentiate and acquire vital energy, we can merely assume them as a tentative hypothesis. But even when the facts are abundantly manifest, it is often difficult to settle the most elementary questions by direct reference to them. The problem of parallelism in evolution is one of these. It is necessary to determine whether the same animal can be evolved simultaneously in more than one region from distinct series of ancestors. Are the pumas and jaguars of America, for example, wandering cousins of the lions and leopards of the Old World, or have they been evolved on the other side of the globe through a distinct set of carnivorous ancestors? The case of the horses is often cited as suggesting that such a parallelism in evolution may have occurred; because the series of ancestral horses traced through the Tertiary strata of Europe is

closely similar to, but not quite identical with, the ancestral series found in the same order in the corresponding rocks of North America. Here the facts are tolerably well known, but they admit of more than one interpretation. An easy land-connection between Europe and North America, throughout the Tertiary period, if allowed by geological considerations, might account for the phenomena observed, even if all the horse-like animals were evolved from one stock in one and the same area.

" *Theory of Recapitulation.*—There is also the well-known and widely-accepted principle that the stages in the development of an individual organism at the present day repeat in a general manner the successive phases through which the ancestors of that organism have passed in former periods of the earth's history. There is no doubt, for example, that in the course of its individual development the homocercal tail of a modern bony fish passes through the same stages as those successively exhibited by the majority of the adult fishes at the different geological epochs. It is also evident that the family of deer (Cervidæ) has gradually acquired complex antlers in precisely the same manner as every modern stag acquires them during the course of its individual life. Again, the ' cloven foot ' of the existing ruminant appears in the embryo with separated metapodial bones, like those of the adult ancestral ruminants. It is also tolerably certain (though fossils have not yet provided absolute demonstration) that the rudimentary teeth and hind limbs of the existing whalebone whales (Mystacoceti) are inherited from functionally toothed quadrupedal ancestors. Embryology, however, cannot afford much precise information concerning these processes of evolution, because an embryo usually exists under physiological conditions totally distinct from those influencing an adult. The embryo exhibits features derived from its ancestors (*palingenetic* characters), inextricably mingled with features due to the peculiar circumstances under which it develops (*cænogenetic* characters). In most cases it has hitherto been impossible to distinguish these two sets of characters satisfactorily ; and a final appeal must thus be made to Palæontology, notwithstanding its imperfections, to determine the laws by which evolution proceeds.

" *Origin of the Vertebrata.*—Perhaps the most disappointing element in palæontological results thus far, is the lack of all information concerning the origin of the great sub-kingdoms or phyla of animals. Even in what might appear to be the most promising case, namely, that of the Vertebrata, there are no known facts distinctly favouring any of the rival theories concerning their origin based on embryology. Possibly all the earliest types were destitute of hard parts, and thus incapable of fossilization. In any case, the oldest Ostracoderms (p. 3) from the Upper Silurian and Lower Devonian, sometimes claimed as the immediate allies of the Crustacean or Arachnid Merostomata of the same period, are fundamentally different from the latter in every character which admits of detailed comparison ; they are to be regarded merely as an interesting example of mimetic resemblance between organisms of two different grades, adapted to live in the same way and under precisely similar conditions."

As this volume is designed for the use of students, it may not be improper to suggest that in every case where *new terms* are introduced a gloss should be given explanatory of such terms.

Again, it is hardly consistent to place *Tritylodon* (p. 154, fig. 97) with the Theriodonts, as a matter of course, if it has (as the author admits) been commonly ascribed to the Mammalia by Owen and others who have written upon the subject; whilst *Polymastodon* (p. 253, fig. 149 B), with precisely similar multituberculate molars and similar number of incisors, remains unchallenged and is admitted as one of the Prototheria.

And why should "other double-rooted multituberculate teeth from the Rhætic of Europe, commonly claimed as mammalian" (p. 248), be suspected of being Anomodonts in disguise?

The illustrations of amphibian and reptilian skulls, and of mammalian teeth, have in some instances been borrowed from authors whose views as to their interpretation are not quite the same; as a consequence we have the nomenclature given in one illustration at variance with that given in another. In one case, for instance, on p. 143, fig. 91, the squamosal and supratemporal change places in figures B and E.

In fig. 183, p. 323, the cheek-teeth of *Hyracotherium* (after Wortman); fig. 185, of *Palæotherium* (after Gaudry); fig. 187, *Mesohippus* (after Osborn); and fig. 189 (after Earle), the references do not always agree; the cones being differently lettered. In the fourth premolar Gaudry's *paracone* E is equal to the protocone in the other figures.

One is inclined to question the advisability of the adoption of the terms *Asterospondyli* and *Tectospondyli*, in place of the time-honoured and well-known Selachoidea and Batoidea, especially as these terms are based upon the minute structure of the vertebræ (radiations being more pronounced in one and concentric layers in the other), structures which are not easily to be made out, and whose absolute constancy one might be inclined to doubt.

There is a good table of geological periods given, facing p. 411; but in the blank part folded for drawing out the table, there is ample space afforded to have given four columns for the leading groups of Fishes, Reptiles, Birds, and Mammals, briefly summarized, which might have proved exceedingly useful to the palæontologist.

On the whole, we like the book very much, and consider it distinctly in advance of any similar effort in Vertebrate Palæontology.

The geographico-geological chapter at the end is useful, and contains much good matter. Why, we may ask, should the Protospondyli of the Jurassic be spoken of as the *dominant race of vertebrate life*? One would suppose the Sauropterygia and the Ichthyopterygia were the dominant aquatic races of vertebrate life, and the Dinosauria the terrestrial reigning type.

But let the work stand upon its own feet; we have commended it, and we will stand by our word. Those who desire a good book on Vertebrate Palæontology will certainly do well to procure a copy for their reference library.

II.—The Extinct Rhinoceroses. By Henry Fairfield Osborn. Mem. Amer. Mus. Nat. Hist., vol. i, pt. 3 (1898), pp. 75–164, pls. xiia–xx.

SINCE the appointment of Professor Osborn as Curator of Vertebrate Palæontology in 1892, the American Museum of Natural History has published some of the most remarkable contributions to our knowledge of the Tertiary Mammalia which have yet reached us from the New World. Year after year expeditions have been sent to the West to make systematic geological explorations, and to collect fossils in the Tertiary lake-deposits, which began to yield their startling novelties to Leidy in the early fifties. The collections have been prepared, and the best specimens mounted, under the direction of a skilled preparator, Mr. Hermann. Preliminary studies have then been made by Professor Osborn, Dr. Wortman, Dr. W. D. Matthew, and Mr. Hatcher; and the results have been published in a series of " Bulletins," illustrated by the well-known careful drawings of Mr. Rudolf Weber.

A still more important departure has now been made, in the issue of the first two sections of an exhaustive quarto memoir on the extinct rhinoceroses by Professor Osborn himself. This is illustrated, not only by diagrams and the usual text-figures of fossils, but also by nine lithographed plates; and the plan of the work is not confined to a bare record of the facts, but also comprises a discussion of some of the most fundamental problems in the philosophy of Palæontology. We commend the memoir both to the notice of the specialist in the study of mammals, and to the general reader who desires to become acquainted with the latest-discovered facts bearing upon the phenomena of organic evolution.

Professor Osborn first discusses the differentiation of the Hyracodonts, Amynodonts, and true Rhinoceroses. These, he remarks, may be popularly described respectively as the Cursorial or Upland Rhinoceroses, the Aquatic Rhinoceroses, and the True or Lowland Rhinoceroses. To the first family belong agile, three-toed genera (such as *Hyracodon*), simulating the Miocene horses in skeletal structure and in the development of true hoofs. To the second family are referred short, heavy animals, with four-toed spreading feet, enlarged canine teeth, and probably a prehensile lip or proboscis (such as *Metamynodon*). The third family comprises rhinoceroses much like those still surviving in the Old World, the extinct American forms only differing from the latter in the non-development of the nasal horn. These families were all differentiated, at least in the North American area, before the middle portion of the Eocene period; and as they are traced upwards in time, they exhibit a curiously parallel course in the evolution of the molar teeth, while in the characters of the incisor teeth, skull, vertebræ, and limbs they rapidly become more and more divergent. Professor Osborn describes this parallelism and divergence in detail and adds much to the value of his memoir by giving concise tabular summaries of his results. It is indeed strange that we should thus

receive the most important and fundamental information concerning the ancestry and evolution of the rhinoceroses from the Tertiary formations of the New World, where no one, prior to the discoveries of 1850, could ever have suspected the occurrence of so characteristic an Old World type of mammalian life.

In the second chapter of the memoir, Professor Osborn deals with the true rhinoceroses, and begins with a useful synopsis of the existing species of the Old World, illustrated by a series of drawings of the skulls. Next, he gives a brief historical statement of the discovery of the extinct rhinoceroses, both in Europe and North America. Finally, he discusses the characters of the skull and teeth in formulating a basis of classification to be adopted in the technical account of the extinct rhinoceroses which follows. There is also a " preliminary bibliography."

Of the technical part of the memoir only the first section is now published, namely, a description of the cranial and dental characters of the hornless rhinoceroses (" Aceratheres ") from the American Oligocene, or White River Beds, of which a stratigraphical table is inserted. Seven species of *Aceratherium* are successively treated; and the so-called *A. trigonodum* is placed in a new genus, *Leptacera-therium*, on account of the persistence of its upper canines. Two important immature skulls with the complete milk-dentition are referred to *A. occidentale*.

The forthcoming sections of this memoir are announced to deal, not only with the remaining American forms, but also with those of the Old World. We understand that Professor Osborn is at present enjoying a year's leave of absence from his professorial and curatorial duties, and is thus favoured with the opportunity of continuing his extensive studies of the European collections. We await the result, so far as our knowledge of the extinct rhinoceroses is concerned, with great interest and high expectations.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—June 22, 1898.—W. Whitaker, B.A., F.R.S., President, in the Chair. The following communications were read :—

1. " Post-Glacial Beds exposed in the Cutting of the new Bruges Canal." By T. Mellard Reade, C.E., F.G.S.

The following beds, enumerated in descending order, were found in this cutting :—

        5. Argile des polders supérieure.
        4. *Cardium (edule)*-sand.
        3. Argile des polders inférieure.
        2. *Scrobicularia (plana)*-clay.
        1. Peat with the remains of trees.

Mechanical analyses of beds 5 and 2 are given. The argile des polders supérieure consists mainly of extremely finely divided material, in which sponge-spicules and foraminifera were found.

The *Cardium*-sand yielded many foraminifera and ostracoda, with a few diatoms.   The *Scrobicularia*-clay contained sponge-spicules, many of them apparently derived from older deposits, diatoms, and foraminifera.

The land-surface on which the peat grew appears to have slowly subsided, in such a manner as to allow of the inosculation of beds 1 and 2 at their junction.   Beds 3 and 5 represent the shallower-water phases, and the *Cardium*-sand the deepest-water phase through which the area passed as the deposits accumulated.   As a whole, these beds are correlated with those "in Lancashire and Cheshire which overlie the Peat and Forest Bed," but the wide horizontal extent of the deposits, at levels varying very little, has no parallel in Britain.

2. "High-level Marine Drift at Colwyn Bay."   By T. Mellard Reade, C.E., F.G.S.

This paper describes a mound of sand capped by Boulder-clay, which occurs one mile south by west of Colwyn Bay Station.   It measures about 90 yards on the longer axis, which runs north-east, 50 yards on the shorter axis, and is situated 560 feet above O.D. Among the pebbles and boulders in the drift, and scattered about in the sandpit, were granites from Eskdale and the South of Scotland, small flints, and local and Welsh rocks identified by Mr. Ruddy as derived largely from the head of the Conway Valley.   The base of the sand is not exposed, but the author has no doubt that it is geologically above the grey till with Welsh boulders.

At Groes and Old Colwyn a "typical marine-drift sand," with well-rounded quartz-grains, also occurs, at one place possibly 60 feet thick, and at another resting on "marine brown boulder-clay."   The marine sands of Groes, Old Colwyn, and the Vale of Clwyd "lie on the east side of their respective valleys, and the marine boulder-clays to the greater extent on the west side," while the marine drift has accumulated as bars near the mouth of the valleys.

3. "Observations on the Geology of Franz Josef Land."   By Dr. Reginald Kœttlitz.   (Communicated by E. T. Newton, F.R.S., F.G.S.)

This paper opens with a detailed description of the geography and geology of various portions of the archipelago.

The basaltic rocks occur in tiers from 10 to 70 feet high, and range to a height of 1,300 feet above sea-level.   The associated and interbedded rocks consist of shale, sandstone, and basaltic tuff.   The stratified rocks are not appreciably altered by the heat of the basalt, which is often vesicular both at the base and summit of the tiers. From this and other evidence the author concludes that many of the sheets are contemporaneous flows, and that as the fossil plants and ammonites are of Jurassic age, some of the lavas date back to Jurassic time.   Dykes, sills, and necks are also described.

The Jurassic rocks consist of shales and sandstones; they have yielded ammonites and belemnites, a portion of a specimen of *A. Lamberti* having been found embedded in "basaltic tuff."   Pebbles

of radiolarian chert have also been found embedded in these rocks, and a granite-block, mentioned by Payer as having been seen embedded in an iceberg, is believed to have come from the same source.

The raised beaches are very numerous, and occur at various heights, from just above sea-level to 287, 310, 340, and even 410 feet, drift-wood and bones of seals, walrus, and whales having been found on them. On Cape Mary Harmsworth twelve beaches are seen in a series one above another. The entire skeleton of a seal was found on the summit-plateau of Cape Neale, together with waterworn stones, at a height of 700 feet above sea-level. The highest waterworn pebbles noted were found at 1,111 feet on Cape Flora. In some cases floe-ice at sea-level becomes covered over and preserved by gravel heaped upon it by the sea; and some of the raised beaches seem to consist of a similar mixture of ice and gravel, as is proved by the formation of pitfalls in them where the ice melts. Ice-masses are also sometimes preserved under taluses, avalanches, and slips.

The "ice-cap" is probably not so thick as is generally supposed, and it has little downward movement. It forms domes on the summits and plateaux, but it seems to be a mere mantle on the terraced slopes, as it is ridged and dimpled, and during warm seasons raised beaches and terraces are thawed out under the ridges. Comparatively few evidences of glaciation were met with. Roches moutonnées and rounded hills are absent, and only in the two valleys separating Cape Flora from Cape Gertrude were the rocks planed, scratched, and polished.

Some of the landscape features, including the separation of the group into individual islands, are attributed to marine action following lines of fault.

The paper concludes with observations on soundings, the temperature of glaciers, the size of icebergs, and the finding of reindeer-antlers by Mr. Leigh Smith and the members of the Jackson-Harmsworth Expedition.

4. "Notes on Rocks and Fossils from Franz Josef Land brought home by Dr. Kœttlitz, of the Jackson-Harmsworth Expedition, in 1897." By E. T. Newton, F.R.S., F.G.S., and J. J. H. Teall, M.A., F.R.S., V.P.G.S.

In this communication an analysis of the basalt is given, which compares closely with those of basalts from Iceland. The silicification of the rocks, presumably by geyser action, the presence of a black analcime, pebbles of radiolarian chert, and crystals of selenite, probably formed *in sitû* in shale, are also described.

Notes are given on some of the fossil plants, on the drift-wood, and on apparently new species of *Inoceramus* and *Belemnites*.

5. "On the Corallian Rocks of Upware." By C. B. Wedd, B.A. (Communicated by J. E. Marr, M.A., F.R.S., F.G.S.)

The opinion usually held that the "Coralline Oolite" of the northern quarry at Upware is of older date than the "Coral Rag"

of the southern quarry, gains support from the work detailed in this paper, although the results of recent excavations show that a rock of different lithological character from that of the northern quarry probably underlies the rocks of the southern quarry.

A list of the fossils found in the lowest beds of the southern quarry includes eleven species not yet found in the " Oolite " of the northern quarry ; a second list comprises the fossils found just below the " Rag " in the Oolite of the southern quarry. Both these faunas are intermediate between those of the "Rag" of the southern and the " Oolite " of the northern quarry.

During the deepening of a well less than a quarter-mile north of the northern quarry, fossils identical with those of the northern quarry were found ; the lowest rock enclosed lumps and streaks of bluish-black clay, as though the Oxford Clay were not far underneath. From this excavation and other evidence, the author considers that the " Oolite " can hardly be less than 40 feet thick, and that this rock is geologically below the " Rag " of the southern quarry.

Excavations at the southern end of the ridge and south of the southern quarry show that beds containing the " Rag " fauna are conformably underlain by a rock 16 feet thick, identical with the " Elsworth Rock " both in lithology and fossils. The discussion of the fossils from this rock and that of Elsworth itself indicates that " there is no longer any palæontological evidence for correlating it with the Lower Calcareous Grit rather than with higher beds."

On the whole, the author is in favour of the view that the " Oolite " of the northern quarry is the lateral equivalent of the Elsworth Rock seen in the excavations south of the southern quarry.

The next meeting of the Society will be held on Wednesday, November 9, 1898.

CORRESPONDENCE.

"THE LLANBERIS UNCONFORMITY."

SIR,—The letter from the Rev. J. F. Blake which appears in your issue of July, p. 335, seems to call for a short comment from me. The paper by Professor Bonney and myself published in the Q.J.G.S. for 1894 was founded on the work done in Wales by both authors. Previous to my investigations, the work of Professor Bonney had led him to conclusions mainly identical, I believe, with those which we enunciated. He had visited the district after the publication of his earlier paper ; [1] and he re-examined in 1893 the critical sections in both the Bangor and the Llanberis area. His opinion on the question of the ' unconformity ' which has been claimed as exhibited along the L. Padarn railway, was drawn from his own examination of the section. Of the sections not examined by him, the only important one, I believe, is that at Bryn Efail, and of those rocks he saw all my specimens. But his scrupulous sense of justice

[1] I believe this was in 1880 ; I am not sure of the exact year.

demanded that he should give away the credit for the "larger
share of the work." I did not anticipate, when I saw the note
appended by him to our joint paper, that it could be misinterpreted
to mean that, because Professor Bonney had not seen or re-examined
certain sections (many of them supplementary), therefore he had not
seen sufficient to draw his own conclusions. To those who know
his work this statement must seem unnecessary.

<div style="text-align: right">Catherine A. Raisin.</div>

ON A QUARTZITE AND SYENITE ROCK IN WORCESTERSHIRE.

Sir,—The valuable note by Mr. Charles St. Arnaud Coles in your
July number (p. 304) suggests several questions of interest to
students of Malvernian geology. I can quite confirm his descriptions
in a general way, as I have visited Martley, and collected specimens
of the rocks. The so-called syenite is an altered form of one of the
Malvern diorites, the biotite and quartz being of secondary origin ;
but, as the modifications undergone by these diorites have been
described in my series of papers on the Malvern Hills (Quart.
Journ. Geol. Soc., August, 1887, August, 1889, and August, 1893),
I need not here discuss them. The chief point of interest is the
relation of the quartzite to the Malvernian. Mr. Coles compares
the former with the quartzite of the Lickey. He might with equal
probability have included in his correlation the basal Cambrian
quartzite which clings like a blanket round the Malvernian and
Uriconian masses of Shropshire. Whether this quartzite occurs in
the Malvern chain I cannot say from personal knowledge ; but, in
the well-known section at the southern end of the Raggedstone Hill,
the Hollybush Sandstone is thrust over the upturned edges of the
contorted gneiss, and the quartzite is wanting, its absence being
probably due to dislocation.   C. Callaway.

July 15, 1898.

OBITUARY.

PROFESSOR GEORG BAUR, Ph.D.

Born January 4, 1859.   Died June 25, 1898.

We deeply regret to record the death of Dr. Georg Baur, of the
University of Chicago, at the early age of 39 years. He was born
at Weisswasser, in Bohemia, where his father was at the time
Professor of Mathematics ; but he spent the greater part of his youth
in Hesse and Würtemberg. He passed through the Gymnasium at
Stuttgart, and in 1878 entered the University of Munich, where he
devoted special attention to zoology, palæontology, geology, and
mineralogy. In 1880 he went to Leipzig, where he studied under
Credner and Leuckart. Two years later he returned to Munich and
took the degree of Ph.D. He remained at this University as assistant
to Prof. von Kupffer until 1884, when he left for America and
became assistant to Professor Marsh at Yale. Dr. Baur held this
appointment until 1890, when he removed to the Clark University,

Worcester, Mass. Two years later he was appointed to be Assistant Professor of Comparative Osteology and Palæontology in the newly-founded University of Chicago, and in 1895 he became Associate Professor — the position he held at the time of his death. Last autumn his health began to fail, on account of excessive mental strain. He then came to Europe to spend a holiday with his relatives in Germany ; but his mental powers were never recovered, and the disease rapidly culminated in death.

Dr. Baur was a vertebrate morphologist of the modern school, who looked as much towards extinct animals as towards the existing fauna for the basis of his researches. He thus added greatly to our knowledge of vertebrate palæontology, not so much in describing new types, as in formulating new and clearer conceptions of forms already named and made known by other workers. His contributions, though mostly very brief, have had considerable influence upon the classification of the Reptilia now most widely adopted ; and some of his papers contain important new facts concerning the skeleton of the Ichthyosauria, Chelonia, and Mosasauria.

Dr. Baur also made a valuable contribution to geology in his researches on the Galapagos Islands, the well-known haunt of the giant tortoises. He conducted an expedition to the islands in 1891, and made large collections both of the animals and plants now living there. His conclusion was that the Galapagos Islands were not of the Oceanic type, as commonly supposed, but must be regarded as the peaks of mountains which once existed on a western extension of the Central American region now submerged. The Galapagos tortoises were thus to be considered as the stranded survivors of the large forms which were abundant on the American continent in the middle part of the Tertiary period.

The more important of Dr. Baur's papers having special reference to vertebrate palæontology are enumerated in the following list :—

1. "Osteologische Notizen über Reptilien," Fortsetz. i : Zool. Anz., 1886, pp. 733-743.
2. "Ueber die Homologien einiger Schädelknochen der Stegocephalen und Reptilien" : Anat. Anz., 1886, pp. 348-350.
3. "On the Morphology of the Ribs" : Amer. Nat., 1887, pp. 942-946.
4. "Ueber die Abstammung der amnioten Wirbelthiere" : Biol. Centralbl., vol. vii (1887), pp. 481-493.
5. "On the Morphology and Origin of the Ichthyopterygia" : Amer. Nat., 1887, pp. 837-840.
6. "Ueber den Ursprung der Extremitäten der Ichthyopterygia," Bericht xx : Versamml. Oberrhein. geol. Vereins, 1887, with plate.
7. "On the Phylogenetic Arrangement of the Sauropsida" : Journ. Morph., vol. i (1887), pp. 93-104.
8. "Osteologische Notizen über Reptilien," Fortsetz. iii : Zool. Anz., 1888, pp. 417-424.
9. "*Palæohatteria*, Credner, and the Proganosauria" : Amer. Journ. Sci., vol. xxxvii (1889), pp. 310-313.
10. "Mr. E. T. Newton on Pterosauria" : Geol. Mag., Dec. III, Vol. VI (1889), pp. 171-174.
11. "The Systematic Position of *Meiolania*, Owen" : Ann. Mag. Nat. Hist. [6], vol. iii (1889), pp. 54-62.
12. "On the Morphology of the Vertebrate Skull" : Journ. Morph., vol. iii (1889), pp. 467-474.

13. " *Kadaliosaurus priscus*, Credner, a new Reptile from the Lower Permian of Saxony " : Amer. Journ. Sci., vol. xxxviii (1889), pp. 156–158.
14. " On the Classification of the Testudinata " : Amer. Nat., 1890, pp. 530–536.
15. " Die systematische Stellung von *Dermochelys*, Blainv." : Biol. Centralbl., vol. ix (1889), pp. 149–153, 180–191.
16. " Nachträgliche Bemerkungen über die systematische Stellung von *Dermochelys*, Blainv." : ibid., vol. ix (1889), pp. 617–620.
17. " The Horned Saurians of the Laramie Formation " : Science, vol. xvii (1891), pp. 216, 217.
18. " Remarks on the Reptiles generally called Dinosauria " : Amer. Nat., 1891, pp. 434–454.
19. " On the Relations of *Caerttochelys*, Ramsay " : ibid., 1891, pp. 631–639.
20. " Notes on some little-known American Fossil Tortoises " : Proc. Acad. Nat. Sci. Philad., 1891, pp. 411–430.
21. " On the Morphology of the Skull in the Mosasauridæ " : Journ. Morph., vol. vii (1892), pp. 1–22, pls. i, ii.
22. " Bemerkungen über die Osteologie der Schläfengegend der höheren Wirbelthiere " : Anat. Anz., vol. x (1894), pp. 315–330.
23. " Die Palatingegend der Ichthyosauria " : ibid., vol. x (1894), pp. 456–459.
24. " Cope on the Temporal Part of the Skull, and on the systematic position of the Mosasauridæ: A Reply " : Amer. Nat., 1895, pp. 998–1002.
25. " The Paroccipital of the Squamata and the Affinities of the Mosasauridæ once more " : ibid., 1896, pp. 143–147, pl. iv.
26. " The Stegocephali " : Anat. Anz., vol. xi (1896), pp. 657–673.
27. " Bemerkungen über die Phylogenie der Schildkröten " : ibid., vol. xii (1896), pp. 561–570.
28. [With E. C. Case.] " On the Morphology of the Skull of the Pelycosauria and the Origin of the Mammals " : ibid., vol. xiii (1897), pp. 109–120.
29. " Ueber die systematische Stellung der Microsaurier " : ibid., vol. xiv (1897), pp. 148–151.
30. " Archegosaurus " : Amer. Nat., 1897, pp. 875–980.

JOHN CARRICK MOORE, M.A., F.R.S., F.G.S.

BORN 1804. DIED FEBRUARY 10, 1898.

By the death of John Carrick Moore, science loses the last of that band of ardent field-geologists who, during the first half of the present century, did so much to investigate the underground structure of the British Islands. Inspired by the example and animated by the scientific principles of William Smith, they carried out in fuller detail than was possible to their master, his great idea of delineating in maps and sections the distribution and relations of the British strata, guided everywhere by the organic remains which they contain. But while this band of workers—which included such names as those of Buckland, Conybeare, Webster, Mantell, Dixon, Lonsdale, Sedgwick, Murchison, Fitton, De la Beche, Godwin-Austen, and Phillips—were so deeply influenced by the teaching of William Smith, yet they were seldom, with the exception of the last-mentioned, personally instructed by him, but derived their knowledge of his principles and methods at second-hand from men like Richardson, Townsend, and Farey, who were proud to act as the disciples and interpreters of the distinguished " Father of English Geology."

John Carrick Moore came of a famous stock. His grandfather, Dr. John Moore, the friend and biographer of Smollett, was the author of many well-known works, of which the novel " Zeluco " has been longest remembered. Three of the sons of Dr. John Moore

had very distinguished careers. The eldest surviving son was General Sir John Moore, the hero of Corunna, and a younger son was Admiral Sir Graham Moore, whose exploits on the sea were scarcely less notable than those of his elder brother in the field. The father of John Carrick Moore was James Moore, the second surviving son of Dr. John Moore, who studied medicine in Edinburgh and London, and became one of the most distinguished surgeons of his day. He was the friend of Jenner, and, as a well-known writer in favour of vaccination, was appointed to succeed that surgeon as director of vaccine establishments.

James Moore, who practised extensively for many years in London, was the author of various medical treatises and of a biography of his brother, General Sir John Moore, published in 1833. Having had bequeathed to him by a Mr. Carrick, a banker in Glasgow, the estate of Corsewall, in Wigtownshire, near Stanraer and Port Patrick, James Moore added to his own surname that of Carrick. In 1825 James Carrick Moore retired from practice, and, having built himself an excellent house upon his estate on the shores of Loch Ryan, spent the remainder of his life there, dying in 1834 at the age of 71. On their mother's side, the Moores were descended from Robert Simson, the celebrated geometrician.

John Carrick Moore was the second son of James Carrick Moore, and was born in 1804. He went to Cambridge, and was educated at Queen's College, proceeding to the degree of M.A., and devoting much attention to mathematics and physics. Before the year 1838, his attention seems to have been attracted by the rocks of the Rhinns of Wigtownshire, near his residence, for we find that he was in communication with Charles Lyell, who identified the fossils found by him as graptolites. In the year named, he was elected a Fellow of the Geological Society.

In 1839 he traced out carefully the succession of strata along the west shore of Loch Ryan, and in the following year a paper on the subject was read by him to the Geological Society. In 1841, Sedgwick, crossing from Ireland, paid a visit to Corsewall, and was accompanied by John Carrick Moore in a tour through Ayrshire. In September, 1843, Lyell and his wife paid a visit to the same hospitable dwelling, examining and confirming the accuracy of Moore's sections. Much of Lyell's time seems to have been spent in studying the rain- and hail-prints, with the fucoid- and crustacean-markings on the shores of Loch Ryan, and he subsequently wrote to Moore : "The Loch is a grand magazine of geological analogies— tidal, littoral, conchological, sedimentary, etc., which I envy you having at your door." Subsequently to this visit, Lyell, under the direction of Moore, visited the remarkable rocks in the neighbourhood of Ballantrae, and bore testimony to the accuracy of his friend's work there.

In 1846 we find John Carrick Moore had become so identified with the work of the Geological Society that he was elected Secretary, and in the same year he became a member of the Geological Society Club. He held the office of Secretary for six years (1846–52), when

he was elected a Vice-President of the Society (1853-4), resuming his post of Secretary in 1855 for one year. So active, indeed, was Carrick Moore in the administration of the Geological Society's affairs, that between 1846 and 1875 we find him absent from the Council only in four years; he was a Vice-President in 1862, and again in 1864-5. In 1848 he read a more extended paper to the Geological Society on the Silurian rocks of the Wigtownshire coast, the fossils being described and figured by Salter. In 1856 and 1858 Moore communicated accounts of further observations on Wigtownshire geology to the Geological Society, while his general interest in geological research was shown by the papers written by him in 1850 and in 1863, on fossils collected and sent home from San Domingo by Mr. Heniker, and from Jamaica by Lucas Barrett. In 1849 we find him describing the Oligocene fossils found in the New Forest.

John Carrick Moore was proposed as a Fellow of the Royal Society in November, 1855, his nomination paper being signed first by his friend Charles Lyell, while others who subscribed from personal knowledge were Sedgwick, Murchison, Hopkins, Leonard Horner, and Faraday. He does not appear, however, to have ever contributed a paper to the Society. By his patient labours in studying the geology of Galloway he made valuable additions to our knowledge of the stratified rocks of Britain, and he took a distinguished place among the band of amateur workers—including many landed proprietors, clergymen, soldiers, and doctors—to whose painstaking and detailed work in the field English geology owes so much. Among these men, John Carrick Moore was always held in the highest esteem, and his time and energy were ungrudgingly devoted alike to the advancement of his favourite science by careful studies in the field, and to the promotion of the interests of the Society identified with that science, during the parts of the year when he resided in London.

In 1864 Andrew Ramsay spent a few days with John Carrick Moore at Corsewall, mapping the peninsula which terminates in Corsewall Point, for the Geological Survey of Scotland. Of John Carrick Moore's wide sympathies with all matters connected with geology, and of the knowledge and ability with which, owing to his early training at Cambridge, he was able to deal with those questions of physical geology demanding an acquaintance with mathematical methods, we have abundant evidence. Between 1865 and 1867 he sent a series of letters to the Philosophical Magazine, dealing in a very able and critical manner with Ramsay's theory of the origin of lake-basins, and with Croll's theory of the cause of the Glacial Period. These letters show that Moore had not forgotten his early training, and had kept himself abreast of the science of the day by his studies of physical questions; and the substantial justice of his criticisms has been abundantly shown by later researches. In 1875 he wrote to *Nature*, pointing out a curious oversight of Humboldt in his "Cosmos."

In 1875 John Carrick Moore finally withdrew from the Council of the Geological Society, upon which he had served so long and so

faithfully; and from that time forward he would seem to have ceased to take any active part in scientific work. Few of the present generation of geologists can even recollect having seen the stately and courteous gentleman, who was at one time so indefatigable in the service of their Society, and who had so frequently acted as one of its officials. For nearly a quarter of a century after this withdrawal from public activity, however, John Carrick Moore lived on, spending his time between his seat in Wigtownshire and the house in Eaton Square, where he died on February 10, 1898, at the great age of 94. His only son had predeceased him, but a daughter survives, the estate passing to his nephew Colonel Sir David Carrick Buchanan, of Drumpellier. Besides the Corsewall estate, John Carrick Moore owned property in Kirkcudbrightshire and in England, and he was a Deputy-Lieutenant of the county of Wigtownshire. He was not less highly respected among the gentry of his county and the tenants of his estate than in the circles of scientific society in London, in which his presence was so long conspicuous.   J. W. J.[1]

MISCELLANEOUS.

THE HEREFORD EARTHQUAKE OF DECEMBER 17TH, 1896.—A report on this important earthquake by Dr. Charles Davison, F.G.S., will be published in the autumn, if a sufficient number of subscriptions be obtained to defray the cost of printing. The work is founded on nearly 3,000 observations made at places distributed over an area of about 100,000 square miles. This area exceeds that disturbed by any other known British earthquake, and includes every county in England but three, the whole of Wales, the Isle of Man, and the eastern counties of Ireland. Copies of the prospectus may be obtained from Messrs. Cornish Bros., 37, New Street, Birmingham.

OSSIFEROUS CAVES IN THE BASQUE COUNTRY (BAYONNE).— Mr. George Greenwood, Broadhanger, Petersfield, Hants, lately visited the ossiferous caves at Isturitz, Hasparren, in the Basque country (Bayonne), and brought away specimens of the teeth of the Great Cave Bear *Ursus spelæus*, Horse, and Ibex. The deposits are so rich in mammalian remains that the proprietor is working them for the purpose of selling the deposit for manufacturing bone-manure for the farmers. It is to be regretted that no effort is being made to save the splendid specimens of the Cave Bear and other animals, as well as remains of primitive man, which these caverns afford. Could not a committee of the British Association under Section C take the matter up, and obtain a grant to work these interesting caves? Monsieur Roth, of Bayonne, is the only gentleman in the neighbourhood with scientific tastes who might be induced to help in such a good work.—OLD BONES.

[1] Proceedings of the Royal Society, vol. lxiii.
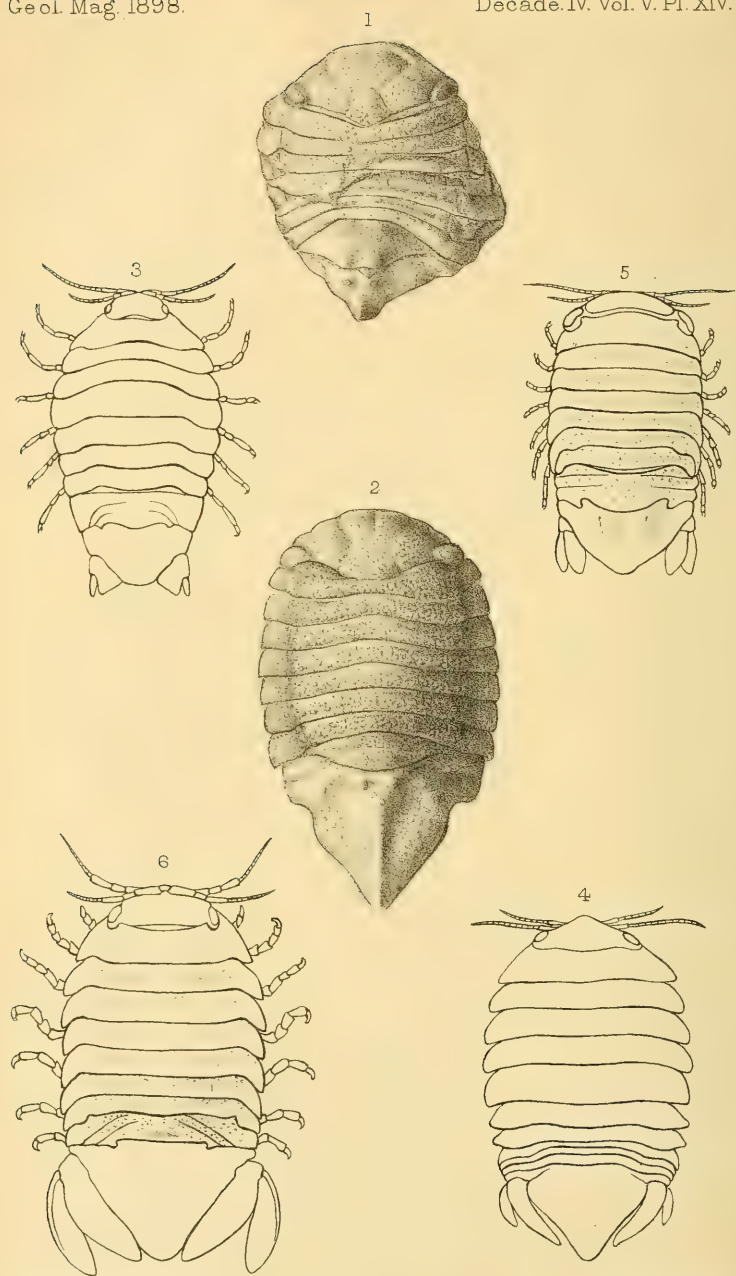
Recent and Fossil Isopoda.

ORIGINAL ARTICLES.

I.—On the Discovery of *Cyclosphæroma* in the Purbeck Beds of Aylesbury.

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

(PLATE XIV.)

IN December, 1890, I had the good fortune to describe a new Sphæromid discovered by Mr. Thomas Jesson, B.A., F.G.S., in the Great Oolite of Northampton, which I named *Cyclosphæroma trilobatum* (see Geol. Mag., 1890, Dec. III, Vol. VII, pp. 529–533, Pl. XV). This specimen, which is redrawn on the accompanying Pl. XIV (Fig. 1), is remarkable for its rounded outline, which induced me to apply to it the name *Cyclosphæroma*.

Great was my joy when, in March last, I received from my friend Mr. E. J. Garwood, M.A., F.G.S., another Jurassic Isopod, of which both the intaglio and the relievo had been obtained by him in the Purbeck beds near Aylesbury. This remarkably beautiful Crustacean proves to be a more perfectly preserved example of the same Sphæromid which I had described in 1890, from the Great Oolite of Northampton, and it needs but to compare Figs. 1 and 2 upon the Plate to perceive that in Fig. 1 the thoracic segments are much compressed together posteriorly, and that the hinder part of the telson is wanting; otherwise the resemblance between it and the newly-found and much more perfect example from the Purbeck beds of Aylesbury (Pl. XIV, Fig. 2) is unmistakable.

A reference to the diagnosis of the genus (as given in Geol. Mag., 1890, p. 530) will show that it must now be amended in consequence of the discovery of the more complete specimen by Mr. Garwood.

CYCLOSPHÆROMA, H. Woodw., 1890 (*emended* 1898).

General outline of body longer than broad in the proportion of 5 to 3. Cephalon trilobate one-fifth the length of body, rounded and tumid, surface granulated; eyes moderately large, cornea vitreous, but facets of eye distinctly visible with a hand-lens; thoracic segments seven in number, rather broader than the head-shield or telson, with square margins, epimeral portion of segments distinctly defined by a lateral line; first thoracic segment coalesced with cephalon and encircling the eyes; segments of

abdomen coalesced together; telson distinct, triangular in outline, with a strong median ridge, equal in length to the seven thoracic segments; surface of telson more sparsely ornamented, granulations coarser, with three larger tubercles marking a small triangular area at the proximal end of the median ridge. Traces of the epimera of two coalesced abdominal segments are seen near the union with the telson.

Although no appendages are preserved in the fossil, the deep emargination on the sides of the telson, at its union with the coalesced segments of the abdomen, indicates with certainty the exact point of articulation of the last pair of pleopoda or uropoda, as certainly as if they had been preserved in the fossil, and as actually shown in place in the four recent examples figured on our Plate XIV (Figs. 3, 4, 5, and 6). We give an ideal restoration of these appendages below :—
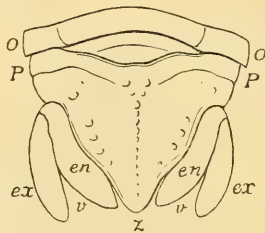
Diagram of posterior segments and telson (*z*) of *Cyclosphæroma*, with appendages restored.

o, last thoracic segment (vii). *P-z*, abdominal segments and telson. *v*, paired uropods or pleopods, appendages of last segment. *ex*, exopodite; *en*, endopodite. *z*, telson or terminal segment.

Having consulted my carcinological friend, the Rev. T. R. R. Stebbing, F.R.S., F.L.S., Tunbridge Wells, concerning the affinities of this fossil, I am glad to know that, in the absence of appendages to guide one more certainly, and from the general appearance of the body itself, he considers that I am fully justified in referring it to the Sphæromidæ.

He has further suggested that the forms among recent members of this family which appear to be most suitable for comparison with it are the following :—

1. Cassidina typa, H. Milne-Edwards.[1]

Hist. Nat. Crust., vol. iii, pp. 223-4, pl. xxxii, figs. 10-16.

Milne-Edwards speaks of the side-plates as ending in an almost straight edge, as in *Cyclosphæroma*.

2. Cassidina emarginata, Guèrin. (Pl. XIV, Fig. 3.)

This specimen is well represented in the British Museum by specimens from Otter Island collected by Dr. Cunningham in 1868,

[1] I could not obtain a spirit specimen of *C. typa*, so I decided to draw an example of *C. emarginata*, Guèrin, as preferable to reproducing a small and very indistinctly-drawn figure of the former species.

and from Kerguelen Island by the Rev. A. E. Eaton, and from Kelp, off Direction Hills, Pacific, $143\frac{1}{2}°$ E. long., $13°$ S. lat. (Dr. Cunningham).

This form shows very clearly the straight lateral margins of the epimera of the thoracic segments. The head in *Cyclosphæroma* is much larger than in *Cassidina*, and the general form of the body of the recent genus is more ovate and the head much more narrow in front than it is in the fossil form.

3. Cassidina maculata, Studer. (Pl. XIV, Fig. 4.)

Anhang. zu den Abhandlung. der k. Akad. der Wissensch. Berlin, 1883 (1884), p. 20, Tab. ii, fig. 7 (from Kerguelen Island).

The figure of *C. maculata* is after Studer, and I have unfortunately been unable to examine an actual specimen of this species. The form of the telson resembles that of *Cyclosphæroma*.

4. Sphæroma curtum, Leach. (Pl. XIV, Fig. 5.)

See "British Sessile-eyed Crustacea," Bate & Westwood, 1868, vol. ii, p. 412 (woodcut figure in text).

This specimen has been redrawn for me by Miss G. M. Woodward from an actual specimen from Devonshire, $\times$ 6 nat. size. In the straighter sides of the body, the broader head, the position of the eyes, the pointed form of the telson, and the finely granulated ornamentation of the body-segments, this little species comes very close to the Purbeck fossil.

5. Sphæroma gigas. (Pl. XIV, Fig. 6.)

From Kerguelen Island; $\times$ 2 nat. size.

This, like the preceding species of *Sphæroma*, offers many interesting points for comparison with the fossil form, in the broad head and the pointed telson, as well as in the finely granulated ornamentation of the body-segments.

Notwithstanding the fact that *Cyclosphæroma trilobatum* so far exceeds *Sphæroma gigas* and the great majority of living Sphæromids in size, yet the deep-sea dredge has brought to light several extremely large Isopods such as *Bathynomus* (*giganteus* ?), dredged off the coast of Bombay in 696 fathoms (measuring about 4 inches in length and 2 inches in breadth), originally described by Professor Alphonse Milne-Edwards from the West Indies. (See *Comptes Rendus*, Paris, 6 January, 1879, p. 21. A translation of Milne-Edwards' paper appeared in the Ann. and Mag. Nat. Hist., ser. 5, vol. iii, pp. 241–243.)

Professor Alex. Agassiz writes : "From the collection made in the West Indian region only a single species of Isopod, *Bathynomus giganteus*, has been described, but this is *by far the largest Isopod known*, and is more than eleven inches long! The eyes of this giant are placed on the lower side of the head, and consist, according to

Milne-Edwards, of no less than four thousand facets." (See Alex. Agassiz, "Three Cruises of the ' Blake,' " vol. ii, 1888, pp. 49–51, and figure.)

Although these recently discovered living deep-sea Isopods exceed it very considerably in size, I think we may justly conclude that the fossil *Cyclosphæroma* was in all probability also a deep-water form.

In comparing the fossil Sphæromid with various living Isopods, one cannot fail to be struck with the resemblance it offers in the telson to the pointed and keeled terminal plate of the pleon in *Æga monophthalma* and in *Idotea*, particularly in *Idotea entomon*; but there the resemblance ceases, for in other respects this form is an undoubted Sphæromid. One need not be surprised, however, to find in a Mesozoic form evidence of more generalized Isopod characters than now prevail in the family of the Sphæromidæ, to which we are led to refer it. One is only astonished to find an Isopod resembling so nearly our existing Sphæromids, but dating back in time to the Purbeck and the Great Oolite rocks.

EXPLANATION OF PLATE XIV.

Fig. 1. *Cyclosphæroma trilobatum*, H. Woodw., 1890. Great Oolite: Northampton. Drawn of the natural size. The original specimen preserved in the British Museum (Natural History). Jesson Collection.

Fig. 2. *Cyclosphæroma trilobatum*, H. Woodw., 1898. From the Purbeck Beds near Aylesbury; discovered by E. J. Garwood, Esq., M.A., F.G.S., by whom the original has been presented to the British Museum (Natural History). Drawn of the natural size.

Fig. 3. *Cassidina emarginata*, Guérin. Recent: Kerguelen Island. Twice natural size. From a specimen in the British Museum.

Fig. 4. *Cassidina maculata*, Studer. Recent: Kerguelen Island. Copied from Studer's figure.

Fig. 5. *Sphæroma curtum*, Leach. Coast of Devonshire. Six times natural size. From a specimen in the British Museum.

Fig. 6. *Sphæroma gigas*. Kerguelen Island. Drawn twice natural size. From a specimen in the British Museum.

II.—ON SCOTTISH ROCKS CONTAINING ORTHITE.

By JOHN S. FLETT, B.Sc., M.B., C.M.;

Assistant in Geology, University of Edinburgh.

FROM America and from many different localities on the continent of Europe the occurrence of Orthite or Allanite as an accessory mineral in crystalline rocks of different kinds has been frequently described. But so far it does not seem that its occurrence in Great Britain has been recognized, or at any rate I have failed to find any mention of it. Quite recently two instances of Scottish orthite-bearing rocks have come under my notice which I wish to describe briefly in the present communication. Both are in acid holo-crystalline rocks—granites and gneisses—and in both it is associated with the closely allied mineral epidote, as is usually the case. For specimens of the granite of Fell Hill I am indebted to Mr. James More, jun., M.Inst.C.E., Edinburgh, who sent sections of this rock for microscopic examination to Professor James Geikie, Edinburgh University. Although only two in number, the sections contain at

least eight recognizable crystals of orthite, besides smaller pieces
about the identity of which there might be room for doubt, and some
of these are fortunately so cut as to render possible not only a certain
identification of the mineral, but also a fairly complete account of
its optical properties.

The granite of Fell Hill, Creetown, Kirkcudbrightshire, is shown
on the 1 inch Ordnance Survey Map as occupying a small triangular
area about a mile south of the town of Creetown on the shore of
Wigtown Bay. In the hand-specimen it is a fine white granite,
rich in black scales of biotite, with muscovite in subordinate quantity.
The microscope shows it is a true granite with both muscovite and
biotite. The principal felspar is orthoclase, which is sprinkled over
with scales of muscovite, but microcline is also abundant, and an
acid plagioclase is present in fair quantity. Micropegmatite is almost
absent, and the rock shows distinct traces of shearing. The accessory
minerals are apatite, zircon, iron ores, sphene, epidote, and orthite.

The epidote is very abundant, scattered through the whole slide
in small grains which are often grouped in irregular aggregates, but
do not show any evident idiomorphism. At the same time it seems
in every way probable that the mineral is largely of primary origin,
and not a product of the decomposition of the felspathic and
ferro-magnesian constituents of the rock. These are too fresh to
have produced epidote in such quantity, the biotite in particular
being in good preservation and not greatly exceeding the epidote
in amount. In several cases epidote is found in rounded grains
enclosed in biotite; the mica is perfectly fresh, and around the epidote
are broad pleochroic halos, such as are usually seen about embedded
zircons. In such a case the epidote can hardly be other than primary
in origin. For the most part the epidote is scattered over the
felspar in such a way as to suggest its derivation from it. The
usual cleavage is well seen in the larger epidote grains, and when
they are elongated they usually have a straight extinction and yield
the emergence of a bisectrix or of an axis. The twinning on the
orthopinakoid which is so common in epidote was not observed
in any section. It is almost colourless or very pale yellow in
ordinary light, and the pleochroism is so faint as to be hardly
noticeable, ranging from colourless to a pale greenish yellow.
(a and β = colourless, γ = pale yellow.) The refraction and double
refraction are both high, and in polarized light the colours are
brilliant, except in those sections from the orthodiagonal zone which
are nearly perpendicular to an axis, and such sections are by no
means uncommon.

The orthite in thin section is deep brown in colour, and rather
resembles hornblende and biotite when cut in certain directions, the
more so as the outlines are sometimes hexagonal and resemble
closely those of transverse sections of an amphibole prism. From
hornblende, however, it is distinguished by its lack of cleavage and
its faint dichroism, while, unlike basal sections of biotite (with which
it would otherwise correspond), it does not yield the central emergence
of a uniaxial cross in convergent polarized light. The mineral is

often zonal, bands of a paler and darker brown running parallel to the edges of the section. Unlike the epidote it usually accompanies, it has a strong tendency to idiomorphism, and its outlines are straight lines, evidently the traces of crystalline faces. But scattered through the epidote are many little brown flakes of irregular form, feeble pleochroism and strong double refraction, which in all probability are to be ascribed to orthite, though they cannot with certainty be determined as such. Two principal forms are to be recognized in the sections of this mineral, one of these being elongated, bounded by two parallel faces and having obtuse terminations. These have all a straight extinction, their axis of elongation being evidently the orthodiagonal. In convergent light they yield the emergence of an axis or bisectrix, and the optic axial plane is transverse to the length of the section or parallel to the plane of symmetry. The other typical section is that perpendicular to this (parallel to the optic axial plane), and in consequence showing neither axis nor bisectrix in convergent light. Its outlines are generally six-sided, though not of symmetrical shape. Its bounding faces seem to be the basal plane (001, M), the orthopinakoid (100, T), and an orthodome (101, r); at any rate, the measured angles in the sections giving the most oblique extinction, and hence most nearly perpendicular to this zone, show a fair approximation to the angles between these faces. Cleavage is either absent or too imperfect to yield any index to the faces present, but the face M is parallel to the principal cleavage of the associated epidote. In the section which gives the most oblique extinction the extinction angle is 34° in the acute angle between the vertical and clino-axes. One crystal is twinned simply, the twin plane being the orthopinakoid.

In convergent polarized light one section from the orthodiagonal zone yields a bisectrix, emerging in the centre of the field, the broad bar of which is coincident with the length of the section. Hence the optic axial plane is the plane of symmetry. In the diagonal position the apices of the hyperbolæ cannot be grasped by a dry lens, the angle 2 E being apparently great. This bisectrix is positive, but as an oil-immersion lens of 1·3 N-A fails to grasp the axes it must be the obtuse bisectrix, the acute bisectrix being $\mathfrak{a}$, and the mineral optically negative. We have, then, for the optic orientation $\mathfrak{b} = \mathfrak{b}$, c : $\mathfrak{a} = + 34°$.

The pleochroism of the mineral, while distinct, cannot be said to be strong, and may be expressed as follows:—

γ, brownish green.
β, yellow brown.
a, darker yellow brown.
Absorption : $\gamma \gt a \gt \beta$.

The refraction and double refraction are both strong, the colours in polarized light being bright, but distinctly lower than those of the epidote in the same slice.

As already stated, the orthite occurs frequently in the midst of patches of epidote, sometimes in grains of ill-defined shape, more

usually in sharply idiomorphic crystals. The epidote is never idiomorphic, but from the parallel position of its principal (basal) cleavage with one of the faces of the orthite the association is undoubtedly that of parallel growth between two isomorphous minerals.[1] I failed to find sections parallel to the orthodiagonal in which both minerals extinguished in the same position. In most cases the extinctions were distinctly and even widely different. Some of the orthite crystals are apparently free from any epidote; in others there is a very narrow rim of a clear mineral which could not be identified, but is in all probability epidote; and around the twinned orthite this narrow border was also twinned, the composition plane being identical for both centre and margin. Finally, in the centre of the orthite crystals was frequently to be observed a pale rose-coloured mineral with slight dichroism and lower double refraction than either epidote or orthite. The orthite gives about the same polarization colours as the common green hornblende of granites, but this substance gave only pale greys and whites. It may be a product of the decomposition of orthite, than which it seems to be considerably softer, as it is often ground out of the interior of a crystal in preparing the section, while the orthite and epidote remain intact. It seems to vary somewhat in character, as between crossed nicols it never has uniform colours and extinction, and while irregularly cracked it has no definite cleavage. In one crystal it forms the whole centre, being ·24 millimetre in breadth; around it lies an orthite zone, sharply idiomorphic, and varying from ·01 to ·04 millimetre in breadth; around this, again, a clear zone, probably of epidote, ·02 millimetre broad, with its faces parallel to those of the orthite. All three minerals are twinned on the same plane, but they differ considerably in the obliquity of their extinction. The nature of this mineral I have been unable to determine. It may be a manganese epidote, which I think is hardly probable, or a product of the decomposition of orthite, although it should be noted that it is always found at the centre and not on the surface of the crystals.

A second instance of an orthite-bearing rock is to be found in the island of Sanday, almost in the extreme north-east of the Orkneys. Here there is a large erratic, which from its size has always attracted the attention of geologists visiting the county. It is known as the "Savil" boulder from the farm on which it lay; but the proprietor, Major Horwood, has recently had it removed and placed on the lawn at the front of the mansion house at Scar. In his "Geognosy of Orkney," part i,[2] Professor Heddle describes it as consisting of "white, finely striated oligoclase, the crystals of which are penetrated by fine filaments of actinolite; glassy quartz, in much smaller amount; dark-green, finely foliated, lustrous hornblende, in well-marked crystals; very little of a pale-green mica; a minute amount of crystals of a pale-brown mineral, which may,

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[1] Hobbs, "Paragenesis of Epidote and Allanite": Amer. Journ. Sci., xxxviii, p. 223.

[2] Mineralogical Magazine, 1880, p. 127.

but does not appear to, be sphene; and a speck or two apparently of thorite." From the microscopic sections in my possession it seems to be a biotite gneiss consisting of orthoclase, microcline, and plagioclase, quartz, and biotite. A bright yellow epidote is very abundant in needle-like crystals which radiate from the iron ores and the mica, and form nests and strings running through the rock. Orthite is present in fair amount in large crystals, which are rounded and without trace of crystalline form, but here and there have parallel faces and a straight extinction, showing that the ortho- axis is the direction of elongation. In one or two crystals it is zonal, and an indistinct cleavage is to be made out. In convergent light it is widely biaxial and of negative sign. Its colour is brown, more intense than in the Fell Hill granite, and the pleochroism more marked, being—

γ, deep greenish brown.
β, dark yellow brown.
a, paler yellow brown.
Absorption : $\gamma \, 7 \, \beta \, 7 \, a.$

Twinning and parallel growths with epidote were not observed.

Professor Heddle's opinion was that this is not a Scottish rock, and the microscopic evidence goes to support this view, for while similar rocks have not been described from Scotland they are well known in Sweden and Norway. A glance at the map given by Messrs. Peach and Horne in their paper on the Glaciation of the Orkney Islands[1] shows how close, in their opinion, the Norwegian and Swedish ice came to the Orkneys. In the south and west of the group they found many rocks in the Boulder-clay to which they could confidently ascribe a Scottish origin. It is in accordance with all we know about the glaciation of the Orkneys to believe that, at certain times at any rate, the north-east corner of the archipelago was overridden by Norwegian ice, and that this boulder is of Scandinavian derivation.

III.—On a supposed Tropical American Fish (*Poecilia*) from the Upper Miocene of Oeningen, Baden.

By Arthur Smith Woodward, F.L.S., F.G.S.

IN 1861,[2] the late Dr. T. C. Winkler, of Haarlem, published a memoir on some fishes from the well-known Upper Miocene fresh-water formation of Oeningen, and among other new forms he believed he could recognize an extinct species of the Cyprinodont genus, *Poecilia.* This peculiar fish not being known elsewhere beyond the fresh waters of tropical America, the determination of a Miocene representative in a European fresh-water deposit excited some interest both among geologists and ichthyologists; and the occurrence of *Poecilia oeningensis* in Baden has been almost

[1] Quart. Journ. Geol. Soc., xxxvi, pl. xxvii.
[2] T. C. Winkler, "Description de quelques Nouvelles Espèces de Poissons Fossiles des Calcaires d'Eau Douce d'Oeningen" (Haarlem, 1861).

universally quoted in textbooks and treatises as a fact worthy of special note.

In his memoir Dr. Winkler mentions that he founds the species in question on a series of specimens, partly in the Teyler Museum, partly in the collection of Van Breda. As the latter collection was acquired by the British Museum in 1871, four of the specimens studied by Winkler are destined to be included in the forthcoming vol. iv of the "Catalogue of Fossil Fishes." They have thus been recently examined during the preparation of this work; and the result is so completely at variance with Winkler's interpretation of the fossils, that it seems advisable to publish an amended description of the fish without delay.

Among the specimens in the Van Breda collection, it is easy to recognize the original of Winkler's figure (op. cit., pl. iv, fig. 16), which is preserved in counterpart and numbered 42,779. The figure, however, seems to have been made by an artist without technical knowledge, and the description is evidently based upon this drawing, not upon the actual fossil. The general proportions of the fish are correctly indicated, and the imperfect remains of the head show little more than the drawing; but the fins are incompletely represented and the figure gives a false impression of their characters and arrangement. The pectoral fin is relatively large and comprises eleven slender spaced rays, which are divided distally: it is spread over the flank of the fish. The pelvic fins, not distinguished by Winkler, are relatively small; and the base of one, with indications of six rays, is observed directly beneath the base of the pectorals. There are quite clearly two dorsal fins, of which only the posterior is shown in the figure. The foremost dorsal is the smaller, and consists of six spinous rays, each supported by a dagger-shaped bone. The second dorsal comprises twelve rays, all of which are probably articulated and divided distally. The anal fin arises slightly further back than the second dorsal, and is somewhat smaller than the latter, with only nine rays, none spinous. The caudal fin is distinctly rounded, not forked.

Most of the characters thus briefly noted are also observed in the other specimens of the so-called *Poecilia* in the Van Breda collection. Moreover, the small clustered teeth are shown in the mandible of No. 42,778, while they appear among the remains of both jaws in Nos. 42,780–81. It is evident that there are four, possibly five, stout branchiostegal rays. There are also distinct indications of scales, with radiating markings on their covered portion, at least in the caudal region of the trunk.

It is thus obvious that the so-called *Poecilia oeningensis* is neither a member of the family Cyprinodontidæ nor a physostomous fish. It is indeed a typical Acanthopterygian, and is most suggestive of the families Cottidæ and Gobiidæ. In fact, if comparison be made with the small fish from Oeningen described by Agassiz under the name of *Cottus brevis*,[1] duly allowing for imperfections in preservation, it will at once be perceived that there are no essential differences

[1] L. Agassiz, "Poiss. Foss.," vol. iv, p. 185, pl. xxxii, figs. 2–4.

between the latter and the fish now under consideration. As remarked by Von Zittel [1] this species is to be placed in the genus *Lepidocottus* of Sauvage.[2] *Poecilia oeningensis*, Winkler, thus falls in the synonymy of *Lepidocottus brevis*, and is proved to be not an anomalous element in the Oeningen fauna, but a typical European form.

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IV.—ON SOME CRETACEOUS SHELLS FROM EGYPT.

By R. BULLEN NEWTON, F.G.S.

(PLATES XV AND XVI.)

A COLLECTION of Invertebrate fossils, obtained from various horizons and localities in Egypt and consisting principally of molluscan remains, has been sent home for examination and description by Captain H. G. Lyons, R.E., Director of the Geological Survey of that country.

The oldest specimens represented belong to Upper Cretaceous rocks, and are dealt with in the present communication. They include one species of Gasteropod and eight Lamellibranchs, two of the latter group being regarded as hitherto undescribed forms. It need hardly be stated here that most of our knowledge respecting these groups of Mollusca as represented in Egypt during this period has been ably summarized by Professor Dr. von Zittel, in his elaborate memoir, "Beiträge zur Geologie und Palaeontologie der Libyschen Wüste und der angrenzenden Gebiete von Aegypten," published in the *Palæontographica* for 1883. For subsequent details we are mainly indebted to the researches of Professor Mayer-Eymar and Prof. Johannes Walther: to the former for his monograph, "Zur Geologie Egyptens," [3] which includes a list of Cretaceous shells from the neighbourhood of the Great Pyramid; and to the latter for his paper, "L'Apparition de la Craie aux Environs des Pyramides," [4] containing a list of molluscan species from the same district and horizon, though particularly localized as Abu Roasch, Golea, etc.

A paucity of Gasteropod species is noticeable in the faunistic lists of the Upper Cretaceous period of Egypt, with, however, a large representation of bivalve mollusca. The most abundant forms appear to belong to the genus *Ostrea* and its allies, a fact also observable in the corresponding faunas of Algeria and Tunis. In all three countries a similar conchological facies is apparent, whilst some species show a marked resemblance to Syrian forms. Certain difficulties have arisen in assigning a satisfactory horizon to the Egyptian species here discussed, though the evidence appears to be

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[1] K. A. von Zittel, "Handbuch der Palaeontologie," vol. iii (1888), p. 310.

[2] H. E. Sauvage, "Sur le *Cottus aries* d'Aix-en-Provence": Bull. Soc. Géol. France, [3] vol. iii (1875), p. 637.

[3] Viert. Nat. Ges. Zurich, vol. xxxi (1886), p. 246: *Cucullæa Chiemensis*, Gümbel; *C. Ligeriensis*, Orb.; *C. tumida*, Orb.; *Cardium productum*, Sowerby; *Pholadomya Royanensis*, Orb.; *Nerinea Buchi*, Keferst.; *N. nobilis*, ? Münst.; *N. pyramidarum*, May.-Eym. (new); and *Acteonella voluta*, Münst.

[4] Bull. Inst. Egyptien, ser. 2, No. 8 (1888), p. 8: *Radiolites*; *Ostrea acanthonota*, Coq.; *O. Costei*, Coq.; *Plicatula Ferryi*, Coq.; *Nerinea*; and *Acteonella voluta*, Münst.

G.M.Woodward del. et lith.

West, Newman imp.

Egyptian Cretaceous Fossils.

Egyptian Cretaceous Fossils.
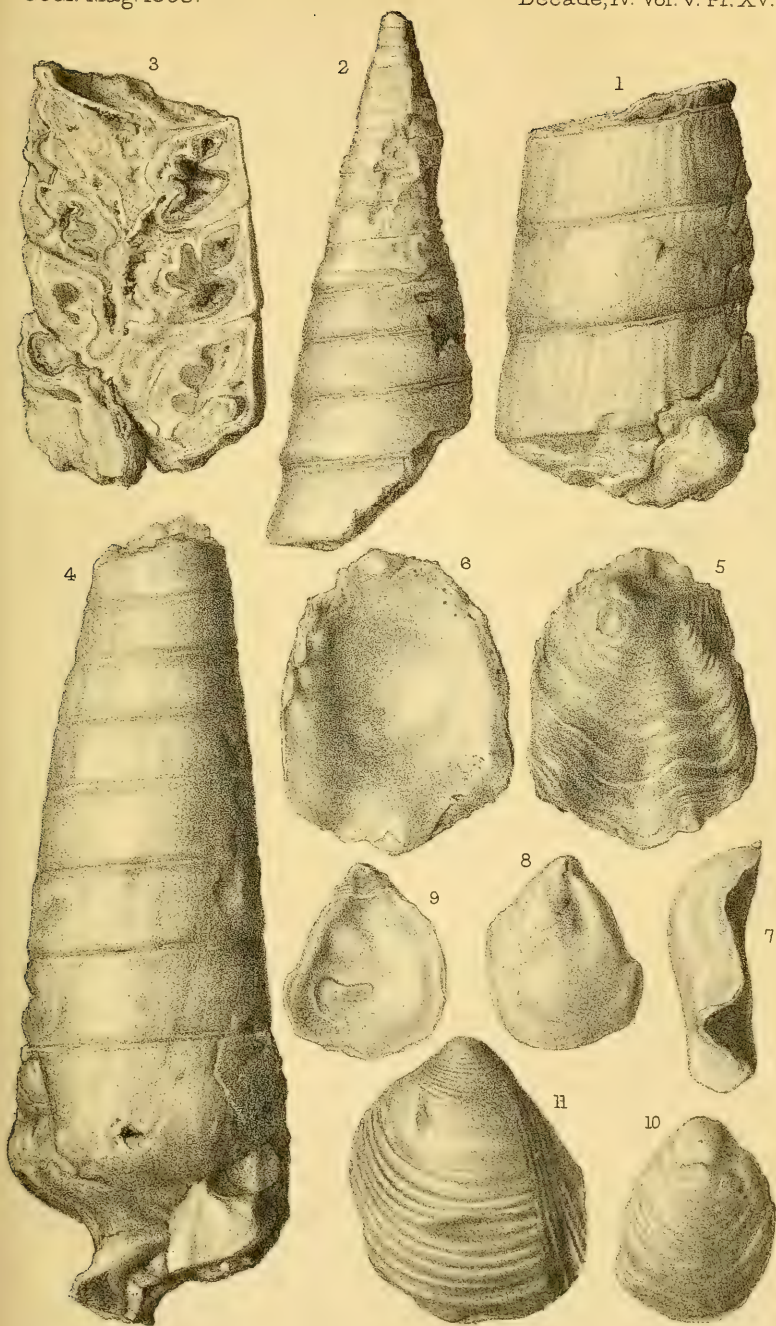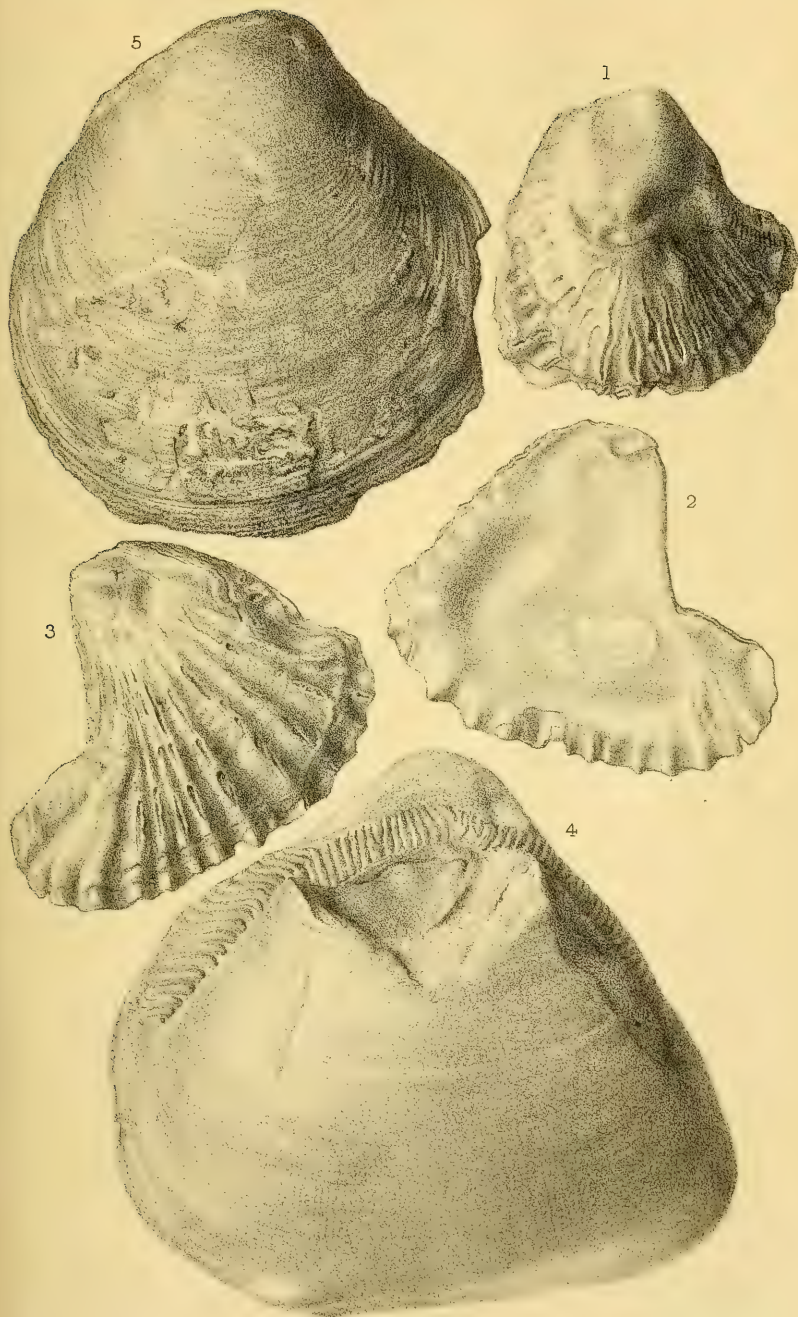
in favour of a Turonian age—an opinion somewhat suggested by the palæontological work of M. Jules Welsch,[1] who has discovered in Algeria, *Sphærulites (Sauvagesia) Sharpei*, Bayle, a typical Turonian shell of Portugal, associated with *Ostrea acanthonota, O. Boucheroni*, etc. This author, therefore, inclines to the belief that the majority of Algerian species hitherto recognized by Coquand, Peron, and others as of Santonian age, are more probably Turonian. If this be accepted, then the Cretaceous rocks near Cairo (Abu Roasch, etc.), containing similar shells, which have been considered as Senonian by Schweinfurth, Walther, etc., should equally be regarded as Turonian, though apparently the Portuguese mollusc, *Sauvagesia Sharpei*, has not yet been identified in Egypt.

"Hills W. of Jebel Zait" and "Sheet 33" are districts given for other of the fossils referred to in this paper. The specimens from the former were probably obtained from the Cretaceous outliers occurring to the south-west of Jebel Zait (see Zittel's map), whilst those marked "Sheet 33" might come from the same area, on account of a similarity of matrix, although no explanation has been sent as to the region embraced in this particular division of the Egyptian map. These shells are likewise recognized as Turonian.

GASTEROPODA.

Genus NERINEA (Defrance), Blainville, 1825.

Dict. Sci. Nat., 1825, vol. xxxiv, p. 462, pl. xxxiv, fig. 3; Man. Malacologie, 1825, p. 404.

TYPE.—*Nerinea nodosa*, Voltz (= Nériné tuberculeuse, Defr.), [syn. *Helicoceras*, König, 1825].

NERINEA REQUIENIANA, Orbigny.   Pl. XV, Figs. 1–4.

Nerinea Requieniana, Orbigny : Pal. Française Terr. Crétacés, 1842, p. 94, pl. clxiii, figs. 1–3 ; Fraas: "Aus dem Orient," 1867, p. 96.

Nerinea pyramidarum, Mayer-Eymar, "Zur Geologie Egyptens" : Viert. Nat. Ges. Zurich, 1886, vol. xxxi, p. 246.

DESCRIPTION.—*Testa elongato-conico, imperforata; spira, angulo 21°; anfractibus angustatis, lævigatis, inferne limbatis; apertura subquadrata, 5-lobata; labro 1-plicato; columella 3-plicata.* (Orbigny.)

The above original diagnosis applies to a species of large size, slightly pupoid, compressed, non-umbilicated, and with numerous whorls (about 20) ; the whorls are depressed, slightly concave, and convexly margined at the base ; sutural band narrow (1 mm. wide), sunken, and immediately below the rounded edge of the whorl; surface bearing longitudinal striations, inflected near the suture, and more apparent on the later than on the earlier whorls ; aperture subquadrate, with a prominent, nearly central tooth on the

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[1] J. Welsch, Bull. Soc. Géol. France, ser. 3, vol. xviii (1890), p. 493 ; ser. 3, vol. xxv (1897), p. 554 ; and P. Choffat, ibid., ser. 3, vol. xxv (1897), p. 470.

labrum ; columella provided with three plications ; anterior canal short, twisted ; spiral angle diminishing with growth.

DIMENSIONS.

Length	...	...	...	...	120 mm.
Spiral angle	...	...	...	...	20° to 15°
Sutural angle	...	...	...	...	85°

The present specimens, although rather fragmentary and crystalline, are sharp, well-defined, and exhibit both internally and otherwise all the characters of this species. One piece shows the early condition of the spire with an angularity of 20°, while a later portion has a spiral angle of 15°. An oval section seen in a transverse fracture of another specimen clearly indicates a compression of the spire. The width of the whorls increases from 1 mm. to 16 mm.

REMARKS.—In his monograph on the Geology of Egypt, Professor Mayer-Eymar refers to the great abundance of a new *Nerinea,* under the name of *N. pyramidarum,* in rocks of Senonian age occurring W.N.W. of the Great Pyramid. He regards it as an intermediate form between *N. nobilis* and *N. Buchi,* having oblique ribs, more or less obsolete, on the earlier part of the spire, with a tendency to a marginal thickness of the whorls. Although no figure accompanies his brief remarks, there is little doubt that this shell, with the characters alluded to, is identical with D'Orbigny's *Nerinea Requieniana,* which according to the original account was not peculiar to European areas alone, but had also been found in Egypt by a M. Lefebvre.

Some of the specimens are encrusted with concentric chalcedony (" Beekite "), the matrix being a yellowish-white limestone.

HORIZON.—Turonian.

DISTRIBUTION.—Various localities in the west and south-west of France ; environs of Jerusalem ; W.N.W. of the Great Pyramid ; Abu Roasch : Coll. Geol. Surv. Egypt (No. 63, Box No. 32c) ; and Coll. British Museum, G. 11,485.

LAMELLIBRANCHIATA.

Genus OSTREA, Linnæus.

Systema Naturæ, 1758, ed. 10, p. 696.

TYPE.—*O. edulis,* Linnæus.

OSTREA ACANTHONOTA, Coquand.

Ostrea acanthonota, Coquand : "Mon. genre *Ostrea* Crétacé," 1869,
            p. 103, pl. xxxviii, figs. 1–4. Walther, " L'Apparition
            de la Craie environs Pyramides": Bull. Inst. Égyptien,
            1888, ser. 2, No. 8, p. 8.

DESCRIPTION. — Shell subequivalve, oblong, convex, arched ; valves ornamented with prominent ribs, which commence a short way from the beaks and afterwards bifurcate ; ribs regular, angulose, imbricated, obtusely spined, and separated by deep and wide grooves ; summits ostreiform, equal ; muscular scar nearly central, antero-lateral.

DIMENSIONS.

Largest specimen (both valves)—Height ... ... 103 mm.
                              Length ... ... 73 „
                              Diameter ... ... 68 „

This species has certain resemblances to *O. dichotoma*, Bayle, an Algerian shell, but differs from it in being curved or arched and possessing a rough spiny exterior. It may be compared also with another Algerian species, *O. syphax*, which, however, has more or less exogyriform umbones, especially during the earlier period of its development.

REMARKS.—It is interesting to note that M. Peron, in his work on the Cretaceous Mollusca of Tunis, has united the two species *O. dichotoma* and *O. acanthonota*, but for present purposes it seems desirable to regard them as separate forms. The Egyptian examples of this species are in a splendid state of preservation and consist of both old and young shells. The matrix is a soft white limestone, resembling chalk.

HORIZON.—Turonian.

DISTRIBUTION.—Algeria ; Golea, west of Abu Roasch ; west of the Gizeh Pyramids : Coll. Geol. Surv. Egypt (No. 64, Box No. 31*c*).

OSTREA LYONSI, sp. nov. Pl. XV, Figs. 5–7.

DESCRIPTION.— Species oblong, oval, small, and of variable dimensions ; lower valve convex, lamellose, and prominently plicated ; ligamented area narrow, small, triangular, and rather oblique ; muscular scar antero-ventral, semilunate, and concentrically striated ; upper valve depressed, possessing moderately deep marginal plications, and ornamented with concentric growth-lines.

DIMENSIONS.

Largest lower valve—Height ... ... 40 mm.
                    Length ... ... 30 „
                    Diameter ... ... 14 „

This is a very distinctive form of *Ostrea*, which appears to differ in many details from other species. The lower valve is often much inflated at the umbones, where it has a steep flattened adherent surface ; the plications are rounded, elevated, few (four or five), and most prominent at the ventral margin. The valves, according to age, differ a good deal in relative convexity, many being depressed. The species is related to *O. Nicaisei*, Coquand, from the Cretaceous of Algeria, which is of a similarly lamellose structure and having the same kind of widely distant plications, but differing in its flatter and more equally convex valves, as well as in its generally more circular shape.

REMARKS.—From the number of specimens sent for determination, this species may be regarded as fairly abundant. The shells, largely mineralized with incrustations of " Beekite," are found in a grey compact limestone associated with *Arctica Barroisi*, as well as in a softer limestone of a fawn colour.

HORIZON.—Turonian.

DISTRIBUTION.—Hills west of Jebel Zait : Coll. Geol. Surv. Egypt (No. 637, Box No. 48*a*).

OSTREA VILLEI, Coquand.   Pl. XVI, Figs. 1–3.

Ostrea Villei, Coquand : " Géol. Paléont. Constantine," 1862, p. 231,
    pl. xxii, figs. 1–4.
O. bomilicaris, Coquand : ibid., p. 230, pl. xxi, figs. 4–6.
O. Villei, Coquand : " Mon. genre *Ostrea* Crétacé," 1869, p. 27, pl. iv,
    figs. 1–8 ; pl. v, figs. 1–4.
O. bomilicaris, Coquand : ibid., p. 24, pl. ii, figs. 12–15.
O. Villei, Peron, " Desc. Moll. Foss. Crétacés Tunisie " : Explor. Sci.
    Tunisie, pt. ii (1891), p. 182.

DESCRIPTION.—Shell of subtriangular or triangular contour, in-
equivalve ; lower valve convex, ornamented with numerous regular,
bifurcating ribs, separated by deep grooves and sometimes provided
with a smooth surface of attachment at the umbonal region ; upper
valve of less convexity than the lower and similarly ornamented ;
muscular impression large, oval and ventral.

DIMENSIONS.

		Upper valve.	Lower valve.
Medium-sized single valves—Height	...	45 mm.	40 mm.
Length	...	45 ,,	40 ,,
Diameter	...	10 ,,	21 ,,

Several isolated valves of this species are in the collection, and
vary somewhat in their characters.   They all, however, preserve the
more or less triangular shape and the bifurcated character of the ribs.
The lower valve is considerably arched, whilst the other is only
moderately convex and more often depressed ; most of the valves
exhibit the characteristic enlargement of the pallial area, with
frequently decided lateral extensions.

REMARKS.—Coquand's two species, *Ostrea bomilicaris* and *O. Villei,*
have been united under the latter name, on account of their similar
characters, by M. Peron.   A careful comparison of specimens in the
British Museum, and a study of the figures of this species given by
Coquand and others, appear to confirm the correctness of the present
determination, although the shell does not seem to have been hereto-
fore recorded from Egypt.   It occurs in soft and hard varieties of
a fawn-coloured sandstone.   This harder matrix, identical with that
containing *Trigonoarca multidentata* and *Protocardia biseriata,* shows
also a fragment of bone of probably reptilian origin, but which
Mr. A. S. Woodward informs me is not determinable.[1]   Other
examples of this oyster are met with in a grey, compact limestone,
encrusted with " Beekite," being the same material as contains
Arctica Barroisi and *Ostrea Lyonsi.*

HORIZON.—Turonian.

DISTRIBUTION.—Algeria ; Tunis ; and " Sheet 33 " : Coll. Geol.
Surv. Egypt (No. 1,043, Box No. 55c).

[1] It may be incidentally mentioned that remains of *Mosasaurus* have been recorded
from the Cretaceous rocks of Wadi Ouh, near El Radsieh, Egypt, by Figari Bey
(" Studii Scientifici Egitto," vol. i, 1864, p. 29), which were subsequently identified
by Zittel as *Mosasaurus mosensis* (" Beit. Geol. Pal. libysch. Wüste " : Palæonto-
graphica, pt. i, 1883, p. lxxvii), but, as far as can be ascertained, no figures or
description of this species have yet been published.

OSTREA THOMASI, Peron. Pl. XV, Figs. 8–10.

Ostrea Brossardi, Coquand: "Mon. genre *Ostrea* Crétacé," 1869,
p. 45, pl. x, figs. 18, 19, *non* figs. 15–17.
Ostrea Thomasi, Peron, "Desc. Moll. Foss. Crétacés Tunisie":
Explor. Sci. Tunisie, pt. ii (1891), p. 167.

DESCRIPTION.—Shell small, irregularly inflated, narrow, straight,
enlarged in rear but always tapering at the beaks; lower valve
more convex than the upper, both ornamented with lamellose,
concentric, and often irregular striæ, with no indication of radial
markings.

DIMENSIONS.

Lower valve—	Height ...	...	...	...	...	27 mm.
	Length ...	...	...	...	...	21 ,,
	Diameter	...	...	...	...	10 ,,

Several isolated valves of this small oyster are represented in the
Egyptian Collection, and they resemble in every detail Coquand's
figures (18 and 19) and agree with certain parts of his description,
as well as with the later account furnished by M. Peron. This
last-named author very properly separated two distinct forms which
Coquand recognized under the one name of *O. Brossardi*, and
founded the species *O. Thomasi* for the smaller specimens repre-
sented by Coquand's figures 18 and 19, which showed the tapering
beaks and were entirely without radial structure.

REMARKS.—The species may be said to slightly resemble young
forms of *O. vesicularis* and *O. Boucheroni*, and from the number
sent for determination it appears to be fairly abundant in Egypt.
The specimens are of a light-grey colour and entirely free from
matrix. The shell does not occur in Tunis, although its history has
been discussed by M. Peron.

HORIZON.—Turonian.

DISTRIBUTION.—Algeria; west of the Gizeh Pyramids: Coll.
Geol. Surv. Egypt (No. 61, Box No. 29c).

Genus GRYPHÆA, Lamarck, 1801.

Syst. Anim. sans Vert., 1801, p. 398.

TYPE.—*Gryphæa angulata*, Lamarck.

GRYPHÆA COSTEI, Coquand.

Ostrea Costei, Coquand: "Mon. genre *Ostrea* Crétacé," 1869,
p. 108, pl. xxvi, figs. 3–5; pl. xxxviii, figs. 13, 14.
Gryphæa Costei, Stoliczka, "Cretaceous Pelecypoda Southern India":
Mem. Geol. Surv. India, vol. iii (1871), p. 457.
Ostrea Costei, Walther, "L'Apparition de la Craie environs
Pyramides": Bull. Inst. Egyptien, 1888, ser. 2,
No. 8, p. 8. Peron, "Desc. Moll. Foss. Crétacés
Tunisie": Explor. Sci. Tunisie, pt. ii (1891), p. 140.

DESCRIPTION.—Shell globulose, thick, sometimes longer than
wide, and *vice versa*, and having a postero-lateral expansion; lower
valve very convex, with a large adherent surface, and ornamented

with concentric, lamellose, irregular growth-lines crossed by numerous obscure plications ; upper valve concave, truncated at the summit, operculiform, and of similar sculpture to the opposing valve, but without radial ornamentation.

DIMENSIONS.

Both valves in contact—Height   ...   .   82 mm.
                  Length   ...   .   101 ,,
                  Diameter   ...   .   45 ,,

The shells referred to this species have very robust, thick tests, and vary somewhat in size. From *O. biauriculata* and other allied species, they differ in the possession of radial costæ and the usually scaly appearance of the lower valve. On account of the presence of a posterior expansion, this species is placed in the genus *Gryphæa*, a view first adopted by Stoliczka.[1]

REMARKS.—All the specimens are in a fine state of preservation, and what little matrix accompanies them is a yellowish-white limestone.

HORIZON.—Turonian.

DISTRIBUTION.—Algeria ; Tunis ; Golea, westward of Abu Roasch, Egypt ; west of Gizeh Pyramids : Coll. Geol. Surv. Egypt (No. 68, Box No. 30c).

Genus PROTOCARDIA, Beyrich, 1845.

Zeitschrift Malakozoologie (Hanover), 1846, p. 17.

TYPE.—*Cardium Hillanum,* J. Sowerby.

PROTOCARDIA BISERIATA, Conrad.   Pl. XV, Fig. 11.

Cardium biseriatum, Conrad, " Desc. Fossils Syria " : Official Report United States Exped. Dead Sea, etc. (W. F. Lynch), 1852, p. 216, pl. vi, figs. 38, 39 (*non* fig. 40).
Cardium (Protocardia) Hillanum, Hamlin, " Syrian Molluscan Fossils " : Mem. Mus. Comp. Zool. Harvard College, vol. x (1884), p. 50.
Protocardia Hillana, var. *typica,* Blanckenhorn : " Beiträge Geologie Syriens," 1890, p. 89.

DESCRIPTION. — Shell " rotundate-cordate ; ventricose, subequilateral ; posterior side rather longer than the anterior ; the margin subtruncated and nearly direct ; summits prominent, acutely rounded ; basal margin profoundly rounded anteriorly, obliquely truncated in rear ; surface of the valves marked with concentric lines as far as the umbonal slope ; posterior submargin with about fifteen slender minutely echinated radii ; posterior margin crenulated within. This abundant species resembles *Cardium peregrinosum,* Orbigny, and *C. Hillanum,* Sowerby, but is proportionally more elongated, and the sulci are much larger. The largest specimen measures 2½ inches in length."— *Conrad.*

[1] It should be stated here that *G. Costei* is only quoted by Stoliczka in a general list of Cretaceous species, and not as occurring in India, where, apparently, it has never been identified.

The above represents Conrad's original account of a Lebanon shell which was regarded as Jurassic, but which later authorities have more correctly recognized as Cretaceous (Turonian of Hamlin). Certain specimens in the Egyptian Collection exhibit the sculpture of this species. The broad, convex, concentric ribs are each separated by a furrow of lesser width, whilst a series of radial costæ ornament the oblique posterior area. The concentric striæ are finer, closer together, and more numerous on the umbonal region than in a more ventral direction. The species is closely related to *Cardium Hillanum* of Sowerby, from the Blackdown Beds of England, and seems to differ chiefly in its coarser and more deeply sulcated concentric ornamentation.

DIMENSIONS.

Single valve—Height ...	...	...	...	...	45 mm.
Length ...	...	...	...	...,	44 ,,
Diameter	...	...	...	...	15 ,,

REMARKS.—The valves occur in a fawn-coloured sandstone, and are associated with *Trigonoarca multidentata* and one of the specimens of *Ostrea Villei.* They are partially covered with matrix, so that the posterior areas are not seen in all cases.

HORIZON.—Turonian.

DISTRIBUTION.—Bhamdûn, Mount Lebanon, Syria; and "Sheet 33": Coll. Geol. Surv. Egypt (No. 1,042, Box No. 54c; No. 1,044, Box No. 56c).

Genus TRIGONOARCA, Conrad, 1867.

American Journ. Conch., vol. iii (1867), p. 9.
Journ. Ac. Nat. Sci. Philadelphia, ser. 2, vol. iv (1860), p. 281, pl. xlvii, fig. 20.

TYPE.—*Cucullæa Maconensis,* Conrad.

TRIGONOARCA MULTIDENTATA, sp. nov.   Pl. XVI, Fig. 4.

DESCRIPTION.—Shell subtrigonal, arched, anterior margin rounded, posterior area obtusely angulated and abruptly truncated; cardinal region nearly semicircular, composed of numerous, slightly flexuous, radiately arranged, elongate, depressed denticles, which extend down each side to the ventral margin of the adductor scars; scars large, posterior one longest and furnished with a projecting marginal edge; surface with more or less distant concentric growth-lines, which are crossed in the ventral area by nearly obsolete radial costæ.

DIMENSIONS.

Left valve—Height	...	...	...	...	75 mm.
Length	...	...	...	...	79 ,,
Diameter ...	...	...	...	...	25 ,,

These characters have been drawn up from a single left valve which represents the only specimen in the collection. Although more or less of the nature of a cast, it is in a fair state of preservation, and is distinguished from all other forms by the regular formation and enormous number of the closely arranged

teeth, which amount to about 65. These teeth have depressed summits, hook-shaped ends, and are longest on the anterior side, besides being of almost vertical disposition at the umbo. In these details it differs from *Cucullæa tumida* of D'Archiac, a shell which in some other characters appears to show certain resemblances, though of less size and less inflated. It is of interest to mention that *C. tumida* has already been recorded from the Senonian rocks of Egypt by Professor Mayer-Eymar.[1]

REMARKS.—The specimen is contained in the same fawn-coloured sandstone as *Protocardia biseriata* and a valve of *Ostrea Villei.* Conrad's genus *Trigonoarca* is essentially Cretaceous, and from the peculiar character of its teeth appears to be related to *Cucullæa, Axinea,* and *Noetia.*

HORIZON.—Turonian.

DISTRIBUTION.—" Sheet 33 " : Coll. Geol. Surv. Egypt (No. 1,044, Box No. 56*c*).

Genus ARCTICA, Schumacher, 1817.

Nouv. Syst. Hab. Test., 1817, p. 145.

TYPE.—*Venus Islandica*, Linnæus [syn. *Cyprina*, Lamarck, *non* Linnæus].

ARCTICA BARROISI, Coquand. Pl. XVI, Fig. 5.

Cyprina Barroisi, Coquand, " Études Suppl. Pal. Algérienne " : Bull. Ac. Hippone (Bone), No. 15 (1880), p. 113 (not figured). Peron : " Desc. Moll. Foss. Crétacés Tunisie," pt. ii (1891), p. 298, pl. xxix, figs. 8, 9.

DESCRIPTION.—Shell triangular, thick, very convex, higher than wide, marked by concentric striations, inæquilateral ; anterior side short, excavated beneath the umbones ; posterior region long, narrow, rounded at margin ; umbones prominent, incurved ; muscular scars prominent.

Coquand's original diagnosis of this species as here given was founded upon specimens obtained from the so-called Santonian beds of Algeria, but without being represented by figures. The excellent illustrations, however, given by M. Peron, of the same shell from Tunis, help to supply this omission in the history of the species. It is evidently chiefly found as a cast, for the excavation beneath the beaks is very apparent, not only in Peron's figures, but also in actual specimens from Tunis preserved in the British Museum. Furthermore, neither Coquand nor Peron refer to internal characters, but one of the present Egyptian specimens exhibits a great width of hinge-area and shows the lower of the two anterior teeth ; and, although somewhat obscure in details, the hinge-area may be said to resemble what is present in such forms as *Arctica rostrata* (Sowerby), etc.

The species is related to *Cyprina cordiformis* of D'Orbigny, a European Albian shell, which, however, has prominent radial striæ in addition to concentric ornamentation on its valves, besides

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[1] " Zur Geologie Egyptens " : Viert. Nat. Ges. Zurich, vol. xxxi (1886), p. 246.

being of greater length than height, and having an increased diameter.

DIMENSIONS.

Largest valve—Height	...	...	...	...	71 mm.
Length	...	...	...	...	61 ,,
Diameter	...	...	...	...	24 ,,

REMARKS.—The Egyptian examples consist of two opposite valves, belonging to distinct individuals. They are contained in a grey compact limestone associated with "Beekite," and exactly similar to the matrix bearing a valve of *Ostrea Lyonsi* and a specimen of *O. Villei.*

HORIZON.—Turonian.

DISTRIBUTION.—Algeria; Tunis; and "Sheet 33": Coll. Geol. Surv. Egypt (No. 1,044, Box No. 56*c*).

EXPLANATION OF PLATE XV.

NERINEA REQUIENIANA, Orb.
Turonian of Abu Roasch.

FIG. 1. Fragment from near the base, showing obscure ribbing and marginal thickening of the whorls.

FIG. 2. Upper portion of spire, with its numerous whorls.

FIG. 3. Vertical section of Fig. 1, exhibiting the plicated structure of columella,

FIG. 4. Front aspect of a weathered specimen in the British Museum, presented by W. M. Newton, Esq. [G. 11,485].

OSTREA LYONSI, sp. nov.
Turonian, from hills west of Jebel Zait.

FIG. 5. External view of lower valve.

FIG. 6. Inner view of same.

FIG. 7. Profile of a natural cast of interior of another specimen, showing the plicated character of the valves.

OSTREA THOMASI, Peron.
Turonian, west of the Gizeh Pyramids.

FIG. 8. External view of upper valve.

FIG. 9. Internal view of same.

FIG. 10. External view of lower valve of another specimen.

PROTOCARDIA BISERIATA, Conrad.
Turonian, "Sheet 33."

FIG. 11. External aspect of a left valve, showing the concentric and postero-radial sculpture.

EXPLANATION OF PLATE XVI.

OSTREA VILLEI, Coquand.
Turonian, "Sheet 33."

FIG. 1. External view of lower valve.

FIG. 2. Internal view of upper valve.

FIG. 3. Exterior of Fig. 2.

TRIGONOARCA MULTIDENTATA, sp. nov.
Turonian, "Sheet 33."

FIG. 4. External view of a left valve, showing dentition, scars, etc.

ARCTICA BARROISI, Coquand.
Turonian, "Sheet 33."

FIG. 5. External view of a left valve, exhibiting the regular concentric sculpture of the species.

(The figures on both plates are drawn natural size.)

V.—MEMORANDA CHIEFLY ON THE DRIFT DEPOSITS IN VARIOUS PARTS OF ENGLAND AND WALES: BEING EXTRACTS FROM THE NOTEBOOKS AND OTHER MSS. OF THE LATE SIR JOSEPH PRESTWICH, M.A., D.C.L., F.R.S., etc.

Communicated by Lady PRESTWICH, and edited by H. B. WOODWARD, F.R.S.

[For a period of nearly sixty years Sir Joseph Prestwich recorded his geological observations in a series of notebooks. These records, together with the illustrative sections, were afterwards copied, in many instances, into folio volumes dealing respectively with the Eocene and Miocene, the Pliocene and Post-Pliocene formations, and with well-sinkings, springs, etc. The systematic arrangement and indexing of his very copious notes no doubt greatly facilitated the labours of the author. The majority of his notes and sections have been published, but here and there among the notebooks and MSS. there are records of pits and railway-cuttings, as well as some statements of opinion, which appear never to have been printed. A selection of these is now given, together with references to published papers dealing with the same subjects. All additions are put in square brackets.

It was the desire of Sir J. Prestwich to have dealt more fully with the phenomena of the Glacial Period, but owing to the many calls upon his time, and to his aim invariably to obtain and to submit fully to his readers all the evidence bearing upon his subjects, he was led to postpone for many years his more elaborate works. Thus his important papers on the Crag formations were issued long after most of his observations had been made. Meanwhile other geologists had entered the field and made known many of the facts which he had previously gathered, a proceeding natural enough and one by no means to be regretted. Thus Sir J. Prestwich remarks in his paper on the Westleton Beds, Part I (Quart. Journ. Geol. Soc., vol. xlvi, 1890, p. 86), that " The Memoirs of the [Geological] Survey, to which I shall have frequent occasion to refer, now supply a mass of valuable details, which greatly facilitate the task and do away with the necessity of much local description."

The notebooks rarely contain any particular expressions of opinion ; they simply record facts and only occasionally suggest correlations. The conclusions were for the most part worked out subsequently and embodied in various published papers.

Among the MSS. left by Prestwich is the rough draft of the Table of Contents of a paper dated 1892. It includes the following heads : —]

ON THE GLACIAL SERIES OF THE SOUTH OF ENGLAND.

The history of the Westleton Beds showed that the valleys of the South of England were excavated subsequently to them.

The Westleton the base of the Quaternary or Glacial. The Rubble Drift the last term. These are two definite horizons.

The Westleton followed by elevation.

Subaerial action commenced in the west, while marine action continued on the east coast.

Distribution of Glacial beds affected thereby.

Abrupt setting in of Lower Boulder-clay on the Westleton Beds.

Gradual rise of land westward—a slow process.

On the Lower Glacial Series.

I have shown[1] that, during the deposition of the Westleton Shingle, a movement of depression of the surface from eastward to westward caused it to pass transgressively over the Crag series of the Eastern Counties and the Lower Tertiaries of Essex and

[1] Quart. Journ. Geol. Soc., vol. xlvi (1890), pp. 114, 148, 178.

adjacent counties, as far westward as Wiltshire, if not beyond. This was succeeded at the end of the Westleton epoch by a movement of elevation which raised that sea-bed from nearly its then level on the east coast gradually to a height of 600 to 650 feet in a north-westerly direction in Buckinghamshire, Oxfordshire, and Berkshire.

The physical and structural features by which I traced this bed thus far cease on the north-western brow of the Chalk escarpment—cease with the range of the Chalk and Tertiary strata on which it rests. I have sought for it on the high grounds in the north of these and other Midland counties, but without success. The denudation which swept away the underlying Chalk and Tertiaries has not left a trace of the Westleton Beds.

It is, however, a curious circumstance that if we take the Westleton Shingle in South Essex where it is [160 to 200][1] feet above the sea-level, and its outliers on the Chalk escarpment where it is 650 feet high, and prolong this gradient to Derbyshire and North Wales, it will be found to accord very nearly with the levels of the fossiliferous gravel above Macclesfield and with the shelly sands on Moel Tryfaen.

[Comparisons were then to be made between the Marine Mollusca recorded from the Westleton Beds, Quart. Journ. Geol. Soc., vol. xlvi, p. 116, and the species obtained from Moel Tryfaen and Macclesfield, but the references were not completed.]

[The MS. of a portion of another paper was commenced by Prestwich, and five pages of foolscap were written by him on Nov. 1st, 1895, the day when he was seized with his last illness. The paper commences as follows :—]

ON SOME LOCAL FRESH-WATER DEPOSITS UNDERLYING THE GLACIAL SERIES IN THE SOUTH OF ENGLAND.

In succession to the Westleton Beds, and following on the changes of level which then took place, are a few local deposits which are important as indicating the nature and extent of those changes. Overlaid, however, as they are generally by the Glacial series they are rarely to be seen. In fact, the overlying Glacial series has generally worn into and denuded these soft fresh-water beds so that they are to be met with in very few places. They are sufficient, however, to prove the fact.

[Among these fresh-water beds the author would include the shell-marl underlying the brickearth at Witham in Essex. See Wood & Harmer, Quart. Journ. Geol. Soc., vol. xxxiii, p. 110 ; Prestwich, ibid., vol. xlvi, p. 135 ; and Whitaker, "Geology N.W. Part of Essex," Geol. Survey, pp. 67–69. The deposit is usually considered to be newer than the Boulder-clay of the locality.

He also refers to the fresh-water deposit at Casewick in Lincolnshire, long ago described by Professor Morris, and referred to by Professor Judd ("Geol. Rutland," p. 244) as a "Pre-glacial? Lacustrine deposit." Mr. Clement Reid has recently named a few plants, obtained by him from a lump of the Casewick clay, which was given to him by Prestwich. Mr. Reid says : "There is nothing in the list to throw any light on the age of the deposit, and so far as the flora shows it may be of extremely recent date " (Quart. Journ. Geol. Soc., vol. liii, p. 463).]

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[1] [Quart. Journ. Geol. Soc., vol. xlvi, p. 135.]

[The following are extracts from Notebooks :—]

1. Thames Valley and Eastern Counties.

Aug. 19, 1849.—With Morris through Kensington. Half-way up the hill leading to the waterworks a bed of light-coloured sand crops out. Mr. Earle says that is underlaid by gravel. A short distance above this the ochreous gravel, which is very irregular, sets in.

[The general section of the hill is thus stated :—]

> Mixed yellow clay and gravel.
> Compact gravel, ochreous.
> Light-coloured sands.
> ? Gravel.
> London Clay.

At the old Kensington gravel-pits brickearth now only is worked. [The brickearth is shown in diagram to rest partly on the gravel and partly on London Clay.]

Kensington Park Villas, the old Hippodrome-ground, shows the bare London Clay coming to the surface.

At the foot of Notting Hill the valley drift shows beds of loam and brickearth which are largely worked.

South of the Kensington Road, by the side of the canal, thick beds of ochreous gravel again appear. [Section given of] Bright ochreous gravel of angular and rolled flints, roughly bedded, with irregular sandy beds, 12 feet. Bones are said to have been found in the pit. Could not by sight distinguish this gravel, which is in the valley, from that on the top of the hill.

Aug. 30, 1853.—With [R. W.] Mylne to Kensington gravel-pits. It is doubtful whether the gravel caps the hill at the reservoir. The brickearth goes close up to it; the surface of the clay is also mixed with gravel. In the Queen's Road the gravel is 15 to 20 feet thick, and is of a brown ferruginous colour, very compact, and with only a few sand-veins of the same colour.

Resumed the following day [August 31] at the corner of the Addison Road. Passing thence into Potter's Field we found a brick-earth 10 to 16 feet thick, underlaid by a light quicksand, and then gravel a few feet thick and full of water. This brickearth is remarkable for its resemblance to the London [Clay]; it is this remanié. The outcrop of the gravel is not visible [being concealed by overlap of brickearth on to London Clay]. In an old brickfield at Shepherd's Bush we found some of the gravel in a heap. It contained the same foreign rocks [New Red Sandstone débris] as are found in the gravel at West Drayton ; differs from that in Hyde Park.

Mammalian remains have not been found in the brickearth at Potter's Field, but they have been found in the gravel near Shepherd's Bush.

1853.—With Mylne to Chelsea to see the sewer now making on the west of the Hospital. [The section noted was :—]

Earth		1 foot.
Bright ferruginous gravel, chiefly subangular flints ...	⎫	
Yellow and ochreous gravel	⎬	23 feet.
Yellow loam, 2 [feet]		
Light-coloured sharp gravel, with mammalian remains	⎭	

In the upper part of the gravel there are few quartz, etc., pebbles. In the lower part quartz and sandstone (quartzite) pebbles are common. The mammalian remains consist of ox, horse, and stag.

1853.—To section west of Shepherd's Bush. Brickearth very much like London Clay, [resting irregularly on] ochreous gravel. The lower part of the brickearth is lighter and full of 'race.' This also is the case at the Addison Road pits, where the brickearth is 10 to 12 feet thick, and the gravel not worked on account of water.

1889.— [Notes section at] Castle Hill, Ealing, pit by side of railway, showing London Clay remanié, with a few flints and flint-pebbles, 2 to 4 feet; [resting on] ochreous flint gravel, 15 feet.

[The occurrence of remanié London Clay at Hendon and elsewhere has been noted by Dr. Hicks: Quart. Journ. Geol. Soc., vols. xlvii, p. 575; xlviii, p. 460. See also J. Allen Brown: Proc. Geol. Assoc., vol. vii, p. 173; and Quart. Journ. Geol. Soc., vol. xlii, p. 192.]

1859.—[Notes the following section at] Victoria Road gravel-pits, Clapham Common :—

	Feet.
Earth and flints	1
Brickearth	4
Sand and gravel	9
London Clay—Brown clay	1
Blue clay	

Visited the above with General Emmet. . . . . [Found] a cast of shell in a New Red Sandstone pebble. . . . . No bones found here.

Thence to Wandsworth Common pit, near top of Nightingale Lane. Bones found under gravel on top of clay. Could not make out species; brown and mineralized.

No Date.—[Mentions that] great quantities of peat were taken out during the digging of the foundations of the Westminster Palace Hotel in Victoria Street.

N. D.—[Between Highbury and Barnsbury the railway-cuttings showed gravel and loam resting irregularly on London Clay. In places the London Clay comes to the surface.]

The gravel consists of brown clay and ochreous sand, with more or fewer white and black Tertiary flint-pebbles; scarcely a subangular flint to be found. No stratification. The pebbles at all angles, some upright. They more resemble the pebbles of the Bagshot Beds. At places where the sand and pebbles are scarce or disappear, the drift passes into what looks merely as remanié London Clay.

Sept. 29, 1861.—With [Alfred] Tylor to Highbury. Between Balls Pond and Highbury :—

Black pebble-gravel and a few subangular flints [in pockets] ⎱	6 to 8 feet.
Brown clay ... ... ⎰	
Fine yellow sand, a few small flints	9 to 10 feet.

At the back of the new road by the Canal [New River] :—

Brown clay	...	...	...	...	...	3 feet.
Gravel [in pockets]	...	...	...	...	2 to 3 feet.
Sand and clay ...	...	...	...	...	1 to 2 feet.
Yellow sand						

Pit in centre of field :—

							ft.	in.
Brown clay	...	...	...	...	...	...	} 4	0
Gravel ...	...	...	...	...	...	...		
Light greenish-grey clay	...	...	...	...	...		1	6
Yellow clay	...	...	...	...	...	...	1	6
Peaty bed ...	...	...	...	...	...	...	0	6
Brown clay	...	...	...	...	...	...	3	0
Yellow sand								

Large pit behind Highbury Barn :—

					ft.	in.
Brown clay—London Clay remanié	...	...	}		8 to 10	0
Gravel [in pockets]	...	...	...	...		
Yellow sandy and brown clay and seams of gravel			}			
Grey and brown clay and ferruginous gravel in thin seams					4	0
Peaty seam	...	...	...	...	...	0	6
Ferruginous sand and small gravel		...	...	...	1	6
Brown clay banded with grey clay		...	...	...	3	6
Peaty clay and angular black flints		...	...	...	2	0
Brown clay	...	...	...	...	...	1	0
Light brown sand ...	...	...	...	...	...	1	0
Laminated clay ...	...	...	...	...	...	2	0
Fine light yellow sand	...	...	...	...	...	10	0

Could find no shells or fossils.

A few hundred yards to the north (just across the road) the Brickearth is said to end. On brow of hill London Clay, with a few pebbles at top. ·

Tylor states that at Church Street, Stoke Newington, the lower sands were 20 feet thick in places.

Sept. 15, 1848.—Mr. Wetherell showed me a specimen of rolled *Astræa*, 2 inches over (Carboniferous Limestone), from the gravel at Whetstone gravel-pits. Also a trilobite from Muswell Hill.

Great Northern Railway, Wood Green cutting (south of Bounds Green cutting) showed :—

						Feet.
Tertiary flint-pebbles in sand	...	...	...	...		3
Stratified white and yellow sands, no fossils		...	...		15
Subangular flint-gravel and Tertiary flint-pebbles, with beds						
of sand						4
London Clay—Fine brown clay						2
Dark or black clay with very small (1 to 2 inches) Septaria						

May 29, 1855.—The swallow-holes at North Mims are in a field. The water rises in this field sometimes 12 to 15 feet, and sinks there slowly through the several holes, which are not deep, and sided with silt. The water comes up again beyond the church.

[See also Whitaker, "Geology of London," vol. i, p. 203.]

March 3, 1850.— Hitchin. The sand and gravel of the hills around the town appear to be the drift above the Boulder-clay.

It is disposed very irregularly. In [some] places the Chalk rises to the highest levels. In others the sands and gravel form the hill-tops.

Sept. 14, 1851.—[Visit to Bushey, near Watford, and Aldenham.] Gravel caps the whole of this (three-quarters of a mile north-east of the Blackbirds Farm) and the adjacent hills. A fine section of it is shown by the side of the lane half-way between Newlands and Batlers Green. I could find no trace on this hill of the Puddingstone pit formerly worked—or rather, it seems, now worked out; only the overlying gravel now remains.

1855.—Victoria Docks :—

	Feet.
Soil	1
Stiff bluish-grey clay ...	7
Peat with trees and fresh-water shells	11
Black clay passing into white	[about 2]
Gravel (washed)	

A large flat bone (? whale), 2 feet by 2 feet, was found at a depth of 16 feet in the peat. A grindstone was also found. A lead shield was found at a depth of about 16 feet. Antlers were also found at about the same depth. Urns with [human] bones were also found (apparently British) on the peat. Some of the bones were coated with phosphate of iron.

[See also Whitaker, " Geology of London," vol. i, p. 461 ; vol. ii, p. 284.]

September, 1847.—Section of Mr. Meeson's pit, Grays Thurrock :—

	Feet.
a. Surface soil	12 to 20
b. Yellow sands with irregular seams of gravel	
c. Grey and yellow loam with a few pebbles : contains some mammalian remains and a few *Unios*, etc.	3 to 6
d. Subangular flint-gravel	0 to 1
e. Fine yellow sand with numerous bones and fresh-water shells, some masses of wood, and blocks of stone	2 to 6
f. Roughly laminated yellow clay with a few shells and some lignite and seams of sharp white drift sand with shells...	6 to 8
g. Finely laminated grey clay with, in places, numerous impressions and traces of plants, and shells mostly in fragments ...	5 to 6
h. Ash-coloured and ochreous gravel and loam with numerous shells	2 to 3
i. Laminated ash-coloured and yellow loams with *Unio* and other shells	2 to 4
j. Coarse ferruginous subangular flint-gravel with white and black veins...	1 to 4
Soft yellow Chalk, surface irregular	

All the beds are very irregular, and while *b* to *i* thin out towards the Thames, *j* expands to a thickness of 10 to 12 feet. The shells are very numerous, including the *Cyrena* [*Corbicula*] *fluminalis.* In *e* boulders of Tertiary sandstone [greywethers] are occasionally found. One was a broken concretionary mass with the edges rounded off. It was in the midst of brittle and perfect shells, and was about 1½ feet in largest diameter.

[This appears to contain fuller particulars of the strata than elsewhere published. See references by B. B. Woodward, Proc. Geol. Assoc., vol. xi, p. 364.]

June 27, 1852.—By boat to Grays. . . . . Chadwell church
stands on gravel over Thanet Sands, which show in the lane below.
In a pit at the bottom of this lane and overlooking the marshes the
T. Sands are 15 to 20 feet thick, and abound in oviform-shaped
bodies (eggs of Molluscs?).   Between Chadwell church and Gun
Hill the gravel is very ferruginous and worked in many places.
It consists chiefly of rounded Tertiary flint-pebbles, not often broken,
some subangular flints, a few quartz pebbles, and subangular
pebbles of sandstone or imperfect chert (Greensand?).   It caps
Gun Hill.

1852.—To Stoke Newington. Confirmed the fact of an overlie
of irregular gravel over a roughly stratified one throughout the
district between the Kingsland Station and Tylor's House [in
Paradise Row].   The general section is thus :—

> Brown clayey irregular gravel, chiefly B. [Black Tertiary] pebbles and some
> blocks of sandstone.
> Roughly-bedded light yellow-whitish and ferruginous sand and gravel, with
> mammalian remains.

Oct. 29, 1853. — Braintree. In the drift $1\frac{1}{2}$ [mile] from
Wethersfield on the (Nashes Green) Braintree road, a mass of
micaceous sandstone was found in a field, the dimensions of which
could not be ascertained.   The portion exposed measured about
10 to 12 feet across and no edge exposed.   A second mass was
found in a field $\frac{1}{4}$ mile north of Wethersfield.   It was a grey
limestone, 10 feet were exposed and no edge seen.

September, 1849. — Through Bergholt to Stutton. . . . .
Beyond Stutton, by the side of the river and forming the base of one
of the hills, is the clay-pit in which the bones of Mammalia and
shells have been noticed by Mr. Wood :—

	Feet.
Brown clay and flints [coating surface]	2 to 3
Thin-bedded brown clay, appears like London Clay (no fossils)	10
Semi-stone [band]	
Bluish clayey sand ... { Passes to south-west into } Light ash-coloured brickearth { light yellow sand }	6 to 8
Very dark tile-clay with remains of plants	2 to 3
Sand, not exposed and depth not proved	20 ?

The bones were said to have been found in the lowest part of the
section.

[See Whitaker, "Geology of the Country around Ipswich, etc." : Mem. Geol.
Survey, p. 95.]

1859.—Stutton.   The fresh-water deposit commences about half
a mile east of Stutton Mill in a low cliff, first of gravel, then of
London Clay, and then fresh-water deposit.   This then continues for
about half a mile, being in part formed of reconstructed gravel and
London Clay :—

	Feet.
Brown clay with gravel in places, no shells...	4
Light marl	1
Gravel and sand	1
Light-coloured clay with gravel and perfect shells	4
Coarse gravel and clay	1

There are few shells at first, but further on the *Cyrena* becomes abundant with several large *Unios*. The common shell is the *Cyclas* or *Pisidium*, then the *Bythinia*. Only a few *Planorbis*. The Cyrena usually in single shells and in all positions ; a few double.

1864.—The watershed of the Waveney and Ouse is at Lopham Ford. The valley there is as important as elsewhere, and a bed of high-level valley-gravel occurs at least 30 feet above the valley, close to the watershed. There is no dividing ridge ; a peaty marsh fills the bottom of the valley, and the Waveney flows out of it. A bed a few [feet] high of sand and gravel rises to level of peat, and this seems to form the division of the two streams. Trees and numerous bones (skeleton of deer) are found in the peat.

[See also Rev. O. Fisher, GEOL. MAG., vol. v, p. 557; and F. J. Bennett, "Geology of the Country around Diss, etc.": Geol. Survey, p. 16.]

2. WESTERN COUNTIES.

July 18, 1878.—To Wantage with Morris. . . . . Thence through East Challow, where the Hippopotamus is said to have been found. The pit is no longer worked, but appears to have been a shallow Gault pit. The H. tusk in possession of Mr. [E. C.] Davey looks very fresh, as though out of a peat.

July 14, 1857 (6 p.m.).—Chippenham. Walked out to Kellaways. . . . . Found a small pit in a field by Avon Farm :—

						ft.	in.
Brown clay	...	...	...	...	...	1	6
White small gravel	...	...	...	...	...	3	0
Clay							

The brown clay contains only a few pebbles, and would not lead one to suspect the presence of gravel. The gravel consists of small, flat, worn fragments or pebbles of the local oolitic rocks—some of the harder ones in subangular pieces, and fragments of angular flint (both direct from Chalk, but more from the ferruginous drift on the Downs). The matrix is sand. Saw no bones or shells.

[See also H. B. Woodward, Proc. Geol. Assoc., vol. xiv, p. 341.]

July 15, 1857.—Devizes. Section at Broughton, near Melksham :—

				Feet.
Brown clayey sand with few pebbles	...	...	...	3 to 4
White gravel with irregular thin beds of sand		...		4 to 5
Oxford Clay				

Brown subangular flint from old gravel. Angular black and white chalk flints. A few quartz and lydian-stone pebbles—Lower Greensand. [Stones, septarian fragments, etc., from] Oxford Clay and Kellaways Rock—abundant, chief mass. Forest Marble. All the mass is in small pieces, rounded and flattened, worn, except the flints, which are sharp and nearly unworn. This gravel rises 10 to 20 feet above the river-level, ranges to Broughton Church and Holt on the west of the river. A small peat-bed overlies the gravel (replacing the brickearth) by the river. The gravel is all derived from material to the north-west.

Mr. Wilkinson, the vicar of Broughton, accompanied us. He stated that the tusk of an elephant (now in the Bath Museum, presented by Mr. Macneill) was found in the gravel on the line by Broughton.

[See also R. N. Mantell, Quart. Journ. Geol. Soc., vol. vi, p. 313.]

July, 1857.—To Warminster. Stopped at Codford Station. Up the valley to Chittern [east of Heytesbury] . . . . slope of hills bare. Top covered with flints 1 to 2 feet deep in an earthy-coloured sand and clay, occasionally also small white quartz pebbles. At the clump on top of Clay-pit hill sand and clay have been dug. The section is much obscured, traces of mottled clay, yellow and white sands, a carbonaceous bed, concretions of ironstone. Small masses of a soft white sandstone (?) were, however, strewn about, and led me to believe that the Tertiary beds were *in sitú*, and protected by being in a large sand-pipe. In one hole, however, the section was clear :—

White gravel	...	...	...	...	2 to 10 feet.
White siliceous sand	...	...	...	...	10 feet.

The gravel consists of perfectly rolled (although some broken), largish pebbles of white-coated flints, very light, of a few small black flint-pebbles in a white and light yellow coarse sand, full of small white quartz pebbles, with a few quartz and black slate (?) pebbles, all spread confusedly over the white sand into which they penetrate but with which they do not mix. They appear to be a Tertiary bed either remanié or drifted.

The white sand is very fine, pure, and white, just the stuff that when solidified would form the Druid Sandstone.

The order of superposition appeared to be :—

Yellow clayey and sandy drift, full of quite angular yellow flints and small quartz pebbles				...	1 to 2 feet.
White flint pebbles and quartz pebbles	...		...		6 feet.
White sand ⎫ Carbonaceous clay ⎬ Mottled clay ⎭	...	...	...	...	10 feet.

The flint drift continues to Oldbury Camp.

[In his paper on Westleton Beds, Part II, Quart. Journ. Geol. Soc., vol. xlvi, p. 144, Sir J. Prestwich refers to "a large Tertiary remnant" on the Chalk Downs of Copford (Codford), east of Warminster, and remarks that it has been preserved from denudation by having been let down into a cavity in the Chalk.]

October, 1848.—Marlborough. [Notes the occurrence of ochreous clay and flints which rest on a "piped" surface of Chalk.] The flints are large and unrolled. The clays appear to consist of the breaking up of the mottled clays and sands, the action not long continued. In some places the clay is free from flints. In others they occur piled one on another as close as they can be packed.

No Date.—Calne. Surface of Chalk, top of Monument Hill. It is drilled in places with Serpula-like cavities, 2 to 3 inches in length, but more irregular in form ; made by the action of water and the roots of grasses ? Some of the latter still remain in the tubes.

Mendips, Drift on top of. It consists of a bright red clay, with flint-pebbles (small Tertiary) and angular fragments of flint (chalk ?).

[See also Prestwich, Quart. Journ. Geol. Soc., vol. xlvi, p. 143.]

Sept. 19, 1849.—Sarum. See gravel on Alderbury Hill, said to [be] different and better than any for 20 miles around.

The gravel at the abandoned Andover railway consists almost entirely of some large but mostly small angular white flint-pebbles, with 2 or 3 per cent. of black pebbles (some broken) and traces of sandstone in bits, embedded in brickearth, this latter sometimes pure, at other places the gravel being all of a mass and loose. Below this is a chalk-rubble of Chalk and a few angular flints, and with many small white flat pebbles. The general section of these valleys would be thus [diagram showing Alderbury Hill as Hill gravel]. All the valleys in the district, such as the valley of the Romsey river and that of the Southampton and Winchester rivers, appear gorged with gravel. Also in the valley at Dean, where it is underlaid by a chalk-rubble.

[In his paper on the Westleton Beds, Part III, Quart. Journ. Geol. Soc., vol. xlvi, pp. 176, 181, Sir J. Prestwich is inclined to regard the Alderbury gravel as an outlier of Westleton Shingle. Eolithic implements have been found in the Alderbury gravel by Dr. H. P. Blackmore.]

December, 1845.—Section at Studland.

[Base of Bagshot Beds.]	{ Light-coloured laminated grey and brownish clay. { Light-coloured sands.
[London Clay, etc.]	Gap, section hidden, apparently clays.
[Reading Beds.]	{ Fine white sand, 2 to 3 feet ? { Bull-head flints, consisting of a conglomerate of large { angular flints, small flint pebbles, and small quartz { pebbles, in greenish clay and compact iron-sandstone. Chalk.

[The Lower Eocene strata at this locality have not been described in detail owing to the general obscurity of the coast-section. See also J. S. Gardner, Quart. Journ. Geol. Soc., vol. xxxix, p. 208 ; C. Reid, ibid., vol. lii, p. 490.]

No Date.—Section on the Chalk hill above the tunnel on the Dorchester and Weymouth Railway :—

Irregular mass of rolled white flint-pebbles, some of a very large size (1 foot in diameter), and angular flints with the edges abraded.
Irregular mass of yellow sand, layers of gravel (roughly stratified) as above, but finer, and white pipe-clay full of grains of quartz ; quartz pebbles abound in the gravels. The flints are generally white all through, a few only are black in and out.
The line of separation [between the gravels] is very uncertain.
[Total thickness marked 50 feet.   Bedding approximately horizontal.]

[See also Prestwich, Quart. Journ. Geol. Soc., vol. xxxi, pp. 40, 41 ; O. Fisher, Geol. Mag., 1896, p. 246 ; A. Strahan, ibid., p. 334 ; C. Reid, Quart. Journ. Geol. Soc., vol. lii, p. 494.]

N. D.—Crewkerne, Drift on Chalk hill one mile south of.   Green clay with black portions, and angular fragments of flint coated black, passing into a fine breccia of very small fragments of Chalk in the green clay ?

Fragments of Inocerami, hard, not effervescing, in red clay from gravel on the hill 1½ mile north-east of Crewkerne.   [Composition of gravel :—]

1 pebble soft ragstone.
2 subangular fragments of decomposed white flint.
1 angular fragment of flint unaltered.
1 angular pebble of grey quartzite.
2 subangular fragments of white veined quartz.
1 subangular fragment of hornstone.
1 rough pebble of compact slate.
1 subangular fragment of iron-sandstone.
1 piece of ironstone with white quartz pebbles.
                    W. ? [= Westleton Beds ?].

[See Prestwich, on Westleton Beds, Part III, Quart. Journ. Geol. Soc., vol. xlvi, p. 162.]

1852.—Sidmouth. The hills to the west are capped by a mass of broken flints in yellow clay and sand ; they are *perfectly* sharp and associated with a mass of small sharp fragments ; sometimes the clay is ochreous and slightly ferruginous. The whole is confusedly heaped together. In places there is hardly anything but the clean sharp flints, no matrix. A few subangular pieces of iron-sandstone occur in the gravel.

Large blocks consisting of a hard light-drab or white siliceous limestone paste, embedding sharply angular flints and fragments of flints, occur also in the gravel ; some of the blocks are 4 to 5 feet in diameter, some of them are mere small hand-pieces. A gravel covers slightly the slopes of the hills, and is accumulated thickly in the valleys. The same flint-gravel caps the hills around Lyme Regis.

[A section at the railway cutting, Newton Bushel (Newton Abbot), was noted in April, 1847. This was represented roughly in diagram as showing :—]

Gravel and sand irregularly overlying a series of inclined beds as follows :—
Red clays and lumps of limestone.
Coarse sands and gravels, white quartz sands, chert nodules, black angular
        pebbles.
Fine white clay and sandy clay.
Coarse white sands and fine gravel.
Red clay passing into light clay with lumps of carb. wood [lignite].
Coarse sands, as above.

[See also Prestwich, Quart. Journ. Geol. Soc., vol. xlviii, p. 318; H. B. Woodward, ibid., vol. xxxii, p. 230 ; Ussher, ibid., vol. xxxiv, p. 448 ; C. Reid, ibid., vol. liv, p. 234; A. E. Salter, Proc. Geol. Assoc., vol. xv, p. 282 ; D. Mackintosh, Geol. Mag., 1867, p. 392.]

Easter excursion, April, 1867. —J. P. [Prestwich], Godwin-Austen, Gwyn Jeffreys, and Captain Galton joined at Plymouth by Spence Bate.

To Newton Bushel, upper gravels of Bovey Tracey, large and coarse, mostly quartz pebbles. They seem to be about 50 feet above level of river. Portion of Bovey Tracey Beds rises out from them.

Beyond Bovey Tracey the rocks are bare, but descending to the river at Woolford [Wilford] bridge we found ledges of a gravel terrace fringing the valley at a height of about 25 feet above river. It contained largish blocks of rolled granite, no scratched pebbles, and is about 4 to 6 feet thick. At one place it is overlaid by imperfect loess and angular débris.

At Willoway [about one mile south of Wray Barton] the river-banks show the lower gravel (about 5 to 6 feet above stream) more worn and generally finer, but with more numerous blocks of granite.

3. Midland and Northern Counties and Wales.

1851.—Cutting at Winslow on L. & N.W. Railway to Oxford shows :—

Coarse gravel [about 2 feet]   ...   . }
Blue Boulder-clay [about 8 feet]   ...   . 12 feet.
Light-coloured gravel [about 2 feet]   ...   .)

Aug. 10, 1856.—Cock Hotel, Stony Stratford.   Oolite quarry near Cosgrove :—

		Feet.
a.	Earth and worn fragments of oolite, with a few angular flints and New Red Sandstone pebbles	2
b.	Oolitic flags, broken at top	2
c.	Oolitic marl	6
d.	Oolite in thick beds—bluish	

Pupa and a small *Helix* are found in *a*, but may have been washed in.   This bed covers the oolite down to the canal, same thickness all the way.   The top of this pit appears to be only about 20 to 30 feet above the river.

Descending the hill, and on another low hill on same level as the oolite, is a gravel and sand pit.   The sands are composed of oolitic and quartz grains, with a few oolitic and quartz pebbles, flint fragments, full of false stratification.   No shells.

The coarse gravel is composed of :—

Large coarse pebbles and worn fragments of hard oolitic beds—some blocks 1 foot in diameter.
Hard chalk.
Subangular flints, brown from gravel and white from Chalk.
Clay and shale nodules, Lias and Oolite.
Small ironstone fragments.
Quartz pebbles, a few large.
A few grey and reddish siliceous sandstone pebbles, but not numerous—no supply, or a very small one, from New Red Sandstone.
A few pebbles of slate and old rocks.

Fossils of the oolites are numerous.   They are not much worn. In the upper soil are a few New Red Sandstone pebbles.

1856.—Pit just above valley at the foot of Cosgrove Hill.
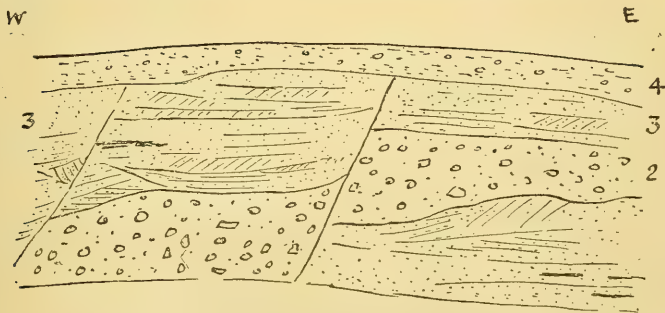
4. Surface drift and earth, local, and New Red Sandstone }
      pebbles.   } About
1 and 3. Sand with false lamination, coaly bands.   } 17 feet.
    2. Very coarse gravel—some blocks 1 ft. in diam.: 4 to 8 ft.)

Fault with downthrow of about 5 feet in centre of section.

Feb. 24, 1859.—Northampton to Stamford. Mr. Bentley informed me that just above the town [Stamford], in some large stone-pits, a great fissure 20 feet deep and closed in at top was exposed by the workings. The bottom was covered by a light-coloured clay or loam, in which many bones were found, white and well preserved. He had kept only a few : among them is a small plate of an elephant's tooth, teeth of deer, of hyæna, and bear?

[With the exception of bear the occurrence of these animal remains was confirmed by S. Sharp, Quart. Journ. Geol. Soc., vol. xxix, p. 254.]

Mr. Bentley directed my attention to the drift near Saxby and Melton Mowbray, where great beds of sand and gravel, disturbed by faults, underlie the Boulder-clay, not disturbed.

Aug. 29, 1859.—Hill S.E. of Pershore ; bare clay on slope, gravel on top. Same on next hill nearer Cropthorne and at Cropthorne itself. There it is more sandy, almost all sand derived from the New Red Sandstone. This gravel is 4 to 8 feet thick, not stratified, no oolitic débris, almost all N. R. S. débris and a few flints.

Beyond Cropthorne, in a low hill, is another gravel with oolitic débris. Returning through Cropthorne to the new pit at New Inn, [section showed :—]

	Feet.
Brickearth [resting irregularly on]	2 to 3
Gravel of N. R. S débris with angulite oolitic débris in small quantities and a few flints	1
Brickearth with *Cyclas*, *Succinea*, etc.	2
Brown solid gravel with *Succinea* (perfect, 5 feet from top), also a small *Helix*. More sandy at base, fragments of bones	9

This is on rather a lower level than Cropthorne.

Mr. Strickland's old pits are all filled up. The section, I was informed by Charles Price, consisted of :—

	Feet.
Brickearth	18
Gravel, bones at top	4
Sand with shells	2
Brown clay	

A few bones were also found in the brickearth, but not so perfect.

[See W. C. Lucy, Proc. Cotteswold Club, vol. v, p. 85.]

No Date.—Criccieth [Carnarvonshire]. Boulder-clay gravel. The grey matrix of this gravel consists entirely of fine small flat grains, much worn, of shales and slates, varying in size from a grain of sand to a threepenny piece.

Nov. 23, 1859.—Accompanied Mr. Denny and Mr. Teale to Wortley [Leeds]. Section in the town near the Square showed :—

	Feet.
Made ground	4
Sandy beds	2
Yellow clay	1 to 2
Blue clay	1

The workmen said this last was 10 to 12 feet thick, and reposed on the solid rock. At Wortley the pits are almost obliterated. The

ground is but little above the level of the river and at the foot of slight slope down from the jail. The beds seemed to me to be blue clay with traces of rootlets, with the upper surface decomposed to a bright yellow and 5 to 6 feet thick. In places the Coal-measure rocks showed beneath the clay. The Hippopotamus remains, Mr. Denny said, were found deeper down (10 to 12 feet) in a more sludgy and peaty matter. They were solid and dark-coloured and entire. The elephant and ox remains were rather higher up, more broken and worn. . . . . . The remains of the Hippopotamus are the finest I have seen : there is nearly an entire skeleton.

[See H. Denny, Proc. Geol. and Polyt. Soc., W. Riding, for 1853, 1854, p. 325 ; and T. P. Teale, Rep. Brit. Assoc. for 1858, Sections, p. 111.]

March 4, 1859.—Newcastle. Approaching Shields the Boulder-clay seems to become thinner. It is in fact deposited on a lower [level], for at Jarrow dock it passes under[1] the bed of the river and is overlaid by 50 feet $+$ of silt, the upper part of which contains thin seams of gravel, and the whole of which abounds in perfect and double estuarine shells such as now inhabit the river ; also with traces of wood and a few trunks of trees, and hard lumpy nodules of grey angular limestone enclosing recent shells and beautiful impressions of recent leaves, looking altogether more like nodules and fossils of far older date. Pieces of branches of trees are also found fossilized, more or less in the centre. In one specimen of birch stem the outer bark or peel alone remains unaltered, the inner bark was quite petrified and seemed to possess structure. Crystals of Gay-Lussite [hydrated carbonate of lime and soda] occur commonly in the centre of the nodules.[2] Altogether it is a very curious and interesting recent deposit.

Bones and entire skeletons of the red deer have been found at the base of the deposit near its edge and on top of the Boulder-clay. The nodules are found low down in the silt and up to within 5 feet of surface. Mr. Howse thinks the chemical works may have had something to do with them. He said some of the blocks were as large as a large stool.

[See also Richard Howse, Trans. Tyneside Nat. Field Club, vol. v, pp. 117, 118, and Trans. N. Eng. Inst. Engineers, vol. xiii, p. 169.]

NOTICES OF MEMOIRS.

The Pelican as an Indigenous British Bird. On some Bones of a Pelican from the Cambridgeshire Fens.[3] By Sidney F. Harmer, M.A., B.Sc.

IN February, 1897, some bones from the Fens were brought to the University Museum of Zoology at Cambridge. Most of these specimens belonged to the Beaver, Pig, Swan, Goose, and

[1] In a later note the writer says : " It seemed to me almost to pass under it."
[2] [A mineral described under the name of ' Jarrowite ' by E. J. J. Browell was obtained from Jarrow Slake. It consists of carbonate of lime with nearly 4 per cent. of carbonate of magnesia.—Trans. Tyneside Nat. Field Club, vol. v, p. 103.]
[3] Reprinted from the Transactions of the Norfolk and Norwich Naturalists' Society, vol. vi (1897).

Pike ; but three of them proved, on examination, to have belonged
to a Pelican, a bird which has been recorded on two previous
occasions from the same part of the country.

The first account was given by Professor Newton (Proc. Zool.
Soc., 1868, p. 2), and refers to a left humerus, in the Woodwardian
Museum at Cambridge. This specimen was described by Professor
Alphonse Milne Edwards in the *Annales des Sciences Naturelles*
(5ᵉ sér., Zool., vol. viii, 1867, p. 285) ; and a translation of this
paper appeared in *The Ibis* (N.S., vol. iv, 1868, p. 363). Milne
Edwards described in detail the characters by which the humerus
of a Pelican can be distinguished, the great size of the bone being
alone an almost certain indication of the genus. He further pointed
out that the ossification of the specimen submitted to him was
incomplete at the articular extremities ; and that the bird was
therefore a young one, which was probably native to the Fens, and
not an accidental immigrant.

A second left humerus from Feltwell Fen, in Norfolk, was
presented in 1871 to the University Museum of Zoology by
Mr. J. H. Gurney, jun., to whom it was given by Mr. John Baker,
the well-known Cambridge birdstuffer. In exhibiting it to the
Zoological Society, Professor Newton called attention (Proc. Zool.
Soc., 1871, p. 702) to its correspondence in size with the humerus
of a recent specimen believed to belong to *Pelecanus crispus*.

The bones which have recently been acquired by the University
Museum of Zoology were found at Littleport, near Ely. They were
formerly in the possession of James L. Luddington, Esq., who has
been kind enough to inform me that they were found on his farm
in Burnt Fen, Littleport, some seven or eight years ago. They
consist of the lower end of a humerus and the upper ends of a
radius and ulna, all of the left side, and appearing to belong to the
same individual. The conclusion that these are the associated
bones of a single specimen is quite in accordance with previous
experience of the way in which the bones of various animals are
found in the peat of the Fens.

The humerus of the Littleport specimen agrees closely with the
Feltwell bone, and the three Littleport bones have the closest
resemblance, in form and size, to the corresponding bones of the
recent *P. crispus*, to which reference has already been made. The
ulna is, however, abnormal at a distance of 11 or 12 cm. from its
upper or proximal end, and it has the appearance of having been
broken, although the fracture was repaired during the life of the
bird. The part of the ulna which is preserved measures only
15 cm., so that the whole of the injured region of the bone is not
visible. The resemblance, in other respects, between the Littleport
bones and those of the recent *P. crispus* certainly lends support to
the view hinted at by Professor Newton in 1871, and repeated on
page 703 of his " Dictionary of Birds " (part iii, 1894), that the
Fen specimens belonged to that species.

It is worthy of remark that a left humerus has been found on
each of the three occasions on which the remains of a Pelican have

been recorded from the Fens. The evidence thus afforded of the occurrence of three individuals goes far in support of the view that the Pelican was really native to this part of England.

REVIEWS.

I.—WACHSMUTH AND SPRINGER'S MONOGRAPH ON CRINOIDS.[1]
THIRD NOTICE.

THE fundamental plates in a crinoid cup are the five *radialia*. Oddly enough they are the last of the calycal plates to appear in the development of *Antedon*, and yet they are the very elements in whose constancy and regularity lies the difference between the Crinoidea and their Cystidean ancestors. Intimately correlated as they are with those characteristic crinoid structures, the *brachia* or arms, they are the sole permanent elements of the cup. Other parts may be added to or taken away from, but the radialia, or ·'radials' *par excellence*, always remain.

The radials, I have said, are five; that is, one in each ray. In old days other plates that happened in some genera to be incorporated in the cup along the lines of the radii were called radials; but such plates are now understood to have been primitively arm-ossicles, and are therefore known as fixed brachials. The recognition of these facts, due to Wachsmuth & Springer and P. H. Carpenter, has enormously simplified the task of description, and has for ever closed the wearisome discussions as to where the arms began in the various genera.

It must not, however, be supposed that the facts are quite so simple as might appear from the above statement. As our authors express it: "In the earlier Inadunata and Articulata—not in the Camerata so far as observed—the radials are frequently compound, i.e. constructed of two segments or parts, which are closely united by a horizontal suture, and in the organization of the Crinoid count as one plate." For the two halves of such a compound radial Wachsmuth and Springer adopt the terms *superradial* and *infer-radial*, proposed by me in January, 1892. The latter term is certainly superior to 'sub-radial,' used by Jaekel in 1895 for the same element, since not only does sub-radial mean a plate below the radial, but it was actually applied to such plates, viz., the basals, for many years by some authors.

The mutual relations of inferradials and radials, and the varying number of compound radials in the several genera of Inadunate Crinoids, lead our authors, by steps which I do not follow, to the conclusion "that there was a time in the early history of the Crinoids when the arm-bearing section [the superradial] was altogether unrepresented. This was apparently the case in

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[1] The North American Crinoidea Camerata. By C. Wachsmuth and F. Springer. Mem. Mus. Comp. Zool. Harvard, vols. xx and xxi, containing 838 pp. and 83 plates. (Cambridge, U.S.A., May, 1897.) For First and Second Notices, see June and July Numbers.

Baerocrinus, in which two of the radial plates are non-armbearing,
and as these plates occur in the same rays as the compound plates
of *Anomalocrinus*, we may infer that *Baerocrinus* is the ancestral
form, lower in its development than either *Anomalocrinus*, *Hoplo-
crinus*, or *Iocrinus*." Sad experience prevents me from attempting
any interpretation of Wachsmuth and Springer's views on this
difficult genus *Baerocrinus*; it is enough to point out that fresh
material has led Professors Fr. von Schmidt and O. Jaekel to the
conclusion that it is based on an abnormal form of *Hoplocrinus*.

Apparently Messrs. Wachsmuth and Springer regard the presence
of inferradials as a primitive character. They do not, however,
accept the statement published by me in 1893, that " a very large
number of Inadunata Monocyclica closely resemble one another,
either in the horizontal bisection of certain radials, a character
which in Dicyclica is entirely confined to the right posterior radial,
or in the greater development of certain other radials." [1] These
facts appeared to me to confirm the separation of monocyclic from
dicyclic forms. The justice of this conclusion may be debated;
but as to the facts there should be no question, and I regret to find
the above statement seriously objected to by the learned Americans.

First let us examine their remarks on the compound radials.
As to their presence in Dicyclica, setting aside the right posterior
radial, they say, " He overlooks the dicyclic *Tribrachiocrinus*, which
has three compound radials." This statement does not agree with
Wachsmuth and Springer's own diagnosis (" Revision of Palæo-
crinoidea," iii, p. 251), or with their remark in the present Monograph
(p. 72) that " the later Fistulata have no true compound radials ";
nor, as is more important, does it agree with the full descriptions by
Mr. R. Etheridge, jun. (1892), abstracted in the GEOL. MAG., Dec. III,
Vol. X, p. 82, descriptions which the courtesy of Mr. Etheridge and
others enabled me to verify in person when at Sydney. Supposing
it to be the case that two radials of *Tribrachiocrinus* have fused with
the first primibrachs, this does not make them horizontally bisected.
Messrs. Wachsmuth and Springer write as though it made no
difference whether one got a half-crown or two shillings in change
for a florin.

Next our authors say that among the twenty-four genera which
I referred to the Monocyclica " only eight have three compound
radials," " there are three with two compound radials, *Anomalocrinus*,
Ohiocrinus, and *Baerocrinus*, and three with a single one; the
remaining ten genera have simple radials throughout." Even
were these statements correct, the group Monocyclica would have
58.3 per cent. of its genera with compound radials, as opposed to
a problematical 1 per cent. in Dicyclica. Such a fact cannot be
" seriously in the way of making the presence or absence of
infrabasals a subordinal character." But the statements neither
were nor are correct. *Ohiocrinus*, for instance, is here said to have
but two compound radials; but in the same authors' " Revision "
(pt. iii, p. 208) it was said to have " the plates of the calyx

[1] " Crinoidea of Gotland, I," p. 20: *Svenska Vet-Akad. Handl.*, xxv, No. 2.

arranged as in *Stenocrinus*," which is now called *Heterocrinus*, and has three compound radials. *Anomalocrinus* also was formerly described by Wachsmuth and Springer (Revision, iii, p. 211) as having two or three compound radials, the "left postero-lateral" being "either simple or bisected vertically." They subsequently figured it with no less than four compound radials,[1] a figure that also conflicts with their present statement that at least two of the radials in every crinoid are always simple (p. 71). Even more unwarranted is their next remark: "Neither do we find [in Monocyclica] any remarkable development of certain radials, except when these are compound." The large left posterior and anterior radials of *Pisocrinus*, *Triacrinus*, and *Haplocrinus* are not compound, but their modification is undoubted, and similar enlargement is very remarkable indeed in the Calceocrinidæ and in *Mycocrinus* and *Catillocrinus*.

But if they will not admit these facts in Monocyclica, my critics try to maintain that they do occur in Dicyclica. "Bather," they continue, "claims that among the Dicyclica departures from the pentamerous symmetry of the cup plates occur only in the right posterior radial. [When and where I made this preposterous claim is not stated. I said, "horizontal bisection" occurred only in r. post. R.] Exceptions to this, however, are found in *Atelestocrinus* and *Nanocrinus*, in which the symmetry is disturbed by the anterior radial, and in the latter genus by the right antero-lateral together with the anterior." This is a curious way of expressing the fact that in those genera the anterior radial is smaller than the others and bears no arm, a fact which is not in either of the categories under discussion.

But enough of controversy! Let me state what I now believe to be the facts of the case. Thirty-one genera may be referred to the Monocyclica Inadunata. Of these, twenty diverge from the normal symmetry to a greater extent than by the introduction of anals, viz., ten[2] through the horizontal bisection of certain radials other than the right posterior (usually the right and left anterior radials), while the remaining radials often increase in width; eight[3] through such increase in width of certain radials (usually l. post. R. and ant. R.), often accompanied by a variation in the number of arms directly springing from the radials; one[4] by disappearance of a radial (an occurrence also found in some of the other genera[5]) and apparent increase in the number of arms springing from the radials (as in some other genera[6]). The proportion of forms asymmetrical in the manner described would be larger if only Palæozoic genera

[1] "Perisomic Plates": *Proc. Acad. Nat. Sci. Philadelphia*, 1890, pl. x, fig. 10.
[2] *Heterocrinus, Ectenocrinus, Ohiocrinus, Anomalocrinus, Herpetocrinus, Castocrinus, Euchirocrinus, Calceocrinus, Halysiocrinus, Haplocrinus,* and perhaps *Phimocrinus.*
[3] *Hybocystis, Hoplocrinus, Pisocrinus, Triacrinus, Calycanthocrinus, Mycocrinus, Catillocrinus,* and *Allagecrinus.*
[4] *Zophocrinus.*
[5] e.g. *Tetracrinus,* and probably *Herpetocrinus.*
[6] e.g. *Catillocrinus, Mycocrinus.*

were dealt with, to wit, 75 per cent. No amount of ingenuity could discover a proportion anything like this among Dicyclica Inadunata. I therefore affirm "the extreme importance of these points" with far greater confidence than in 1893, a confidence strengthened by the nature of the criticism hitherto passed on my views.

That part of the dorsal cup below the radials may consist of either one or two circlets of plates. The plates next below the radials are called *basalia*; they alternate with the radials, i.e. each basal is interradial in position. The plates that may occur below these are called *infrabasalia*, and are radial in position. When there are basals only, the base is said to be monocyclic; when there are also infrabasals, it is dicyclic. A monocyclic form with infer-radials may appear to have a cup composed of three circlets; but these cannot be confused with the three circlets of a dicyclic form, since inferradials do not alternate with radials proper as do basals. Occasionally, it is true, the radials appear a little shifted to one side, and it seems as though a continuance of such shifting might render the inferradials indistinguishable from basals. Thus Dicyclica might be derived from Monocyclica. A very obvious objection to this view lies in the coexistence of basals with a radianal in many Dicyclica, for the radianal is generally admitted to be nothing other than the right posterior inferradial. That difficulty could be overcome by denying the accepted homology; but there remains a more fundamental objection, which will be understood from comparison of figures D and M in Fig. 1 :—
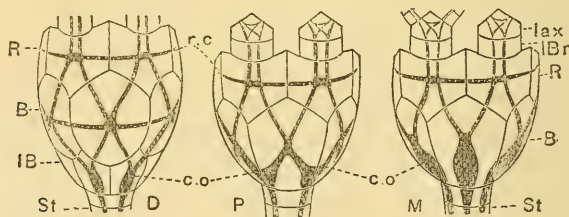
Fig. 1.—Course of axial nerve-cords in Dicyclic (D), Pseudomonocyclic (P), and Monocyclic (M) Crinoids.

These show the course of the axial nerve-cords in a dicyclic and monocyclic form respectively. It will be seen that these cords, on their passage from the nerve-centre called the chambered organ (c.o.) to the arms, bear a definite relation to the plates of the cup. If this relation held good in early Palæozoic crinoids, as we have reason to suppose, then I find it impossible to conceive of any shifting of the lower part of R in Fig. M that should produce such an arrangement as that shown in R and B of Fig. D. Therefore I reject the hypothesis of the derivation of Dicyclica from Mono-cyclica. That hypothesis is not discussed by Wachsmuth and Springer; in fact, they refuse to consider a somewhat similar

suggestion of Dr. J. Walther's. It is here alluded to with the view of emphasizing the fundamental distinction between Monocyclic and Dicyclic crinoids.

Another hypothesis—the descent of Monocyclica from Dicyclica—stands on a different footing. No one has done more than Wachsmuth and Springer to point out that the infrabasals often diminish in size, become hidden beneath the stem, and may eventually disappear altogether, at least in the adult. At the same time they have insisted on important differences between such forms and those that were without infrabasals from the beginning. To express this conception in nomenclature I proposed the term Pseudo-monocyclica for crinoids with obsolete infrabasals. The differences just alluded to are identical with certain differences that always (or almost always) obtain between Dicyclica and Monocyclica, and have been summarized in the well-known Law of Wachsmuth and Springer. They are diagrammatically represented in Fig. 2 :—
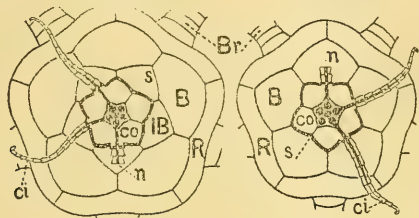
Fig. 2.—Comparison of the dicyclic and monocyclic base. B, basal; Br, brachials marking the five rays; ci, cirri, only three out of the five are shown; co, pentameres of column; IB, infrabasal; n, nerves going to cirri; R, radial; s, sutures between pentameres of stem.

The law is given in the Monograph under review in the form of a table (p. 60), and may be stated thus: when infrabasals are, or have been, present, the exterior angles and the pentameres of the stem are interradial (ie. alternating with IBB), but the longitudinal sutures, the sides, the lobes of the axial canal, and the cirri of the stem are radial; in crinoids with a truly monocyclic base these positions are reversed. "This law," its authors observe, "is only applicable, to its full extent, in species with pentangular or pentapartite stem and canal." Unfortunately it is not universally applicable even to those, and although the law as it stands is a remarkable piece of induction from which have been deduced conclusions at first unexpected but subsequently proved, yet it requires placing on a firmer basis before it can be accepted as other than a purely empirical statement liable to random exceptions.

This basis I shall now attempt to furnish. But first let us consider the exceptions. Wachsmuth and Springer say there are two, "and, so far as we know, only two. In *Pentacrinus* [$=Iso-$ *crinus*] and the monocyclic *Glyptocrinus Fornshelli*, S. A. Miller, the axial canal has the same orientation as the outer angle of the stem." Other examples could be adduced from the Silurian crinoids of England and Gotland, but those given serve to show

the unreliability of the law as now stated. Wachsmuth and Springer
say that the structure in *Pentacrinus* [= *Isocrinus*] "simply points
to the existence in some groups of transition forms intermediate
between Monocyclica and Dicyclica" (p. 66), and again, the
structure in *G. Fornshelli* "proves nothing more than that in this
species the monocyclic stage was as yet incompletely developed."
At the same time they are not clear whether Monocyclica were
derived from Dicyclica, or *vice versâ*, though they favour the former
view; also they find it "difficult to explain the change in the
orientation of the stem."

Now all these difficulties can be overcome, and the differences
between Monocyclica and Dicyclica seen in their true light, if we
pay rather less attention to the particular shapes of the ossicles, and
rather more to the relations of the axial nerve-cords and the
chambered organ. The middle drawing (P) in Fig. 1 shows the
relations of the cords in a pseudomonocyclic form. What has taken
place is a compression, not a torsion: the orientation of the cords
both above and below remains precisely as in Dicyclica and unlike
that in Monocyclica. Confirmation of the hypothesis of compression
may be obtained by cutting transverse sections across the chambered
organ of an admittedly pseudomonocyclic form. Figure 3 is
a diagram reconstructed from several such sections of *Pentacrinus*
[= *Isocrinus*] as figured by P. H. Carpenter in his "Challenger"
Report. We here trace the nerves as they pass out of the radials
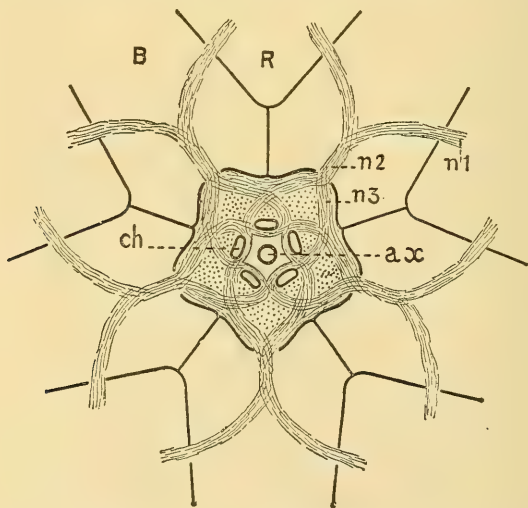
Fig. 3.—The course of the axial nerve-cords in *Isocrinus*.

into the basals (*n* 1), then meeting in the middle of the basals and
passing down as interradial cords (*n* 2). Now comes the important
point: these cords, instead of passing directly into the capsule of the
chambered organ, as in Monocyclica, fork again: the branches (*n* 3)

of the forks meet radially, and then enclose the radially placed chambers of the central organ (*ch*). These, as usual, are disposed around the axial organ (*ax*), and extensions from all of these pass down into the lumen of the stem. Thus, in *Isocrinus* the five nerves and vessels of the stem are, as is well known, radial in position, and give off branches to the radially placed cirri, as becomes a dicyclic or pseudomonocyclic crinoid.

Admitting the prime importance of the chambered organ and its various extensions, we see that the cirri must follow the course of the axial cords from which they are innervated and nourished; we may also imagine that the pentameres of a quinquepartite stem were brought from their original alternating arrangement, into vertical lines, by the extensions of the axial cords, between which they therefore lie. On the other hand, there is nothing in the fundamental constitution of a crinoid to prevent the outer angles of the stem, and by consequence its sides, from assuming any position; and although the angles of the lumen most naturally correspond with the orientations of the axial cord, still secondary formation of stereom may readily cause a change in this respect without upsetting the morphology of the animal. That such secondary formation of stereom does take place is no hypothesis; it has been described in *Antedon* by W. B. Carpenter, H. Bury, and others. In fact, the odd thing about that genus is that the very features on which Wachsmuth and Springer relied in their famous prediction that it would be proved dicyclic, are of purely secondary nature. It is to such secondary stereom that the changes in the lumen of the *Isocrinus* stem may be ascribed. As for *Glyptocrinus Fornshelli*, it is surprising that no figures are given by Wachsmuth and Springer of a structure that leads to so much discussion, but S. A. Miller's description (1874) is certainly suggestive of a similar explanation.

For the table given by Wachsmuth and Springer, I propose therefore to substitute the following, in which the statements liable to exception are marked with ※.

			DICYCLIC.	MONOCYCLIC.
BB (lobes of capsule in Monocyclica)	...	...	Interradial	Interradial
IBB (lobes of capsule in Dicyclica)	...	...	Radial	—
Pentameres of stem, when present	...	...	Interradial	Radial
*Outer angles of stem	...	...	Interradial	Radial
Vertical sutures of stem, when present	...	...	Radial	Interradial
*Sides of stem	...	...	Radial	Interradial
*Angles of lumen of stem	...	...	Radial	Interradial
Cirri, when present	...	...	Radial	Interradial
Axial cords of stem	...	...	Radial	Interradial

From this it appears that the sole constant characters are those presented by the aboral nerve-system, characters which find no place in Wachsmuth and Springer's statement. Thus, I believe, the law first discovered by these eminent palæontologists can at last be used

with certainty as a means of determining the true nature of an apparently monocyclic crinoid. Neither space nor the subject in hand permit the application of it on the present occasion to all doubtful cases. I may, however, state that it leads me to regard *Rhizocrinus* as pseudomonocylic, a conclusion to which Wachsmuth and Springer have come on other grounds (p. 63). On the other hand, they consider *Bathycrinus* and *Hyocrinus* as "true monocyclic forms." Direct evidence is entirely wanting in the case of *Hyocrinus* ; but as for *Bathycrinus*, the figures of the nerve-cords published by P. H. Carpenter and D. C. Danielssen [1] lead me to place it among the Dicyclica Inadunata.

Hitherto scant attention has been paid by neontologists to the orientation of the axial cords of the stem, and of the chambered organ, and to the intimate structure of the capsule of the latter. For example, the magnificently detailed and elaborately illustrated account of *Calamocrinus* by that skilled anatomist of Echinoderma, Mr. Alexander Agassiz, throws no light whatever on this essential point. Perhaps it is not too late to hope that he may yet be able to elucidate it from his material. If those provided with the modern means of microscopic research and with opportunity to use them have their attention turned to this inquiry by the present review of Wachsmuth and Springer's important researches, it will have been written to good purpose.

Both basals and infrabasals are primitively five in number. But the basals of monocyclic, and the infrabasals of dicyclic, crinoids may become changed in number and shape by fusion and growth. These changes and their relations to the anal plates of the cup are fully discussed in the Monograph. There are also several statements as to the position assumed by the smaller basal or infrabasal in those cases where the base consists of one small and two large plates. This latter is a point on which much stress has been laid, but I believe its importance is exaggerated. It is, for instance, stated by Wachsmuth and Springer that "in all Crinoids with an unequally tripartite, monocyclic base, the smaller plate is located to the *left* of the anterior radial." This is not correct. In *Storthingocrinus* the small basal is the left posterior, as may be gathered from the figures of Schultze [2] on pl. x (not on p. 69, which is wrong), and from the recent description by D. and P. Oehlert,[3] who discuss this question under somewhat mistaken notions. In the "Crinoidea of Gotland" specimens of *Gissocrinus* were described with the small infrabasal in the left posterior and right anterior radii ; but Wachsmuth and Springer have always found it in the anterior radius in allied genera. It is hardly correct to state that "the anal plate of 'Dicyclica' rests invariably upon the truncated upper face of the posterior basal" (p. 59).

[1] "Norske Nordhav's Expedition : Crinoida."

[2] "Echinodermen des Eifler Kalkes " : *Denkschr. Akad. Wiss. Wien*, xxvi, pp. 113–230, pls. i–xii ; 1867.

[3] "Foss. Devon. de Sta. Lucia " : *Bull. Soc. Geol. France*, xxiv, pp. 814–875, pls. xxvi–xxviii ; 1897.

I believe the following to be a true summary of the facts concerning the structure of the base :—
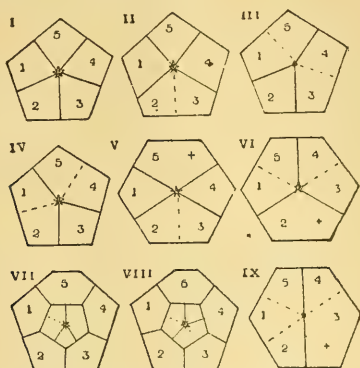
FIG. 4.—Bases and their modifications.
i–vi and ix, monocyclic ; vii and viii, dicyclic.
i–iv, pentagonal, unaffected by anal.
v, vi, ix, hexagonal, affected by anal.
In all the anal side is uppermost; the imaginary additional piece is marked +.
i, 5 BB ; ii, 4 BB ; iii, 3 BB, Crinoid type ;
iv, 3 BB, Blastoid type ; v, 4 BB ; vi, 3 BB ;
vii, 3 IBB, as usual in Dicyclica Inadunata ;
viii, 3 IBB, as usual in Flexibilia Impinnata ;
ix, 2 BB.

The first stage is the fusion of one pair, producing one large and three small plates (Fig. 4, ii). This is almost entirely restricted to Monocyclic genera, where the plates that fuse are r. and l. ant. BB. Next comes the fusion of two pair, producing one small and two large plates (Fig. 4, iii). This occurs in both Monocyclica and Dicyclica. In the former the small plate is l. ant. B, or rarely l. post. B, whereas in Eublastoidea it is r. ant. B (Fig. 4, iv). In Dicyclica 3 IBB have been observed only among Inadunata and Flexibilia; in the former group the small plate is often, but not always, ant. IB (Fig. 4, vii) ; in the Palæozoic representatives of the latter it is (*apud* W. & Sp.) always r. post. IB (Fig. 4, viii), but this is not the case in *Antedon*. A bipartite base is formed only in a few Monocyclica ; the two plates lie on the r. and l. sides of the sup. (Fig. 4, ix). Finally, all plates of the proximal circlet may fuse into a solid ring, both in Monocyclica and Dicyclica. IBB may fuse with the proximal columnal in Flexibilia, thus forming a pseudomonocyclic type. BB may be overgrown by and incorporated with the RR, as in *Eugeniacrinus*.

The symmetry of the base is modified by the presence of anals. An anal resting on the basal circlet causes one of the BB to double in width, so that the base becomes hexagonal instead of pentagonal. Thus the quadripartite base comes to consist of a post. and ant. large plate, and two small lateral plates (Fig. 4, v). These tend to approximate in size. In *Xenocrinus* interbrachials as well as anals come down between RR, so that the BB are nearly equal in size,

but irregular in shape, and make the base decagonal. Removal of anals and Br from the radial circlet leaves a pentagonal quadripartite base, such as is found in Melocrinidæ. An anal resting on a tripartite base is accompanied by increased width in the small l. ant. B (Fig. 4, vi). But in the bipartite base the small B fuses with the combined post. and l. post. BB, while the combined right-hand BB increase in width (Fig. 4, ix). In most Dicyclica the IBB do not assume a hexagonal outline ; for the anals do not occur in the basal circlet, but x, when it occurs within the cup, truncates the upper surface of post. B. Exceptions are *Sagenocrinus, Carabocrinus,* and *Thenarocrinus.*   F. A. BATHER.

<div style="text-align:center">(To be continued.)</div>

II.—BOLLETTINO DELLA SOCIETÀ SISMOLOGICA ITALIANA. Vols. II and III, 1896 and 1897.

THE Italian Seismological Society appeals to a limited circle of members (there are not more than 53 altogether), but one out of every three is a contributor to the last two volumes. The *Bollettino* for these years not only reaches, but surpasses, the high level attained during the first year of its publication.

The designing and construction of earthquake instruments still claim a large share of the attention of Italian seismologists ; but it is a noteworthy feature of the later attempts that their object is rather to improve and perfect old forms than to introduce new and untried apparatus. Several of the papers belonging to this class are of great value. Professor Grablovitz and Professor Riccò describe the instruments at work in the geodynamic observatories of Ischia and Catania respectively. Dr. Agamennone gives a full account of a sensitive electric seismoscope and instructions for its installation and working. Dr. Cancani describes the horizontal pendulums with mechanical registration recently erected at the observatory of Rocca di Papa, and, in illustration, adds the beautiful records given by it of the Indian earthquake of June 12, 1897. Dr. Pacher contributes a detailed study of the Vicentini micro-seismograph at the University of Padua ; while Signor Arcidiacono closes the wearisome controversy on the indications of the normal tromometer by applying the simple test which ought to have been made long before the controversy began.

In addition to the splendid series of records of earthquakes observed in Italy (January, 1896, to June, 1897), Dr. Agamennone contributes notes on earthquakes in the Epirus (Jan. 1897), the Persian Gulf (Jan. 10–11, 1897), the Ionian Sea (May 28–29, 1897), etc. Dr. S. A. Papavasiliou continues the catalogue of Greek earthquakes formerly published in the *Bulletins* of the Observatory of Athens ; but, whether it be due to the author's retirement from the observatory or to the unfortunate war with Turkey, the number of shocks recorded during the first half of 1897 is far smaller than in the year before. Professor Omori investigates the decline in frequency of the after-shocks of the great Japanese earthquake of 1854 ; in another paper he shows that the mean direction of fall of 245 chimneys, etc., in Tokio during the earthquake of June 20,

1894, agrees almost exactly with the direction of the principal vibration at the same place; and, in a third, he estimates that at Gifu and other places in the Mino-Owari plain the movement of the ground during the earthquake of 1891 was not less than one foot.

The study of the pulsations from distant earthquakes is as fascinating to seismologists in Italy as it is to those in other countries. Professor Grablovitz makes a good suggestion for the organized investigation of earthquake pulsations : he proposes that a series of stations should be established near the great circles which approximate most closely to the main lines of volcanic action. Dr. Agamennone calculates the mean velocity of the earth-waves produced by the earthquake of Paramytlria (Epirus) of May 13–14, 1895, and the earthquake of Amed (Asia Minor) of April 16, 1896 ; but in both cases he is hampered by uncertain initial data. Dr. Cancani estimates that the waves from the Indian earthquake of June 12, 1897, as they crossed Italy, were about 30 miles in length and 22 inches in height.

Among the miscellaneous papers may be mentioned two of considerable interest by the last-named author. Pheasants and other birds, it is known, feel the preliminary tremors of an earthquake before man, but Dr. Cancani believes that this is only the case at a distance from the epicentre, and he therefore infers (though the conclusion seems to me doubtful) that these tremors travel more rapidly than the main earthquake-vibrations. In the second paper he collects and discusses a number of observations on the so-called *marina* observed in the inland province of Umbria, and shows that they are identical with the *barisàl-guns* of India and the *mist-poeffers* of the North Sea coast.

The active volcanoes of Italy are the subject of incessant observation by a small, but careful, band of workers. Professor Mercalli, upon whom the mantle of Dr. Johnston-Lavis has fallen, devotes himself especially to the study of Vesuvius, and describes the phenomena observed from July, 1895, to December, 1896. Professor A. Riccò, the Director of the Observatory of Catania, communicates a few notes, chiefly relating to the central crater of Etna, while his assistant, Signor Arcidiacono, summarizes the principal eruptive phenomena of Sicily and the adjoining islands during the years 1896 and 1897.   C. Davison.

CORRESPONDENCE.

THE SUBMERGED PLATFORM OF WESTERN EUROPE.

Sir,—Prof. Hull is right in thinking that there is still much to be learned from a careful study of hydrographic charts. The existence of the submarine platform west of our Islands and of the great declivity which he calls an escarpment was of course well known, but the details of the submerged surface certainly merit more attention than they have received, and I do not think their interest is even yet exhausted.

But when Prof. Hull passes from observation to theory he makes several assumptions which are open to question. He calls the great

declivity " an escarpment," comparing it with true escarpments in
England and France, and with the cliff-borders of the Nile valley
(which are not technically escarpments). He says " all these
escarpments have been formed over the surface of emergent lands,"
that they are absolutely terrestrial, and " that in ascribing a similar
origin to those here under consideration we are only drawing a logical
deduction from the premises laid down."

The logic of this does not seem very clear.   Can Prof. Hull point
to a true escarpment anywhere in Europe which has a length of
700 miles and a height above its base of 7,000 to 8,000 feet ?   More-
over, this so-called escarpment does not stop in the Bay of Biscay ;
it is continued round the coasts of Spain, it crosses the mouth of the
Mediterranean, and runs down the whole length of Africa.   It is
part of the elevated shelf on which two continents stand, and Prof.
Hull may call it an escarpment if he chooses, but it is not com-
parable with ordinary escarpments, and he is not justified in
assuming that it has been formed by atmospheric agencies.

He also tells your readers that " a solid escarpment of this kind
indicates a slow continuous elevation *after* the British platform had
been planed down by wave action, and subsequent depression after
a lapse of time."   Here he assumes that the platform was formed
first and the escarpment afterwards.   I think most writers have
supposed that the great declivity which marks the ancient border
of the continent is a much older feature than the platform.

Finally, we are told that the formation of the platform " may be
referred back with confidence to the Mio-Pliocene period, and that
of the grand escarpment to the succeeding early Pleistocene or
Glacial stage."   There are probably others beside myself who would
like to have the reasons for this confident assertion.   Is there any
reason why the formation of the escarpment and the union of Great
Britain with Iceland should not have taken place in the Eocene
period ?   That such a union may have been repeated at a later date
is quite possible, but I think the history of the features described
by Prof. Hull is much longer and more complicated than he supposes,
and I would not like to say that either of them was formed wholly
at any one period.

Prof. Hull may have good reasons for his statements, but he does
not give them, and as his conclusions are not the only inferences
that may be drawn from the facts, they must be discussed before
they can be accepted.   A. J. Jukes-Browne.

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VERTEBRATE PALÆONTOLOGY.

Sir,—While thanking you for the gratifying review with which
my " Outlines of Vertebrate Palæontology " are honoured in the
August number of the Geological Magazine, I should like to
correct two misapprehensions of the reviewer.

Firstly, it is a mistake to suppose that any *" new terms* are
introduced."   All the terms employed are to be found in current
literature, and most of them are in nearly universal use.   Moreover,
on its first mention each term which is not likely to be familiar to the
elementary student, is not only printed in italics and briefly defined,

but also indexed for ready reference. Under these circumstances the editor and author considered a special glossary to be superfluous.

Secondly, your reviewer is mistaken in describing the lettering of fig. 91, p. 143, as the result of undigested compilation. The interpretation of the squamosal and supratemporal bones in the Squamata there given, is intentional, and based especially upon the researches of my colleague, Mr. Boulenger. Anyone interested in the subject may refer to the figures of the skulls of the Agamoid *Calotes* and the typical Varanoid, *Varanus*, given in his volume on Reptiles and Batrachians contributed to Dr. Blanford's " Fauna of British India." He seems to demonstrate clearly that in Lacertilia the squamosal always retains its normal connection with the postfrontal in front, but eventually separates from the parietal behind; while the supratemporal in that case slips backward to occupy the cleft thus formed.

I am much indebted to your reviewer for pointing out that the legend of fig. 185 (*Palæotherium*) only applies to the true molars, not to the fourth premolar, which, I had omitted to observe, bears the same lettering. In the matter of new illustrations, I have met with unusually liberal treatment at the hands of the publishers; but it was unfortunately impossible to dispense with borrowed electrotypes, and hence the non-uniformity of lettering which is sometimes perplexing. A. Smith Woodward.

OBITUARY.

JAMES HALL.

Born September 12, 1811. Died August 7, 1898.

By the death of Professor James Hall geology has lost its oldest and one of its most distinguished leaders. He was born at the quaint old town of Hingham on the south shore of Boston Bay, and was educated at the Rensselaer Polytechnic Institute at Troy, and at the age of twenty-five received an appointment on the Geological Survey of New York State. Two years later he issued his first original scientific contribution,—a short note on some trilobites. His official duties were connected with both stratigraphy and palæontology, and at first he was apparently more interested in the former branch of geology. He studied the recession of the Niagara Falls and acted as guide to Lyell, who visited the Falls in 1841. In 1843 Hall was appointed State Palæontologist, in which capacity he wrote or edited no fewer than thirteen large imperial quarto volumes on the Palæontology of New York, which have been issued at intervals between 1847 and 1894. The first volumes of this series formed the most magnificent contribution to extra-European Palæontology that had been issued at that time, and some of the later volumes are still the richest mine of information on some branches of Devonian palæontology. In addition to the extensive series of new fossils described in these monographs, Hall published many further important additions to American Palæontology in the reports of other State Surveys, as of Iowa, Wisconsin, and Missouri, and in papers in various

serials. The collections of many of the early expeditions in the Western States were entrusted to Hall for description; thus he described the Cretaceous fossils collected by the Mexican Boundary Commission, the Carboniferous Crinoids of Missouri, the general collections of the Pacific Railway Survey, and he wrote the appendix on the geology and palæontology of the Great Salt Lake of Utah, from materials brought back by the Stansbury expedition. The number of interesting fossils which it was Hall's privilege to describe is enormous, and the following are a few of the well-known and important genera we owe to him : Among the graptolites there are *Callograptus, Dicranograptus,* and *Phyllograptus*; among the corals, *Cœlophyllum, Heliophyllum,* and *Streptelasma*; among the Pelmatozoa, *Calceocrinus, Heterocrinus, Dendrocrinus, Glyptaster, Glyptocrinus,* and *Hemicystis*; there is the star-fish *Palæaster,* and the echinid *Lepidechinis*; the additions to the Monticuliporoids and Bryozoa are very numerous, including *Favistella, Callopora, Bactropora,* and *Trematopora*; and among the Crustacea are *Pleuronotus, Bathynotus, Mesothyra,* and *Ptychaspis.* His Memoir on North American *Eurypterida, Pterygoti,* and *Ceratiocaris* (1871), is one of the most valuable contributions to these forms of Crustacea. The number of his additions to the Palæozoic mollusca and Brachiopods reminds us of Disraeli's account of how Charlemagne made Christians, for Hall founded new genera in legions and christened them in platoons. But Hall was not only a palæontographer; his papers on the microscopic structure of Palæozoic brachiopod shells, and his discovery and description of the convoluted plate that supports the digestive tube in crinoids, show that he paid attention to anatomy. He was also keenly interested in the broader questions of stratigraphical geology. It was Hall who in 1859 first definitely stated the connection between the elevation of mountain chains and the previous accumulation of sedimentary deposits, and argued that "the direction of any mountain chain corresponds with the original line of greatest accumulation."

Among other palæontological contributions not connected with his own State, Hall described the Graptolites for the Canadian Survey; and owing to his especially friendly relations with the Canadian geologists he was appropriately chosen President of the American Association for the Advancement of Science when it met at Montreal in 1857. He was elected on the list of Foreign Members of the Geological Society in 1848, and received the Wollaston Medal from that Society in 1858, and as the doyen of American geologists was elected the first President of the Geological Society of America in 1889. In spite of his great age, he last year visited the Ural Mountains with the International Geological Congress, and, aided by J. M. Clark, he has continued his palæontological studies to the last. Professor Hall's courtesy, energy, and cheeriness endeared him to all with whom he was brought in contact, and his personal popularity frequently proved of great service to the State Survey, as when its work was harassed by the faction fights over the Erie Canal, or when the department was attacked by the State Librarian, Mr. Melvil Dewey, in 1895.

ORIGINAL ARTICLES.

I.—The Directorship of the Natural History Museum.

THE retirement of Sir William Flower from the office of Director of the British Museum of Natural History, which took place on September 30, after fourteen years of extremely efficient and active service, will be viewed with regret by the great majority of naturalists throughout the country. That he achieved the completion of all his plans would be to claim too much in so limited a period of time, but that he succeeded in illustrating how a Natural History Museum may be rendered attractive to the general public and may also be a place of instruction to the student, no one will deny.

The cases illustrating structures in the skeleton and dermal covering of mammals, birds, reptiles, and fishes, along the western side of the Great Hall, and those of insects, mollusks, sponges, and plants, upon the eastern side, convey an admirable idea how a teaching series should be arranged; whilst the groups of mammals, birds, and insects in the glazed cases on the floor of the Hall illustrate how the general public may be attracted and interested in Natural History.

For the arrangement of the beautiful series of nesting birds, with eggs and young, in their natural surroundings, so liberally presented to the nation by Lord Walsingham and other donors, the public is indebted to Dr. Günther, F.R.S., for so many years the able Keeper of the Zoological Department, aided by Dr. R. Bowdler Sharpe and other members of the staff. Sir William Flower had undertaken the reorganization and rearrangement of the entire exhibited collection of mammals and birds, the former of which, with the aid of Mr. R. Lydekker, F.R.S., he had largely carried through, but of the latter only a small portion has as yet been accomplished. Sir William Flower's last efforts were devoted to complete the exhibition of Cetacea in the new Whale Room, in which models of right whales and toothed whales are shown with their skeletons, giving an admirable idea of both the exterior and the bony framework of these huge marine mammals such as has never before been displayed in this country, although previously initiated in America.

Writing on behalf of the Trustees, Lord Dillon, Chairman of the Standing Committee, said "they wished to record their high appreciation of his services, and of the rare combination of wide

scientific knowledge with marked administrative ability with which he had carried through his difficult task. Under his direction the Natural History Collections have been so arranged that no one can examine them without admiration. To Sir William Flower, as a worthy successor of Sir Richard Owen, will attach the honour of having organized a museum which now occupies a prominent position among all the museums of the world. For these services the Trustees offer their hearty thanks and sincere good wishes on his retirement."

The new Director—Professor E. Ray Lankester, M.A., LL.D., V.P.R.S., Linacre Professor of Comparative Anatomy, etc., Fellow of Merton and Hon. Fellow of Exeter College, Oxford, born 1847, the eldest son of the late Dr. Edwin Lankester—occupies a most distinguished position as a naturalist and zoologist, and carries with him the support of a large majority of the leading men of science throughout the country. He will doubtless ably achieve the completion of the arrangement of the zoological collections which fall immediately under his charge as Keeper, in addition to the office of Director of the whole Museum. He is to be congratulated upon succeeding such eminent predecessors as Owen and Flower, whose honourable careers have added lustre to the post upon which he will enter to-day with the good wishes of all his scientific friends.

II—Discovery of a second Specimen of the Fossil Egg of Struthiolithus.

By C. R. Eastman, Esq.,

Of the Museum of Comparative Zoology, Cambridge, Mass., U.S.A.

(PLATE XVII.)

IN the year 1857, or thereabouts, a remarkable fossil egg was discovered in the Government of Cherson, in South Russia. The circumstances of its being brought to light were peculiar, and its subsequent history is instructive enough to repay a brief recapitulation, which we give as follows:

During a freshet, a stream occupying an old watercourse excavated a recess below a milldam not far from Malinowka, in the Chersonesus. Some peasants happening to pass along at the time observed floating on the surface of the pool an egg-shaped object, which they immediately captured. Happily their curiosity as to its nature was so far tempered by mercenary instincts that they did not break it, and after several exchanges of ownership it was finally offered for sale by a man named Dobrowolsky to various scientific institutions of Russia for the sum of one thousand roubles. In the course of time it was submitted to Professor Kessler, of Kiev, for examination ; and some years later to Professor Alexander Brandt, of Charkow, who obtained permission to take a plaster cast of the specimen, and also prepared a description of it, which attracted considerable attention.[1] The owner of the egg, however, although disappointed

[1] Bull. de l'Acad. Imp. des Sci. St. Petersburg, vol. xviii (1873), pp. 158–161. Translated in *Ibis* [3], vol. iv (1874), pp. 4–7.

Egg of *Struthiolithus Chersonensis*, Brandt.

Found in a Post-Tertiary deposit at Kalgan, Hsi Ning, Northern China.
(Reduced about one-third natural size.)

in realizing the high price set upon his treasure, was unwilling to part with it for less, and it consequently remained in possession of the family for many years. But ultimately a sad fatality overtook it. Through some accident it was shattered into nearly forty pieces, and its commercial value being looked upon as ruined, steps were taken to present it to the St. Petersburg Museum, where we understand it is now preserved, the fragments having been restored as well as possible.

Professor Brandt was apprised of the loss at the time, and forthwith communicated the intelligence to the *Zoologischer Anzeiger*.[1] This prepared the way for W. von Nathusius to obtain a fragment for microscopic investigation, the results of which were shortly afterwards published in the same journal.[2] Nathusius found the shell structure so similar to that of the common ostrich that he did not hesitate to declare the parent bird must have belonged to the genus *Struthio*. Professor Brandt, however, in view of the extraordinary size of the egg, and the fact that no fossil bones were discovered which might throw light on its relationships, had already proposed the new genus *Struthiolithus*, for the reception of both the ovulite and its as yet unknown parent bird. Now, as most persons are aware, egg-shells vary considerably in structure, even when those of the same species are compared; in some cases, indeed, if one had but the mere shells to deal with, he might infer greater differences between the birds laying them than actually exist. On this account, and in lieu of specific anatomical evidence to the contrary, we prefer to follow Professor Brandt's example, and recognize *Struthiolithus* as a distinct genus until it shall be proved to be identical with some other known form. The specific title applied by Professor Brandt is *S. Chersonensis*, which up to the present time has been illustrated only by the unique type.

By great good fortune a second specimen has recently been brought to light, fully as perfect as the type, and agreeing with it so closely in form and dimensions that we cannot doubt for a moment it belongs to the same species. A comparison with the type was facilitated through the courtesy of Professor Brandt, who presented the Museum of Comparative Zoology at Cambridge, Mass., with a cast of the original. It is expected that this institution will eventually acquire the new example also, negotiations to that effect having been entered into, and for the present it is deposited there.

The history of the new specimen is as follows:—Four or five years ago a farmer in Northern China, while working at the foot of a bank of earth about six metres high, dug out what he considered to be a pair of 'dragon's' eggs. One was broken, the other entire, and presuming the latter to have some commercial value, he took it with him to Kalgan, and succeeded in selling it for a small sum to one of the American Board missionaries—the Rev. William P. Sprague, who was residing there. The Rev. James H. Roberts,

[1] Zool. Anzeiger, vol. viii (1885), No. 191, p. 191.
[2] Ibid., vol. ix (1886), No. 214, p. 47.

a brother missionary who has likewise spent many years in China, was present when the egg was sold, and on revisiting the United States last spring, brought the specimen with him at the instance of Mr. Sprague, to be offered for sale to some scientific establishment.

The Chinese workman who found the egg was well-known to the servants of the missionaries as a native of Yao Kuan Chuang. This is a small village in the district of Hsi Ning, about fifty miles south-southwest from Kalgan by road, but somewhat nearer in a straight line, as that region is very mountainous. Subsequently Mr. Sprague visited the exact spot where the eggs were dug up, in company with the man who found them, and thus satisfied himself of the authenticity of the discovery. The fragments of the second specimen were unfortunately not preserved, and as Mr. Sprague was in doubt whether the perfect one was indeed an egg, or perhaps only a geode, he made a small incision at one end to ascertain if there were crystals on the inside. But on illuminating the walls of the interior, they were found to present the same general appearance as the external surface, and a loose calcareous mass, partly in the form of powder and partly flakes that appear to have become scaled off from the inner surface, was found within the cavity. This mass is still preserved in the same condition as when found, and weighs 18·1 grams. Possibly it represents in part the calcified shell membranes, such as have been found fossilized in certain moa eggs. Examined with a pocket lens, the flakes present no appearance of having an organized structure. Without this interiorly contained mass, the shell weighs a trifle more than 310 grams. Its other dimensions are given in the following table, together with measurements of other large fossil eggs.

COMPARATIVE DIMENSIONS OF THE EGG-SHELLS OF STRUTHIOUS BIRDS.

Name of Species.	Longitudinal axis.	Transverse axis.	Major circumference.	Minor circumference.	Capacity.	Weight.
	cm.	cm.	cm.	cm.	c. cm.	grams.
Æpyornis maximus, Geoff.	35·1	24·5	92·1	76·8	11,035·8	—
,, ,, ,,	34·0	22·5	85·0	71·0	9,012·5	—
,, ,, ,,	32·0	23·0	84·0	72·0	8,863·5	—
Dinornis, sp.	25·2	17·8	—	55·9	4,180·6	—
Struthiolithus Chersonensis,						
Bdt. (type)	18·0	15·0	52·0	46·0	2,075±	819±
Struthiolithus Chersonensis	18·0	14·75	51·35	46·45	1,896·9	310·05
Struthio camelus, Linn. ...	16·4	13·40	47·10	42·20	1,423·6	310·95
Rhea Darwinii (Gould) ...	13·5	9·45	35·85	29·90	570·44	79·89

It is probable that the Chinese specimen was only partially embedded in the soil when found, the evidence for this being that the greater portion of the surface is incrusted, more or less granulated, or otherwise affected by atmospheric erosion. The least

weathered side is that shown in the accompanying figure, repro-
duced from a photograph, and on this several areas are to be
observed where the original shell has remained unaltered. Some
discoloration has been brought about through the agency of iron
oxide, and grains of ferruginous sand still adhere to the shell in
places, or are even partially embedded in the crust. This side of
the shell is of a brownish yellow colour, somewhat darker than the
opposite or more weathered side. Numerous fine pittings are to
be seen over the greater part of the periphery, especially in the
equatorial region, some of which may be due to destructive agencies,
but the majority of them are clearly to be regarded as the round
terminal pores of air-canals. To determine their precise relation-
ships it would be necessary to sacrifice a portion of one of the best
preserved areas for the purpose of making a thin section, but as
no such area is contiguous to the aperture at one end cut by
Mr. Sprague, and as sections from the polar regions afford but little
information, no further mutilation has been attempted. Indeed, it
is doubtful in any case whether a section would show more than
has already been ascertained from Nathusius's study of the type-
specimen, which merely proved that the air-canals terminated in
a similar fashion as in *Struthio camelus.*

As to the age of the deposit from which the specimen was
exhumed, it is reasonably certain from the accounts furnished by
Mr. Roberts and Mr. Sprague, the former of whom related his
observations in full to the writer, that no earlier date can be assigned
to it than the Pleistocene. The gravel bank yielding the remains
is situated in a loess basin which is drained by the Sang Kan.
Such basins are not uncommon along the upper course of this river,
and are mentioned by Von Richthofen and Pumpelly in their works on
the Geology of China. According to Von Richthofen, the superficial
deposits of these basins were laid down over the bottom of isolated
salt lakes having no outlet, and were afterwards buried by alluvial
detritus. Traces of former shore-lines exist along the mountain
sides, and one is confronted on every hand with the evidence of
recent dessication. The moderate depth to which ravines have cut
through the former lake beds, and the straight narrow gorge of the
Sang Kan, through which their waters were drained off, corroborate
the belief that this event took place at no very remote period—
in all probability since the Pleistocene. The occurrence of fossil
ostrich remains in such widely separated regions as Northern China
and Russia during the late Tertiary has a signal bearing upon the
distribution of Struthious birds. The only existing representative
of the Struthionidæ (*S. camelus*) is confined to Africa and Arabia,
but the Pliocene of the Siwalik Hills in India has yielded a closely
related species (*S. Asiaticus*), and other remains, described as
S. Karatheodoris, have been found in the Lower Pliocene of Samos.
On the theory of the multiple origin of the Ratitæ, we are obliged
to disclaim any genetic relationship between *Struthio* and other
Oriental forms commonly classed as Struthious birds, such as the
emeu, cassowary, and extinct wingless birds of New Zealand. But

with *Rhea* the case is different. No one can deny that the physical resemblances between *Rhea* and *Struthio* are very great ; in fact, the popular term ' South American ostrich ' is an obvious commentary on their similarity. Although both genera are regarded as typical of distinct families, and are even commonly placed in separate suborders, yet if one were asked to specify the nearest living ally of the African ostrich, he would unhesitatingly point to *Rhea*. Now either these resemblances are proof of actual blood relationship between the two genera, or else they furnish a most marvellous instance of convergence. The simplest, and as we believe, most natural interpretation, would be to regard forms so like one another as genetically related, at least until it is demonstrated that by no possibility could they have been descended from the same stock. To us it seems incredible that two separate derivatives of Carinate birds should become specialized in exactly the same manner in Africa and South America, and should assume such a close resemblance to one another, through the operation of fortuitous natural conditions, or as the result of adaptation. For the chances are slight indeed that the environment, of itself dissimilar, should act in such a way as to produce an identity of ultimate results out of originally heterogeneous material.

If *Rhea* had different progenitors from the ostrich, we are in utter ignorance as to what they were like, since no other descendants of the parent stock can be pointed out. That there is anything in common between *Rhea* and the Tinamous we cannot believe for a moment, owing to the very different organization of the latter. Captain Hutton's theory, therefore, which derives both *Rhea* and the moas from a Tinamou-like ancestor which crossed into Australia and New Zealand by means of an imaginary Antarctic continent, must be relegated on both biological and geological evidence to the same category as the Lemurian hypothesis.

Rhea still enjoys a comparatively wide distribution in South America, and its remains have been found in the bone caverns of Brazil. If the evidence of *Diatryma* from New Mexico means anything at all, it would point to a connection between a fossil North American and the existing South American ostrich. It is true that the late Tertiary yields no evidence of Struthious birds in North America. But it is also true that until the discovery of *Struthiolithus* under the shadow of the Great Wall in China, no one could have suspected the whole intervening territory between North-Eastern Asia, Russia, and South Africa to have been in comparatively recent times inhabited by genuine ostriches. The palæontological record is from the nature of things very deficient in the case of land birds, and many gaps can be filled up only on indirect evidence. One such hiatus is now partially filled by the occurrence of *Struthiolithus* in Northern China. A race having the constitutional vigour and numerical force to establish itself in this latitude—and in a mountainous region as well, where the struggle for existence is always intensified by a larger number of enemies than are encountered on the plains, to say nothing of the rigours of winter—

must have been able to penetrate still further northward, and might readily have accompanied the mammals that migrated across the land-bridge formerly connecting the Palæarctic and Nearctic regions.

In a word, if we can predicate any blood relationship between the African and South American ostriches, it is certain that the latter could have reached its present habitat in no other way than along the route marked by *Struthio camelus*, *S. Karatheodoris*, and *S. Asiaticus*, *Struthiolithus*, *Diatryma*, and the *Rhea* of Brazilian bone caverns. If any will presume to deny a relationship between *Struthio* and *Rhea*, they are confronted with these difficulties : to explain how two separate derivatives from Carinate stock should come to present such remarkable similarity to one another through the agency of purely fortuitous conditions, and to point out a lineage for *Rhea* connecting it more closely with Carinates than with the ancestors of *Struthio*. Sceptically inclined individuals are welcome to regard *Rhea* as one of the " waifs and strays of a lost avifauna left by the sea of time stranded on the shores of the present," [1] but we personally prefer the more positive view, which connects the New and Old World ostriches in the manner indicated.

Further remarks on the distribution of Struthious birds, as well as a more extended account of the new specimen of *Struthiolithus*, illustrated by photographic reproductions, will be found in a forthcoming number of the Bulletin of the Museum of Comparative Zoology,[2] of which the present paper is largely an abstract.

III.—BLIND TRILOBITES.

By F. R. COWPER REED, M.A., F.G.S.

Introduction.

THE occurrence of certain genera and species of trilobites which are destitute of eyes has long been known, and so much importance was attached by Dalman to the presence or absence of the visual organs that he instituted two principal divisions of the trilobites based simply on these characters. Goldfuss followed the same lines in his system of classification, though he took into consideration also the structure of the eyes ; and Emmrich likewise regarded the possession or lack of these organs to be of taxonomic value. Although in modern schemes of classification more stress is laid on other features of the organization, yet with our increasing knowledge of the ontogeny of various species of trilobites it is perceived that the presence, position, and nature of the eyes are points which must by no means be overlooked.

In a group such as the trilobites, the majority of which possess eyes, it is a matter of great interest to discover the meaning of their absence in certain species and genera ; and as a result of recent researches on the fauna of caves and of the deep sea the conclusion

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[1] *The Auk*, new ser., vol. xiii (1896), p. 63.
[2] Vol. xxxii, No. 7.

has been drawn, perhaps too hastily, that we have an example of the operation of causes similar to those which have led to the atrophy of the organs of sight in these modern forms. It is, however, possible to offer two different explanations of the phenomenon of blindness in the case of the trilobites; and it may be that the same explanation is not applicable to all. In the first place we may regard the absence of eyes as a result of functional disuse, and consequently as an adaptive character suggestive of the environment or mode of life, but of no phylogenetic importance. Owing to the attention which is now directed to the conditions of life, particularly to those of the deep sea, this view finds much favour. The alternative explanation is that the absence of eyes is a morphological feature of ontogenetic or phylogenetic significance, and consequently must have due weight attached to it in any natural system of classification. We shall see that the evidence derived from the development of various trilobites as well as of the whole group points to this being the true explanation in the majority of cases.

Nature and Position of the Eyes of Trilobites.

It should first be noticed that the visual organs found in trilobites do not all belong to the same category, for they fall into two classes. There are the so-called 'simple' eyes or ocelli, and the so-called 'compound' eyes. They are of widely different origin and are not homologous structures. It is unnecessary here to describe in detail their peculiarities and modifications, except in so far as they affect the question under consideration.

The most important differences as regards their comparative morphology which we have to remember are that the compound eyes are always borne on the free cheeks and lie on the line of the facial sutures, while the simple eyes (which may more conveniently be termed eye-spots) occur on the fixed cheeks without any connection or relation to the facial sutures. It is also possible that visual organs of the same nature as these eye-spots occur on the glabella of some forms. There is a general but superficial resemblance in the position of both these kinds of visual organs from the fact of their being on the lateral portions of the headshield and from the presence of a pair in each case; but these are merely accidental analogies connected with their function and with bilateral symmetry.

The distribution of these two kinds of eyes is of considerable importance and interest to us in our present inquiry, and while much stress has been rightly laid on it by many palæontologists, yet it is possible to differ from their conclusions. In the case of eye-spots we find them existing as a single pair in the larvæ of some trilobites which when adult possess no visual organs (*Trinucleus*); or we find them persisting through life (*Harpes*). Certain tubercles on the fixed cheeks of other forms may have a similar function, but of this we have at present no proof; and as far as we know paired eye-spots on the fixed cheeks and compound

eyes on the free cheeks never exist together at the same time in the same individual.

It should also be noticed that the paired eye-spots are generally situated at the outer end of the so-called 'ocular ridges' which run outwards from the glabella, and though morphological structures which are apparently homologous run out in the same way as ridges to the compound eyes of certain other forms, yet we shall see that this feature is not so anomalous or difficult of explanation as it may at first appear.

We shall also perceive when we consider the families of the trilobites separately that paired eye-spots are only found amongst those of a low phylogenetic rank, and that compound eyes are characteristic of the higher and more differentiated genera.

All the principal features of those forms possessing eye-spots are of a primitive type, corresponding to those exhibited in the larval and pre-adult stages of those with compound eyes. Further remarks on this fact will be made later. It may, however, be mentioned here that since no such organs as eye-spots have been found in the larval stages of the higher forms, we must not in the light of present knowledge regard them as larval structures common to the whole group, but rather as separately developed in certain genera possessing a low phylogenetic rank more or less masked by a considerable amount of secondary specialization, just as is the case with the Metatheria in Australasia and in many smaller groups of animals. These lowly organized trilobites, while retaining certain essential primitive characters, have developed other characters analogous in function or even in structure to those present in forms much higher in the scale of evolution. Bearing this idea in mind, we may understand how the possession of visual organs, though inferior in quality to those of the higher trilobites, may have been one of the causes which enabled such a form as *Harpes* to maintain so long the struggle for existence.

That there were other factors at work than the power of sight is evident from *Trinucleus* losing its eye-spots when mature, and in one species of *Harpes* being blind. These considerations suggest that the conditions of life have left marks of their influence as well as the phylogenetic rank, and indicate that the same explanation is not applicable to every case. We must therefore examine each on its own merits.

With regard to the compound eyes of trilobites, their precise position along the line of the facial suture is subject to considerable variation, and their size in relation to that of the whole head-shield is also variable within wide limits. The very small eyes of such a genus as *Acidaspis* afford the greatest contrast to those of *Cyclopyge* (*Æglina*). But while to some extent the development and position of the compound eyes is of phylogenetic importance, yet we shall be able to show that in some cases it is certainly a secondary adaptation and apt to mislead us if regarded in any other way. We can, however, in this article only deal with the subject of the size and position of the compound eyes in so far as it concerns the inquiry into the meaning of blind trilobites.

The Development of the Compound Eyes of Trilobites.

Beecher [1] has recently brought together and admirably summarized the results of recent researches on the evolution of the head-shield in trilobites, and his conclusions are of much significance to us in our present inquiry. He emphasizes the fact that the most primitive larvæ show no eyes on the dorsal shield and have no free cheeks visible, for the latter are ventral in position and the suture is marginal or submarginal. It has, moreover, been observed that a number of genera possess in the adult condition characters which agree closely with those found in the larvæ of other and higher genera. For instance, the mature individuals of such genera as *Carausia* and *Aneucanthus* possess the principal cephalic features of the simple protaspis larval stages of the higher genera *Ptychoparia*, *Solenopleura*, and *Liostracus*; they show no eyes and no free cheeks, and thus indicate that they belong to a lower grade in the evolution of the group.[2] These primitive types predominate in the earlier Palæozoic faunas, so that their stratigraphical distribution confirms the deduction from their morphological characters. The absence of eyes, therefore, in such primitive forms as these cannot be interpreted as an adaptive character, but must be regarded as a mark of their phylogenetic rank. All the genera which are characteristic of the Cambrian faunas, and the development of which is known, pass through this blind larval stage, and a number of genera (*Agnostus*, *Microdiscus*, etc.) never pass beyond this stage, but preserve their primitive features to maturity.

The next stage in the larval history of the more advanced forms is marked by the appearance of the free cheeks on the upper surface of the head-shield as narrow marginal bands, and by the simple curved course of the facial suture which cuts them off. The genera *Ampyx* and *Conocoryphe*, s.str., exhibit these features when adult and have no compound eyes. In genera of a higher rank which possess compound eyes, the latter generally appear on the margin almost simultaneously with the free cheeks which bear them; but this simultaneous appearance is due to accelerated development and to the operation of the law of earlier inheritance. In later larval stages the free cheeks increase in width and the eyes move inwards. The successive acquisition of the foregoing characters in definite order is more or less indistinct in the higher and more specialized trilobites which attain their maximum in Post-Cambrian times, for there is a considerable acceleration of development, and their larvæ consequently exhibit characters which do not exist in the corresponding larval stages of the more ancient and primitive genera, but which only appear in the later larval or even adult stages of the latter. The two principles (1) that ontogeny furnishes the means of recognizing the true affinities of organisms, and (2) that the development of the individual correlates with the development of the group, are so firmly established that it is needless to remark

[1] Amer. Geol., vol. xvi (1895), p. 166.
[2] Beecher, Amer. Journ. Sci., vol. iii (1897), pp. 89 and 181.

further than that the above evidence from the trilobites (and much more that might be adduced) is completely in harmony with them.

We find in the trilobites a group with an uniform generalized structure and with a singularly complete geological history, and in addition to this we possess a knowledge of the ontogeny of all the principal families of different geological periods, and it is found to correspond with the phylogeny and geological succession of the members of the group. We can therefore proceed with a considerable amount of confidence in determining what are true larval and primitive characters, and in separating from them those which are of the nature of adaptations or the result of degeneration.

Characteristics of Blind Trilobites.

As may be gathered from the above remarks, it will be found that the characteristics of a large proportion of blind trilobites will be those of the earlier, lower, and more primitive families or genera which possess no compound eyes, because of their phylogenetic position. Those of this rank which possess organs of vision do so, not by virtue of their stage of evolution, but by reason of secondary specialization; and these 'eye-spots' with which they are furnished are not homologous with the compound eyes of the higher forms. In anticipation of much which is to follow we may remark that the blind higher forms, on the other hand, which have their phylogenetic position determined by their close structural resemblance to and association with forms possessing compound eyes, so that their affinities admit of no doubt, are characterized as a rule by the degeneration of the free cheek into a mere marginal band. This feature appears to indicate that the development of the compound eye and free cheek is in some way interdependent, for we find no blind form of high rank with a large triangular free cheek; the free cheek is always narrow; and the lower blind forms, as we have seen, have either no free cheek or else a very narrow marginal one. This reduction of the size of the free cheek is accompanied by the migration outwards of the facial suture and its simplification; and we remember that the marginal and simple course of the facial suture was a primitive feature. Thus the loss of the compound eyes in the higher forms is accompanied by a certain amount of reversion to primitive conditions in the head-shield. The other parts of the body are, so far as we know, unaffected, but we may reasonably assume that some modifications in the appendages took place in conjunction with the loss of eyesight, as we find to be the case in most of those modern blind crustacea which are allied to species or genera possessing eyes. Details of each individual genus of blind trilobites are given below.

The Blind Genera.

The most natural system of classification which has so far been proposed for the trilobites is that given by Beecher.[1] It has a close correspondence with that drawn up by Salter, and, being based on

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[1] Beecher, Amer. Journ. Sci., vol. iii (1897), p. 183.

phylogenetic and ontogenetic principles deduced from recent in-
vestigations, is here employed.   The presence of free cheeks and
compound eyes and the position of the facial sutures are accorded
the great phylogenetic importance which they are now ascertained
to possess.

(1) ORDER HYPOPARIA.

In the order Hypoparia, which Beecher considers the lowest of the
three into which the Trilobita may be divided, the three families
Agnostidæ, Harpedidæ, and Trinucleidæ, and the genera which they
include, show a combination of features characteristic of the earliest
larval stages of higher families.   Particularly is this fact apparent
in the head-structure.   Compound paired eyes are absent; the
free cheeks form a continuous marginal ventral plate, and do not
show on the upper surface of the head; the suture is ventral,
marginal, or submarginal.   Secondary specialization has, however,
in some respects obscured these primitive features and destroyed the
simplicity of their appearance.   But in spite of these superinduced
characters, such as the marginal fringe in *Trinucleus*, and the loss of
segmentation in the glabella of some *Agnosti*, we cannot fail to
perceive the general stamp of a low stage of development.   Of the
family Agnostidæ, the two genera *Agnostus* and *Microdiscus*, which
constitute it, are blind.   Matthew[1] has remarked that the genus
Agnostus is the simplest known trilobite and shows the most perfect
retention of embryonic features, and that it is especially characteristic
of the early Cambrian period in America and also Europe, as the
writings of Tullberg, Brögger, and Hicks have shown.   Its
geological distribution is thus just what we should expect from
its morphological features.

In the family Harpedidæ eye-spots are frequently present on the
fixed cheeks.   It has been thought that eye-spots are a primitive
character and of some phylogenetic importance; but from the fact
that they are only found in this family, which abounds in marks
of secondary specialization, and that it has not been proved that
they are present even in any of the larval stages of other genera
(except in *Trinucleus*, which is discussed below), it seems to me that
we should regard them as special products of the extremely high
degree of secondary development reached by the members of this
aberrant family.

These eye-spots may reach a considerable degree of complexity
in their structure, as, for instance, in *Harpes macrocephalus* (Goldf.),
from the Devonian,[2] but they are in no way structures homologous
to the compound eyes on the free cheeks of higher trilobites.   The
eye-spots are situated on the fixed cheeks at the end or along the
course of the ocular ridge or eye-line which has been thought to
represent the course of the optic nerve.

A structure with a similar but more extended course, and also
termed the eye-line, is found in the later larval stages of some
primitive Olenidæ (*Ptychoparia, Solenopleura*, etc.), and in these

[1] Trans. Roy. Soc. Canada, vol. v (1887), p. 160.
[2] Whidborne, Monogr. Devon. Fauna, vol. i, p. 32: Palæont. Soc., 1879.

forms it persists to an adult condition. In the later and higher genera of the Olenidæ (*Sao* and *Triarthrus*) in which it occurs it appears at an earlier larval stage owing to acceleration of development, and in *Sao* it persists throughout life. It is, however, entirely absent from every stage of all later and higher genera which have been studied.

It is interesting to find an eye-line present in some of the Conocoryphidæ, which are all devoid of eyes and are of a more primitive type than the Olenidæ, though in many respects allied to them. We are only acquainted with the later larval stages of some of the Conocoryphidæ,[1] and in these it is present. It is certainly an archaic feature, for it is characteristic of the Cambrian genera of trilobites, and four-fifths of them are said to possess it, but in later and higher genera it is absent, with the exception of the Olenidæ above mentioned. But from the fact that in the Olenidæ it makes its appearance on the dorsal shield earlier than the compound eyes on the free cheeks, and that it is also present in larval and adult stages of the more primitive Conocoryphidæ which possess no compound eyes, it cannot be maintained that its presence is consequent on the development of eyes or indicates their former existence. Moreover, from its absence in the earliest larval stages of simpler forms and in the least modified members of the Hypoparia, it seems likely to prove to be a secondary and superinduced structure, and not characteristic of the earliest and simplest stages in the phylogeny of the group. With regard to the supposed homology of the eye-line in the Olenidæ and Conocoryphidæ with the eye-line in the Harpedidæ and larval *Trinucleus* we have not sufficient evidence to draw any definite conclusion ; but from the fact that in the highest forms (the Olenidæ) in which the eye-line is found it runs direct to the palpebral lobe of the compound eye and ends at the facial suture, while in the Conocoryphidæ it generally ends short of the facial suture, and branches out into a ramifying network of veins suggesting nerves (e.g. *Carausia*), and that in the Harpedidæ the eye-spot is situated upon it, though not always at its outer termination, it appears probable that this line indicates the course of a nerve or nerve-plexus along which organs of vision in some cases are developed. That its association with eye-spots and compound eyes is more or less accidental and temporary, and is not intimately bound up with its existence, is suggested—(1) by its absence in all the higher and later genera with the best developed compound eyes ; (2) by its larval appearance before any organs of vision are developed ; and (3) by its presence in the adult stage of the primitive blind family, the Conocoryphidæ.

It is of considerable interest to find a blind species[2] of the genus *Harpes* (*H. benignensis*, from Dd 1 Barr.), and its significance will be discussed later.

With regard to the origin of the eye-spots themselves, it has been explained that it does not seem possible to regard them as

[1] Matthew, Trans. Roy. Soc. Canada, vol. ii, sect. iv.
[2] Barrande, Syst. Sil. Boh., Suppl., vol. i, p. 4.

primitive or characteristic larval structures, and we cannot for the same reasons consider them as rudiments of a structure once generally present in the ancestors of the trilobites. Their exact nature in the case of *Harpes* is still not fully determined. Packard [1] does not regard them as comparable with the simple eyes or ocelli of *Limulus*, and Clarke [2] is inclined to think that they may prove to be of an aggregate character similar to the schizochroal eyes of *Phacops*. If the latter is the case we have an interesting example of parallel independent evolution. On the whole, it appears safer to consider the eye-spots in *Harpes* as the attempt on the part of a primitive type of trilobite to develop organs of vision which might enable it to hold its own in the struggle for existence with its more highly organized contemporaries, which possessed well-developed compound eyes. Similar conditions of life required similar organs of sense, and the primitive types which failed to develop them ceased to exist. Only those of which the habits removed them from the conflict, or which were able quickly to develop the necessary powers of defence or flight, managed to survive. In support of this view the long range of the genus *Harpes* may be adduced, for it appears in the Cambrian and lasts till the Devonian.

In the case of the Trinucleidæ, none of the genera in their adult condition possess organs of vision; all are blind. But some immature *Trinuclei* have eye-spots, as already mentioned. McCoy [3] was led by the occurrence of these eye-spots in certain individuals to institute a new genus which he called *Tretaspis*. It has, however, been abandoned,[4] since it is believed to be proved that it was founded on larval forms of species which in the adult condition have lost the 'ocular' tubercles. The remarks made on the eye-spots of *Harpes* apply partly to these in the larval *Trinucleus*. Thus we cannot regard them as an inherited character, nor as a primitive or larval structure common to lowly types of trilobites. It only remains to consider them as special generic or perhaps specific features, peculiar to the ontogeny of *Trinucleus* or of some of its species. They appear, therefore, to be adaptive characters, acquired to meet certain conditions of life; and in explanation of their absence in the adult we may either suppose that the adult had a different environment and mode of life which led to their degeneration, or that other organs developed which played an equivalent part, as is the case of the tactile organs of blind cave-animals. It may be mentioned that the visual function of these tubercles in the larval *Trinucleus* has never been demonstrated, and no description of lenses or visual surface has ever been published, so far as

[1] Amer. Nat. (1880), p. 503.

[2] Journ. Morph., vol. ii (1888), p. 253.

[3] Ann. Mag. Nat. Hist., vol. iv (1849), p. 410; and Brit. Pal. Foss., 1851, p. 146.

[4] Barrande, Syst. Sil. Boh., vol. i, pp. 617, 620. Nicholson and Etheridge, Mon. Silur. Foss. Girvan, fasc. 2 (1879), pp. 188–197. Beecher, Amer. Journ. Sci., vol. xlix (1895), p. 307.

I know. The general similarity, however, between the eye-line and eye-spot of *Harpes* and these structures in the larval *Trinucleus* is in favour of regarding the latter as organs of sight. From the resemblance of the tubercle on the glabella to those on the cheeks, we ought probably to regard it as possessing likewise a visual function.

The other two genera, *Ampyx* and *Dionide*, which are placed in the family Trinucleidæ, have no eyes at any stage of their development, so far as is known, and they show the typical Hypoparian characters. In neither genus have we any reason to suspect degeneration. The genus *Ampyx* displays the intermediate stage in the migration of the free cheeks from the ventral to the dorsal surface of the cephalon. Œhlert's [1] view that the marginal position of the suture of *Trinucleus*, *Ampyx*, and *Harpes* is the result of the displacement of the normal facial suture, and is therefore a secondary character and less primitive than the dorsal position, is opposed to all our knowledge of the ontogeny and phylogeny of the trilobite.

There are two genera, *Salteria* and *Endymionia*, with doubtful affinities, which are usually placed in the family Trinucleidæ. The genus *Salteria* (Wyv. Thomson) [2] possesses linear free cheeks which are supposed to bear eyes; but the evidence for their presence is weak, [3] and it is most probable that the genus is really blind. The other genus, *Endymionia* (Billings), [4] has only been found in America, and is considered to be allied to *Trinucleus* and *Ampyx*, and, so far as is known, it possesses no organs of vision.

(*To be continued.*)

IV.—ON DENEHOLES AND BELL PITS.

By T. V. Holmes, F.G.S., Hon. Sec. Anthrop. Inst.

IN the GEOLOGICAL MAGAZINE for July appears an article by Mr. Charles Dawson on Ancient and Modern Dene Holes. As Mr. Dawson mentions Essex deneholes, and comes to conclusions contrary to those arrived at by Mr. Cole and myself, the authors of the Report of the Essex Field Club on the Deneholes of Hangman's Wood, near Grays Thurrock, [5] I shall be glad to be allowed space

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[1] D. P. Œhlert, Bull. Soc. Géol. France, vol. xxiii (1895), p. 319.

[2] Mem. Geol. Surv., dec. xi, No. 6 (1864), p. 1.

[3] Nicholson and Etheridge, Mon. Sil. Foss. Girvan, fasc. 2, p. 199.

[4] Geol. Canada: Pal. Foss. (1865), vol. i, pp. 33 and 281.

[5] Report on the Denehole Exploration at Hangman's Wood, Grays, 1884 and 1887: by T. V. Holmes and W. Cole (with three coloured plates and other illustrations). Note on the Bones found in the Deneholes in Hangman's Wood: by E. T. Newton. Note on a fragment of Millstone from a Denehole: by F. W. Rudler. On Chalk Wells: by F. J. Bennett. Note on some Pits near Chipping Norton, Oxfordshire: by H. B. Woodward. Ensilage, or Preserving Grain in Pits: by F. C. J. Spurrell.

(*Essex Naturalist*, December, 1887.)

for a reply. For though our views do not appear to be injuriously affected by Mr. Dawson's remarks, yet as the Denehole Report is now more than ten years old it is probable that few of the readers of the GEOLOGICAL MAGAZINE have both seen and remember it. And the impression which the reader would derive from Mr. Dawson's article is, that his Bell Pit hypothesis is something quite new, and therefore unnoticed by us, whereas it was an old view before the Report was written, having been put forward by the late Roach Smith in the *Gentleman's Magazine* in 1867 ; and an account of workings for chalk, of the kind described by Mr. Dawson, written by Mr. F. J. Bennett, of the Geological Survey, is appended to the Denehole Report.

The name 'denehole' is said by the highest authority, that of Dr. J. A. H. Murray, to mean *dane*hole, not *den*hole, as we supposed when the Report was written. Of course, this etymological question concerns us here only as throwing light on the traditional view as to the makers of these pits. So far as the name goes it divides these pits somewhat more decidedly from primitive mines than *den*hole would do. For *dane*hole implies not merely a hiding-place, but a hiding-place from the last and best remembered of the piratical invaders of our shores, though it by no means excludes the possibility that daneholes may have been useful in the time of earlier marauders. On the other hand, as the late Roach Smith pointed out, pits for chalk, of the class described by Mr. Bennett and by Mr. Dawson, are mentioned by Pliny. It would seem, therefore, that both classes of pits, the deneholes and the bell pits, were known many centuries ago. But while collections of bell pits, such as Grime's Graves and the Pen Pits, have received various local names, the name denehole seems to have been applied only to excavations which, in the popular view, could hardly have been made for anything but hiding-places. Excavations made for the sake of the material extracted, and excavations made for the sake of the space so obtained for some domestic purpose, are both common throughout the world. Whether any given group of pits should be classed as belonging to the danehole or the bell-pit division is purely a matter of the evidence in each case, that afforded by their sites and construction being the most decisive. For gravel obtained from the site of a new town-hall is utilized as much as that from a gravel-pit on a common, though the makers of each excavation had very different purposes in view. And the mere presence or absence of human implements is, in itself, of little weight. At the present day they may usually be found most abundantly, not in ruined dwellings, but in disused gravel-pits and deserted brickyards.

The mode in which any people make excavations in a rock evidently depends partly on the position and nature of the rock, partly on the nature of the tools and appliances known to them. And we should not expect to find among a primitive people the immense variety of form in structures or excavations for different purposes which might be looked for in more advanced countries.

What we may expect to see are those differences in the nature of the site and structure which are absolutely essential, but nothing more. A primitive excavation in chalk, for example, made to obtain subterranean space, will be likely to have some superficial resemblance to another excavation of the same period made in order to procure chalk. In the case of many isolated pits the evidence may amount to so little as to prevent any decided conclusion. In such cases, however, it is as absurd to decide that they must be pits made for the sake of the material extracted as to conclude that they must have been used for domestic purposes. To us at the present day the mining explanation may seem the more probable, excavations in rocks for domestic purposes being comparatively rare. But among primitive people they are usually far more common than excavations for mining. Even in Brittany at the present time pits in the fields are used for the storage of grain. The top of the pit is covered with a layer of earth or clay to keep out the wet, and a slight mound indicates the site.[1] However, in writing of deneholes with the view of making the distinctions between them and pits for mining purposes as clear as possible, it is best to leave out of consideration excavations of doubtful affinities.

The name denehole is not confined to certain excavations in the Chalk, nor to pits with vertical entrances. A much esteemed Northern archæologist, Mr. R. O. Heslop, of Newcastle-on-Tyne, pointed out to me many years ago that deneholes exist, and are known by that name, in the county of Durham. They are mentioned in a paper read by one of the most eminent of Northumbrian antiquaries, Mr. W. H. D. Longstaff, at the Newcastle meeting of the Archæological Institute in 1852 the title of the paper being, "Durham before the Conquest." Mr. Longstaff remarks that the name 'Danes Hole' is applied to several hiding-places in the county, and that it may perhaps have originated during the warfare between Saxon and Dane, from their use as retreats during Danish incursions. He adds :—

"They are frequent in Hartness, where the struggle seems to have been most bitter, and are described as excavations in the sides of eminences, in those sides from which the most extended views might be obtained." On the map accompanying Mr. Longstaff's paper are the words, "Excavated halls called Danes Holes"; and they are shown as existing on the Magnesian Limestone of South Durham, chiefly in the neighbourhood of Embleton, six or seven miles west of Hartlepool. And in Hutchinson's History of Durham (1785), vol. iii, p. 82, there is in a note by 'Mr. Cade' the following remark : "There is a large cavity on the summit of the camp at Mainsforth which is at this day called the Danes-Hole, where there was lately dug up a pair of moose deer horns," etc. Mr. Cade thinks the site of Athelstan's victory over the Danes was about two miles from this camp, and is interested in determining

[1] Note on the use of Pits in Brittany for the Storage of Grain : by Charles Browne, M.A., Barrister-at-Law. (*Essex Naturalist*, vol. ii, 1888, p. 3.)

the spot at which the battle took place, the Danes Hole being only mentioned as having a possible bearing on that question.

If we look at a map of South Durham, the reason why Danes Holes were especially numerous about Embleton becomes obvious on the supposition that they were hiding-places from the Danes and earlier piratical marauders, but utterly unintelligible from the mining point of view. The ground slopes to the east and south-east, towards the sea and the valley of the Tees. Between Embleton and Hartlepool, the surface rock is Magnesian Limestone; south of Embleton, to Stockton-on-Tees, an equal distance away, most of the ground is occupied by Triassic beds. There must have been a natural harbour at Hartlepool one or two thousand years ago, while the Tees, three or four miles southward, offered every facility for piratical expeditions inland, to and beyond Stockton. Hence Embleton would afford hiding-places for the fishermen of Hartlepool and the inhabitants of the lower part of the Tees Valley, at a convenient distance both from the river and the sea.

Here it seems worth while to remind the reader that the southern and eastern shores of Great Britain were especially subject to piratical attacks both before and for centuries after the Roman Occupation. For the country was inhabited by scattered tribes and clans but little in the habit of acting in concert, and without any common system of defence. While during the Roman Occupation, the 'Count of the Saxon Shore' appears to have concerned himself almost wholly with the defence of the coast from the Wash southward, increased distance from the Continent forming the chief protection to the people of the Humber, the Tees and the Tyne. In short, the inhabitants of the shores of the British Isles probably suffered as much from piratical marauders before the Norman Conquest as did those living in the islands of the Mediterranean, many centuries later, from the attacks of the Barbary corsairs.

I now pass to the deneholes of Kent and Essex, more especially to those of the last-named county. Here we have three highly concentrated groups of pits, two of them at Bexley in Kent, and a third in Hangman's Wood, near Grays Thurrock, Essex. In each case there are some fifty or sixty pits, close to each other, yet without connection below the surface, except where the wall of separation has here and there been made too thin for permanent stability. The two Bexley groups, at Cavey Spring and at Stankey Wood, are about 600 yards apart. For some account of the Bexley deneholes the reader may be referred to a paper by Mr. F. C. J. Spurrell, F.G.S., which appeared in the Archæological Journal, vols. xxxviii and xxxix (1881 and 1882). Mr. Spurrell was, indeed, the first person to make any personal exploration of deneholes and to consider the probable purposes of their makers in a scientific spirit, and his paper is a storehouse of facts either about the pits themselves or the uses for which they were probably designed; his opinion being that they were mainly ancient granaries.

These three groups all occupy positions analogous to those of the Durham deneholes. In each case they are near, but not close to

the Thames, the Bexley pits at Stankey Wood (Fig. 1) and Cavey
Spring (Fig. 2) being between three and four miles from the river,
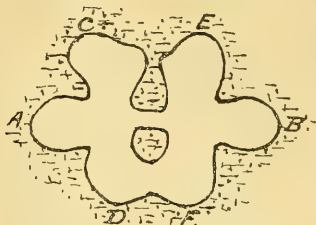
FIG. 1.—Ground-plan of Pit at Stankey Wood (west of fence), visited by the Sidcup
Literary and Scientific Society, June 6th, 1885. Scale 40 feet to an inch.

Greatest length from A to B, about 52 ft. 6 in.
    ,,   ,,   ,, C to D, ,,   36 ft. 6 in.
    ,,   ,,   ,, E to F, ,,   36 ft. 6 in.
Height ...   .   18 ft. 0 in.

and the Hangman's Wood pits, at Grays, about a mile and a half
(Fig. 3). But at Bexley the river Darent, a little eastward of the
deneholes, would have allowed piratical craft to come a mile or two
nearer these groups than the course of the Thames, apart from its
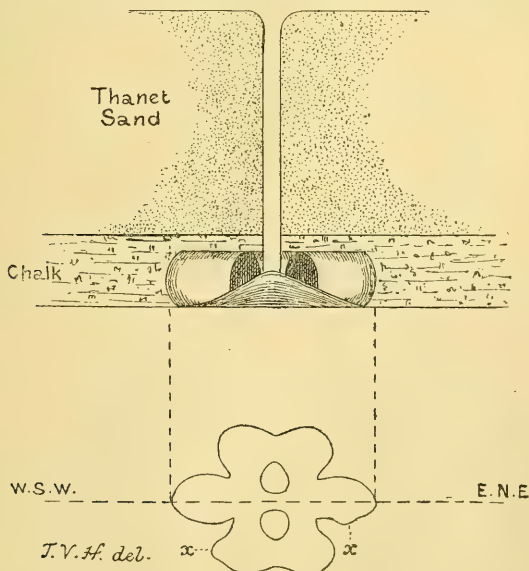
FIG. 2.—Denehole at Cavey Spring, Bexley. Scale 40 feet to an inch.

x–x, points at which the next pillars were being made.
Length of chamber from W.S.W. to E.N.E. ... 42 ft. 6 in.
Height ...   .   11 ft. 6 in.
Depth to bottom of chamber, from surface   ...   61 ft. 6 in.
Thickness of chalk roof   ...   .   3 ft. 6 in.

tributary, would allow, while at Grays the Thames has no tributary stream giving additional access to the land there. As to height above the sea, the three groups are on nearly the same level, those at Bexley being slightly over 100 feet above ordnance datum and that at Hangman's Wood a trifle below. They do not occupy ground of any natural strength, but in each case a slight valley leading up to them would allow fugitives to get to them from the borders of the Thames with but little risk of discovery.
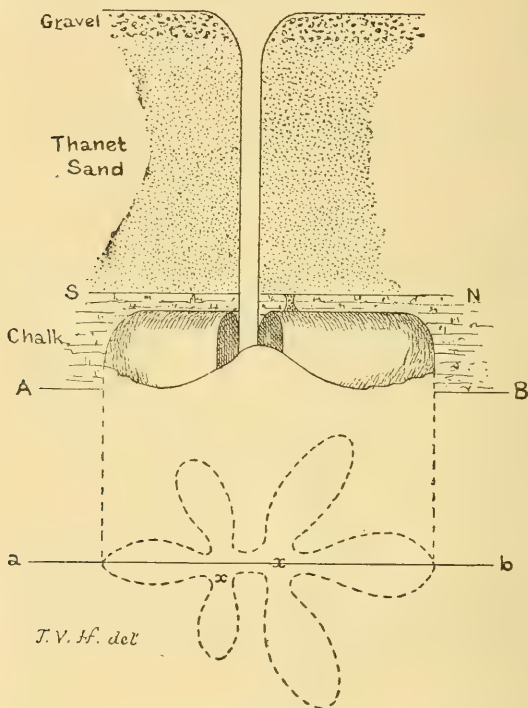
Fig. 3.—Hangman's Wood, No. 4 Pit.
Scale, 40 feet to an inch. Height of chambers, 14 to 16 feet.

These groups also resemble each other in geological position. In each case the surface bed is either Thanet Sand or gravel overlying Thanet Sand. The greater part of the shaft is in Thanet Sand and ends in the Chalk (see Figs. 2 and 3). Where there is gravel above the Thanet Sand, as at Hangman's Wood, the present mouth of the shaft is much enlarged through the tumbling in of the gravel, while where gravel is absent the Thanet Sand has stood so well that but little enlargement has taken place. The pits at Hangman's Wood are about 80 feet deep, the lowest 22 feet, or thereabouts, being Chalk. Those at Stankey Wood and Cavey Spring average from 20 to 30 feet less. The Bexley pits are also smaller in size (judging

from those entered), averaging from 40 to 50 feet in length, while at Hangman's Wood they are 70 feet long and about 18 feet high. The height of the Bexley pits is less. The thickness of the Chalk roof varies from 2 to 5 feet. At the bottom of each shaft is a conical heap, consisting of the material which has fallen down the shaft since the disuse of the pit. At Hangman's Wood we found that the lower part of this mound consisted chiefly of gravel with lumps of chalk and many very large flints. The upper part was chiefly sand. The large flints had evidently been used to 'stein' the upper part of the shaft and keep the gravel from tumbling in. It was noticeable that the Thanet Sand had stood much better than either the gravel above or the Chalk below, the footholes by means of which the shaft had, when in use, been ascended and descended, being still visible in the Thanet Sand, and still allowing ascent and descent to some extent. Most of the shafts are now filled with débris.

A most noteworthy point with regard to these groups of deneholes is, that while they are most conveniently situated for hiding-places, their position is in the highest degree absurd if they are supposed to be pits for chalk. For whereas there is plenty of bare chalk within a mile, both at Bexley and Grays, these pits have been sunk where the Chalk is covered by from 30 to 60 feet of other beds. It is said, on the other hand, that "chalk is considered to be better the deeper it lies, and the top chalk, particularly if it lies within three or four feet of the surface, very indifferent," etc. (GEOL. MAG., July, 1898, p. 299). But, granting that such may be the case, that offers no explanation of the sites chosen for these groups of deneholes. It must be obvious that the course which would then commend itself to all seekers after superior chalk would be to begin operations where chalk is at the surface, make a shaft 10 to 20 feet deep, and procure chalk lying at that depth. But at Hangman's Wood, after penetrating through nearly 60 feet of gravel and sand, the excavators have taken chalk from the uppermost 20 feet.

It is of course possible that in primitive times pits close to that great highway the Thames might compete, even if the chalk were unusually deep there, with others shallower but a mile or two inland. But both at Bexley and at Grays there is plenty of bare chalk much nearer the river than the groups of deneholes.

Again, the fact that an isolated denehole might be found here and there of unusual depth, would not necessarily tell against the chalk-pit hypothesis. A farmer might naturally prefer to get chalk at a depth of 60 to 80 feet on his own land rather than procure it from some one else's pit a mile or two away. But when we are asked to believe that any people at any period deliberately concentrated their pits where they got the least return for their labour, and where there was no counterbalancing advantage whatever—as they must have done at Hangman's Wood and Bexley on the Chalk-pit hypothesis—the inference necessarily follows that the makers of the pits were lunatics.

About three-quarters of a mile west of Hangman's Wood I had the good fortune to see a real primitive pit for chalk in 1889,

a year and a half after the publication of our Denehole Report.[1]
Mr. J. B. Ogle, a member of the Geologists' Association, was then
good enough to tell me of some subsidences which had recently
occurred between Stifford and Grays Thurrock. Close to but west
of the road connecting Grays and Stifford, just where the boundary
between the two parishes comes to the road from the east, were two
holes, the result of a recent subsidence. They were nearly cylindrical
in shape, each being between 7 and 8 feet in diameter and from
9 to 10 feet apart. Mr. Frank, residing at The Lodge, Stifford, had
kindly provided a ladder, and we descended into the pit. The sides
of the shaft were approximately vertical, and the section displayed
consisted of—

Red clay	...	...	...	...	...	about 8 feet.
Yellow sand		...	...	...		about 2 to 3 ,,
Gravel, green-coated flints here and there						1 to 2 ,,
Chalk.						

On reaching the Chalk the pit had been at once widened out, the
thickness of the Chalk roof increasing as the distance from the
shaft increased. It was found possible to creep through a chalk-
roofed excavation connecting the two openings, which were similar
in the section they presented and in general appearance. The chalk
had been worked in various directions somewhat irregularly and
without any regard to permanent stability. There were many
pick-marks here and there. The shape and size of the workings
were much obscured by fallen material, but judging from what we
saw they may have extended to a distance of 20 to 25 feet from the
centre of the shaft we descended. I remarked in the *Essex
Naturalist* at the time, and still think, that " the purpose of the
excavators seems to have been simply the extraction of chalk for
agricultural purposes." The workings had apparently been filled
with vegetable refuse capped by earth, which had remained firm
long after the stuff beneath had rotted away, a sudden subsidence
being the result. Another subsidence had occurred in the road
nearer Stifford shortly before our visit, but had naturally been
filled up as soon as possible.

It would seem that these workings for chalk must be of consider-
able age. About 150 yards westward there is a huge open chalk-
pit, which had then been disused about 30 years. And two others
of much smaller size, but also disused, may be seen, a little
northward and a little southward of the subsidences, east of the
road. The large chalk-pit may cover perhaps 12 to 14 acres.
The workings at the subsidences can hardly have been made after
any of these open pits were begun, but must have been of much
earlier date.

The beds above the Chalk at these workings appear to be old
river-deposits. Similar beds were also visible at the northern end
of the very large chalk-pit west of the road between Grays and
Stifford, but much nearer Grays. The old river, which formed

[1] See Essex Naturalist, vol. iii (1889), p. 183.

them when flowing at a considerably higher level than the Mardyke
at Stifford, must have had a course from north to south from Stifford
to Grays, not westward from Stifford like the Mardyke of the
present day.

It is easy to understand the existence of pits of this class; the
Chalk, where Tertiary beds are absent, is frequently covered by
irregular deposits of various kinds, and where the covering of the
Chalk is thin there are usually many pipes in it. But a short
shaft allows the extraction of pure chalk at a depth to which pipes
seldom penetrate. In this case, no pipes having been found,
opening out had been begun on reaching the Chalk. Mr. R. Meeson,
at a meeting of the Archæological Institute in 1869,[1] stated that
deep cavities known as 'daneholes' existed in every field in the
neighbourhood of Grays Thurrock, below which there is "a sub-
stratum of Chalk." He does not give the positions of any of them,
nor does he mention Hangman's Wood, the pits which he had in
view being evidently such as caused these subsidences. In one
case, however, he states that on opening one of them he found it
full of Roman burial vases, which had been crushed by the fall of
the roof.

It becomes obvious, on consideration, that we should expect to
find pits of this class made to obtain chalk for purely local use in
agriculture, not highly concentrated in certain spots but scattered
here and there in the way mentioned by Mr. Meeson. For in
Central and Northern Essex, Suffolk, and Norfolk, chalk was until
lately obtained for marling the land, not directly from that formation,
but from the Chalky Boulder-clay, which occupies a large proportion
of the surface of those counties. Thousands of marl-pits may be
seen scattered over the Eastern Counties, mostly disused. They are
all open, though the uppermost two or three feet of the Boulder-clay
is useless for marling, having lost the Chalk it originally contained
through the action of rain.

On the other hand, where chalk is required for a broad area
outside that in which it is easily obtainable, large open chalk-pits
would best supply the want. The huge open chalk-pit near Stifford,
west of the subsidences, must have supplied much chalk for the
district northward, in which the Chalk lies deeper and deeper and
there is no Chalky Boulder-clay. Immense pits like those at
Grays and around Gravesend, close to the Thames, would furnish
what might be best conveyed by water up the rivers of Essex
and Suffolk.

Few old workings in Chalk are better known than Grime's
Graves, near Brandon, on the borders of Norfolk and Suffolk, which
were examined by Canon Greenwell many years ago.[2] He describes
them as being 254 in number and as covering 20 to 21 acres of
ground. One which he explored was 39 feet deep, the shaft being
28 feet in diameter at the mouth and gradually narrowing to
a width of 12 feet at the bottom. At the surface about 13 feet of

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[1] Archæological Journal, vol. xxvi, p. 191.
[2] See Journal of the Ethnological Society, new series, vol. ii (1870), p. 419.

sand covered the Chalk. All the pits were filled up to within 4 feet of the surface. "This seems to have been done," he says, "by throwing into an open shaft the waste materials taken out of one or more pits in course of being excavated." The object in this case was the extraction of flint; that from a band at the bottom being of specially good quality for the manufacture of implements. This band being reached, the flint on the floor was removed, and galleries about 3 feet high and from 4 feet to 7 feet wide were driven in various directions, and the flint in them extracted till the shafts were more or less connected together by means of these galleries.

Similar workings in Chalk for flint were those at Cissbury, near Worthing, which have been explored by Lieut.-General Pitt-Rivers, Mr. Park Harrison, and others. Mr. Spurrell, in the paper which I have already mentioned, says that at Cissbury the shafts varied in depth from 17 feet to 42 feet. The width of the simplest shaft decreased from 18 feet at the top to 4 ft. 6 in. at the bottom, but other shafts were sunk with terraces and burrows at various depths as seams of flint were cleared out and followed.

Passing from the Chalk, we have mines of a similar kind in the well-known Pen Pits, near Stourhead, on the borders of Wiltshire and Somerset. Here on a promontory of a plateau of Upper Greensand, there are hundreds of cup-shaped hollows varying in diameter from 10 to 20 feet and in depth from 5 to 10 feet. Lieut.-General Pitt-Rivers examined some of them, which he found had been used as mines, to a band of stone lying a few feet below the surface, which was suitable for querns, etc. It had been thought by an eminent antiquary that the Pen Pits were the site of an ancient British village. But against this view there is not only the fact that stone has certainly been procured from these pits, but there is another point which has hardly received the attention it deserves. Similar workings are visible on the same horizon on the other side of a valley too broad and deep to allow of all of them having formed part of the same village.

The pits in Purbeck stone, described by Mr. Dawson in the GEOLOGICAL MAGAZINE for July, seem to have a strong general resemblance to the workings in Chalk for flint at Cissbury and Grime's Graves, and to the Pen Pits of Stourhead. In all these cases the concentration of the pits is a natural result of the fact that whether a narrow band of stone or a particular seam of flint was required, the seekers have felt it necessary to keep in touch with it. In each instance we have a vertical shaft of no great depth but of considerable breadth, from the bottom of which a widening out takes place, the details varying with the stability of the rock, the proportion required for removal, etc. At Grime's Graves galleries connect the shafts; in no case can this be objectionable in mines except on the score of stability. And at Grime's Graves, as in Mr. Dawson's Purbeck pits, we find that the débris from a new shaft goes to fill up an old one. This of course becomes necessary when so small a proportion of the rock in which the excavations are

made is required at the surface as in these examples. But whatever may be the differences in detail between the workings in Chalk for flint at Grime's Graves and Cissbury, the Pen Pits or the Brightling Pits, they are all palpably mines, and suggest no other explanation to those acquainted with their structure.

In the case of the deneholes of Stankey Wood and Cavey Spring, Bexley, and of those of Hangman's Wood, Grays, the fundamental differences between them and mines of the bell-pit class reveal themselves simply in proportion to the closeness of the examination they receive. We have already seen that the spots chosen as the sites of each of these three collections of pits are well suited for hiding-places, but the worst possible situations for chalk-mines, being where the Chalk is from 30 to 60 feet below the surface, though there is plenty of bare chalk in each case within a mile. Now though single pits might easily be of unusual depth without any significance attaching thereto, no people ever deliberately concentrated their pits where they received the least return for their labour —as they must have done at Grays and Bexley on the Chalk-pit hypothesis. And there is no imaginable counterbalancing advantage in their sites, from the Chalk-pit standpoint.

Passing from the sites to the structure of these three collections of deneholes, the essential differences are these :—The shafts of the bell-pit groups are necessarily broad to allow of the passage upwards of a considerable amount of material at a single haul, as shown by Mr. Dawson in his section of a Brightling pit. The shafts of these groups of deneholes are, on the other hand, extremely narrow. In some cases at Hangman's Wood we found them, in places, with a diameter still under three feet, and with the footholes at the sides so little obliterated that Mr. Miller Christy ascended and descended several feet, in the Thanet Sand part of one shaft, by their aid. The Gravel above and the Chalk below have not weathered so well as the Thanet Sand, but when in use the shaft throughout must have been somewhat narrower than the narrowest part of a shaft to-day. The length (80 feet) and narrowness of the Hangman's Wood shafts were indeed as unfavourable to the operations directed by Mr. Cole and myself, as they would have been to seekers after chalk for agricultural purposes. For when we considered how we might remove from certain chambers the débris resulting from the weathering of the shaft during centuries of disuse, it became obvious that the length and narrowness of the shafts were fatal, on account of the great expense involved, to any project for removing it to the surface.

Then, at the base of the denehole shaft, another contrast presents itself. The bell pit simply widens out for a certain distance round the shaft, as indicated in Mr. Dewson's plan and section of the Brightling pit. The 'ancient Essex denehole,' on the same page, however, gives an inaccurate notion of the plan of a denehole near the shaft, as may be seen on comparing it with the ground-plan of the Hangman's Wood pits visited, given in our Denehole Report. As I have already stated, the Chalk at the base of the shafts has

by no means weathered as well as the Thanet Sand, and in many cases the passage from the base of the shaft to the chambers is much broader than it originally was. But even now an inspection of the ground-plan shows that in none of them is there any widening out from the base of the shaft like that of the Brightling pit, and that in almost all of them the passage at the base of the shaft is very decidedly narrower than any other part of the pit. It must have been still narrower, at one time, to allow of the continuation of the footholes to the floor of the pit. Then, those deneholes which we were able to enter, though their makers had apparently been restricted to a greatest length of 70 feet, showed certain differences in plan and development such as might be looked for if each denehole were a family hiding-place and storehouse, but unintelligible on the supposition that they were originally pits for chalk.[1] And the care taken at the surface to preserve the flattened contour characteristic of a gravel plateau, is a care that would be simply silly were these deneholes pits for chalk, though absolutely necessary if they were hiding-places and secret storehouses.

I might enter into further details, but trust that enough has been said to make it evident that Deneholes and Bell Pits belong to totally different classes of excavations, the resemblances between them being superficial and the differences fundamental. In short, Deneholes were made for the sake of the excavation, and Bell Pits for the sake of the material extracted from the excavation. The archæological evidence bearing on deneholes ancient and modern and the uses to which they have been put, though of great interest, would seem out of place in the GEOLOGICAL MAGAZINE.

NOTICES OF MEMOIRS.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
BRISTOL, September 8, 1898.

ADDRESS TO THE GEOLOGICAL SECTION, BY W. H. HUDLESTON, M.A., F.R.S., President of the Section.

Introductory.

ABOUT this time last year British geologists were scattered over no inconsiderable portion of the Northern Hemisphere, partly in consequence of the International Geological Congress at St. Petersburg and partly owing to the meeting of the British Association at Toronto. From the shores of the Pacific at Vancouver, on the one hand, to the highlands of Armenia on the other, there were parties engaged in the investigation of some of the grandest physical features of the earth's surface.

The geologists in Canada were especially favoured in the matter of excursions. Everything on the American continent is so big that

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[1] It is worth adding that no attempt had been made to extract flint from a prominent band seen in each pit at Hangman's Wood 4 to 6 feet above the floor, or from any other band.

a considerable amount of locomotion is required to enable visitors to realize the more prominent facts. If there be no great variety of formation in Canada, yet the Alpha and Omega of the geological scale are there most fully represented, from the great Laurentian complex at the base to the amazing evidences of glacial action, in a country where it is possible to travel for a whole day without once quitting a glaciated surface. But Russia presented equal attractions, and in Finland almost identical conditions were observed, viz. glacial deposits on Archæan rocks. The great central plain of Russia, too, with its ample Mesozoic deposits often abounding in fossils, offered attractions· which to some may have been stronger than the mineral riches of the Urals or the striking scenery of the Caucasus.

It seems almost incredible, even in this age of extraordinary locomotion, that scenes so wide apart were visited by British geologists last autumn. This year we are more domestic in our arrangements, and Section C finds its tent pitched once more on the classic banks of the Bristol Avon, and in that part of England which has no small claim to be regarded as the cradle of English geology. But we may go a step further. For if the strata observed by William Smith during the six years' cutting of the Somersetshire coal-canal imprinted their lessons on his receptive mind, it is also equally true that Devonshire, Cornwall, and West Somerset first attracted the attention of the " Ordnance Geological Survey." And thus it comes to pass that the region which lies between the Bristol Channel and the English Channel claims the respect of geologists in all parts of the world, not only as the birthplace of stratigraphical palæontology, but also as the original home of systematic geological survey.

The city of Bristol lies on the confines of this region, where it shades off north-westwards into the Palæozoics of Wales, and north-eastwards into the Mesozoics of the Midland Counties. There are probably few districts which display an equal amount of variety within a limited circumference. The development of the various formations was excellently pourtrayed by Dr. Wright, when he occupied this chair twenty-three years ago—so well indeed, that his address might serve as a textbook on the geology of the district. In the following year (1876) there appeared the Survey Memoir on the Geology of East Somerset and the Bristol Coalfield, by Mr. H. B. Woodward, who has since contributed important memoirs on the Jurassic rocks of Britain, which are so largely developed in Somerset and the adjacent counties. Since that date many papers also have appeared in various journals, and some of these, as might be expected, give new and perhaps more accurate interpretations of phenomena previously described. In addition to this, portions of the south-west of England have been geologically re-surveyed, and in some cases new maps have been published.

I would call especial attention to the Survey Map on the scale of four miles to the inch, known as the " Index Map," which has recently been issued. Sheet 11 includes this particular district; but

if a portion of Sheet 2 is tacked on to its southern border we obtain a block of country about 120 miles square, which has not its equal for variety of geological formation in any part of the world within the same space. If Europe is to be regarded as presenting a geological epitome of our globe, and if Great Britain be an epitome of Europe, then, without doubt, this particular block of the south-west, which has Bath for its more exact centre, with a radius (say) of fifty miles, may be said to contain almost everything to be found on the geological scale, except the very oldest and the very youngest rocks ; while east of the Severn and south of the Bristol Channel true Boulder-clay is rare or absent.

It may be convenient to consider a few points which have arisen of late years in connection with the geology of portions of the district now under consideration.

Palæozoic.

If we omit the Silurian inlier at Tortworth, the geological history of the country, more immediately round Bristol, may be said to commence with the Old Red Sandstone, whose relations with the Devonian towards the south-west have always presented some difficulty. And this difficulty is accentuated by doubts as to the true Devonian sequence in West Somerset and North Devon. Ever since the days of Jukes that region has been fruitful in what I must continue to regard as heresy until the objectors have really established the points for which they are contending. The uncertainty is to be regretted, since it is through these beds of West Somerset that the system is to be made to fit in with the several members of the Old Red Sandstone.

There is a mystery underlying the great alluvial flats of Bridgewater which affects more than one formation ; so much so that one cannot avoid asking why there should be Old Red Sandstone in the Mendips and Devonian in the Quantocks. The line which separates the Old Red Sandstone of South Wales and the Mendips from the West Somerset type of Devonian lies here concealed. I have already suggested[1] that, if we regard the Old Red Sandstone of South Wales as an inshore deposit over an area which was deluged with fresh water off the land, we can believe that further out to sea, in a south-westerly direction, the conditions were favourable for the development of a moderate amount of marine mollusca. This view not only does away with the necessity for a barrier, but it also, in a general sense, suggests a kind of gradation between the Old Red and Devonian deposits. Mr. Ussher, whose practical acquaintance with this region dates from a long period, stated a few years ago that, "As far as Great Britain is concerned, the true connections of the Old Red Sandstone beds with their marine Devonian equivalents have yet to be carefully worked out on the ground."[2] I am not aware that further progress has been made in this direction.

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[1] Trans. Devonsh. Assoc., vol. xxi (1889), p. 45.
[2] " Prospects of obtaining Coal by boring South of the Mendips " : Proc. Som. Nat. Soc., vol. xxxvi (1891), pt. 2, p. 104.

The Carboniferous Limestone of the Bristol area has attracted the attention of so many distinguished geologists that its palæontology and general features are tolerably familiar. Of late years we owe some interesting petrographic details to Mr. Wethered. The varying thickness of the Carboniferous Limestone and also of the Millstone Grit in this part of England is noteworthy. If we follow the Carboniferous Limestone in a south-westerly direction, across the mysterious Bridgewater flats, a change is already noted in the case of the Cannington Park limestone, which was the subject of so much discussion in former years. Referring to this, Mr. Handel Cossham [1] was so sanguine as to believe that .its identification with the Carboniferous Limestone would have the effect of extending the Bristol Coalfield thirteen miles south of the Mendips. However this may be, all further traces of Carboniferous rocks fail at this point. After crossing the Vale of Taunton, when next we meet with them in the Bampton district, the Culm-measure type, with its peculiar basal limestones, is already in full force.

In the new " Index Map " the Culm-measures are placed at the base of the Carboniferous series—below the Carboniferous Limestone. It is no part of my purpose to attempt any precise correlation, but I would point out the somewhat singular circumstance that the change to Culm rock occurs only a few miles to the south-west of the line where, in the previous system, we have already seen that the Old Red Sandstone changes into the Devonian. This curious coincidence may be wholly accidental, or it may be the result of some physical feature now concealed by overlying formations.

Since 1895 a new light has been thrown on the lower Culm-measures by the discovery of a well-marked horizon of Radiolarian rocks. One result of the important paper of Messrs. Hinde and Fox has been to alter materially our views as to the physical conditions accompanying the deposition of a portion of the Culm-measures. The palæontology leads the authors to conclude [2] that " the Lower *Posidonomya*- and Waddon Barton Beds are the representatives and equivalents of the Carboniferous Limestone in other portions of the British Isles ; not, however, in the at present generally understood sense that they are a shallow-water facies of the presumed deeper-water Carboniferous Limestones, but altogether the reverse, that they are the deep-water representatives of the shallower-formed calcareous deposits to the north of them. . . . . The picture that we [Messrs. Hinde and Fox] can now draw of this period is that while the massive deposits of the Carboniferous Limestone—formed of the skeletons of calcareous organisms— were in the process of growth in the seas to the north [i.e. in the Mendip area and elsewhere] there existed to the south-west a deeper ocean in which siliceous organisms predominated and formed these siliceous radio-larian rocks."

This is probably a correct view of the case, but one cannot help wondering that the ocean currents and other causes did not effect

[1] Proc. Cottes. Club, vol. viii (1881–2), p. 20 et seq.
[2] Quart. Journ. Geol. Soc., vol. li (1895), p. 662.

a greater amount of commingling of the elements than seems to have taken place. As a practical result, this discovery of a Radiolarian horizon in the Culm-measures has been of service in enabling surveyors to discriminate between Devonian and Carboniferous in the very obscure area on the other side of Dartmoor. This, I ventured to predict, would be the case when the paper was read before the Geological Society.

The principal features of the Bristol Coalfield are too well known to call for many remarks. It would seem that the Pennant rock was formerly regarded as Millstone Grit, until Mr. Handel Cossham, in 1864, pointed out the mistake. Mr. Wethered gave a good description of the Pennant in his paper on the Fossil Flora of the Bristol Coalfield.[1] It might seem almost unnecessary to refer to the existence of such a well-known formation as the Pennant, but for the fact that in a recent scheme of the Carboniferous sequence in Somersetshire the Pennant rock was wholly omitted.

The interest now shifts from the almost continuous deposition of the later Palæozoics, in one great geosynclinal depression, to an entirely different class of phenomena. Nowhere, perhaps, are the effects of the Post-Carboniferous interval better exhibited than in those parts of the south-west of England where Tertiary denudation has removed the Mesozoic deposits. Here we perceive some of the effects of the great foliations which terminated the Palæozoic epoch in this part of the world. The immense amount of marine denudation which characterizes this stage is particularly obvious in the anticlinals, which were the first to suffer, as they came under the planing action of the sea.

Attention may be drawn to a peculiarity which has no doubt been observed by many persons who have studied a map of the Bristol and Somerset Coalfield. It will be seen that the strike of the Coal-measures is widely different on either side of a line which may be drawn through Mangotsfield to a point north of Bristol. The beds north of this line have for the most part a meridional strike, nearly parallel with the present Cotteswold escarpment ; south of this line the strike is mainly east and west, though much curved in the neighbourhood of Radstock and the flanks of the Mendips. Of course, this is only part of an extensive change in the direction of flexure, much of which is still hidden under Mesozoic rocks. Mr. Ussher, in the paper previously quoted, tells us that the line of change of strike may be traced in the general mass of the Palæozoic rocks, from near Brecon in South Wales to the neighbourhood of Frome. This means that within the Bristol district two distinct systems of flexure must have impinged on each other in Post-Carboniferous times. Have we not here, then, another instance of extraordinary change within the limits of our area ? This time it is not a mere change in the nature of a deposit, like that of the Old Red Sandstone into the Devonian, or of the Carboniferous Limestone into the Culm-rock, but a change in the direction of the elevatory

[1] Proc. Cottes. Club, vol. vii (1878), p. 73.

forces, which had made its mark on the structure of our Island even at that early date.

At this point I ought to quit the Palæozoics; but there is just one subject of interest which claims a momentary attention, viz., the probability of finding workable coal east of the proved Somersetshire field. I avoid the question of coal south of the Mendips as being too speculative, on account of the chances of deterioration of the Coal-measures in that direction. But in view of the forthcoming meeting of the British Association at Dover, the question of finding coal to the eastward of Bath becomes a specially interesting subject for discussion. It is also a matter of some consequence whether the hidden basin or basins belong to the meridional or to the east and west system of flexures. The latter is most likely to be the case.[1] The Vale of Pewsey has been mentioned as a suitable locality for boring along the line of the recognized axis.

But prospectors should bear in mind the warning of Ramsay, that the basins containing coal are but few in comparison with the number of basins throughout the Palæozoic rocks. No doubt the line indicated is more favourably situated for coal-exploration than the Eastern Counties; where, for instance, the Coal Boring and Development Company has lately gone into liquidation. The un-suitability of East Anglia as a field for coal-prospecting was insisted on in my second anniversary address to the Geological Society,[2] and the results seem to have been very much what might have been expected. If coal is to be found beneath the Secondary rocks the line of search should be carried through the counties of Kent, Surrey, Berkshire, and Wiltshire, though the three latter counties have hitherto been content to leave their underground riches un-explored. The Kent Coal Exploration Company is doing some good work with a reasonable chance of success; though if they wish to find coal sufficiently near the surface they had better adhere as much as possible to the line of the North Downs, since operations on the Sussex side are only too likely to be within the influence of the Kimmeridgian gulf, which was proved to exist at Battle (Netherfield). Mr. Etheridge, I hope, will have something to tell us as to the progress of the Kent Collieries Corporation, who now carry on the work at Dover.

Secondary Mesozoic Rocks.

Commencing a totally different subject, I must now direct attention to the 'red beds' and associated breccias so characteristic of Eastern Devonshire. These rest in complete discordance on the flanks of the Palæozoic highlands, and must be regarded as forming the base of the Secondary rocks of that district.

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[1] The boring at Burford, where coal was found at a depth of 1,100 feet, below a surface of Bathonian beds, at a point thirty-five miles E.N.E. of the extreme end of the Bristol Coalfield at Wickwar, is not included in this category; since it must belong to the meridional system, and is altogether outside the prolongation of the axis of Artois.

[2] Quart. Journ. Geol. Soc., vol. L (1894), p. 70.

By the Geological Survey this series has hitherto been mapped as Trias, but in the new "Index Map" they are coloured as Permian. There is no palæontological evidence which would connect them with the fossiliferous Permians, usually regarded as of Palæozoic age, but it has been evident for some time past that opinion was inclining to revert to the views of Murchison and the older geologists, more especially as to the position of the breccias so largely charged with volcanic rocks. The subject was dealt with by Sir A. Geikie in his address to the Geological Society, where he speaks of some of these rocks as presenting the closest resemblance to those of the Permian basins of Ayrshire and Nithsdale.[1]

One difficulty which presented itself to the Devonshire geologists in accepting the Permian age of the 'red beds' was, that the whole of the lower Secondary rocks appeared as an indivisible sequence, proved by its fossils to be of Keuper age at one end, and therefore inferentially of Keuper age at the other. Dr. Irving, however, considered that at the base of the Budleigh Salterton pebble-bed there is a physical break of as much significance as that between the Permian and Trias of the Midlands. In the marls which underlie this pebble-bed he recognized a strong resemblance to the Permian marls of Warwickshire and Nottinghamshire; and Professor Hull, who had been studying the sections east of Exmouth about the same time, ultimately acceded to this view.[2] Its acceptance by the Survey thus throws all the Exmouth beds into the Permian; and that formation, according to the new reading, has an outcrop of some 35 miles from the shores of the English Channel to within 3 miles of Bridgewater Bay. The fertility of these red clays, loams, and marls has long been recognized by agriculturists, and it is not improbable that the abundance of contemporaneous volcanic material may in some measure have contributed to this result.

In conformity with the new mapping, the Budleigh Salterton pebble-bed and its equivalents to the northwards are accepted as of Bunter age, and thus constitute the base of the Trias in the south-west. Like most pebble-beds, they are irregularly developed between the Permians and a strip of reddish sandstone (coloured as Keuper), which runs up from the mouth of the Otter to within a short distance of Bridgewater Bay. The materials of the pebble-beds are not of local origin, like so much of the breccia at the base of the Permian. The general resemblance, both as regards scenery and composition, to the Bunter conglomerate of Cannock Chase has been pointed out by Professor Bonney, who seems prepared to endorse the recognition of the Budleigh Salterton pebble-bed as a Bunter conglomerate. He was not impressed by any marked unconformity with the underlying series. To some extent we may accept this view, since whatever may be the age of the Devonshire

[1] Quart. Journ. Geol. Soc., vol. xlviii (1892), p. 161.
[2] Cf. Irving, Quart. Journ. Geol. Soc., vols. xliv (1888), p. 149; xlviii (1892), p. 68; and xlix (1893), p. 79; and Hull, op. cit., vol. xlviii (1892), p. 60.

breccias and 'red beds,' they, in common with the Trias, must have been deposited under fairly similar physical conditions in a sort of Permo-Triassic lake basin.

The bulk of the Trias, including the Dolomitic Conglomerate of the Bristol district, is still regarded as of Keuper age, though it is now admitted, as insisted on by Mr. Sanders years ago, that the Dolomitic Conglomerate does not necessarily occupy the base of the Keuper, but is mainly a deposit of hill-talus, which has been incorporated with the finer deposits of the old Triassic lake as the several Palæozoic islands gradually became submerged. The great blocks which fell from the old cliffs were formerly regarded as proofs of glacial agency, and there are persons who still believe, more especially with respect to the Permian breccias, that such rocks are indicative of a glacial origin.

In the " Index Map " the Dolomitic Conglomerate and the Red Marl are thus included under the same symbol and colour. But this is also made to include the Rhætic—an arrangement which is hardly in accordance with the facts observed in the Bristol area. On a small-scale map so narrow an outcrop as that of the Rhætic could hardly be shown ; yet its affinities are probably with the Lower Lias rather than with the Trias. The late Edward Wilson, whose recent death we all deplore, in his paper on the Rhætic rocks at Totterdown,[1] showed most clearly that the ' Tea-green marls,' which had previously been associated with the Rhætic, represent an upward extension of the Red Marls of the Trias, in which the iron had suffered reduction ; although there are indications of a change of conditions having set in before the deposition of the Rhætics. The black Rhætic shales which succeed usually have a sharp and well-defined base in a bone-bed with quartz pebbles, etc., indicating a sudden change of physical conditions, though perhaps no marked unconformity. In the South Wales district the Rhætic limestones are said to be largely of organic origin and, in addition to a Rhætic fauna, to abound in the lamellibranchs so plentiful in the lowest Lias limestones.[2]

The late Charles Moore always deplored the comparative poverty of the Trias in fossils. In his last communication to the Geological Society,[3] he set himself to describe certain abnormal deposits about Bristol, and to institute a comparison with the region of the Mendips. He then suggested, on the faith of a sketch by Mr. Sanders, that the famous Durdham Down deposit, already inaccessible, might have been a fissure-deposit in the Carboniferous Limestone like those at Holwell. He also stated that at one time he had been inclined to regard the Reptilian deposit on Durdham Down as of Rhætic age ; but the discovery of teeth of *Thecodonto-saurus*, identical with those of Bristol, in a Keuper Marl deposit near Taunton, induced him to refer the Durdham Down deposit to the middle of the Upper Keuper. He had arrived at the conclusion

[1] Quart. Journ. Geol. Soc., vol. xlvii (1891), p. 545.

[2] Ann. Rep Geol. Survey for 1896, p. 67 (1897).

[3] Quart. Journ. Geol. Soc., vol. xxxvii (1881), p. 67.

that the same genera of vertebrata are found in the Keuper and Rhætic beds, though the species, with few exceptions, are quite distinct.

But it is with the Lias that the name of Charles Moore is most intimately associated. Time does not permit me to do more than allude to the wonderful collections of Rhætic and Liassic fossils made by him from the fissure-veins of the Carboniferous Limestone, or of the treasures which are stored in the Bath Museum. There never was a more enthusiastic palæontologist, and nothing pleased him better than to exhibit the fossilized stomach of an *Ichthyosaurus*, stained by the ink-bag of the cuttle-fish, on which it had been feeding, or some similar palæontological curiosity. Everyone here knows how deeply the West of England is indebted to Charles Moore for his unceasing researches, and I have been thus particular in alluding to them because it was under his auspices that I first became acquainted with the geology of this part of the country just thirty years ago.

Amongst more recent work in the Rhætic and Lias I might mention papers by Mr. H. B. Woodward and Mr. Beeby Thompson, each in explanation of the arborescent figures in the Cotham Marble. The latter revives an old idea with modifications, and his theory certainly seems plausible. Mr. H. B. Woodward's Memoir of 1893 does full justice to the Lias of this district, and much original matter is introduced.

It is, however, in the Inferior Oolite that the most important interpretations have to be recorded since the days when Dr. Wright and Professor J. Buckman endeavoured to correlate the development of the series in the Cotteswolds with that in Dorset. To this subject I alluded at considerable length in my address to the Geological Society in 1893, pointing out how much we owed in recent years to the late Mr. Witchell and to Mr. S. S. Buckman. In the following year appeared Mr. H. B. Woodward's Memoir on the Lower Oolitic Rocks of England ("Jurassic Rocks of Britain," vol. iv), wherein he did full justice to the work of previous observers. Meantime Mr. Buckman has not been idle, and his paper on the Bajocian of the Sherborne district [1] marks the commencement of a new era, where the importance of minute chronological subdivisions, based upon the prevailing ammonites, is insisted on with much emphasis. This system he considers to be almost as true for the Inferior Oolite as for the Lias.

There can be no doubt that its application has enabled Mr. Buckman to effect satisfactory correlations between the very different deposits of the Cotteswolds and those of Dorset and Somerset. In subsequent papers also he brings out an important physical feature, viz., the amount of contemporaneous denudation which has affected deposits of Inferior Oolite age in this country. This serves in part to explain the absence of well-known beds in certain areas. For instance, in the Cotteswolds contemporaneous

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[1] Quart. Journ. Geol. Soc., vol. xlix (1893), p. 479.

erosion has, prior to the deposition of the Upper *Trigonia*-grit, cut right through the intervening beds, so as to produce in the neighbourhood of Birdlip a shelving trough six miles wide and about 30 feet deep. Thus the extensively recognized overlap of the *Parkinsoni*-zone is accentuated in many places.

We have a further instance of good work in the case of Dundry Hill. An inspection of the 1-inch Survey map would lead one to suppose that the Inferior Oolite there rests directly on the Lower Lias. Recently, owing to the investigations of Messrs. Buckman and Wilson,[1] this apparent anomaly has been removed, whilst beds of Middle and Upper Lias age and even Midford Sands have been recognized. In this way the authors claim to have reduced the thickness assigned to the Inferior Oolite on Dundry Hill by about 100 feet. In the paper above quoted the vicissitudes and faunal history of the Inferior Oolite from the *opalinus*-zone to the *Parkinsoni*-zone inclusive are shown with much detail; whilst the position of the chief fossil-bed in time and place has been well established. The general resemblance of the Dundry fossils to those of Oborne, which I could not fail to notice in working out the Gasteropoda of the Inferior Oolite, now admits of explanation. Although the quondam *Humphriesianus* - zone is richly represented, yet the particular *Humphriesianum*-hemera is held to be absent at Dundry. But if there be a *Sowerbyi*-bed anywhere it should serve to connect these two localities, where, according to Mr. Buckman's phraseology, the principal zoological phenomenon is the acme and paracme of *Sonnininæ*.

Mr. Buckman, as we have seen, is no longer satisfied with the old-fashioned threefold division of the Inferior Oolite, and his time-table includes at least a dozen hemeræ, with prospect of increase. Granting that it would have been difficult to solve the Dundry problem without a detailed knowledge of ammonite horizons, there arises the question as to the utility of such minute subdivisions for the purposes of general classification. Mr. Buckman has earned the right to put forward, if he pleases, the several stratigraphical rearrangements in which from time to time he indulges. The Inferior Oolite has been his especial playground, and, as the kaleidoscope revolves, this formation is perpetually made to assume different proportions, even to the verge of extinction. But this practice is not without its disadvantages; whilst the invention of new names tends to clog the memory, and the novel use of old ones is apt to produce confusion.

We have not quite finished with Dundry yet, since that classic hill serves to illustrate in Mesozoic times a peculiarity of which I have already pointed out two notable instances in this district, where an abrupt and seemingly unaccountable difference is observed in beds which are approximately synchronous. The problem to be solved is this—Why does the fossiliferous portion of the Inferior

[1] Quart. Journ. Geol. Soc., vol. lii (1896), p. 669. Cf. also Proc. Brist. Nat. Soc., vol. viii (1897), pt. 2, p. 188.

Oolite on Dundry Hill resemble that of the neighbourhood of
Sherborne, both in lithology and fossils, rather than that of the
Cotteswolds, only a few miles distant?

Nine years ago Mr. Buckman offered an ingenious solution of this
difficulty;[1] although his recent investigations at Dundry, and
especially his appreciation of the effects of contemporaneous erosion,
may have caused him to alter his views. Like most people who
wish to account for strong local differences, he placed a barrier of
Palæozoic rocks between Dundry and the southern prolongation
of the Cotteswold escarpment. At that time it was not fully
realized that the Inferior Oolite in the Bath district is, for the
most part, limited to the *Parkinsoni*-zone, so that the comparison
was really being made between beds of different age as well as
different physical conditions. The question resolves itself into one
of local details, which are not suited for a general address. Still,
I think it may be taken for granted that, notwithstanding the east-
and-west barrier of the Mendip range, which acted effectually
previously to the *Parkinsoni*-overlap, there was in some way
a communication by sea between Dundry and Dorsetshire, more
especially during the *Sowerbyi*-stage, and this most probably was
effected round the western flank of the Mendips. Thus, without
acceding to the necessity for a barrier facing the southern Cottes-
wolds, we may readily believe that much of the Inferior Oolite of
Dundry Hill is to be regarded as an outlying deposit of the Anglo-
Norman basin. If this be so, it is difficult to avoid the conclusion
that the low-lying area of the Bridgewater flats was, during part of
the Inferior Oolite period, occupied by a sea which was continuous
from Sherborne to Dundry, and that, although the barrier of the
Mendips was interposed, communication was effected round the west
flank of that chain. This would make a portion of the Bristol
Channel a very ancient feature.

We must now take a wide leap in time, passing over all the rest
of the Jurassics, and just glancing at the Upper Cretaceous system,
which reposes on the planed-down surface of the older Secondary
rocks. The remarkable double unconformity is nowhere better
shown than in the south-west of England. Some of the movements
of the older Secondary rocks, prior to the great revolution which
brought the waters of the Cretaceous sea over this region, have been
successfully localized by Mr. Strahan, more especially in the south
of Dorset.

Owing to Tertiary denudation the Chalk in this immediate
district has been removed, and we have no means of judging
the relations of the Cretaceous deposits to the Palæozoic rocks
of Wales. If we may judge by results recently recorded from
Devonshire[2] the Lower Chalk especially undergoes important
changes as it is traced westwards, and, generally speaking,
terrigenous deposits seem more abundant in this direction. At the

[1] Proc. Cottes. Club, vol. ix (1890), p. 374.
[2] Cf. Jukes-Browne and Hill, Quart. Journ. Geol. Soc., vol. lii (1896), p. 99.

same time the more truly oceanic deposits, such as the Upper Chalk, appear to be thinning. As regards the possible depths of the Cretaceous sea at certain periods, we are supplied with some interesting material in Mr. Wood's two papers on the Chalk Rock,[1] which has been found especially rich in Gasteropoda at Cuckhamsley, near Wantage.

Tertiary, Pleistocene, and Recent.

Although the Tertiaries of the Hampshire basins are within the "Index Map" which we have been considering, they may be regarded as beyond our sphere. Some of the gravels of Dorsetshire, which have gone under the name of plateau gravels, are held by Mr. Clement Reid to be of Bagshot age. Many of the higher hill gravels most likely date back to the Pliocene, and even further, and represent a curious succession of changes, brought about by meteoric agencies, where the valley-flat of one period, with its accumulated shingle, becomes the plateau of another period—an endless succession of revolutions further complicated by the Pleistocene Cold Period, which corresponds to the great Ice Age of the north.

In the more immediate neighbourhood of Bristol, since some date in Middle Tertiary time, the process of earth-sculpture, besides laying bare a considerable amount of Palæozoic rock, has produced both the Jurassic and Cretaceous escarpments as well as the numerous gorges which add so much to the interest of the scenery. These phenomena have been well described by Professor Sollas,[2] when he directed an excursion of the Geologists' Association in 1880. Should any student wish to know the origin of the gorge of the Avon at Clifton, for instance, he will find in the Report an excellent explanation of the apparent anomaly of a river which has been at the trouble of sawing a passage through the hard limestone, when it might have taken what now seems a much easier route to the sea by way of Nailsea.

The origin and date of the Severn Valley is a still bigger question, and this was broached by Ramsay, some five-and-twenty years ago, in a suggestive paper on the River-courses of England and Wales.[3] He there postulates a westerly dip of the chalk surface, which determined the flow of the streams in a westerly direction towards the long gap which was being formed in Miocene times, near the junction of the Mesozoic with the Palæozoic rocks. The still more important streams from the Welsh highlands had no doubt done much towards initiating that gap; and by the end of the Miocene period, if one may venture to assign a date, the valley of the Severn, which is one of the oldest in England, had already begun to take form, though many of the valleys of Wales are probably much older.

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[1] Quart. Journ. Geol. Soc., vol. lii (1896), p. 68, and vol. liii (1897), p. 377.

[2] Proc. Geol. Assoc., vol. vi (1881), p. 375.

[3] Quart. Journ. Geol. Soc., vol. xxviii (1872), p. 148.

We may now be supposed to have arrived at a period when the physical features of this immediate district did not differ very materially from what they are at present. The great Ice Age was in full force throughout Northern Europe, and, according to views which meet with increasing favour, the German Ocean and the Irish Sea were filled with immense glaciers. What was taking place at that time in the estuary of the Severn ?

This is a case which requires the exercise of the scientific imagination, of course under due control. There is probably nothing more extraordinary in the history of modern investigation than the extent to which geologists of an earlier date permitted themselves to be led away by the fascinating theories of Croll. The astronomical explanation of that ' will o' the wisp,' the cause of the great Ice Age, is at present greatly discredited, and we begin to estimate at their true value those elaborate calculations which were made to account for events which in all probability never occurred. Extravagance begets extravagance, and the unreasonable speculations of men like Belt and Croll have caused some of our more recent students to suffer from ' the nightmare.'

Nevertheless Croll, when he confined his views to the action of ice, showed himself a master of the subject, and his suggestions are often worthy of attention, even when we are not convinced. Writing in the GEOLOGICAL MAGAZINE in 1871, he points out that the ice always seeks the path of least resistance ; and he refers to the probability that an outlet to the ice of the North Sea would be found along the natural hollow formed by the valleys of the Trent, the Warwickshire Avon, and the Severn. Ice moving in this direction, he says, would no doubt pass down into the Bristol Channel and thence into the Atlantic. Again,[1] referring to the great Scandinavian glacier, he says : " It is hardly possible to escape the conclusion that a portion of it at least passed across the south of England, entering the Atlantic in the direction of the Bristol Channel." These views were not based on any local knowledge, but merely on general considerations. The problem as to whether there are any traces of the passage of such a body of ice in the basin of the lower Severn must be worked out by local investigators. Irrespective, too, of the hypothetical passage of a lobe of the North Sea glacier, we are confronted by a much more genuine question, namely, what was the possible termination towards the south of the great body of ice with which our more advanced glacialists have filled the Cheshire plain.

A recent President of the Cotteswold Field Club, of whom unfortunately we must now speak as the late Mr. Lucy, took a lively interest in the Pleistocene geology of the district, and his papers in the Proceedings of the Cotteswold Field Club have always attracted attention. His map of the distribution of the gravels of the Severn, Avon, and Evenlode, and their extension over the Cotteswold Hills, prepared in conjunction with Mr. Etheridge, is a valuable contribution

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[1] GEOL. MAG., Dec. II, Vol. I (1874), p. 257.

to the history of the subject.[1]   Again, he wrote on the extension
of the Northern Drift and Boulder-clay over the Cotteswold Range,[2]
and on this occasion described the interesting section in the
drifts presented by the Mickleton Tunnel.   In his previous paper
Mr. Lucy had carried the drifts with northern erratics to a height of
750 feet, but he now claimed that " the *whole* Cotteswold Range had
ceased to be dry land at the time the Clays and Northern Drifts
passed over it."   We perceive from this passage that Mr. Lucy was
a ' submerger,' and in this respect differed from Croll, who most
probably would have attributed the phenomena to the action of his
great ice-lobe traversing the south of England.

The question which more immediately concerns us relates to the
value of the evidence which would require either a glacier or
a ' great submergence ' to account for these things.   The alleged
phenomena are in many cases capable of other interpretations.   We
have the authority of Mr. Etheridge that little or no true Boulder-
clay occurs in the Cotteswold area.[3]   On the other hand, the
distribution of much of the erratic gravel is probably due to
agencies of earth-sculpture long anterior to the great Ice Age.
There remains one special piece of evidence adduced by Mr. Lucy
in favour of his contention, and this he considered of so much
importance that it formed the principal part of the subject of his
annual address to the Field Club on quitting the chair in 1893.[4]

He there referred more especially to the discovery *in* the Inferior
Oolite, on Cleeve Cloud, of quartzose sand and of a boulder of
a similar character to some described in his previous papers.   The
sand and the boulder, he says, belong to the period of the great
submergence.   Similar sand also appears in several places on the
hillside.   He had previously recorded boulders of Carboniferous
Limestone, Millstone Grit, etc., in the northern Cotteswolds, but
not at so great an elevation.   He further proceeds to account
for the absence of striæ, and of the fact that the Cotteswold rocks
are not *moutonnée*, on the supposition that the soft oolites would
not retain striation, but would be crushed by pressure.   Con-
sequently, he claims the top of Cleeve Cloud as a fine example of
' glacial denudation,' whatever that may mean.   The boulder from
Cleeve Cloud is now in the Gloucester Museum, and might well
become a bone of contention between the submerger and the
glacialist as to how it got into its elevated position of over
1,000 feet.   Fortunately there is a third explanation, which, if
it be correct, shows how dangerous it is to build theories, as well
as houses, upon sand.   Other distinguished members of the
Cotteswold Club are of opinion that the whitish sands on Cleeve
Common belong to the ' Harford Sands,' which constitute an
integral part of the Inferior Oolite itself.   There may be some
difference of opinion as to the concretionary nature of the boulders,

[1] Proc. Cottes. Nat. Club, vol. v, pt. 2 (1869), p. 71.
[2] Op. cit., vol. vii, pt. 1 (1878), p. 50.
[3] Proc. Cottes. Nat. Club, vol. xi (1893), p. 83.
[4] Vol. cit., p. 1.

though these may well be nothing more than the 'doggers,' or
'potlids,' so characteristic of calcareous sandstones. Mr. Winwood
believes that "the so-called foreign boulder" in the Gloucester
Museum evidently came from the 'Harford Sands.'

So far, therefore, the evidences of glacial action in the Cotteswolds
do not rest on a very sure foundation. Yet the Severn Valley
separates that range from an area on the west, where there are
clear evidences of local glaciation, as described in the Annual
Report of the Geological Survey for 1896. Portions of this
material find their way into the river bed and elsewhere as Drift
which has most probably been rearranged; hence the so-called
Boulder-clay and Drift in the bed of the Severn. Once more,
then, in the cycle of geological time we perceive that our district
lies on the confines of two distinct sets of phenomena. West of
the Severn and north of the Bristol Channel the evidences of
considerable local glaciation are obvious, whilst this can hardly
be said of the Cotteswolds, the Mendips, or the Quantocks.

To the more recent geological history of our district it will be
sufficient to allude in the briefest terms, when I remind you of the
paper by Mr. Strahan on the deposits at Barry Dock, and the still
later one by Mr. Codrington on the submerged rock valleys in
South Wales, Devon, and Cornwall. Here we have important
testimony to certain moderate changes of level which have taken
place, and a picture is presented to us of the Bristol Channel as
a low-lying land-surface, with streams meandering through it.
Thus a depression of something like 60 feet appears to be the
most recent change which the geologist has to record in the estuary
of the Severn.

REVIEWS.

I.—Contribution à l'Étude Micrographique des Terrains Sédi-
mentaires. I. Étude de quelques dépôts siliceux secondaires et
tertiaires du Bassin de Paris et de la Belgique. II. Craie du
Bassin de Paris. Par Lucien Cayeux, D. ès Sc. 4to; pp. 589,
pls. x, and 20 figures in the text. (Lille: Le Bigot Frères,
1897.)

IN this elaborate work Dr. Cayeux gives the results of an extended
series of investigations into the minute structure of the sedi-
mentary rocks mainly of the Paris Basin, but including as well some
in the North of France and adjoining areas in Belgium. The age of
the rocks treated of ranges from the Jurassic to the Eocene, but the
greater number belong to the Cretaceous Series, from the Albian to
the Senonian, or, in English terms, from the Gault to the Upper
Chalk with *Belemnitella mucronata.* The author's aim has been, by
a close study of the present characters of the deposits, to ascertain
their natural history, and to trace the effects of the various
mechanical, chemical, and physiological agencies to which they

have been subjected, and thus to gain an idea of their original structure and of the conditions under which they were formed. The work has been carried on by means of microscopic sections, chemical analyses, and more particularly by the study of the residues after treatment of the calcareous rocks with acid.

The first part of the volume contains a description of the siliceous deposits known in France and Belgium under the names of 'Gaize,' 'Meule,' 'Smectique,' 'Têtes de Chat,' 'Rabots,' and 'Tuffeau.' Other synonyms of the Gaize are 'Grès Vert,' 'Craie tufau,' 'Pierre morte,' and 'Pouzzolane.' Typical Gaize is a soft, porous, dirty gray or yellow siliceous rock of a sandy texture, with a varying amount of soluble silica in its composition. It frequently contains harder compact nodules, comparable in some respects to chalk flints, but unlike them in not being sharply delimitated from the softer matrix. It is as a rule rich in the débris of siliceous organisms, with variable amounts of quartz (sand-grains) and glauconite, also in some instances a small proportion of carbonate of lime. These constituents are usually cemented together by opalized or by chalcedonic silica. It may be said in passing that the 'Gaize' corresponds with those siliceous beds in the Lower and Upper Greensand of this country generally referred to as 'Chert,' 'Malm,' 'Sponge-rock,' etc.

Deposits of Gaize are prominently developed on three distinct horizons in France: (1) in the Oxfordian beds of the Middle Jurassic Series in the Ardennes; (2) in the Albian (= Lower Gault), also in the Ardennes; and (3) in the Cenomanian (= Upper Greensand) in Argonne and Pays de Bray.

The Jurassic Gaize, in the zone of *Amm.* (*Cardioceras*) *Lamberti* and *Amm. Mariæ*, is only known in the Ardennes, where it attains a thickness of about 50 metres. The soluble silica varies in different specimens from 9 to 56 per cent., and glauconite forms one-tenth of the rock. The organic constituents are principally minute rounded, oval or kidney-shaped, siliceous bodies, which are sufficiently numerous to constitute one-third to one-half of the rock, and with these are fractured siliceous sponge spicules. In some examples both the matrix and the rounded bodies are replaced by calcite. The author recognizes the similarity of these rounded and reniform bodies to those first described by Dr. Sorby from the corresponding horizon in the Calcareous Grit of Yorkshire, but he does not consider them to belong to *Geodia* sponges, owing to the absence of the corresponding skeletal spicules, and to the hollow condition in which many of these bodies now occur. It has, however, been shown that definite sponges occur in the Yorkshire beds apparently wholly made up of these peculiar rounded bodies (Quart. Journ. Geol. Soc., vol. xlvi, 1890, p. 54), a fact which Dr. Cayeux seems to have overlooked.

The Gaize of the Albian zones of *Amm. mammillaris* and *Amm. interruptus* is partly a soft porous rock, partly a coarse glauconitic grit; one sample yielded 28 per cent. of soluble silica. Spicules of

Monactinellid, Tetractinellid, and Lithistid sponges abound in the beds; they are now mainly of opal, but some are of chalcedonic silica. Not infrequently the spicules have been dissolved, and their empty casts remain in a cement or groundmass of amorphous silica.

The Gaize of Argonne in the Cenomanian zone of *Amm. inflatus* has a thickness of 80 to 105 metres. The amount of soluble silica ranges from 5 to 56 per cent. Sponge-remains in some beds constitute half the rock; they are of opal, chalcedony, pyrites, glauconite, or merely hollow casts. There are also a few Radiolaria, some doubtful diatoms, and, where lime is present, a few Foraminifera, belonging to *Textularia, Globigerina*, etc. The cement is mostly of colloid silica, frequently in the condition of minute globules, like those in the sponge-rock of the Upper Greensand of this country.

The Gaize of the zone of *Amm. Mantelli* in the Department of Cher, is very similar to that of Argonne. The soluble silica in it varies from 15 to 35 per cent.; the sponge-remains constitute from one-tenth to one-eighth of the rock, and there are likewise a few Radiolaria. The cement of this Gaize is also largely of globular colloid silica.

In the Gaizes above mentioned sponge spicules form the essential element. They vary considerably in numbers in different beds: in some they are estimated to form one-half, in others not more than one-tenth of the rock. Radiolaria and diatoms are present, but in very insignificant proportions, and occasionally a few Foraminifera. In the softer and friable kinds of Gaize the silica of the cement or groundmass is colloid in character, but in the harder kinds it is in the form of chalcedony. The author does not consider that the silica of the cement in the Gaize is entirely due to sponge remains, but that a certain proportion of it is derived from the decomposition of the argillaceous constituents of the rock; the evidence for this, however, is not by any means convincing.

The Meule de Bracquegnies, near Mons, belonging to the zone of *Amm. inflatus*, is practically of the same character as the Gaize of Argonne. The soluble silica ranges up to 25 per cent.; some beds are nearly wholly composed of sponge débris, in others this forms about one-half the rock.

In the vicinity of Liège and in the district of Herve (Belgium) the rock known as Smectique, belonging to the zone of *B. quadrata* (= Upper Chalk), consists of marls and glauconitic sands from 20 to 30 m. in thickness. It contains 15 per cent. of soluble silica. The rock is rich in sponge remains, now converted into chalcedony; it has also some well-preserved Radiolaria, a few diatoms, and a considerable number of Foraminifera. Unlike typical Gaize, the cement in this rock is mainly calcareous.

The deposits of 'Tuffeau' of Eocene age which occur in the North of France and in Belgium are very similar in character to the Gaize and Meule. They may be described as greenish or greyish glauconitic sands with argillaceous and calcareous materials, and a cement of soluble silica. Some beds are hard and tenacious, others

friable. Sponge spicules, and in some instances diatoms, appear to have furnished the soluble silica, which varies in amount from 11 to 27 per cent.

A chapter is devoted to the study of the glauconite so common in the Gaize and Tuffeau. The author brings forward evidence to show that a considerable proportion of this material has been formed long after the deposition of the beds in which it now occurs, and consequently that its origin is entirely independent of organic matter.

Chapter VI contains a description of the Radiolaria occurring in the Smectique de Herve. Though limited in numbers, there is a great variety of forms present, which are placed under twenty-seven genera. The predominant forms belong to the Discoidea, and mainly to the family Porodiscida; the Cyrtoidea are also well represented. Two or three new genera are proposed : one of these, *Monostylus*, appears to be a synonym of *Dorysphæra*, Hinde (Ann. and Mag. Nat. Hist., ser. VI, vol. vi, 1890, p. 52). The rock containing these Radiolaria is regarded as a terrigenous rather than a pelagic deposit, since sand grains are present in it; the organisms are, however, altogether too few to give the rock any pretension to be radiolarian in character.

The second part of the volume contains a detailed description of the composition of the Turonian and Senonian Chalk of the Paris Basin. The different areas treated of are : the North, Pays de Bray, Rouen and district, South-East, South-West, West, and North-West of the Basin. The Turonian Chalk is subdivided into the zones of *Actinocamax plenus, Inoceramus labiatus, Terebratulina gracilis*, and *Micraster breviporus*, and the Senonian into those of *Micraster cor-testudinarium, M. cor-anguinum*, and the Chalk with Belemnitellas. The composition of the Chalk of the respective zones in each area is given, showing the various kinds of organic remains, the nature of the minerals in the residues, whether formed in the rock or of clastic derivation, and also the nature of the cement.

Excepting in the Turonian beds of the Nord and Pays de Bray, the proportion of mineral residues in the Chalk of the Paris Basin— leaving the argillaceous material on one side—is less than 1 per cent. Quartz or sand grains are the most important constituents. The grains range on an average between 0·04 mm. and 0·12 mm. in diameter, but in all the deposits there are some reaching to 0·2–0·4 mm. They are mainly angular, with blunted edges; some are rounded, and a few crystals have been formed *in situ*. Many other kinds of mineral grains are associated with the quartz, such as zircon, tourmaline, rutile, magnetite, apatite, chlorite, etc.

Quartzite pebbles (galets) and fragments of schist occur not infrequently in the Senonian beds in the vicinity of Lille. Most of them are between 2 and 8 grams in weight; the largest noticed weighed 300 grams (= 10 oz. av.). They resemble some of the primary rocks of the Ardennes.

The principal secondary minerals formed in the Paris Chalk, in addition to flints, are glauconite, phosphate of lime, calcite, pyrite,

limonite, manganese, quartz, opal, etc. Glauconite occurs through-
out, both as casts of organisms and as independent grains. The
phosphate of lime is either amorphous or crystalline ; some of the
grains are free from all connection with organisms and formed in
place. The nodules of this material have a strong preservative
influence on the organisms, whether calcareous or siliceous, which
they inclose. They are more numerous in beds which indicate some
disturbance or interruption of the normal conditions of deposition.

The calcite in the Chalk occurs in isolated rhombohedric crystals,
which are very generally distributed ; these are oftentimes dissolved,
leaving perfect geometrical cavities. This dissolution frequently
takes place in an apparently capricious manner ; certain bands of
Chalk retaining the crystals, whilst in alternating bands they are
completely removed. The rock with the hollow casts is usually
soft and friable, that with the crystals hard and durable ; and in
beds where the calcite crystals have been partially dissolved, the
portions intact appear as nodular masses inclosed in a soft matrix.

With respect to the flints, the author considers that they may
have been formed at several periods in the history of the Chalk in
which they now occur, and, further, that in the Paris Basin the
amount of silica they represent bears a close relation to the number
and volume of the sponge spicules in the same beds which have been
replaced by calcite. The rarity or absence of flints in the Chalk
cannot be taken as a reliable index of the part played by sponges in
the particular beds, for the silica of the sponge remains may be
dispersed through the Chalk in the form of minute colloidal globules,
instead of being aggregated into flints, or it may have been carried
by solution into lower beds.

Of the organic remains in the Paris Chalk, the débris of Molluscan
and Brachiopod shells occurs throughout ; more particularly is
this the case with the detached prisms of the shells of *Inoceramus,*
which in certain beds near Lille, at the top of the Turonian and at
the base of the Senonian, are sufficiently numerous to form nine-
tenths of the Chalk.

Polyzoa are very largely developed in some of the Turonian
Chalks of the South-West of the Basin, where even the finer particles
of the beds are mainly composed of their comminuted remains.
Echinoderm fragments are present at all horizons, but they are less
abundant in the Turonian than in the lower part of the Senonian.
Corals play an uncertain part, possibly on account of their aragonitic
character.

Though detached sponge spicules occur throughout the Chalk of
the Paris Basin, it is necessary to dissolve a considerable amount
of the Chalk to obtain them in the residues. Occasionally large
numbers are present : for instance, in some beds at Meudon they are
estimated to form one-fifth of the rock, and in the *M. cor-anguinum*
zone at Maintenon, one-fourth. The most constant horizon for
sponge-remains in the Paris Basin is at the summit of the Turonian.
The *I. labiatus* and *T. gracilis* beds of the South-West and West
of the Basin are distinguished by the abundance of Lithistid

spicules and the scarcity of Hexactinellid forms; whilst, on the other hand, the zone of *M. breviporus* is characterized by Monactinellid and Tetractinellid spicules. In the Senonian, Hexactinellid spicules appear in the residues. Detached spicules of Calcisponges are found in all the Chalk beds.

The remains of siliceous sponges are now only exceptionally preserved in colloid silica; most commonly they are replaced by calcite or by glauconite, and more rarely by pyrites, phosphate of lime, or by limonite. The author notes the rarity of empty casts of spicules in the Chalk as compared with those in the Gaize, but this may be less than appears, since the empty casts are very inconspicuous in the Chalk, and careful observation with a lens is needed to distinguish them.

The author also calls attention to the fact that Lithistid spicules are not replaced by glauconite the same as spicules of other groups of sponges in the Chalk. The explanation of this appears to be that the replacement of siliceous spicules by glauconite is effected by way of infilling of their axial canals; and as in the skeletal spicules of Lithistids the axial canals are, as a rule, very slightly, if at all, developed, replacement by glauconite does not occur. The spicules (so termed) in nearly all the groups from the Chalk figured by the author are, in fact, merely the solid infilling by glauconite of the enlarged axial canals of genuine spicules: this is shown by the even thickness and the truncation of the ends of the spicular rays. The contrast between these glauconitic replacements and actual spicules may be seen in the figures of a group of the latter (fig. 13, p. 290) from the upper zone of the Turonian Chalk of Rouen.

A few Radiolaria have been observed at different horizons in the Chalk; they are more numerous in the Senonian. In some instances they retain their siliceous structure; in others this has been replaced by calcite or phosphate of lime.

The proportion of Foraminifera in the Chalk examined varied from 5 to 80 per cent.; the maximum amount was found in the Turonian Chalk of the Rouen district. Forms of *Globigerina* are stated to play a subordinate *rôle* as compared with those of *Textularia* and *Rotalia*. The thickness of the foraminiferal tests varies considerably in different beds, and probably indicates variations of depth in the seas of the period.

Diatoms have been but rarely observed; on the other hand, Coccoliths and Rhabdoliths are present everywhere, the former by far the most numerous. The author regards them as pelagic Algæ.

The cement or matrix of the Paris Chalk is composed of fine particles derived from the breaking up of the various organisms, the microscopic Algæ, and crystals of calcite; it varies in amount from one-tenth to nine-tenths in different beds and localities. In every sample of chalk examined the organisms present show traces of dissolution, and there is no evidence of any direct chemical deposition of carbonate of lime from the sea-water.

The author unhesitatingly considers the typical Chalk of the Paris Basin, such as that of the Pays de Bray, the Rouen district, and the

East and South-East areas, as pelagic sediments. This typical Chalk consists of 90–98 per cent. of carbonate of lime; the proportion of silica is, in general, insignificant, save in the *I. labiatus* zone, which shows an analysis of 14 per cent. ; the argillaceous materials do not, as a rule, exceed 1 per cent. The Senonian chalks, which are now poor in micro-organisms, were probably originally foraminiferal in character. The changes which have taken place in the original sediments tend to produce a crystalline calcite in which all traces of organization have disappeared.

In the two concluding chapters of the work a comparison of the Chalk with the recent *Globigerina* ooze is made, and the conditions of the Cretaceous sea considered. The author's opinion that the depth of this sea at the time of the greatest depression, when the *Belemnitella* chalk was forming, did not exceed 150 fathoms, certainly does not err on the side of excess.

The work is illustrated by some excellent phototypes of sections of different kinds of Gaize and beautifully executed lithographic plates of Radiolaria, enlarged sections of Chalk, glauconite, and other minerals.   G. J. HINDE.

II.—THE GEOLOGY OF THE COUNTRY AROUND BOURNEMOUTH. By CLEMENT REID, F.L.S., F.G.S. Memoirs of the Geological Survey. 8vo; pp. iv, 12, with 14 illustrations. (London, 1898. Price 4*d*.)

IN our July number we noticed the recently published Geology of Bognor issued by the Geological Survey; we have now to announce a companion memoir on Bournemouth, in explanation of the New Series Map Sheet 329. The Director-General, in his preface, briefly refers to previous geological works, while the author gives a concise account of the geological features. Reference is especially made to the labours of Mr. J. Starkie Gardner, who has done more than any other geologist to make known the life-history of the Eocene strata on the Hampshire coast. Figures are given of a number of the characteristic Barton fossils, and it is interesting to observe that most of the species were illustrated more than 130 years ago by Brander. The strata noted are the Upper Chalk, the entire Eocene series, the Headon Beds, and various Pleistocene and Recent deposits.

CORRESPONDENCE.

THE SUBMERGED PLATFORM OF WESTERN EUROPE.

SIR,—Mr. Jukes-Browne's letter in the September number of the GEOLOGICAL MAGAZINE must not be left without some reply, notwithstanding that I have since dealt with its subject in some detail at the Bristol meeting of the British Association. The facts and

arguments I there brought forward may possibly modify his views on the question of the submerged physical features of the North Atlantic.

Mr. Jukes-Browne objects to the term 'escarpment' as applied to the great declivity along which the Anglo-Continental platform terminates, both on the ground of its great lateral extension and because of its elevation. These are only matters of degree. The question is really one of form, and to my mind on the ground of form the term is correct; the declivity has a terraced upper surface, has a descent, sometimes almost precipitous, and falls off in a slope, sometimes gentle, at its base into the abyssal plain. Putting geological structure aside, which in this case is inadmissible, this is the form of the escarpments of the Oolite, New Red Sandstone, Millstone Grit, and older rocks in this country and of parts of Europe. I do not know on what ground the writer objects to the range of the Nummulite Limestone along the south of the Nile Delta being called 'technically' an escarpment. Perhaps he has not himself seen its eastern extremity of Jebel Attaka, where it overlooks the Red Sea, and is one of the grandest escarpments I have ever seen as viewed from Suez.

The writer objects to the statement that I have expressed regarding these submerged physical features having been formed under terrestrial conditions; but he omits to mention the one crucial test of their terrestrial formation, namely, the river channels sometimes traceable up to or in proximity to the existing rivers draining the adjoining lands. He was probably not aware when he wrote his letter to what extent I have been able to determine these channels or cañons along the whole coastline from the English Channel to the Tagus. Such channels, with well-defined walls and ever deepening floors as we proceed outwards, cross the continental platform and the great escarpment opening out on the floor of the ocean at depths of 1,000 to 1,500 fathoms. One of these, commencing at the embouchure of the Adour, is so continuous and remarkable that Elisée Reclus, not recognizing its true nature, contents himself with exclaiming " What shall we say of that deep gulf?" etc., and leaves the question for answer to the future! I quite admit that in the absence of this succession of great channels, each one of which becomes accumulating evidence of its true nature, the question of the origin of the escarpment might have remained problematical, and it might have been supposed, for instance, that it represented the edge of a great depression of the ocean bed. But the river channels, which we cannot conceive could have been formed beneath the ocean itself, are, as it seems to me, the unquestionable proof of subaerial origin, both of themselves and of the physical features with which they are connected. Let Mr. Jukes-Browne procure the Admiralty Charts for himself and trace out the isobathic contours by means of the soundings, and then state his conclusions regarding the views which have been impressed on my own mind.

As regards the geological periods during which the features were elaborated, I cannot here discuss the question. I admit that I have

not up till now sufficiently attempted this part of the subject ; I hope
to do so on a future occasion. Meanwhile the elucidation of the
features themselves, the preparation of cross-sections of the sub-
merged cañons, escarpments, and other phenomena, have occupied
so much of my time and have been of such absorbing interest that
I have thought it better to leave the question of geological age
and mode of formation to the future. This part of the subject
I hope to deal with when the paper, now nearly written, shall
have been brought before one of our scientific societies during the
ensuing session.   EDWARD HULL.

OBITUARY.

PROFESSOR DES CLOIZEAUX, MEMB. INST. DE FRANCE.

BORN 1817.   DIED MAY, 1897.

MONSIEUR ALFRED L. O. DES CLOIZEAUX, the eminent French
mineralogist, was a Membre de l'Institut de France and a Foreign
Member of the Royal Society. He was Professor of Mineralogy
in the Museum of Natural History, Paris, and was elected
a Foreign Member of the Geological Society of London in
1884. Sir Warington Smyth, when receiving the Wollaston
Medal of that Society on behalf of M. des Cloizeaux, said : "It
is more especially in the wide and successful application of
Wollaston's invention of the 'Reflecting Goniometer' that Des
Cloizeaux has attained so deserved an eminence, following closely
upon the steps of Professor Miller, to whom, in his admirable
"Manuel," he pays so high a compliment." Des Cloizeaux's first
paper was published 54 years ago, and was the beginning of a long
series treating of the forms and optical characters of crystals.
After being Professor of Mineralogy for eighteen years at the École
Normal Supérieure, he was appointed to the charge of the minerals
at the Musée d'Histoire Naturelle, in which office he remained until
he reached the limit of age prescribed by the rules of the French
Civil Service. His fame rests upon the thoroughness and accuracy
of his systematic investigation of the crystals of minerals, more
especially as regards their optical properties. The results are
incorporated in his "Manuel de Minéralogie," a standard book of
reference. Professor des Cloizeaux died, in the 80th year of his
age, in May, 1897. Monsieur Damour, his friend and co-worker
for fifty-three years, writes : "In everything he applied himself
to the spread of all that he deemed useful, just, and wise. All
those who knew him honoured him and loved him. His name
as a *savant* remains in the history of Mineralogy ; he there
occupies the most honourable place among the founders of this
science, and among those who have contributed to its progress and
advancement."

ORIGINAL ARTICLES.

I.—On Aggregate Deposits, and their Relations to Zones.

By the Rev. J. F. Blake, M.A., F.G.S.

[A paper read at the meeting of the British Association in September, 1898.]

GEOLOGICAL time, like all other kinds of time, can only be measured by the succession of events. If the events considered are constant in their recurrence and uniform in their nature, their *number* will afford the means of measuring the *length* of time. Thus the oscillations of a given pendulum, the rotation of the earth on its axis, and its revolution round the sun are sufficiently constant and uniform to afford a basis for our seconds, days, and years. Of such uniform and constantly recurring events geology affords no examples by which we could measure the length of geological time.

If, on the other hand, we consider a number of consecutive events as terms of a series, we obtain a scale by which to fix the epoch or moment of occurrence of any other event. The terms of this series may be all alike, as the years of a calendar; or they may be recurrent, like morning, noon, and night; or all different, as the succession of monarchs on a throne. Only in the first of these cases can we expect the scale to be of universal application; in the others we know that the morning at one place may be noon at another, and night at a third; while the dynastic succession in one country has no relation to that in another. Now geology supplies us with time-scale events of the two latter kinds only, and we cannot, therefore, expect that the chronology founded on them shall be of universal application—though the wider the application the better the chronology.

The events the succession of which has been applied to establish our geological chronology have been of two kinds—(1) the deposition of strata; (2) the development of the fauna, or in some cases the flora. The use of the former is the stratigraphical, that of the latter is the palæontological method. It would be very wrong, in my opinion, to put these two methods into antagonism with each other, and to argue in favour of one or of the other: they ought never to be divorced. It is as unscientific and misleading to say that the nature of the deposit is of no consequence as it would be to disregard

the specific character of the fossils. There are, moreover, cases in which one method or the other is the only one available, and therefore a widely applicable chronology must be founded upon both. It is the object of this paper to clear away a difficulty that sometimes arises in harmonizing the two methods.

Every species of fossil, considered as an inhabitant of the various parts of the earth to which it at any time extends, has a definite period of existence; and the same is true of every group of allied species, such as used to go in former times under one specific name; but in this case the range in space and time is greater. It follows from this that the epoch of every fossiliferous deposit must not only lie within the period of every fossil it contains, but also within that part where all the periods overlap. The deposit is like a document containing the signatures of numerous individuals, born at different dates and having different lengths of life; it must have been drawn up during the time that they were all alive together.

It was on this principle, which regards the whole of a fauna of a bed, that the classification of strata by zones was first established by Oppel. Unfortunately this principle of assemblages does not lend itself well to nomenclature, and for the purpose of naming the zone some particular fossil had to be selected. Such a fossil should be an abundant one, restricted as to range in time, but little restricted as to range in space. The selection, however, is arbitrary and may be unsuitable, but to the true student of zones it is a matter of comparative indifference; the zonal assemblage of fossils can be recognized without the presence of the particular name-giving fossil.

Amongst the Jurassic rocks, for the study of which the method of zones was first introduced, the greater number of name-giving fossils have been selected from the ammonites, which to a large extent best fulfil the necessary conditions; and this has apparently led in more recent years to an almost exclusive study of these types for the purposes of correlation, and to the practical assumption that the zone and the zone-naming fossil are strictly coterminous. Theoretically the life-history of a species is divided into three parts—its rise, culmination, and decline; or, as they are technically called, the epacme, acme, and paracme—and the zone is supposed to be the deposit formed during the acme. Practically, however, it is seldom possible to trace these three periods, and the presence or absence of the ammonite is all that can be stated. Thus the original idea of the zone is entirely altered. It is characterized no longer by an assemblage of fossils of all classes, each having its own range in time and each contributing to our estimate of age, but by the range of a single ammonite.

So long as the original idea of a zone was held, the occurrence of two of the name-giving fossils in the same bed caused no trouble beyond the suspicion that perhaps the fossil to be used for the name might have been better selected, but under the new idea such a combination is contrary to the practical assumption on which it rests. It becomes, therefore, incumbent on those who make this assumption to show that the combination of two or more zonal

ammonites in one bed is apparent only, and this they attempt to do by asserting that a careful search will show that these fossils occur in their proper position in different portions even of this single band, the older type being found near the bottom and the younger near the top. Theoretically this might be the case. There is no minimum thickness of a zone except that dependent on the fossils it has to contain to be a zone at all, and even in a uniform bed the fossils *might* be arranged in parallel layers one over the other in their proper order as ascertained elsewhere. Without being acquainted with the strata of all the world one is not in a position to say that this never actually occurs, but personally I have never seen an instance in which a careful attention to the lithology would not enable us to indicate a line of separation, however obscure, between the substance enclosing one fauna and that enclosing another, when both are of the ordinary character of more or less tranquil deposit.

The beds, however, which are claimed as multizonal, in all the cases which I have noticed, possess a peculiar character which removes them from the usual category of deposits, and which it is the object of this paper to point out.

The true value of zones is best observed and appreciated in those massive deposits, such as the Lias, the Oxford Clay, and the Chalk, which are disturbed by no episodes, and which do not vary in facies, but whose formation has been continuous through the life-history periods of several fossil species. The fossils in these deposits are found imbedded in what may be called their natural position, that is, they have been buried as they fell to the bottom, or died there, each being covered by subsequent portions of the deposit before their successors were buried above them. All the species that lived and died together lie on one surface in the rock, every portion of which has in fact formed the sea-bottom at successive times. This is well known to fossil collectors, who, finding some desired form in one place, can find others like it by following accurately the line of stratification. In this way every millimetre in the thickness of the rock represents the successive soft sea-bottoms. The multizonal bands are entirely different from this. The fossils in them do not lie in a natural position, but often stand on end; they are not arranged in horizontal bands, but are confusedly mixed together or huddled up in heaps; amongst them there are often broken fragments, often of a *remanié* character, and sometimes of considerable size. Now, according to the theory that considers these multizonal bands as the attenuated representatives of massive deposits elsewhere, the deposition here must have been very slow; but the irregular arrangement, the mixed character of the fossils, and the size of the fragments show that, instead of being very slow, the formation of the deposit must have been very rapid— indeed, tumultuous. The material can only have been brought to its present position by strong currents carrying it along horizontally.

I propose to assign to deposits having these characters the special term AGGREGATES. Although this is proposed in connection with multizonal bands, and is, indeed, intended to suggest how fossils of

different periods may have been brought together, it is not necessary that an aggregate should contain fossils of more than one epoch, the etymology of the word connoting only the assemblage of materials that have been moved horizontally, like a flock of sheep, over the surface of the ground. I would also propose to distinguish by name the two classes of fossils preserved, as noted above, in different ways. The ordinary fossils which are buried where the animals died or fell to the bottom, we may call *autochthonous*; and those which have been drifted to their final resting-place by currents, *heterochthonous*. The shells which lie scattered on the sands by any seashore, when buried will produce autochthonous fossils, while the heaps of dead shells which are crowded together in certain localities, as the island of Herm, Morte Bay, and the estuary of the Thames, will produce heterochthonous fossils.[1]

From these definitions it follows that the fossils of an aggregate are essentially heterochthonous, though they may be accompanied by others which are practically autochthonous. It follows also that we may expect aggregates to be exceptionally fossiliferous, and conversely, when we hear of a bed being exceptionally fossiliferous we may suspect that it is likely to be of an aggregate character. But the most essential point to notice is, that when a bed is an aggregate the fossils in it have not been buried *pari passu* with the formation of the deposit, but existed before it commenced to be formed, so that we have no proof that the fossils it contains belong to the same age as the deposit itself, or that they belong to any single age. This would, of course, be self-evident if the fossils were recognized as *remaniés*. But it is not necessary that a heterochthonous fossil should have been previously buried in a deposit which became sufficiently hard to make a pebble; it may have lain on the sea-floor, even for geological ages, uncovered by deposit, or so slightly covered that it is washed out again by the current when this begins to flow, and is finally buried in the finer mud brought by this current. The extinct bones and teeth which have been dredged up from the bottom of the Atlantic prove the possibility of this.

These extinct sub - Atlantic remains have also a remarkable peculiarity about them which is very instructive in relation to aggregates—they are phosphatized. If phosphatization be connected with the decay of marine organisms it is plain that lying on the sea-bottom must be more favourable to the process than being imbedded even in a porous deposit. No doubt phosphatization can be produced in the heart of a deposit, many autochthonous fossils having phosphatic aureoles—which may have been produced either during the progress of the deposition or subsequently—but, nevertheless, in a large number of cases, when the nature of the deposit, independently of its chemical composition, would lead us to call it an aggregate, we find that it contains phosphatic nodules, and

[1] At the reading of this paper Mr. Lomas instanced also some drifts of dead shells now forming in the Irish Sea, and gave the interesting information that the deposit had been partly phosphatized.

conversely, the great majority of phosphatic deposits are found to be aggregates.

If it be true that an aggregate is formed, as above explained, by means of a strong current sweeping over ground whence it collects the materials in its path, we have to consider what assistance we obtain from it in the matter of chronology. If the fossils are all of one date the deposit is practically of that date also, and we may have a series of aggregates overlying one another, each of a distinct age, in which case their chronology is the same as that of normal deposits. But when aggregates contain fossils of different dates all we can say is, that the deposit is not older than the youngest of its heterochthonous fossils.

When a series of normal tranquil deposits is followed by an aggregate a great change of physical conditions is indicated. The work of rolling along and collecting débris is the result of a disturbance of equilibrium. So soon as this is restored under new conditions the aggregates are left undisturbed, and are followed by a new series of tranquil deposits; or the disturbance may become chronic for a while and produce a series of aggregates. Now geologists indicate these changes of condition by assigning the later deposits to a new series. We may expect, therefore, that aggregates will commonly be basal deposits. As a matter of fact they are more often disputed deposits, but we may safely say that whenever there is a dispute about the lower limit of a series we are almost sure to find that an aggregate is at the bottom of it. The dispute arises from the fact that the deposit contains fossils of older date than its own formation, which, unless its peculiar nature is observed, leads to assigning it either to the age of its older fossils or to drawing a line between two important series in its midst.

It may be well asked — If these aggregates are of so great a significance, have not their peculiarities been noticed long ago? I have no doubt they have been noticed by many field geologists, and certainly it is many years since I first thought about them what is here written; but it is only recently, since ammonites alone have been taken to indicate zones and disputes have arisen, that it has seemed desirable to draw special attention to the nature of these deposits by giving them a name.

I will now point out instances of beds which I take to be aggregates. The first example with which I became acquainted is at Ilminster. In spite of the Geological Survey map, in which Inferior Oolite is marked as lying directly on Lower Lias, the late Mr. Charles Moore had shown that Upper Lias fossils were obtained near that town. When I was specially studying the Lias between 1873 and 1876 I visited the locality, and all I could find was a kind of consolidated gravel in which were imbedded numerous rolled specimens of *Ammonites serpentinus, communis,* and *bifrons,* which in Yorkshire occupy distinct horizons, but were here all confusedly mingled together. I came away with the conviction that I had failed to find the true Upper Lias, and that these beds were

disturbed and perhaps redeposited. I now know that, though I certainly failed to find the Fish-bed with its truly autochthonous fossils, it is these very rubble-beds which have been taken to indicate the several ammonite zones. I should now call them an aggregate, and assign the date of its formation to the commencement of the Inferior Oolite period.

Another example is the Gloucestershire Cephalopoda-bed as seen at Frocester Hill. The underlying sands appear to be normal deposits, and they contain Liassic ammonites, but the four feet or more which constitute the capping contain numerous species of ammonites and other fossils all confusedly mixed together, so that no definite subdivision of the bed is possible. The mingling in this bed of Liassic ammonites with others of later date has led to much dispute over its correlation. Its character suggests that it is the commencement of a new series, and the other fossils strongly confirm this view, for many are found in the Inferior Oolite and not in the true Lias, the most noticeable perhaps being *Pholadomya fidicula.* It is not a case of passage beds at all, but of a marked break, with a mere mechanical mingling of fossils of different horizons. If its peculiarity as an aggregate is overlooked, we might unite a part of it with the sands below as forming a single zone—that of *A. striatulus*—as has actually been done, thus comprising within the limits of a zone the junction (according to what appears to me to be the truth) of two formations and certainly of two deposits of an entirely different character, and containing to a large extent a different fauna.

It was a similar phenomenon, observed in Russia last year on the occasion of the visit of the International Geological Congress, that persuaded me of the great importance of observing the character of these aggregates, so as to avoid the confusion that otherwise arises. In the upper part of the " Jurassic " rocks of that country, there occurs a well-marked ammonite whose transverse ribs seem collected into bundles, and hence it is called *Ammonites* (or *Virgatites*) *virgatus.* This species is taken as a zonal ammonite, and all deposits which contain it are grouped together as a single zone by those who are guided by ammonites alone. In the greater number and most accessible of its localities it occurs as a heterochthonous fossil, in spite of which it has been taken to characterize the epoch of the deposit. In one locality, however, it is found in underlying beds as a truly autochthonous fossil. It there occurs in thin bituminous shales, exactly of the character of our own Upper Kimmeridge clay, and is accompanied by the characteristic fossils, *Lingula ovalis* and *Discina latissima.* There can be no doubt, therefore, that its true home is the Upper Kimmeridge. In the same locality it occurs also in the overlying aggregate deposit as heterochthonous fragments, and is accompanied by a different group of other fossils. We have here, then, the following alternative : either a single ammonite may survive the change from a very tranquil deposit, following on a long series of similar deposits to a tumultuous one of an entirely different material, followed by other tumultuous deposits, and containing an

otherwise distinct fauna (in which case an ammonite is no guide to the history of physical and faunal changes) ; or the upper bed, though containing the same ammonite, is of later date, the deposit being an aggregate and the fossil heterochthonous, and it marks, as Professor Michalski says, the " first accident of the infra-Cretaceous boreal transgression." In any case, the very distinct nature of the two beds containing the same ammonite cannot be rightly neglected, though the only indication of it, in one of the latest descriptions of the zone, is the heterogeneity implied in the words " Marnes, sables ferrugineux et glauconieux, schistes bitumineux, argiles."

Full of these ideas, I had occasion this spring, in connection with the visit of the Geologists' Association to Bridport, to consider the meaning of that curious deposit in the middle of Thorncombe Cliff, called by Mr. S. S. Buckman " the Junction bed," and claimed by him to contain representatives of at least four separate zones. In explaining the proposed excursion to the Association at their previous meeting, I put forward a sketch of what is here written, and ventured on a prophecy about this bed, which I had never seen and whose lithological structure had not to my knowledge been described in detail, that it would prove on examination to have the characters of an aggregate. A glance at the rock sufficed to show that the prophecy was correct, and I had the satisfaction of hearing some members of the Association who reached it first demonstrate these characters on the spot. I think, therefore, that the views I am here expounding may fairly claim to stand the test of prophecy.

About these four cases I feel pretty certain, but there are several others which more or less probably belong to the same category. The Ludlow bone-bed is possibly one, though its elements being small, the tumultuous character is not so obvious. It is, however, phosphatic, and locally marks the commencement of beds in which the fossils of the underlying rocks are absent and organic remains of a different type take their place. The Rhætic bone-bed of Aust Cliff is probably another. It is full of nodules of all sizes, irregularly arranged, it is phosphatic, and it lies at the base of a new series. The phosphate bed at the base of the Lower Greensand at Potton, with its rolled bones of Jurassic reptiles and fishes, is another. The nodular and phosphatic bed called the " coprolite bed " at Speeton, and the " compound nodular bed " above it, occupying about the horizon of the Russian deposit, and, like it, marking, in my opinion, the commencement of a new series, are further examples. The mixed bed at Beer, recorded by Mr. Jukes-Browne as containing the two zonal fossils *Pecten asper* and *Ammonites Mantelli*, may be similarly explained. The " Cambridge Greensand," which has been shown by the same author to contain both autochthonous and heterochthonous fossils, is in like manner the base of an unconformable series. And, finally, the Mammalian bed at the base of the Red Crag, with its huge rolled bones, its crabs from the London Clay, and its nodules with enclosed ammonites, completes the list of the best known of these aggregates in this country ; and they are not wanting, as I can testify, on the Continent.

I am not here concerned to prove the correctness of these suggestions in every case. It is quite enough to draw the attention of geologists to the necessity of looking out for and interpreting these aggregates ; they will then determine, step by step, which deposits ought rightly to be included in the category.

II.—On the Revision of South Wales and Monmouthshire by the Geological Survey.[1]

By A. Strahan, M.A., F.G.S.

[Communicated by permission of the Director-General.]

THE original geological survey of South Wales was made under the direction of Sir Henry de la Beche. The exact date of its commencement is uncertain, but I am informed by Mr. Aveline that in 1840, when he joined, the staff was engaged in the neighbourhood of Cardiff, and in 1841 Ramsay on his appointment found that the survey had progressed westwards into Pembrokeshire, and was at work at Tenby and St. David's.[2] By the end of 1845 the maps had all been published. A complete list of the names which appear on them consists of H. T. de la Beche, J. Phillips, D. H. Williams, A. C. Ramsay, W. T. Aveline, J. Rees, T. E. James, W. E. Logan, H. W. Bristow, and H. B. Woodward.[3]

Previously, however, to the entry of the Survey into South Wales, a considerable tract had been mapped by Sir W. E. Logan. " Unaided he commenced, in 1831, a geological survey of part of the great South Welsh Coalfield, extending from Crown (Cwm) Avon to Carmarthen Bay, and completed it in seven years, at no small pecuniary sacrifice. Such was the estimate of the accuracy and value of this survey by the late Director of the Geological Survey of Great Britain, Sir Henry de la Beche, that with Sir William's consent it was adopted as part of the national work."[4] At the meeting of the British Association in Liverpool in 1837 Logan exhibited his work, and in 1842 it was referred to by De la Beche as a beautifully executed map.[5] After the lapse of nearly fifty years these maps, admirable though they were considering their date and the circumstances under which they were made, had become obsolete. Not only was the topography scarcely recognizable, but the development of the steam-coal trade had led to the opening out of many of the Monmouthshire and Glamorganshire valleys and the working of what was practically a virgin coalfield. On June 8, 1891, in the House of Commons, Lord Swansea (then Sir Hussey Vivian) asked the Vice-President of the Council whether in

[1] Read before Section C (Geology), British Association, Bristol, September, 1898.
[2] " Memoir of Sir Andrew Crombie Ramsay," by Sir Archibald Geikie, 1895, p. 42 ; London, 8vo.
[3] Revisions chiefly of the Secondary Rocks in 1864, 1871, and 1872.
[4] An article in *The Times* of July 24, 1862, by Dr. Percy, quoted in " Life of Sir William E. Logan, Kt., LL.D., F.R.S., F.G.S.," by B. J. Harrington, 1883, p. 349 ; London, 8vo.
[5] Ibid., p. 127.

view of the great importance of the South Wales and Monmouth-
shire Coalfield, and the fact that the coalfields of Durham,
Northumberland, Yorkshire, and Lancashire had been for the most
part geologically surveyed on the 6-inch scale, he would give
directions that the geological survey of the mineral districts of
South Wales and Monmouthshire should be immediately taken in
hand and vigorously prosecuted on that scale. Answer was made
that it would be arranged with the Director-General that the survey
should be commenced as soon as possible, and prosecuted as
vigorously as the size of the disposable staff of the surveyors and
the exigencies of the other branches of the work would allow.
The revision was commenced five weeks later, and its progress up
to date forms the subject of the following note.

Until the year 1893 I was engaged alone upon the revision, but
in that year I was joined by Mr. W. Gibson, in 1894 by Mr. J. R.
Dakyns, and in 1895 by Mr. R. H. Tiddeman. In 1896 Mr. Dakyns
retired, and his place was taken by Mr. T. C. Cantrill.

The area over which the revision will extend is embraced in the
New Series 1-inch Ordnance Maps, 226–232, 244–249, 261–263,
sixteen sheets altogether, and amounts to a little over 2,000 square
miles. Of these, three sheets (249, 232, 263) have been published,
one (248) is being engraved, while the surveying of two more
(231, 262) is nearly complete. The total area surveyed by the end
of 1897 amounted to 1,006 square miles, in which 5,011 miles of
geological lines had been traced upon the maps.

The work is engraved on the 1-inch New Series Ordnance Maps
only, but the lines are all traced in the field on the 6-inch maps.
Clean copies of these working maps are deposited in the Office, and
can be consulted or copied as soon as the corresponding 1-inch
sheet is published. At the same time sheets of vertical sections
illustrating the Coal-measures are prepared: two of these, giving
series of shaft-sections in Monmouthshire and Eastern Glamorgan-
shire, have been published, and others are in preparation.
Explanations to accompany each sheet of the map are also being
written : in these the local geology will be briefly explained; but
it is proposed to describe the Coalfield as a whole in a separate
volume when the revision is complete.

I take this opportunity of acknowledging, on behalf of my
colleagues and myself, the invaluable assistance which we have
received from the managers, engineers, and surveyors in our work
in the Coalfield. Without such aid the mapping would have been
impossible, and the unvarying courtesy with which it was rendered
has greatly facilitated a task that was far from easy. Of the
important information recorded in the " Proceedings " of the South
Wales Institute of Engineers, and the Cardiff Natural History
Society also, we have freely availed ourselves, acknowledgement of
all of which will be made in due course.

In order that the map of the Coalfield should present the
structure as conspicuously as possible, it was necessary to subdivide
the great mass of Coal-measures which had been represented by

one tint only on the old map. At the eastern end of the field it
was apparent that a suitable threefold division of the strata held
good, the three divisions not only differing in their mineral contents,
but presenting such physical features as lent themselves to the
purposes of the geological surveyor. I wish, however, to point out
that no correlation is intended with the Upper, Middle, and Lower
Coal-measures of other fields. Not only is it extremely improbable
that any representatives of the Upper Coal-measures exist, but it is
an open question how much of the Middle Coal-measures are present
in South Wales. The subdivisions referred to consist of :—

1. An upper series of shales and felspathic sandstones with a few
thin seams of coal and ironstone. The sandstones are often in-
distinguishable from Pennant, but the series is softer on the whole
and forms cultivated land of flowing contour. For its base the
Mynyddislwyn Vein, a valuable and constant house-coal, served
conveniently.

2. The Pennant Series, which in Monmouthshire is made up
almost wholly of hard, current-bedded, highly felspathic grit, with
a few thin and impersistent coal-seams. This series forms un-
cultivated moorlands, intersected by deep valleys with rugged sides.
At its base occurs the seam variously known as the Red Ash,
Tillery, Brithdir, or No. 2 Rhondda.

3. The Lower Coal Series (Steam Coal Series of Glamorgan-
shire), which consists principally of shales and thin beds of quartz-
grit. This series contains the thickest seams of coal and the bands
or nodules of clay-ironstone which were formerly worked in South
Wales. It crops out all along the margin of the Coalfield, but is
exposed only in the deepest valleys or along the crests of the
anticlines in the more central parts.

Through the eastern end of the field these three subdivisions are
readily distinguished, but they expand rapidly westwards, and at
the same time sandstones not to be distinguished from Pennant
appear in the upper part of the lower series, while measures of the
supra-Pennant type replace the upper grits of the Pennant group.
They continue, however, to form the most suitable broad divisions
that could have been selected, though a further subdivision may
become necessary in view of their increasing thickness.

The other rock-groups have been treated on similar principles.
The Old Red Sandstone of Monmouthshire at once lends itself to
division into an upper series of grits and quartz-conglomerates,
a thick mass of red sandstones, and a great underlying deposit of
red marls with thin limestones. Special attention has been paid to
the relations of these subdivisions to one another in view of the
possibility of an unconformity having remained undetected in the
middle of the red strata; but though the grits and quartz-con-
glomerates disappear in Brecknock, no break of any significance in
the sequence has yet been discovered. The conformity of the Old
Red Sandstone to the Upper Silurian rocks of Usk, however, may
prove to be more apparent than real, and must remain an open
question for the present.

The Carboniferous Limestone also expands westwards and south-wards, for, while only 100 feet thick at Abergavenny, it is 500 to 700 feet in northern Glamorganshire, and attains still greater dimensions in the southern part of that county. The lower portion consists of shales with a more or less persistent limestone below, which constitute the Lower Limestone Shales. In the main mass no subdivision has been made, except that certain light-coloured oolitic bands have been picked out.

The mapping of the Millstone Grit is founded on purely litho-logical distinctions. Over a large part of the north-eastern crop it consists of a grit (the Farewell Rock of old miners) in the upper part; shales, and sandstones, occasionally with some coal and iron-stone, in the middle; and a massive grit, usually crammed with quartz-pebbles, in the lower part. This order, however, does not hold good everywhere, and shales and sandstones are traced as far as practicable, and merely coloured on the map as such. Though perfectly conformable to the limestone, the oncoming of the quartz-conglomerates seems to have been accompanied by some erosion, for they fill small hollows in the topmost limestone, and are even suspected of cutting across some of the beds, so as to simulate an unconformity. Matters are further complicated by the fact that the upper surface of the limestone has undergone extensive dissolution during later ages.

Some fossils which occur in calcareous shales and thin impure limestones in the lower and middle parts of the Millstone Grit are all marine, but in the upper part *Anthracomya* becomes the abundant shell, and indicates an approach to Coal-measure conditions. Marine forms, however, recur at intervals high up in the Lower Coal Series. It will be noticed that there is nothing corresponding to the ' Yore-dale Rocks,' or upper part of the Carboniferous Limestone Series of the North of England, nor to the alternating series of sandstones and limestones which border the Flint and Denbigh Coalfields.

The Secondary Rocks which fall within the revised area include Trias (Keuper or New Red Marl), Rhætic, and Lower Lias. These strata were deposited along a land which was undergoing gradual submergence after prolonged exposure to subaerial denudation. The New Red Marl, consequently, was irregularly distributed in what must have been bays diversified by numberless islands, and the old shore-lines, though subsequently buried, have been revealed by denudation, so that it is often possible to examine the cliffs against which the Triassic waves beat and the talus, more or less water-worn, which fell from them. The continued sinking of the land led not only to the Rhætic overspreading the Trias, and extending beyond it, but to the Lias eventually overlapping all earlier deposits. Each formation, as it overlaps its predecessor and comes into contact with the Palæozoic rocks, becomes conglomeratic, and it thus happens that a conglomeratic subdivision though actually continuous is of Triassic, Rhætic, and Liassic age in different parts of its outcrop; a state of affairs which is not easily represented by the usual methods of colouring a geological map.

The boundary between the New Red Marl and the Rhætic has hitherto been taken at the base of some green marls which graduate downwards into the Red Marls, but during the revision it became evident that the only satisfactory base to the Rhætic occurred above the Green Marls and at the base of the black shales of the *Avicula contorta* zone. At this horizon there is generally a grit or small quartz-conglomerate which taken with the incoming of the Rhætic fauna indicates a somewhat sudden change of physical conditions. It marks, in fact, the first complete invasion of this area by the sea.

One of the most important parts of the revision has consisted in the tracing of the various folds and faults through the Coalfield. The main anticlinal and synclinal axes are of course brought into prominence on the map by the subdivision of the measures before referred to. Thus the difference of tint shows the positions of the two deep synclines which introduce the Upper Coal Series at Caerphilly and Llantwit on the south side, and at Blackwood and Gelligaer on the north side of the main anticline; while the anti-clinal axis is itself brought into prominence by the fact that it brings the Lower Coal Series up to the surface at intervals along its course. Especially, also, attention may be directed to the contrast presented by the long dip-slopes of the north crop of the Coalfield to the straight and narrow strips along the highly inclined south crop. Of the numerous flexures which have been traced in the Palæozoic rocks outside the Coalfield it is sufficient to state that they run in about the same direction as those mentioned above, and that they do not affect the Secondary Rocks, which in fact pass horizontally across them. These east and west flexures are consequently assumed to be pre-Triassic.

To this series also we believe the great Vale of Neath disturbance and some other kindred folds to belong. This great faulted fold seems to have attracted but little notice hitherto, though it displays many remarkable features, among others a thrust by which Carboniferous Limestone has been pushed over a large thickness of Millstone Grit. It will be remembered that the Carboniferous Rocks of Somerset were still more intensely plicated and overthrust in pre-Triassic times, and that there also the disturbances run in a general east-and-west direction.

The set of faults which run about north-north-west with such remarkable persistency is a well-known feature of the Coalfield. Some of them can be traced out into the Secondary area, and are there found to dislocate the Secondary Rocks equally with the Carboniferous. While, therefore, they are obviously post-Liassic, they may be of very much later date.

The exact representation of the faults, of whatever age, upon the map is of the greatest importance in the Coalfield, and is managed as follows :—The surface-position of the fault is indicated by a white line, or by a broken white line where the exact position is uncertain. If the fault has been proved in the workings of the Mynyddislwyn Vein, its underground position in that vein is shown by a red line, if in the Tillery Vein by a yellow line, and if in the Lower Coals

by a blue line. Thus a normal fault completely proved would be represented by four lines, the order in which the lines occur indicating the direction, and their distance apart the angle of the hade. A further difficulty remains, however; for the plan-position of a fault encountered in any vein in working up to it from the east would not be the same as the plan-position of the same fault in the same vein if worked up to from the west, owing to the hade. In a fault of 100 yards the discrepancy would amount to 35 or 40 yards, and it becomes necessary to record also from which side the fault was proved, which is not always easily ascertained in old workings. The coloured lines referred to are used on the 6-inch maps only; on the 1-inch maps the underground faults are all shown by yellow lines to avoid undue complication.

The glacial deposits are mapped simultaneously with the solid geology, and are shown on the edition of the map for superficial geology. With the exception of the admirable work of Professor Edgeworth David, and observations by the late Rev. W. S. Symonds, they have not attracted so much attention as they deserve, for South Wales formed a small independent centre of glaciation and exhibits phenomena of great interest. The greater water-partings of the present day formed the ice-partings of the Glacial Period, and the principal valleys gave the route to the ice-flow. Thus a great mass of drift was transported from Brecknock round the north-east corner of the Coalfield down the Usk Valley as far as the depression occupied by the Usk Branch Railway. Another part was pushed over a minor water-parting into the Rhymney Valley, but principally escaped along the Taff Valley, traversing the entire Coalfield and emerging by the ravine at Walnut Tree; while a third portion flowed south-westwards along the Neath and other valleys towards Swansea Bay. The drift consists in part of coarse gravels or fine gravel and sand, and forms characteristic mounds or ridges between which are inclosed innumerable water-logged hollows, or meres. Nearer to its source, however, it becomes an extremely tough boulder-clay packed with glaciated boulders. The composition of the deposit, the direction of the longer axes of the mounds, and, lastly, a large number of striations on rock-in-place combine in determining the directions assigned to the ice-flow. The southern limit to which the ice reached is no less clearly marked than its birthplace, for the gravels get finer and thinner, and eventually die away, sometimes before reaching the shores of the Bristol Channel.

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III.—Blind Trilobites.

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

(Continued from the October Number, p. 447.)

(2) Order Opisthoparia.

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WE now come to the second order of the Trilobita, which Beecher (loc. cit.) calls the Opisthoparia. In common with the third order, the Proparia, compound paired eyes are usually present, and these are invariably situated on the free cheeks, which form part of the dorsal surface of the head-shield.

The development of several genera of the order Opisthoparia has been traced in detail, and in the family Conocoryphidæ, which is placed by Beecher lowest in the order, we find the characters of a pre-adult stage of certain Olenidæ preserved till maturity. In fact, the adult *Conocoryphe* is in the nepionic stage of such genera as *Ptychoparia* and *Sao,* and this fact shows that it belongs to a lower phylogenetic rank. The free cheeks are very narrow and marginal, and the eyes are absent or very rudimentary. Owing, unfortunately, to the loose manner in which the name *Conocoryphe* has been applied, and the confusion arising from its different usage by palæontologists, it has frequently been stated that the genus includes a majority of species possessing compound eyes and a few which are blind ; and, consequently, it has been quoted as analogous to those genera of which the species living in twilight or darkness have almost or completely lost their eyes. Conclusions based on this mistaken analogy are naturally erroneous and misleading. A structural feature which is really of high phylogenetic significance has been misinterpreted as an adaptive modification induced by certain conditions of existence.

The name *Conocoryphe* should be applied in the manner in which its author, Corda,[1] first used it, when he took as its type the well-known blind form *Conocoryphe Sulzeri.* Matthew has insisted on this point, and when the genus is thus restricted so as only to include forms agreeing with this type in important structural characters, a large number of species which are commonly ascribed to this genus have to be excluded. Thus, of the numerous British species which have been described as belonging to the genus *Conocoryphe,* only *C. bufo* (Hicks) and perhaps *C. humerosa* (Salter) can be admitted.[2] Barrande[3] included in his genus *Conocephalites* a large number of species possessing eyes, as well as *C. Sulzeri* and others devoid of eyes, so that *Conocephalites* practically covered Corda's genera *Ptychoparia, Ctenocephalus,* and *Conocoryphe.*

Walcott[4] says that the genus *Conocoryphe,* in its restricted sense, is identical with Emmons' genus *Atops,* and Vogdes[5] takes Corda's *Conocoryphe Sulzeri* (Schlotheim[6]) as the type of the genus *Atops.* Beecher,[7] however, takes this species as the type of the genus

[1] Hawle and Corda, Prodr. Mon. Boh. Trilob., 1847, p. 24, t. ii, f. 10.

[2] *C. Homfrayi* (Salter) is stated to possess eyes, but from a careful examination of the type-specimen, which is much compressed and distorted, I have much doubt if they truly exist. In *C. Lyelli* (Hicks) the free cheeks are marginal, and the eyes which have been described appear to me to be merely the swollen ends of the ocular ridges on the fixed cheeks, and their visual function is doubtful. In cephalic structure this species agrees so closely with the *Conocoryphe,* s.str., of Corda, that after carefully examining the type-specimen, I am inclined to consider it a true member of the genus *Conocoryphe* and to be devoid of compound eyes.

[3] Barrande, Syst. Sil. Boh., vol. i, p. 415.

[4] Bull. 30 U.S. Geol. Surv., 1886, p. 203 ; Amer. Journ. Sci., ser. III, vol. xxxiv (1887), p. 197 ; Fauna of the Olenellus Zone, 1890, p. 647 ; S. W. Ford, Amer. Journ. Sci., ser. III, vol. xix, p. 152.

[5] Bibliogr. Pal. Crust. (California, 1893), p. 255.

[6] Schlotheim, Nachträge z. Petrefakt., ii (Gotha, 1823), pl. xx, fig. 1.

[7] Amer. Journ. Sci., vol. iii (1897), p. 188.

Conocoryphe, and he considers *Atops* to be distinct and its type to be *A. trilineatus* (Emmons). Linnarsson [1] uses the name *Conocoryphe* in the same restricted sense as Walcott. Zittel [2] employs the name *Conocephalites* in the broad manner of Barrande, including the genera *Solenopleura, Ptychoparia, Conocoryphe,* s.str., etc.

Matthew,[3] perceiving the heterogeneous composition of Barrande's *Conocephalites,* splits it up into two divisions, one possessing eyes and the other possessing no eyes. The blind division constitutes, according to him, the subfamily Conocoryphinæ, which consists of two genera—(1) *Ctenocephalus,* type *Ctenocephalus Barrandei* (Corda) = *Conocephalites coronatus* (Barr.), with subgenus *Hartella,* probably including *Conocoryphe solvensis* (Hicks); (2) *Conocoryphe,* type *Conocoryphe Sulzeri* (Schloth.), with a subgenus *Bailiella,* to which perhaps *Conocoryphe bufo* (Hicks) belongs. This subgenus *Bailiella* is not synonymous with Salter's *Erinnys* (type *E. venulosa,* Salter) as Beecher suggests.[4] In *Bailiella,* as defined by Matthew (type *B. Baileyi,* Hartt), there is a facial suture which cuts off the lateral third of the marginal fold. Matthew's [5] other division of Barrande's genus *Conocephalites* consists of those possessing eyes and includes the Ellipsocephalidæ and Ptychoparinæ (*Ptychoparia, Liostracus, Solenopleura*). Hoernes,[6] though remarking on the fact that the facial suture in *C. Sulzeri* and *C. coronatus* is almost marginal, separating only a narrow band-like free cheek, and in this respect differing from that of the other species, yet uses the name *Conocoryphe* in the broad sense so as to include a multitude of very different forms. Koken [7] puts Corda's *Ctenocephalus* and *Conocoryphe* into one genus, which he calls *Conocoryphe.*

The generic name *Conocoryphe* is here employed in the manner which Matthew (loc. cit.) has defined. To the genus *Ctenocephalus,* as also defined by him, belong the British species *Ct. coronatus* (Barr.) and *Ct. solvensis* (Hicks). In both Europe and America these two genera are restricted to the Cambrian, and are especially characteristic of the lower part, which is just as we should expect from their morphology and phylogeny.

Of the other genera belonging to this family we have in Europe *Erinnys* (Salter), *Carausia* (Hicks), *Dictyocephalites* (Bergeron),[8] and the imperfectly described forms [9] *Aneucanthus* (Angelin) and *Eryx* (Angelin).

Erinnys,[10] of which only one species, *E. venulosa* (Salter), is known,

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[1] "Om Fauna i Kalken med Conocoryphe exsulans": Sver. Geol. Undersokn., ser. C, No. 35 (1879).

[2] Handb. v. Palæont., vol. ii, p. 600.

[3] Trans. Roy. Soc. Canada, vol. ii (1884), sect. iv, p. 102.

[4] Amer. Journ. Sci., vol. iii (1897), p. 188.

[5] Trans. Roy. Soc. Canada, vol. v (1887), p. 123.

[6] Manuel de Paléont. (traduit), 1886, p. 462.

[7] Die Leitfossilien, 1896, pp. 21 and 360.

[8] Bull. Soc. Géol. France, ser. III, vol. xxiii (1895), p 469, pl. iv, figs. 4, 5.

[9] Pal. Scand., pp. 4, 5, pl. v.

[10] Brit. Assoc. Report, 1865, p. 285; Quart. Journ. Geol. Soc., vol. xxviii (1872), p. 177.

is considered by some palæontologists to be identical with *Harpides* (Beyrich) ; but *Harpides* is described and figured as possessing eye-spots, whereas *Erinnys* has merely the branching nervures on the cheek, and there are other important differences in its structure which appear amply sufficient to separate it generically.

Carausia (Hicks) [1] is in every respect closely allied to *Erinnys*, and neither genus shows any free cheeks or dorsal facial sutures. Both genera are found in the Menevian beds.

Dictyocephalites (Bergeron) may eventually prove not to be a blind form. It occurs in the Ordovician of Saint-Chinian, but only two imperfectly preserved specimens of it are known. Bergeron considers that it shows resemblances to *Eurycare* (Angelin), but the structure of the head is more suggestive of *Harpides*, and the tubercles on the cheeks resemble eye-spots.

In America there are the genera *Avalonia* (Walcott) and *Bathynotus* (Hall), which, however, may possibly not be blind. *Harttia* (Walcott) is probably only of subgeneric rank.

Beecher (loc. cit.) says in his concluding remarks on this family that "the general average of the characters in the Conocoryphidæ represents the main larval features throughout the other families" of the order Opisthoparia to which it belongs.

The genus *Carmon* (Barrande) [2] is placed by Beecher in this family, but Zittel [3] puts it in the Proetidæ. Only two species of this genus have been described. Of these the first, *C. mutilus* (Barr.), occurs in Étage D*d* 5, and the second, *C. primus*, in D*d* 1. The important point for us to notice is that *C. mutilus* has no eyes or facial suture, whereas *C. primus* possesses both. Barrande (loc. cit.) says these differences are only of specific importance, and he instances *Illænus*, with its blind and eye-bearing species, as an analogous example. Such may be the true explanation, and it is especially probable to be so if the true affinities of *Carmon* are with the Proetidæ. But *C. primus* is only known to us by a head-shield, and though according to Barrande the hypostome of *C. mutilus* resembles that of *Proetus*, yet the thoracic segments and pygidium are more suggestive of the Conocoryphidæ. If its real relations are with the latter family we must regard *C. mutilus* as a solitary survival of a primitive type, and *C. primus* then probably belongs to a different and higher genus. If, on the other hand, we consider that its general characters indicate affinities with higher and eyed forms, such as *Proetus*, we must either regard the absence of eyes and the primitive characters of the head-shield as a sign of reversion or degeneration, probably conditioned by a certain environment, or as an analogous case to *Areia*, which I have described [4] as a primitive form belonging to the Cheiruridæ, in which the normal ontogenetic development has been arrested irregularly

[1] Quart. Journ. Geol. Soc., vol. xxviii (1872), p. 178, pl. vi.
[2] Barrande, Syst. Sil. Boh., vol. i, p. 915, pl. xxxiv, fig. 43. Ibid., Suppl., vol. i, p. 19, pl. ii, figs. 4–6 ; pl. xiv, fig. 45.
[3] Handb. Palæont., vol. ii, p. 625.
[4] GEOL. MAG., Dec. IV, Vol. V (1898), p. 206.

so that the head-shield has retained its early larval features. I do not, however, see that the evidence in favour of putting *C. mutilus* with the Proetidæ, or any other such high group, is stronger than that of putting it in the Conocoryphidæ. It is to be noticed, moreover, that the genus *Proetus* has not been recorded from Étage D, except the doubtful species *Pr.? primulus* (Barr.) from D*d* 1 and *Pr.? perditus* (Barr.) from D*d* 5.

There is considerable uncertainty about the true position of the genus *Holocephalina* (Salter).[1] It is placed by Zittel in his somewhat heterogeneous family Conocephalidæ, together with *Arionellus*, to which, as Salter remarks (loc. cit.), it shows some points of resemblance. There seems to me little reason for associating it with the Asaphidæ, as Beecher does in his scheme of classification. It is very doubtful if eyes are present in either of the two known species, though Salter records them on the minute free cheeks of *H. primordialis*, at the base of the genal spines. The free cheeks in this species consist almost entirely of the genal spines and do not extend along the cephalic margin, and in this way remind us of those forms (e.g. *Trinucleus*) in which the eyes are absent.[2] In *H. inflata* no genal spines or free cheeks are known, and it appears to me that this genus is in reality a Conocoryphid with incipient free cheeks, as in the metaprotaspis stage of *Ptychoparia Kingi*,[3] and that the loss of segmentation in the glabella and other signs of specialization are secondary features, as in *Agnostus*. The fact that *Holocephalina* is confined to such an early stratigraphical horizon as the Menevian is also against regarding it as a degraded or degenerate higher form. *Arionellus* is an allied genus, but it has well developed, though narrow, free cheeks, bearing distinct eyes, which are a mark of a higher stage in the evolution of the cephalon.

Passing now to the family Olenidæ, which is for the sake of convenience split up by Beecher into four subfamilies, we meet first with a group of genera which are generally considered to possess eyes on the free cheeks, though varying much in size and degree of development. But with regard to the genus *Paradoxides* in the subfamily Paradoxinæ, there has long been much dispute as to whether it was possessed of the power of vision or not. By some palæontologists the eye-socket is held to have been occupied by no functional visual organ, but generally this genus is described as furnished with long narrow eyes. Beecher (loc. cit.) does not make any mention of its supposed blindness, nor does Zittel. Salter, Hicks, and other British writers who have described its species always speak of the presence of eyes without suggesting their non-functional nature; but the visual surface and lenses have never been described, and the surface of

[1] Q.J.G.S., vol. xx (1864), p. 337, pl. xiii, fig. 9 ; vol. xxviii (1872), p. 178, pl. vi, figs. 8–10.
[2] Barrande (Syst. Sil. Boh., Suppl., vol. i, p. 156) remarks that, judging from the figures, this species seems to be devoid of eyes.
[3] Amer. Geol., vol. xvi (1895), pl. viii, fig. 6.

the eyes is always spoken of as non-reticulate. Rafinesque[1] puts
Paradoxides in the group Anopsites, the members of which possess
no eyes. Green,[2] in describing *Paradoxides Harlani*, says that
" the organs of vision appear entirely wanting." Milne Edwards[3]
states that there are no reticulate eyes visible in this genus but
that sometimes there exists in their place a fairly distinct scutiform
elevation. Goldfuss,[4] however, includes *Paradoxides* amongst those
trilobites possessing smooth or finely reticulate eyes, which, he says,
are only indicated as cracks in the casts.

After enumerating the genera in which the visual surface is
unknown, Barrande[5] says that it is due to the imperfect state of
preservation in which the Bohemian trilobites of this group occur,
but that this fact does not hinder one from recognizing in the
general form of the eyes that they have the closest analogy with
the reticulate eyes of other genera in which the visual surface has
been observed. He further remarks that *Paradoxides, Olenus*, etc.,
were considered blind by the older palæontologists, doubtless
because the eyes of these genera have usually less prominence, which
is owing perhaps to their natural conformation or the effects of com-
pression. The eyes of *Paradoxides* are described by Barrande as
belonging to the annuloid type. Subsequently he speaks[6] of the
genus as provided with large eyes in contradistinction to its blind
contemporaries.

Emmrich[7] had previously argued for the existence of eyes in
Paradoxides, and thought the reticulation of the surface might
be microscopic.

Steinmann and Doderlein[8] apparently accept the view that the
eyes were functionless.

Matthew,[9] however, in his long description of various species of
Paradoxides from the St. John group, makes no remarks which would
lead one to imagine that the eyes were absent or functionless.
Nicholson, in his " Manual of Palæontology " (p. 519), describes
the eyes as long, reniform, and smooth, and does not hint at the
genus being blind. Suess[10] and Neumayr[11] argue in favour of
Paradoxides being blind because of its association with blind forms.

It should be remembered that some genera (*Arionellus, Sao,
Ellipsocephalus*) have the visual surface of their eyes so rarely or so
badly preserved, that for a long time they were held to be blind.[12]
If the eye of *Paradoxides* be holochroal and the cornea smooth, thick,
and continuous, so as to be practically indistinguishable from the

[1] Atlantic Journ. and Friend of Knowledge, vol. i (1832), p. 71.
[2] Amer. Journ. Sci., ser. i, vol. xxxv (1834), p. 336.
[3] Hist. Nat. Crust., vol. iii (1840), p. 339.
[4] Leonh. and Bronn, Jahrb. f. Min., 1843, p. 546.
[5] Syst. Sil. Boh., vol. i, pp. 131, 145.
[6] Ibid., Suppl., vol. i, p. 161.
[7] Jahrb. f. Min., 1845, p. 18.
[8] Elemente d. Palæont., 1890, p. 490.
[9] Trans. Roy. Soc. Canada, vol. ii (1884), sect. iv.
[10] Das Antlitz der Erde, vol. ii, p. 274.
[11] Erdgeschichte, vol. ii, p. 52.
[12] Zittel, Handb. Palæont., vol. ii, p. 572.

general cephalic integument, the visual surface may very easily escape detection. It is not, however, possible with our present knowledge to determine positively whether the eyes were functional or not. But from the analogy of other forms which were long thought to be blind, and in the absence of indisputable evidence that *Paradoxides* was devoid of the power of vision, we seem to be on the safer side in holding that the long slit-like eyes were of use to the animal. Moreover, it has never been satisfactorily demonstrated that eyes of this type are indicative of degeneration ; and if the form called *Hydrocephalus* by Barrande be indeed the young of *Paradoxides*, as supposed by Beecher,[1] the long eye-lobes are a larval feature in the genus. The undoubted young of *Olenellus*, which belongs to the same subfamily, show also the same feature. The remarks which have been made about the eyes of *Paradoxides* would apply also to a large extent to the genera *Olenellus* (with its subgenera *Holmia, Mesonacis, Olenelloides*), *Plutonides*, and *Zacanthoides*.

The genus *Anopocare* of Angelin,[2] which is described by him as devoid of eyes, may be an immature Olenid, but I have not examined the type.

With respect to the genus *Telephus* (Barrande),[3] there is some uncertainty whether all the species are without eyes or whether some are blind and some are not. What is taken as possibly representing the palpebral lobe in some is described as the cephalic border in others, and we are not in a position to determine which is the correct view. Judging from the figures and descriptions published, I am inclined to think that it possessed an elongated eye-lobe as in *Olenellus, Anopolenus*, etc., and therefore that we must exclude it from the list of blind forms.

We turn now to the family Illænidæ, in which it is most interesting to find that the genus *Illænus* contains undoubtedly a few blind species. The whole head-shield of these blind forms is modified in a reversionary manner, so as to exhibit characters which we have seen mark a definite stage in the phylogeny of the trilobites, or a particular larval stage in those forms which have a complete, non-condensed, and non-accelerated development.

In all the families above the Conocoryphidæ, free cheeks bearing compound eyes are the characteristic feature in the adult, and in the higher and later genera the free cheeks normally exceed in size the fixed cheeks and are of a triangular shape. It is only in the lower forms and pre-adult stages of the higher ones that the free cheeks are narrow, marginal, and band-like. But this latter primitive condition of the free cheeks is found in the blind *Illæni*, in which the facial suture pursues a simple course subparallel to the margin of the cephalon, and the fixed cheek shows no trace of a palpebral lobe nor the free cheek of a compound eye. As these blind species

[1] Amer. Journ. Sci., ser. III, vol. xlvi (1893), p. 142.

[2] Pal. Scand., p. 50, pl. xxvii, figs. 1 and 2.

[3] Barrande, Syst. Sil. Boh., vol. i, p. 890, pl. xviii ; ibid., Suppl., vol. i, p. 155. Angelin, Pal. Scand., p. 91, pl. xli, figs. 21–3. Törnquist, Undersokn. Siljansom. Trilobitf. : Sver. Geol. Undersokn., ser. C, No. 66 (1884), p. 89.

agree in all other respects with those *Illæni* possessing eyes and the normal Illænid structure of the head, we must conclude that they have suffered degeneration of their visual organs, and that it has been accompanied by a reassumption of those primitive features in the free cheeks and facial sutures which are met with in the blind Conocoryphidæ. What has led to the loss of eyesight we will consider later, but we see that we must at any rate regard their condition as a modification of the normal organization of the genus, and not as phylogenetically significant. In other words, we have here to deal with a special adaptive character in contradistinction to one marking a stage in the regular evolution of the group. Similar reversionary or degenerate types in a highly specialized genus or in a family of high morphological rank are occasionally found amongst modern crustacea when surrounded by abnormal conditions in which these organs of special sense are not required.

The blind species of *Illænus* are the following :—

I. leptopleura (Linnarsson),[1] from the *Trinucleus* beds of Sweden.
I. Angelini (Holm),[2] from the same beds and locality.
I. cæcus (Holm),[3] from the Lyckholm Beds (Stage F 1) of Russia, the Keisley Limestone of England [4] and the Kildare Limestone of the Chair of Kildare.[5]
I. galeatus (Reed),[6] from the Keisley Limestone.
I. aratus (Barrande),[7] from Étage D*d* 1, Bohemia.
I. Katzeri (Barrande),[8] from Étage D*d* 1, Bohemia.
I. Zeidleri (Barrande),[9] from Étage D*d* 5, Bohemia.

It is noticeable that the blind forms in Sweden and Bohemia occur in fine argillaceous beds, while in Russia and the British Isles they are found in limestone. This is a significant fact, as it indicates that they lived under entirely different physical conditions in the several areas, and that there is a possibility that different causes have led to the same modification.

In the family Proetidæ no blind genus is known, but in two species of *Proetus*—*P. dormitans* (Richter) and *P. expansus* (Richter)[10]—no eyes have been found. None of the Bronteidæ or Lichadidæ are known to be blind, but amongst the Acidaspidæ there is one blind species of *Acidaspis*, *A. myops* (Richter),[11] which occurs in the

[1] Holm, "De Svensk. Art. Trilobitslag. Illænus" : Bih. t. k. Vet. Akad. Handl., Bd. vii (1882), No. 3, p. 118, t. iv, f. 28 ; t. vi, f. 11.
[2] Holm, ibid., p. 120, t. iv, f. 29.
[3] Holm, "Rev. d. ostbalt. Silur. Trilob.," Abth. iii, Illæniden : Mem. Acad. Imp. Sci. St. Petersb., ser. vii, t. xxxiii (1886), No. 8, p. 162, t. xi, f. 11*a–d*.
[4] Quart. Journ. Geol. Soc., vol. lii (1896), p. 413.
[5] Ibid., p. 593.
[6] Ibid., p. 414.
[7] Syst. Sil. Boh., Suppl., vol. i, p. 68, pl. xiv, figs. 43, 44.
[8] Bull. Soc. Géol. France, vol. xiii (1856), p. 532. Syst. Sil. Boh., Suppl., vol. i, p. 72, pl. v, figs. 28–37 ; pl. vi, figs. 1–4 ; pl. xiv, fig. 36.
[9] Syst. Sil. Boh., Suppl., vol. i, p. 74, pl. iii, figs. 20–29.
[10] Richter, Zeitsch. f. Deutsch. Geol. Gesell., vol. xv (1863), p. 659 ; ibid., vol. xvii (1865), p. 361.
[11] Richter, op. cit., vol. xv (1863), p. 670.

Tentaculites beds of the Continent. In this case, as with the blind *Illæni*, we must regard the loss of eyes as a secondary acquired feature and an adaptation to certain conditions of life.

(3) ORDER PROPARIA.

We come now to the highest order of the trilobites, which Beecher has termed the Proparia. It comprises the families Encrinuridæ, Calymenidæ, Cheiruridæ, and Phacopidæ, and we find amongst them the blind genera *Dindymene, Prosopiscus, Areia,* and *Placoparia.*

The genus *Dindymene* (Corda)[1] belongs to the Encrinuridæ, which is morphologically the lowest family in the order. In this genus free cheeks and compound eyes are wanting, and the facial suture is presumably marginal. The head, therefore, in spite of the secondary specialization of the glabella as shown by its loss of segmentation, exhibits the primitive characteristics of the Hypoparia. Probably this genus is phylogenetically as well as morphologically at the base of the family, as is the case with *Areia* in the Cheiruridæ. It is possible that the tubercle on each fixed cheek in some species (e.g. *D. Hughesiæ,* Roberts) may be a visual organ similar to the eye-spot in the young *Trinucleus,* but of this we have no proof. Only two British species are known, i.e. *D. Hughesiæ* (Roberts),[2] from the Bala beds of Norber Brow, and *D. Cordai* (Etheridge and Nicholson)[3] from the Drummuck beds of the Girvan district.

The genus *Prosopiscus* (Salter),[4] of which little is known, was described as possessing no eyes, and is placed by Beecher amongst the Encrinuridæ.

The genera *Areia* (Barrande) and *Placoparia* (Corda)[5] should probably be included amongst the Cheiruridæ; and from a number of structural features exhibited by these two forms we are led[6] to regard them as early and primitive types of the family in which the ordinary ontogenetic development has been partly arrested, resulting in the retention of some larval characters in combination with secondary modifications. When the loss of visual organs is the result of degeneration or special adaptation, only the head-shield is affected, as is shown by the blind *Illæni*; the process of degeneration does not affect, as a rule, other parts of the body unless their functions are correlated with the sense of sight. The condition of blind cave-animals, with closely allied species provided with eyes outside the cave, teaches us this fact also. So that we are debarred from considering the larval characters in the general body-structure of *Areia* and *Placoparia* as concomitant with or resultant from the absence of eyes. These larval features are not signs of degeneration or adaptation, but are typical of a certain early stage in the evolution of the Cheiruridæ. The early stratigraphical horizon

[1] Hawle and Corda, Prodr. Mon. Boh. Trilob., 1847, p. 119.
[2] S. H. Reynolds, GEOL. MAG., Dec. IV, Vol. I (1894), p. 108, Pl. IV, Figs. 1, 5.
[3] Monogr. Sil. Foss. Girvan, fasc. i (1878), p. 115, pl. viii, fig. 8.
[4] Salter and Blanford, "Palæont. of Niti," 1865.
[5] Hawle and Corda, Prodr. Mon. Boh. Trilob., 1847, p. 128.
[6] GEOL. MAG., Dec. IV, Vol. V (1898), p. 206.

on which these two genera occur (i.e. *Areia* on Dd 1 and Dd 5 in Bohemia ; *Placoparia* in Dd 1 and Dd 2 in Bohemia, and in the Llanvirn of Wales, etc.), and their disappearance before the family reached its maximum of differentiation, point to the same conclusion.

None of the Calymenidæ are analogous to these primitive Cheiruridæ, and none are without eyes.

Amongst the Phacopidæ, one species of the type genus, *Phacops*, is supposed to be without eyes, though possessing the features of one of the most differentiated and latest groups of the genus. This species is *Ph. (Trimerocephalus) lævis* (Münster), and it occurs in the Upper Devonian of England. Salter,[1] while describing the species as devoid of eyes, says that very probably their apparent absence is only due to the imperfect preservation of the specimens. McCoy,[2] however, takes the absence of eyes as one of the characteristics of the subgenus. Barrande[3] reviews the history of this form in some detail, and accepts the view that it is blind. If this be indeed the case, it must be analogous to the blind species of *Illænus*, and of no phylogenetic or ontogenetic significance. For the degeneration of the visual organs we must again seek some pathological or external cause.

Doubtful Genera.

We have now been through all the families of the Trilobita, and discussed their blind forms, but there still remain a few blind genera the position of which is doubtful. We may first mention the blind genus *Typhloniscus* (Salter),[4] from the Lower Devonian of South Africa, which was assigned by Salter to the Cheiruridæ. Another genus whose affinities are uncertain is *Cyphoniscus* (Salter).[5] Only one species (*C. socialis*, Salter) is known, and it occurs in the Upper Bala Limestone of the Chair of Kildare and in the Keisley Limestone. It possesses a facial suture, but no eyes have been observed, and the free cheeks themselves have not so far been discovered. Salter[6] was of the opinion that eyes were present because there were probably separable free cheeks, but as it is now definitely ascertained that there are many blind species which have marginal free cheeks of a narrow band-like form cut off by a simple facial suture, as in this species, it appears probable that *Cyphoniscus* was also blind.

Tiresias (McCoy),[7] first described from the Chair of Kildare Bala Limestone, but recently also from the Keisley Limestone,[8] is destitute of eyes and appears to be allied to *Ampyx*, but only the head-shield is known. *Isocolus* (Angelin),[9] of which the type is *I. Sjögreni*

[1] Mon. Brit. Trilob., 1864, p. 16.

[2] McCoy, Syn. Brit. Pal. Foss., 1851.

[3] Barrande, Syst. Sil. Boh., Suppl., vol. i, p. 158.

[4] Geol. Trans., 2nd ser., vol. vii (1846), p. 221, pl. xxv, fig. 14.   Mon. Brit. Trilob., note on p. 60.

[5] Proc. Brit. Assoc., 1852, p. 60.

[6] Mem. Geol. Surv. Org. Rem., dec. vii, pl. ix.

[7] Syn. Sil. Foss. Ireland, 1846, p. 43, pl. iv, fig. 1.

[8] Reed, Quart. Journ. Geol. Soc., vol. lii (1896), p. 410.

[9] Pal. Scand., p. 58, pl. xxxiii, fig. 8.

(Ang.) from Dalecarlia, is a blind genus, but incompletely known. Törnquist [1] describes it from the *Leptæna* Limestone.

The two genera, *Conophrys* (Callaway) [2] and *Shumardia* (Billings), [3] may be larval forms. Both are blind. Brögger [4] has suggested that the species *Conophrys pusilla* (Sars), from the *Ceratopyge* beds of Sweden, may be the young of *Ceratopyge forficula*. The only known British species is *Conophrys salopiensis* (Callaway) from the Shineton Shales.

The type species of *Shumardia* is *Sh. granulata* (Billings) from Point Levis, Quebec. *Sh. glacialis* (Billings) seems generically distinct.

Origin of Blind Forms.

We have now passed briefly in review all the known blind forms of trilobites, and we see that they fall into two natural divisions, of which the first group comprises those in which eyes are not present because of the low phylogenetic and morphological rank of the genera in question, as their general structure and stratigraphical appearance indicate ; and the second group includes those which are generically identical or closely allied to forms possessing eyes, are of high phylogenetic rank, and have lost their visual organs by a secondary modification, presumably as a result of adaptation to special conditions. In brief, the first group may be called the " primitive group," and the second the " adaptive group." As was mentioned early in this paper, the absence of the compound eyes, which are present in the majority of trilobites, marks a larval stage in the ontogeny of higher forms corresponding with an adult condition in a large proportion of Cambrian genera and species. The phylogeny correlates so completely with the ontogeny that we can have no doubt that we have found the clue to the puzzling question of the meaning of blind trilobites.

Classification.

The following table shows these two divisions of blind trilobites :—

GROUP 1.—PRIMITIVE FORMS.

				RANGE.
Agnostus (Brong.)	...	...	...	Cambrian—Ordovician.
Microdiscus (Emmons)	...	...	...	Cambrian.
Trinucleus (Lhwyd)	...	...	...	Ordovician.
Ampyx (Dalm.)	...	...	...	Ordovician—Silurian.
Dionide (Barr.)	...	...	...	Ordovician.
? *Salteria* (Wyv. Thomson)	...	...	...	Ordovician.
Endymionia (Billings)	...	...	...	Ordovician.
Tiresias (McCoy)	...	...	...	Ordovician.
Conocoryphe, s.str. (Corda)	...	...	...	Cambrian.
Ctenocephalus (Corda)	...	...	...	Cambrian.
Erinnys (Salter)	...	...	...	Cambrian.

[1] Undersokn. ofv. Siljans. Trilob. Svensk. Geol. Undersokn., ser. C, No. 66 (1884), p. 89.

[2] Callaway, Quart. Journ. Geol. Soc., vol. xxx (1874), p. 196 ; ibid., vol. xxxiii (1877), p. 252.

[3] Pal. Foss. Canada, vol. i (1862), p. 92.

[4] Die Silur. Etagen 1 and 2, 1882, p. 125.

RANGE.

Carausia (Hicks)	...	...	...	Cambrian.
Dictyocephalites (Bergeron)	...	...	...	Cambrian.
Eryx (Angelin)	...	...	...	Cambrian.
Aneucanthus (Angelin)	...	...	...	Cambrian.
Anopocare (Angelin) ...	...	...	...	Cambrian.
? *Avalonia* (Walcott) ...	...	...	...	Cambrian.
? *Bathynotus* (Hall) ...	...	...	...	Cambrian.
? *Carmon* (Barr.)	...	...	...	Ordovician.
Holocephalina (Salter)	...	...	...	Cambrian.
? *Telephus* (Barr.) ...	...	...	...	Ordovician.
? *Dindymene* (Corda) ...	...	...	...	Ordovician.
Areia (Barr.) ...	...	...	...	Ordovician.
Placoparia (Corda) ...	...	...	...	Ordovician.
Prosopiscus (Salter) ...	...	...	...	?
Isocolus (Angelin) ...	...	...	...	Ordovician.
? *Typhloniscus* (Salter)...	...	...	...	Lower Devonian ?
? *Cyphoniscus* (Salter) ...	...	...	...	Ordovician.
Conophrys (Callaway) { probably }			...	Ordovician.
Shumardia (Billings) { larval forms }			...	Ordovician.

NOTE.—Special visual organs (eye-spots) are developed in the young of *Trinucleus* and in the Harpedidæ.

GROUP 2.—ADAPTIVE FORMS.

RANGE.

Harpes benignensis, Barr.	...	...	...	E'tage D*d* 1.
Illænus Angelini, Holm	...	...	...	Trinucleus Beds.
—— *aratus*, Barr. ...	...	...	...	E'tage D*d* 1.
—— *cæcus*, Holm ...	...	...	...	Lyckholm Beds, Keisley Limestone, Kildare L.
—— *galeatus*, Reed ...	...	...	...	Keisley Limestone.
—— *Katzeri*, Barr. ...	...	...	...	E'tage D*d* 1.
—— *leptopleura*, Linnars.	...	...	...	Trinucleus Beds.
—— *Zeidleri*, Barr. ...	...	...	...	E'tage D*d* 5.
? *Proetus dormitans*, Richter	...	...	...	Tentaculites Beds.
? —— *expansus*, Richter	...	...	...	Tentaculites Beds.
Acidaspis myops, Richter	...	...	...	Tentaculites Beds.
Phacops (*Trimerocephalus*) *lævis*, Münst.			...	Upper Devonian.

The genera *Dindymene*, *Typhloniscus*, and *Carmon*, which I have with some hesitation placed in Group 1, may have to be regarded as reversionary or degenerate types, on account of their primitive adult cephalic features, combined with general morphological characters which may be found to prove phylogenetic affinity with genera of high rank. But we are not at present able to definitely decide this point. The other genera in Group 1 which are marked with a query (*Salteria*, *Avalonia*, *Bathynotus*, *Telephus*, and *Cyphoniscus*) may be ultimately found to possess eyes.

Barrande [1] gave in 1872 a summary of the blind genera and species found in Bohemia, and incidentally noticed the foreign blind forms. The classification, however, which he adopted took no account of the phylogenetic principles which are now established, and therefore it is to a large extent artificial; but he recognized the fact that the blind forms fall into two natural groups, characterized by the presence or absence of facial sutures. On a comparison of the classification and enumeration in his table as given below with that which I have put forward, it will be perceived that a few additions

[1] Barrande, Syst. Sil. Boh., vol. i, p. 131; ibid., Suppl., vol. i, pp. 155–162.

have been made, and that some alterations have been necessitated by the revised nomenclature, such as in the case of *Conocephalites* and the elimination of the genus *Atops*, upon which I have commented above.

BARRANDE'S GROUP 1.—GENERA OF WHICH ALL THE KNOWN SPECIES ARE BLIND.

(*a*) GENERA RECORDED IN BOHEMIA.

Agnostus, Brong.	*Dindymene*, Corda.
Ampyx, Dalm.	*Dionide*, Barr.
Areia, Barr.	*Placoparia*, Corda.

(*b*) GENERA RECORDED IN FOREIGN COUNTRIES.

Acontheus (= *Aneucanthus*), Angel.	*Microdiscus*, Emm.
Anopocare, Angel.	*Bathynotus*, Hall.
Eryx, Angel.	*Endymion*, Bill.
Isocolus, Angel.	*Shumardia*, Bill.
Atops, Emm.	*Typhloniscus*, Salt.

GROUP 2.—GENERA OF WHICH ONLY SOME SPECIES ARE BLIND.

(*a*) GENERA RECORDED IN BOHEMIA.

Carmon, Barr.	*Illænus*, Dalm.
Conocephalites, Zenk.	*Telephus*?, Barr.
Harpes, Goldf.	*Trinucleus*, Lhwyd.

(*b*) GENUS RECORDED IN FOREIGN COUNTRIES.

Phacops, Emm.

Geological Distribution.

We must now consider the geological distribution of these blind forms. Barrande (loc. cit.) noticed that they were mostly confined to the "Lower Silurian," and in his summary (Suppl., vol. i, pp. 155–162) he brought out the facts of their distribution by means of ratios, showing that the largest proportion occurred in the "Primordial Fauna," amounting to ·296 of the whole number of species of trilobites in Étage C, i.e. eight species out of the twenty-seven recorded from it. In his "Second Fauna" the proportion was less, being only ·2 of the whole, i.e. 25 species out of 127; while in the "Third Fauna" only one out of the 205 species was known. The decrease in the relative abundance of blind forms is thus very marked as we rise in the stratigraphical succession. But out of the total number of blind species in Bohemia about three-fourths occur in the "Second Fauna."

If we now turn to the list I have given of blind forms, and confine our attention first to Group 1—the primitive forms—we shall see that their predominance in the Cambrian is plainly exemplified. Thus, omitting those genera which for various reasons stated above are doubtfully included in this group, or may possibly possess eyes or be immature forms, we find there are eleven genera occurring in the Cambrian, of which ten are peculiar to it and one ranges up into the Ordovician. Nine genera occur in the Ordovician, of which seven are peculiar and one ranges up into the Silurian. Only one genus is known from the Silurian, and this is a survivor from the Ordovician. In the Devonian there is only one, and that is doubtful. As Beecher[1] has shown in a diagram, the Hypoparia are more

[1] Amer. Journ. Sci., vol. iii (1897), p. 182.

numerous in the Cambrian than at later periods, and all the Cambrian
blind genera belong to this order.   In this formation the blind
genera constitute also a much larger proportion of the whole trilobitic
fauna than they do in higher Palæozoic beds.   These facts indicate
that the abundance of blind genera at this geological period marks
a certain stage in the evolution of the Trilobites, and not necessarily
the prevalence of certain conditions which induced as an adaptive
modification the loss of eyes.   In the Ordovician we notice that
all the blind genera which do not belong to this Hypoparian type
are the more or less morphologically primitive ancestors of the higher
families, and still possess many features associated with the lower and
earlier Cambrian forms.   Larval characters are retained in the adult
in spite of secondary specialization, and are accompanied by signs of
progressive differentiation ; as, for instance, in *Areia* and *Placoparia*.
These primitive and ancestral genera have died out when we reach
the Silurian, with the exception of one belated survivor.   We no
longer find the Hypoparia present in any force, and therefore these
trilobites, belonging to the phylogenetic stage anterior to the
evolution of compound eyes, are absent.   All the blind forms which
do occur belong to the higher families and genera, which normally
possess well-developed eyes.   Eyes have been lost in a few species
for special reasons for which we have now to seek ; and we cannot
explain their absence on phylogenetic grounds.

Character of the Rocks.

The character of the rock in which blind genera and species
belonging to both our groups have been found has received con-
siderable attention at the hands of some palæontologists, and much
importance has been attached to it.   But since we have shown that
all the genera in Group 1 owe their want of eyes to their phylo-
genetic position, and that the absence of these organs in their case
cannot be interpreted as a secondary adaptive character, no question
about the manner and materials of deposition apparently concerns
them.   This has not been always recognized, and indeed it is
possible to argue that the persistence and survival of these blind
genera of primitive organization were due to the existence of con-
ditions under which eyes would have been of little or no use.   For
this reason we must look more closely into the character of the
sediment which accumulated, the physical conditions which pre-
vailed, and the fauna which flourished during the existence of the
blind genera of our Group 1.

IV.—On Mr. W. Gunn's Correlation of the Carboniferous
Rocks of England and Scotland.

By Wheelton Hind, M.D., B.S. Lond., F.R.C.S., F.G.S.

ALL students of Carboniferous geology will hail with pleasure
Mr. W. Gunn's masterly paper in the August number of the
Geological Magazine (p. 342), and it is only to be regretted that
the publication of such important stratigraphical facts should have

been delayed for so long; but however useful from the numerous facts it contains, I must take exception to the deductions made from them. The paper is a remarkable one, because, while having for its object the correlation of rocks which occur over a wide expanse of country, no appeal has been made to palæontological evidence to clinch the author's views which are based on purely stratigraphical considerations.

The paper would have been so much more helpful, too, if Mr. Gunn had carried his table of correlations further south, and given his opinion as to the equivalents of the beds shown in his scheme to a typical section of the Carboniferous sequence in Derbyshire; for no correlation of Carboniferous rocks can be satisfactorily established without a consideration of the important Carboniferous sequence of the Midlands.

Mr. Gunn's hypothesis, briefly stated, is, that the Lower Scottish Limestones of the East of Scotland do not represent any part of the Mountain Limestone of Yorkshire, but are the equivalent of the upper part of the Yoredale Series of Phillips, and that the lower part of the Yoredale Series of Phillips and the Great Scar Limestone of Yorkshire are represented in Scotland by the Calciferous Sandstone Series.

Now it is an important fact that the fauna of the Mountain Limestone of Derbyshire and Yorkshire is identical with that of the whole of the Yoredale Series of Phillips and the Great Scar Limestone, and further, that the fauna of the Limestones of the East and West of Scotland is also characterized by the presence of the majority of the same forms; while, on the other hand, the fauna of the Calciferous Sandstone Series is very different indeed, containing only very few species, which go up into the Carboniferous Limestone Series.

I have attempted to show these palæontological results in a paper in the GEOLOGICAL MAGAZINE of February, 1898, and have based a table on them for the correlation of the British Carboniferous rocks, which is very different from that now given by Mr. Gunn; and I believe the recognition that the Yoredale Series of Phillips is nothing more than the upper part of the Carboniferous Limestone of Yorkshire and Derbyshire, which has been split up by wedges of shale and sandstone coming in from the north, to be the key of the problem, a view which the identity of the faunas proves to be almost certain.

A mere consideration of the thickness of the various series of strata tends to the same conclusion. What has happened that the mass of limestone in South Yorkshire is from 2.000 to 3,000 feet thick, while at Ingleborough, a distance of about 20 miles, its supposed representative, the Great Scar Limestone, is only 500 feet thick? What, again, are the representatives in Lower Wharfdale of the 1,000 feet of Yoredale beds in Wensleydale with seven thick beds of limestone?

My contention that the Carboniferous Limestone splits up as it passes north, forming more and more beds of limestones on its way, some of which, however, do not extend as far as others, is splendidly

illustrated in Mr. Gunn's scheme, and is based on the most complete palæontological and stratigraphical evidence ; and these views have been published at length in the GEOLOGICAL MAGAZINE, Decade IV, Vol. IV (1897), pp. 159, 205 ; Decade IV, Vol. V, p. 61.   The Calciferous Sandstone Series, as Mr. Gunn points out, "mainly a fresh-water deposit," is probably almost unrepresented in the Midlands. We know that at Thornton Force, below Ingleborough, only a very few feet of conglomerate exist below the base of the Scar Limestone ; and it is surely a normal state of things that a fresh-water deposit cannot have actual homotaxial equivalents, of wide extent, though, of course, marine and fresh-water beds have been deposited at the same moment in different parts of an area, and may therefore be said to be contemporaneous.   If Mr. Gunn simply means to use the term equivalents in a sense of time, of course it is quite possible that, while some of the beds of the Calciferous Sandstone were being laid down in the north, a deposit of limestone was going on further south, just as that deposit must have been going on while terrestrial conditions obtained in the north, as shown by the various beds of coal.   The Yoredale Series are, however, the real homotaxial and contemporaneous equivalents of the upper part of the Carboniferous Limestone.

The Yoredale type of rocks must have been very local, and seems not to have extended very far west, for the Furness and Shap districts show massive limestones of great thickness quite undivided, and their southern limit appears to be about a line joining Settle with Pateley Bridge, south of which the limestone is quite undivided.

The differences in the Carboniferous succession are due entirely to the conditions of deposit, land being not far away to the north and north-west, so that in the Scottish area, littoral, fresh-water, and terrestrial conditions obtained to a large extent, being replaced by marine beds when the land sank more rapidly, while further south a continuous unbroken deposit of limestone was being laid down.

In order to establish Mr. Gunn's table of equivalence, it will be necessary for him to show a fauna characteristic of the Yoredale Series of Phillips, and to be able to subdivide this fauna into upper and lower and to trace its extension into Scotland, for up to the present there is not a single fossil that can be said to be characteristic of the series.   It would afford some ground, too, for accurate classification if it could be established that any of the limestones themselves possessed a distinctive fauna ; otherwise, however simple it may look in a tabular scheme, the identification of any one bed in a column with one in another is purely theoretical, for different results would be arrived at if a datum-line were taken at the top instead of at the bottom.   For example, the Hardraw Scar Limestone is the fifth limestone below the Millstone Grit at Ingleborough : why should it not be the fifth below the Millstone Grit at Wensleydale, or in Northumberland ?   In fact, correlation without palæontological evidence is absolutely of no value.

V.—On the Age and Origin of the Granite of Dartmoor, and its Relations to the adjoining Strata.

By Alex Somervail.[1]

THE object of this paper is an attempt to furnish proof of what has been a growing conviction in the mind of the writer, that the true age of the Dartmoor granite, and probably its associated line of bosses running south-westwards into Cornwall, might be referable to an interval or period of geological time between the Lower and the Upper Culm, or Carboniferous system.

Up to the present time, as geologists are doubtless well aware, these granite bosses have been considered Post-Carboniferous and Pre-Triassic as to age, and the evidences for this so ably advanced by De la Beche and others have been almost universally accepted. Up to Lower Culm, or Carboniferous times, the nature of the proofs have been of so decisive and convincing a kind as to place the question beyond doubt to the minds of most observers. There are, however, grave doubts and difficulties with regard to the Permian age of the granite. There are no clear proofs that it even belongs to an early portion of that formation ; or that it can in any way be connected with the highly basic lavas of the adjoining Permian strata ; indeed, the evidences for the very reverse of this is the case.

In support of this contention the writer would draw attention to a point which has never before been urged, which appears to him to very materially affect the question as to the true age, not only of the granite of Dartmoor, but also of the other bosses of the same rock already referred to.

In the history of the Culm rocks of South Devon there is what he considers to be a striking gap or break in the sequence between the Lower and the Upper Culm, which without doubt would indicate a prolonged interval of time between these two members of the system, as will immediately appear.

In making use of the term Upper Culm he would more especially to certain conglomerates, grits, and sandstones, which seem only to have a very local development in South Devon. They occur as mere isolated or semi-detached deposits confined to a very limited area in the neighbourhood around Newton Abbot as a centre. The most conspicuous of these deposits are certain conglomerates — coarse, medium, and fine — associated with which are grits and sandstones. These conglomerates are not met with in any of the other extensive general sections where the Lower Culm beds occur, as in the direction of Exeter and the Teign Valley .Neither are they known to occur in the North of Devon. In point of fact these conglomerates show every indication of belonging to a much higher series of beds than any that are elsewhere developed in other portions of the county.

There is a striking lithological contrast presented between this conglomerate series and all the other older members of the Culm in their relations to the granite. The older members are everywhere affected by great earth-movements, bent and plicated sometimes to an

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[1] Read before Section C (Geology), British Association, September, 1898.

extraordinary degree. There is likewise a cleavage structure more or less developed throughout these rocks. With regard to the conglomerate series, the very reverse of all this is the case, and as a rule they repose at low angles and seem to have suffered little disturbance in comparison with the older members of the Culm.

The Lower Culm system has lately received close attention from Messrs. Hinde & Fox in their valuable memoir recently published in the Quart. Journ. Geol. Soc.[1] The Radiolarian cherts and associated beds there described are conclusively shown to have been deposited in a sea of great depth, far removed from the detrital washings of the land ; yet there is the clearest of evidence that this deep-sea bottom was elevated by earth-crust-movements, and even ultimately eroded and wasted, to supply the materials which abundantly occur in the conglomerates just referred to. These conglomerates, in all the various localities where they occur, contain abundant fragments of the Radiolarian cherts, besides those of the other associated rocks of the Lower Culm series.

It has been suggested that the fragments of the Radiolarian cherts may have been brought up to the surface by volcanic explosions. These fragments, however, are as a rule well rounded and water-worn, and they are not accompanied by any true tuff-like matter in the conglomerates. The only intelligible explanation of the fragments of the cherts in the contents of the conglomerates is the long interval separating the former from the latter ; the granting of sufficient time to account for the phenomena of elevation, waste, and reconstruction.

It is most interesting at this point, to note that during the formation and elevation of the Lower Culm there are the clearest proofs of contemporaneous volcanic action. Belonging strictly to this period, there are in the immediate localities concerned numerous examples of eruptive, explosive, and effusive volcanic products, which might have extended over a long period previous to the formation of the conglomerate series. These volcanic outbursts had apparently entirely ceased long before the formation of the conglomerates began to be deposited. It is to the latter portion of this interval—sufficiently long—that the writer would refer the eruption of the Dartmoor granite.

On studying with attention the geological map of the area, it will be perceived that during the early or Lower Culm period the central area of Dartmoor had been long weakened by the extensive volcanic action previously referred to. Volcanic rocks, principally eruptives, are thickly clustered together on each side of what is now the granite—as at Tavistock on the west and in the Teign Valley district on the east side,—running along a line of old pre-granitic fissures. All these volcanic rocks are decidedly Lower Culm in age, but older than the associated granite, as the latter truncates and indurates them.

The central portion of the area of Dartmoor, now occupied by the granite, was clearly a previous centre of volcanic activity

[1] Vol. li (1895), p. 609.

both in Devonian and in Lower Culm times. In the vicinity of the other granitic bosses volcanic action was also active throughout Devonian times, and continued for long periods in these and other parts of the counties of Cornwall and Devon to produce highly basic products; culminating during the Lower Culm period in Devonshire in those very extensive basic products extending in a line through what is now Central Dartmoor.

These long-continued, highly basic products, however, at length came to a close, possibly from sheer exhaustion, and seem to have been followed by the highly acid products which now form the granites of Dartmoor and Cornwall.

Some of the views suggested in this paper occurred to the writer when in Central France, sitting on the basic products of the Puy de Parion, gazing at the trachyte mass of the Puy de Dôme. That enormous mountain of domite, as it is termed, with others in the same chain of puys, together with masses of trachyte elsewhere, if one could exactly explain their history, might throw much light on the granite bosses of Dartmoor. In the case of the Puy de Dôme and other trachyte puys, there are good reasons for regarding these acid protrusions as later than the basic ones, as there are also for the acid magma which now forms our own Dartmoor granite. The Dartmoor granite, though now essentially a portion of a once deeply-seated core, was doubtless formerly represented in its upper and outer portions by a variety of materials—necessarily arising from loss of heat, pressure, and more rapid cooling—of a more trachytitic nature. The boss of granite as it now remains has had stripped from it its more external parts. This even seems true of the Puy de Dôme itself, and other trachyte masses like those of the Rhine district, which certainly have suffered a considerable amount of denudation within the very limited period since their formation.

The question might now be asked—Is the interval between the Lower Culm and the overlying conglomerates, with the included fragments of the former, sufficiently great to allow for the formation or protrusion of the granite? The author is firmly convinced that it is, for the reasons already given. Messrs. Hinde & Fox, in their paper already referred to, say: "It is hardly probable that the Radiolarian beds are directly succeeded by beds of coarse clastic materials, i.e. the Ugbrooke Park conglomerates." The author's own personal observation of these conglomerates impresses him with the fact of their being widely separated in time from the chert series. In addition to the reasons already mentioned, the conglomerate series never seem to occur in direct succession above the lower members of the Culm. They rather seem to rest on their denuded and disturbed surfaces, and many appearances would indicate that the conglomerate series overlap, or are unconformable on the Lower Culm. Indeed, the conglomerate series sometimes rest directly on the Devonian limestones, clearly proving that great denudation of the Lower Culm, and even of the Devonian itself, had occurred previous to the formation of the conglomerates. These unconformabilities were long ago distinctly noted by Godwin-Austen

and De la Beche,[1] as was also the fact of the conglomerates containing fragments of the cherts and other Lower Culm rocks. As to the age of these conglomerates, the author thinks they might, for good reasons, be referred to the Pennant Grit series of the South Wales and Bristol Coalfields, both of which, curiously enough, contain boulders or pebbles of coal and anthracite from the lower measures, indicating similar conditions to what existed in South Devon.

The question of the time required during this interval or break in the sequence between the Lower and Upper Culm deposits, for the protrusion of the granite, is now sufficiently well disposed of. So also is the question of the protrusion of the granite following the old and weakened line of former Culm basic products. There is, moreover, much good reason to suppose that the acid magma of the granite, and its perhaps more trachyte-like external portions, followed very hard after the great basic masses already mentioned.

The most important question of all, however, remains to be answered — Do the contents of the conglomerates contain any materials such as might be derived from the waste of granitic or trachyte-like rocks? To the eye, and with the aid of a lens, these conglomerates, besides the chert fragments, contain much arkose materials, such as quartz, felspars, etc.; and mica in large flakes are most abundant in them. These granitic and trachyte-like materials are present in such large quantities as would make it very difficult to find their source of origin from the wear and tear of any other of the ordinary Devonian or Lower Culm rocks. The felspar crystals and particles are so abundant, so large, and so distinct that the author deemed it quite unnecessary to have specimens submitted for microscopical examination. Fragments of a variety of granite are also present.

With regard to the alleged fragments of the Dartmoor granite said to have been found in the adjoining Permian breccias by the late Mr. Pengelly [2] and others, the writer would remark that if this be really so it would accord very much better with the inter- or late Culm age of that rock than with its Permian or Pre-Triassic age, as formerly held.

In the breccias referred to the author has been able to detect many examples and varieties of a kind of quartz-porphyry. These latter might in some way or other be connected with the outer granite mass of Dartmoor, as also might be the large and numerous crystals of Murchisonite found in the breccias, which seem to have no connection with the subsequent basic flows in that formation.

It is rather unfortunate that none of these Upper Culm rocks or conglomerates are found in connection with the other bosses of granite running into Cornwall, whereby we might better test their age; but many reasons combine to show that they all belong to the same period of protrusion.

There are many other points, such as the denudation of the Devonian

[1] Trans. Geol. Soc., ser. ii, vol. vi, p. 457 ; Geol. Rep. of Cornwall, Devon, etc., p. 111.
[2] Rep. Brit. Assoc., 1861, p. 127.

and Lower Culm strata from portions of the granitic areas in question,
but these must be dealt with subsequently. There is, however, one
important point to which the writer desires to draw attention—that
is, the almost certain fact that the Devonian and Lower Culm
strata had been previously disturbed and folded by great earth-crust-
movements before the protrusion of the granite. The arrangement
and disposition of the strata in relation to the granite certainly
favour this conclusion. The great plications and the cleavage of the
strata had at least in greater part, if not in whole, been completed
before the eruption of the granite had taken place, and also before
the conglomerate series of South Devon had been deposited, which
latter occurrence, however, the author believes was subsequent to the
eruption of the granite. It is extremely probable that these highly
acid cores which now represent the granite never were the stumps
or roots of great volcanic cones, in the correct sense of the term,
as suggested by the late Mr. R. N. Worth,[1] from which proceeded
highly basic lavas, but rather that they were the feeders or more
central portions of extrusions, parts of which came to the surface
as trachyte, forming great dome-like masses after the manner of the
Puy de Dôme, near Clermont Ferrand, in Central France.

In conclusion, the author is aware that the evidences here brought
forward to sustain his views as to the age and origin of the granite
of Dartmoor are not absolutely conclusive; but when compared with
the opinions already held they seem at all events worthy of con-
sideration and discussion.

NOTICES OF MEMOIRS.

I.—Neue Beiträge zur Kenntniss der fossilen Radiolarien
aus Gesteinen des Jura und der Kreide, von Dr. Rüst.
Palæontographica, Band xlv (1898). 4to; pp. 67, pls. i–xix.

New Contributions to the Knowledge of the Fossil Radio-
laria from the Jurassic and Cretaceous Rocks. By Dr. Rüst.

SINCE the completion of his important work on the Palæozoic
Radiolaria, Dr. Rüst has been revising his earlier monographs
on those from the Jurassic and Cretaceous strata. Struck by the
close resemblance of the forms in the Upper Jurassic Aptychus-beds
of Cittiglio, near Laveno, from which 79 new species were described
and figured by Professor Parona[2] some years since, to those which
he himself[3] had described from the Lower Neocomian beds at
Gardenazza near St. Cassian, the Aptychus shales near Urschlau,
and from Kren, and the Tithonian jaspers of the Tyrol and West
Switzerland, Dr. Rüst prepared some hundreds of microscopic
sections of the nodules of siliceous limestone from Cittiglio, and in
these he has discovered no fewer than 212 new species, which, with

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[1] Quart. Journ. Geol. Soc., vol. xlv, p. 398, etc.
[2] Bollettino della Soc. geol. italiana, vol. ix, fasc. 1 (1890).
[3] Palæontographica, Bd. xxxi (1885); Bd. xxxiv (1887–8).

some few other new forms from Gardenazza, and from the Lias Coprolites of Ilsede, are fully described and figured in the 19 plates accompanying this monograph. A comparison of the species from the various localities mentioned above leads the author to consider that they belong to one and the same Radiolarian fauna. The only new genus proposed, *Cyclastrum*, is included in the family Porodiscida. A distinguishing feature of the Cittiglio Radiolaria is the large number of forms of the Order Cyrtoidea; some of them, moreover, are of unusually large size—one specimen of *Stichocapse Umberti*, measuring 1·152 mm. by 0·16 mm. in length and breadth, exceeds in size any fossil form of the group hitherto known. Though the siliceous tests in these organisms are now for the most part replaced by pyrites and marcasite, their structural details have been very perfectly preserved, and they can be determined with as much precision as recent specimens.

Thanks to this new contribution of Dr. Rüst, taken in connection with his earlier work and that of Professor Parona, we are now furnished with a fairly satisfactory standard of reference as to the character of the Radiolarian fauna of the summit of the Jurassic and the base of the Cretaceous rocks in the Tyrol, Bavaria, and Northern Italy.   G. J. H.

II.—Resemblances between the Declivities of High Plateaux and those of Submarine Antillean Valleys. By J. W. Spencer. (Transactions of the Canadian Institute, vol. v, 1898, pp. 359–368.)

[Communicated by Professor E. Hull, F.R.S.]

THIS paper is a sequel to the " Reconstruction of the Antillean Continent,"[1] as in it the analysis of the slopes of the drowned valleys had not been considered. Both in the land and in the submarine valleys their gradients are of two kinds: (1) Those of rivers which are flowing over continental plains, or upon the surface of high tablelands, where the declivities of the streams are so gentle as to be often reduced to even a foot per mile; (2) where the valleys are descending from higher to lower plateaux, in which case the descent is over a series of precipitous steps, separated by short gradation planes, marking pauses in the elevation of the land. Thus, if the mean descent of such a valley be taken, an average gradient would be entirely misleading. While the mean slope may reach from 100 to 200 feet per mile, it is found that in reality it is composed of perhaps twenty abrupt steps with almost level flats between. Or the steps may reach a height of five hundred feet or more. Such features are seen descending from the Mexican plateaux (of 8,000 feet in altitude) to the Gulf of Mexico. The valleys end abruptly in amphitheatres indenting the floors of the tablelands and dissecting them.

In the drowned Antillean valleys long reaches have been discovered with slopes of only a foot per mile like that of the

[1] Bull. Geol. Soc. Amer., vol. vii (1894), pp. 103–140.

Mississippi, or of some plateau valley. These are separated by abrupt steps similar to the succession of those descending from the margins of the Mexican tablelands. This point of analogy between the drowned and land valleys, as well as the occurrence of short amphitheatres indenting the edges of the submarine plateaux, when carefully compared, very greatly strengthens the conclusions drawn in the "Reconstruction of the Antillean Continent," namely, that the valleys traversing the submarine Antillean plateaux were of land origin, and indicate the depth to which the West Indian Continent has sunk, even to a depth of two miles or more.

III.—LATE FORMATIONS AND GREAT CHANGES OF LEVEL IN JAMAICA. By J. W. SPENCER. (Transactions of the Canadian Institute, vol. v, 1898, pp. 324–357.)

[Communicated by Professor E. HULL, F.R.S.]

(PLATE XVIII.)

THIS paper is descriptive of the physical features of Jamaica which bear upon the evidence of great changes of level in late geological times, and extends the conclusions set forth in the author's work upon the "Reconstruction of the Antillean Continent." [1]

Speaking in a broad way, Jamaica is a dissected tableland, surmounting another but submarine plateau, extending from Haiti to the Yucatan banks, now submerged to depths of 3,000 to 4,000 feet. These banks have the form of old base planes of erosion, but they are traversed by deep valleys more than 2,000 feet below the summit of the platform. Even within the limit of the submarine plateau mass the channels reach to a depth of 9,600 feet, or more than 5,000 feet below the surface of the drowned plains. Here, as everywhere, when studied, the valleys have in all respects the features of those of the plateau regions of Mexico and other countries. And they head in embayments of the land, receiving as tributaries the principal rivers of the district.

The modern topographic features of Jamaica date back practically only to the middle Miocene period, for the larger part of the island is covered by old Miocene white limestones. But the subsequent denudation has been enormous, for although the formation still reaches a thickness of 2,000 feet in some places, yet in others the dissection of it has penetrated the whole mass. Upon this old Miocene surface no Mio-Pliocene formations occur, until those at the close of the period, showing it to have been one of long-continued elevation.

Upon these white limestones there was a subsequent mechanical deposit of marls with pebbles (made up in part of older fragments), and in other localities there were gravels and loams (according to the source of the materials). These accumulations rise to a height of 500 feet in stratified beds, still nearly horizontal, in contrast to the upturned beds of the underlying white limestone. They contain

[1] Bull. Geol. Soc. Amer., vol. vii (1894), pp. 103–140.
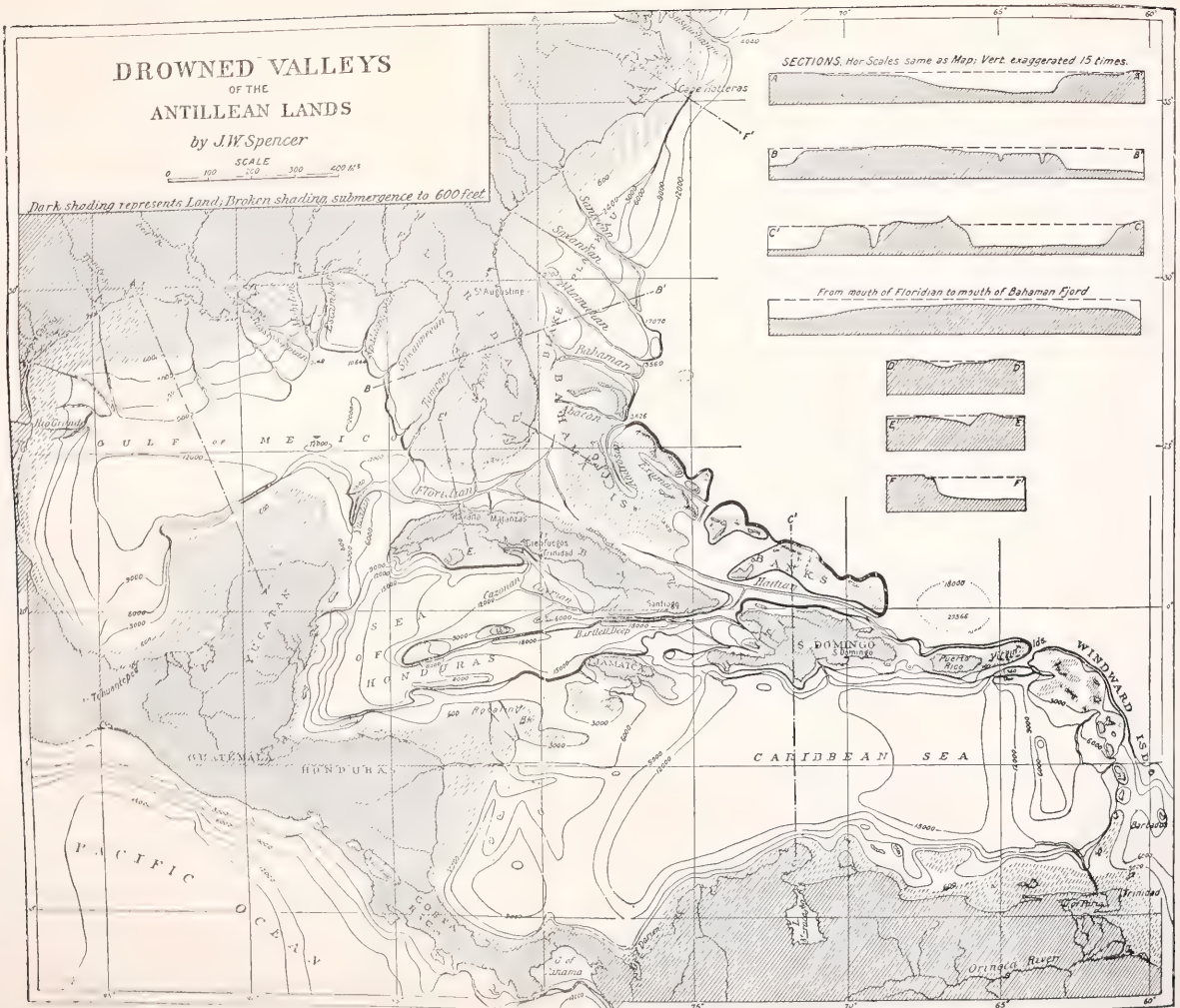
a few shells of modern species. The formations have been found to correspond, in position, with the Lafayette of the continent or the Matanzas of Cuba, which have been provisionally placed at the close of the Pliocene period.

Overlying the Layton beds, where these have not been removed, and other strata formed near the surface of the country, there has been a mantle of stratified loams and gravels laid down. This occurs up to an elevation of 600 feet. It has been named the Liguanea formation, and has been correlated with the Columbia of the continent and the Zapata of Cuba. While no fossils have been found in this fragmental deposit, yet its stratified beds, occurring adjacent to the coast, high above the sea, indicate its origin at sea-level. Thus it appears that the island was submerged to 500 or 600 feet during two distinct epochs since the Mio-Pliocene period.

The paper describes the broad undulating features characterizing the Mio-Pliocene period. These have since been dissected by wide and deep valleys, extending from the land to the submerged plateau, formed subsequent to the Layton epoch ; and from the depths to which they reach in the submerged plateau the inference drawn is that the land stood more than 10,000 feet higher in the early Pleistocene period than to-day. The Layton formation during this elevation was enormously degraded, so that in many localities only remnants are found in protected places. Jamaica affords a favourable region for studying the contrast between the undulating topography developed near base-level of erosion during the Mio-Pliocene period of more extensive lands than to-day, and the great and enormously deep valleys of the post-Layton or early Pleistocene epoch. The moulding of the submarine plateau is supposed to have occurred during the Mio-Pliocene period, while the deeply drowned valleys are continuations of those of the land which are of post-Layton age.

In contrast with these two features of erosion, that of the post-Liguanea epoch of submergence has been of small proportions ; indeed, the post-Liguanea elevation is so recent that it has not passed beyond the stage of making narrow deep cañons. On account of this formation overlying the remains of the Layton series, the different features of erosion up to an altitude of 600 feet are geologically preserved, while at greater altitudes they are not so easily distinguishable from those produced before the Liguanea epoch ; yet when one has become familiar with the features of erosion, the respective epochs are generally recognizable. The post-Liguanea cañon-making epoch was characterized by an elevation of 150 to 200 feet more than at present, for the continuations of the existing rivers are traceable to that depth across the submerged coastal plains. The subsidence which caused the drowning of these valleys reached to an elevation of 10 to 25 feet below the present level ; since which time the coral reefs of the coast have emerged to this amount.

Numerous as these oscillations appear, all of them, since the post-Layton elevation, have been of comparatively small and diminishing proportions. These changes of level of land and

sea have occurred on the other West Indian islands and on the continent; and, from the amount of work accomplished, the Pleistocene period seems to have been one of long duration.

Outside of Jamaica the geological features of that beautiful island would not be of special interest, except that here we find additional evidence, both upon land and in the adjacent sea, supporting the theory of the high continental conditions of the West Indian region in the early Pleistocene period, when the land stood more than two miles above the present altitude, uniting North and South America, as is set forth in the "Reconstruction of the Antillean Continent."

IV.—British Association for the Advancement of Science. Sixty-eighth Annual Meeting, held at Bristol, September 8–13, 1898.

List of Papers read in Section C, Geology.

W. H. Hudleston, M.A., F.R.S., F.L.S., F.C.S., F.G.S., President.

The President's Address. (See Geol. Mag., p. 458.)

Professor C. Lloyd Morgan.—Some Notes on Local Geology.

E. B. Wethered.—On the Building of Clifton Rocks.

A. Strahan.—The Revision of South Wales and Monmouthshire by the Geological Survey. (See Geol. Mag., p. 488.)

H. Bolton.—The Exploration of two Caves at Uphill, Weston-super-Mare, containing remains of Pleistocene Mammalia (*by the late E. Wilson*).

Thomas H. Holland.—The Comparative Actions of Subaërial and Submarine Agents in Rock Decomposition.

H. B. Woodward.—On Arborescent Carboniferous Limestone from near Bristol.

Report of the Committee for collecting Photographs of Geological Interest in Britain.

Report of the Committee for collecting Photographs of Geological Interest in Canada.

Professor O. C. Marsh.—The comparative value of different kinds of fossils in determining Geological Age.

Professor J. F. Blake.—Aggregate Deposits and their relations to Zones. (See Geol. Mag., p. 481.)

T. Groom.—The Geological Structure of the Malvern and Abberley Ranges.

——— The Age of the Malvern and Abberley Ranges.

J. R. Dakyns.—The probable Source of the Upper Felsitic Lava of Snowdon.

E. Greenly.—On the occurrence of Arenig Shales beneath the Carboniferous Rocks at the Menai Bridge.

——— On an Uplift of Boulders at Llandegfan, Menai Straits.

W. L. Addison.—On the Comparative Dimensions of some Atoms.

L. J. Spencer.—Leadhillite in ancient Lead Slags from the Mendip
Hills.
———— Supplementary List of British Minerals.
A. Somervail.—On the Age and Origin of the Granite of Dartmoor,
and its Relations to the adjoining Strata.   (See GEOL. MAG.,
p. 509.)
Professor T. Rupert Jones.—Report of the Committee on Fossil
Phyllopoda.
E. J. Garwood.—Report of the Committee on Life-Zones in the
British Carboniferous Rocks.
R. Etheridge, F.R.S.—On the Relation and Extension of the Franco-
Belgian Coalfield to that of Kent and Somerset.
Dr. Marsden Manson.—On the Laws of Climatic Evolution.
Professor E. Hull, F.R.S.—On the Sub-oceanic Physical Features of
the North Atlantic.
W. H. Hudleston, F.R.S. — On the Eastern Margin of the North
Atlantic Basin.
R. D. Oldham.—The Great Earthquake of 1897.
Professor A. P. Coleman.—Report of the Committee on the Flora and
Fauna of the Interglacial Beds in Canada.
J. Lomas.—On Worked Flints from Glacial Deposits of Cheshire and
the Isle of Man.
E. Greenly and *A. B. Badger.*—The Glacial Sections at Moel Tryfaen.
C. W. Andrews.—On some Dinosaurian Remains from the Oxford
Clay of Northampton.
Professor H. F. Osborn.—Restoration by Charles Knight of the
Extinct   Vertebrates — *Brontosaurus,   Phenacodus,   Coryphodon,
Teleoceras.*
E. Wethered.—The Work of Encrusting Organisms in the formation
of Limestone.
W. H. Wheeler.—The Action of Waves and Tides on the Movement
of Material on the Sea Coast.
Rev. G. C. H. Pollen.—Further Exploration of the Ty Newydd
Caves, Tremeirchion, N. Wales.
T. Plunkett.—Further Exploration of the Fermanagh Caves.
P. C. Kermode.—Report of the Committee on the Remains of the
Irish Elk in the Isle of Man.
Report of the Committee on the Erratic Blocks of the British Isles.
Professor J. Milne, F.R.S.—Report of the Committee for Seismo-
logical Investigation.
Report of the Committee on the Fauna of Caves near Singapore.
Report of the Committee on the Structure of a Coral Reef.
M. Laurie.—Final report on the Eurypterids of the Pentlands.

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Papers bearing on Geology read in other Sections :

Professor O. C. Marsh.—On the Families of Sauropodous Dinosauria.
F. A. Bather.—On the Classification of the Pelmatozoa.
C. W. Andrews.—On Christmas Island.

R E V I E W S.

I.—LIST OF THE TYPES AND FIGURED SPECIMENS OF FOSSIL
CEPHALOPODA IN THE BRITISH MUSEUM (NATURAL HISTORY).
By G. C. CRICK, F.G.S., etc. 8vo ; pp. 103. (London, 1898 ;
printed by order of the Trustees of the Museum.)

THE great utility to specialists of such lists as this cannot be
overestimated, and we are glad to be able to call favourable
attention to the latest of an increasing series. It is to be hoped that
the Museums Association will use their best endeavours to persuade
the various institutions represented amongst their members to respond
to the invitation of the British Association and proclaim their
treasures in like manner, as indeed some of them both have done
and are doing.

The object of the present list is to place permanently on record all
the types and figured specimens, both British and foreign, of Fossil
Cephalopoda preserved in the Geological Department of the British
Museum.

Each specimen is entered under the name given to it when it was
first figured or described, any names subsequently applied being
appended in chronological order ; whilst cross references are given
from these last in the alphabetical order in which the whole is
arranged. Each name is followed by an abbreviated reference to
the work in which it occurs ; while the formation and locality of
the specimen, with its registered number in the collection, are
given at the close of every main entry.

We are heartily glad to observe that corresponding lists of other
groups of Invertebrata in the Museum are to follow ; and though for
the present the student is referred to the catalogues already published
for the Vertebrata, it is to be hoped that the Trustees will ultimately
see their way to issuing similar lists of these also, since much
valuable time is wasted in hunting for the record of some desired
type in a voluminous catalogue, where it has to be sought in its
systematic position and possibly under some other name than the one
it bore when described.

In the production of the present list full measure of praise must
be awarded to all concerned in its production : even the printer
appears at his best.

II.—ON THE MUSCULAR ATTACHMENT OF THE ANIMAL TO ITS SHELL
IN SOME FOSSIL CEPHALOPODA (AMMONOIDEA). By G. C. CRICK,
F.G.S., F.Z.S., etc. (Trans. Linn. Soc. London, ser. II, vol. vii,
pt. 4, pp. 71–113, pls. xvii–xx.)

THE true relationship of the Ammonoidea to other Cephalopoda
has long been a moot question, and there have not been
wanting those, and that quite recently, who, fascinated by the
external resemblance of some ammonite shells to that of *Argonauta*,
have advocated the placing of the ammonite with the Dibranchiata.
The interesting discovery by Mr. Crick, however, of the impression
of the shell muscles and annulus proves the permanent attachment
of the Ammonoid animal to its shell, and consequently its wide

separation from *Argonauta*, whilst it further establishes a point of resemblance in this respect between the Ammonoidea and the Nautiloidea.

The previous literature is scanty. Oppel (1863) figured part of the muscular attachment in *Ammonites steraspis*, but did not apparently even guess its significance. Trautschold in 1870 figured what he considered to be the impression of the muscular attachment in *Ammonites bicurvatus*. In 1871 Waagen accepted Oppel's figures as indicating a trace of the annulus, and diagrammatically completed what he considered to be the form of the shell muscle, which he believed was attached to the inner (umbilical) portion of the lateral area of the whorl. In this he appears to have been correct, though *Ammonites steraspis* proves to be an exceptional form. In the majority of the Ammonoidea the shell muscles were attached to the dorsal portion of the shell : they frequently either met or approximated each other in the median line of the shells, and in the latter case were united by a more or less narrow band corresponding to the dorsal portion of the annulus in the recent Nautilus. They were similarly connected round the ventral side by the annulus, so that an air-tight band fastening the mantle to the shell encircled the animal. Once detected, these scars prove fairly common, and there appears to be some ground for believing that their varying form in the different genera is in part due to the shape of the transverse section of the whorl and to the length of the body-chamber, but also, possibly, to other causes. They will probably ultimately afford important characters for the purposes of classification.

Mr. Crick describes and figures the principal forms detected in twenty-eight different genera. He is heartily to be congratulated on the production of this admirable monograph, and the Linnean Society on having published it in worthy form and with adequate illustrations, in which respect they put to shame a younger Society whose complaint is that it cannot get good palæontological papers. What is wanted now is a companion paper summarizing our knowledge of the muscular scars in the Nautiloidea.

III.—GEOLOGY FOR BEGINNERS. By PROFESSOR W. W. WATTS, M.A., F.G.S. 8vo ; pp. xvii, 352. (London : Macmillan & Co., 1898. Price 2*s*. 6*d*.)

THE student who nowadays wishes to become a geologist, and is desirous not merely to learn the facts but to aid in advancing knowledge, must labour long and seriously. The general knowledge of rocks and fossils which seemed to form a sufficient basis twenty or thirty years ago, must now be supplanted by a more precise acquaintance with the characters of the principal rock-forming minerals and of the principal forms of life whose remains are found embedded in the strata. The young student should be able to recognize in microscopic slides the minerals and structures exhibited by such rocks as granite and basalt, quartzite, statuary marble, and oolite. Precision of knowledge in the beginning is the surest foundation for subsequent success. In the present work

the author aims to teach all that is required for the elementary stage of the Science and Art Examination, and for the examinations of the Oxford and Cambridge Schools' Examination Board. He places before his readers a concise account of all the principal facts and phenomena relating to geology, admirably arranged and expressed. At the end of each chapter is a recapitulation, and this is followed by a series of questions given at different times at the examinations before mentioned.

The work is illustrated by three hundred and ten excellent photographic views of rock-scenery and structure, and diagrams of geological sections and fossils. The descriptions of rocks and minerals, of rock-structures and earth-movements, of denudation and rock-building, leave little or nothing to be desired. Something might have been added to the description of 'subsoil' (p. 47) in reference to soft strata such as sand, gravel, or clay where the subsoil is practically the actual formation or rock. Such instances differ from the illustration relating to freestones where there is an intermediate weathered portion of rock or rubble, between the soil and the undisturbed rock. Opinions will differ with regard to the definitions of loam and grit on p. 135, but it is idle to call attention to such matters when the entire work bears evidence of most careful observation and research, and brings clearly before the student the latest information on all important subjects. A good general account of the leading fossils is given, and the methods of classification are popularly explained. This part of the subject is followed by a review of the principles of Historical Geology, and then each System is described. Taking the Ordovician System, the subject is treated under the headings of *Name, Subdivisions, Volcanic Rocks, Fossils, Economics and Landscape,* and *Conditions of Formation.* Evidently the author leaves for advanced students particulars of the characteristic fossils of the subdivisions. The Origin of Landscape and Economic Geology are the subjects of the last two chapters, and there is an excellent index. We have no hesitation in commending this little work to all beginners desirous of obtaining a sound and thorough introduction to geology; and we heartily congratulate the author on the accomplishment of his useful task.

IV.—Applied Geology. Part I. By J. V. Elsden, B.Sc. (Lond.). 8vo; pp. 96. (London: "The Quarry" Publishing Co., 5, Arundel Street, Strand, W.C., 1898. Price 5s.)

NO doubt there is need of a good general work on Applied Geology, as the excellent little treatises by Ansted & Page do not represent the present state of knowledge. A work professing to deal with all branches of applied geology must treat of them either in a very abridged form, as in the case of Page's Economic Geology, or in a series of volumes, and no single individual can possess intimate knowledge sufficient to justify his dealing fully with the subjects of water-supply, coal-mining, metal-mining, building-stones, etc. We are rather at a loss to know how to criticize the present part of Mr. Elsden's treatise, because in his preface he tells us " that these preliminary chapters scarcely give

an adequate idea of the scope of the completed work." At the outset we are surprised that a sum of five shillings should be charged for so comparatively meagre a volume. We judge that the whole of it is reprinted from the *Quarry* newspaper, in whose pages "the latter portion is still appearing"; and the information now given relates chiefly to geological surveying, to dips, outcrops and faults, to unconformities and overlaps, and other matters. These are well illustrated with diagrams, many of them being after the style of Sopwith's famous models. A good deal of space is occupied with mathematical calculations having reference to the determination of the true dip, and to the throw of faults and dislocated veins : information of questionable value to the practical man. A final chapter of twenty pages deals generally with the economic minerals which occur as stratified ore-deposits. As already stated it is not possible to judge fully of Mr. Elsden's work. So long ago as 1816 William Smith lamented that "the theory is in possession of one class of men, and the practice in another." This state of things is not wholly unknown at the present time, and if Mr. Elsden succeeds in his task of welding the two together, his labour will not have been in vain.

V.—Wachsmuth and Springer's Monograph on Crinoids.[1]

Fourth Notice.

THE Abactinal system of the Crinoid skeleton comprises the elements of the Stem and appendages, the Patina (in which are included only IBB, BB, and RR), and the dorsal ossicles of the Arms. Our authors' account of the two former has already been passed in review. Their description of the brachials (pp. 73–88) needs no elaborate discussion, since the controverted points were dealt with in an earlier notice. Let it be noted, however, that all abactinal elements beyond the five radials belong to the arms. Therefore, every normal crinoid has five arms. Each arm may remain single, or may fork once, or may fork an indefinite number of times, either regularly or irregularly. The branches into which it forks may be of equal or of very unequal size. The proximal regions of the arms may be incorporated with the patina to form the dorsal cup. The portion so incorporated is said to be 'fixed'; the remaining distal portion is termed 'free.' If only the primibrachs of an arm be fixed, then the secundibrachs will be free, and it will appear as though two arms left the calyx in that ray. If the secundibrachs be fixed, and the tertibrachs free and equally developed, then there will appear four free arms in the ray. But to say that the former crinoid has actually two arms to the ray, i.e. ten arms altogether; or that the latter has twenty arms—such statements breed confusion. Yet they are constantly made, and they are to be found in the present Monograph. A crinoid may have almost any number of arms (*Tetracrinus* has

four, *Promachocrinus* ten, and *Catillocrinus* about fifty), but it is not in this sense that Wachsmuth and Springer say that *Techno-crinus spinulosus* has "arms twenty," or *Batocrinus quasillus* "arms twenty-two to twenty-four." This confusion would be avoided by using such a word as *ramus* for the main free branches of an arm. In that case the armlets borne by a ramus might conveniently be called *ramuli*.

The account of the arms is remarkably full, and contains many details not to be found elsewhere. Two conclusions of wider interest are arrived at. First, that " the number of costals [i.e. IBr] does not constitute a reliable character for classification, as heretofore supposed, and that in some groups their number is of but little value for specific distinction. This is even more markedly the case with regard to the higher divisions of the rays." The second conclusion is that the fixed brachials of the Camerata " were free in the early larva," " that smaller specimens have a less number of interbrachial plates, that the number increases with the size of the specimens, and that with the increase of the latter additional brachials are incorporated into the calyx." These two conclusions should win ready acceptance by students of Crinoidea. The second is of high importance, for it carries with it the further conclusion that the Camerata were descended from ancestors of Inadunate type, that is, forms with the arms free and distinct, and with the dorsal cup confined to the patina. In other words, if the statement be accepted, it becomes impossible for us to regard such a genus as *Reteocrinus*, and still more *Melocrinus*, as truly primitive ; it is not open to us to suppose that any branch of the crinoids was derived from those Cystidea that have a large number of thecal plates ; on the contrary, all the cystidean ancestors of the crinoids must be sought among forms that have their thecal plates limited in number and definite in arrangement.

We pass now to the plates of the Actinal system (pp. 88–104). Of these the most important are the Orals. At once we are faced by the question : what are the orals ? The only definition that does not admit of controversy appears to be this : The orals are five sub-triangular plates early developed in the interradii around the peristome of the stalked larva of *Antedon*, but reabsorbed in the adult—and all plates in other crinoids homologous with those five. The disputed point of this definition lies in its application. What plates are homologous ? A full account of the various homologies that have from time to time been maintained by Wachsmuth and Springer and by other writers is given in the Monograph. Additional discoveries have rendered many of these homologies untenable, and what our authors now hold is as follows.

The orals are represented in *Haplocrinus, Pisocrinus, Symbatho-crinus, Allagecrinus,* and allied genera (= Larviformia, W. & Sp.) by five subtriangular interradial plates, occupying the whole of the actinal surface, and meeting by their apices around the oral centre. This homology will scarcely find a hostile critic. Five plates similarly situated in the living *Rhizocrinus, Hyocrinus,* and *Holopus* have always been accepted as orals.

In a unique specimen of *Taxocrinus intermedius*, described by Wachsmuth and Springer in 1889, there are interradially disposed around the open mouth " five rounded or very obtusely polygonal plates rather oval in outline," the posterior of these being " nearly three times as large as any of the others "; the food-grooves pass to the mouth between these plates, which " represent morphologically the five orals of the recent genera." In the absence of further evidence, we may accept this conclusion provisionally, and we may infer that such was the structure of the tegmen in allied genera (viz. in Flexibilia Impinnata).

In *Coccocrinus* and *Culicocrinus*, which are regarded as primitive forms of the ' non-typical Camerata ' (i.e. Platycrinoidea), the greater part of the tegmen is occupied by five interradially disposed plates, which, very naturally, are taken to be orals. In those Platycrinoidea which have a more complicated tegmen, these five plates can still be recognized ; but in many species the posterior oral has been shifted towards the oral centre by the development of the anal tube behind it, and has increased in size while becoming partly surrounded by the four remaining orals. In other words, the so-called ' central plate ' of the *Platycrinus* tegmen is homologized with the posterior oral, while the four so-called ' proximals ' are homologized with the antero-lateral and postero-lateral orals. There seems no reason to doubt the justice of this conclusion. Turning to the ' typical section ' of the Camerata, we find a similar ' central plate ' and ' proximals ' developed in many genera, as well exemplified in *Actinocrinus* ; comparison of these with the structures already described " leaves no room for doubt that these are likewise true orals." Here, however, a conscientious critic is bound to point out that external similarity between structures in highly specialized genera is often deceptive and, in the absence of genetic affinity or of a plain evolutionary series, cannot be regarded as proof of homology. With such splendid material in their hands, it is a pity that Messrs. Wachsmuth and Springer did not attempt the solution of the problem by a method more satisfactory than that of simple inspection. The task remains for others. It may, however, be conceded that the Camerate tegmen contains no other plates capable of being homologized with the orals.

There remain for consideration various Inadunate genera (Fistulata, W. & Sp.) of which *Cyathocrinus* is taken by Wachsmuth and Springer as the type. In this genus are two distinct sets of plates on the actinal surface, either set conceivable as homologous with orals. There are five subtriangular plates (deltoids, F. A. B.) resting on the shoulders of the radials, surrounding the pentagonal peristome, and meeting by their sides underneath the food-grooves; the posterior of these is the largest, and is pierced by water-pores. Again, there are in some individuals five plates (proximals they may be called) interradially disposed, and covering over the peristome ; these plates are continuous with the ambulacrals, often are barely distinguishable therefrom, and often appear absent ; these plates and the ambulacrals, as well as any minute supplementary plates that may be developed in the tegmen,

all lie above the level of the deltoids, which may thus be almost entirely obscured. Where the covering-plates, especially the five proximals, are well developed and preserved the deltoids are scarcely to be detected; but where they are small the deltoids are often conspicuous. Hence these two distinct sets of plates have occasionally been confused. That they are absolutely different morphological elements there can, thanks chiefly to the researches of Wachsmuth and Springer, be no doubt. The question is: which set represents the orals? Wachsmuth and Springer believe that the orals are represented by the proximals, but that these are often resorbed, much as we know the orals to be resorbed in the ontogeny of *Antedon*. They believe that forms with large proximals and hidden deltoids are, phylogenetically, less advanced than those with minute proximals and conspicuous deltoids. *Euspirocrinus*, for instance, is more advanced than *Cyathocrinus*. Neumayr appears to have believed that the deltoids were the orals and that the proximals were modified ambulacrals. Unfortunately, reliance upon the drawings of other authors led him to confuse the two sets in some instances, so that his views were thought more unsound than was really the case.

For many years I have devoted considerable attention to this matter, and have long believed the deltoids to be homologous with the orals, and the proximals, when they exist, to be enlarged ambulacrals. So great, however, was the opposition to this view on the part of my departed friends, P. H. Carpenter and Charles Wachsmuth, that in my published writings I always left the question open and continued to amass evidence. I believe myself to be now in a position to prove both these homologies definitely and step by step. That, however, must be done in another place with the help of adequate illustration. Here it is enough to point out the great difficulty of explaining the deltoids on any other hypothesis (see p. 115 of the Monograph); also, one may draw attention to the fact that the posterior deltoid and the posterior oral stand in similar relations to the water-vascular system.

The remaining elements of the tegmen are next discussed, and a full history of the various opinions that have been held is given. There are no new facts of importance, and no modification of the views published by Wachsmuth and Springer in 1891, and abstracted in the GEOLOGICAL MAGAZINE for May of that year. Details, however, are filled in, and this section with its accompanying illustrations should be carefully studied.

Following on this come some very controversial matters. The ventral sac of the Fistulata "must not," we are told on p. 114, " be confounded with the anal tube of the Camerata, which contains simply the rectum." On the contrary, it "lodged a large portion of the visceral mass," and "is generally composed of longitudinal rows of hexagonal plates, which are often pitted at their sides, or perforated by pores." These pores are supposed to have admitted water for respiratory purposes. Messrs. Wachsmuth and Springer seem to think it curious (p. 161) that in my earlier writings on crinoids I should have regarded this supposed structure "as an excellent

ordinal character," whereas it is omitted altogether in my classification of 1893. At first I accepted the statement of these learned authorities, but when fact after fact showed that it was far from a universal truth, it was impossible to utilize it for classification. The anal tube of *Euspirocrinus spiralis* is as solid as that of *Actinocrinus* ; that of *Cyathocrinus visbycensis* is but little less so; that of *C. ramosus* is a mere knob, and its lumen is quite small. Again, genera, species, and actual specimens that had been stated to possess pores and slits in the tube or sac were definitely proved by me to have nothing but deep folds. Wachsmuth and Springer now admit my statement for " *Cyathocrinus, Euspirocrinus,* and possibly the Cyathocrinidæ generally, in which very likely the madreporite performed the functions of the tube-pores " ; but they " have the most complete evidence that among the Poteriocrinidæ, in many cases, the pores pass through the test." Perhaps they have. And yet I am still sceptical. It was examination of *Scaphiocrinus multiplex* itself, the first and chief species in which such pores were observed, that made me doubt the observation. I have examined, with like result, specimens described and figured by Grenfell and by Lovén. Now, let the impartial reader compare my detailed descriptions and the drawings by Liljevall, Hollick, and myself, magnified 8, 16, and 20 diameters, with the bald statements and drawings, scarcely more than natural size, published by Wachsmuth and Springer. He will admit that scepticism is justified. Nay, more ! Let him examine two of the figures on which they specially rely, namely, pl. vii, figs. 5 and 9. He will observe that the supposed pores are drawn in the middle of each side of each hexagonal plate of the tube ; each pore lies on a line passing between the centres of adjacent hexagonal plates. Then let him look at the other figures, such as 2*b*, and he will note that the supposed pores are at the angles of the plates, and never on these radial lines. Let him then examine a few hundred specimens of Fistulate genera, and he will find that the apparent pores or slits never are on the radial lines, but always at the angles or between the ridges of the folded plates. Some resemblance to the alleged structure of *Aulocrinus* is presented by *Gissocrinus verrucosus*,[1] but this is only partial and superficial. I do not accuse the authors of any intention to mislead, but this I do suggest : that their artist would not have drawn figures 5 and 9 in this way had he not been told to put in structures which he really had a difficulty in seeing. Few scientific writers have not had a like unfortunate experience. If *Aulocrinus* truly has a ventral sac of this nature, it differs far more from other Fistulata than Messrs. Wachsmuth and Springer have stated. If the structure is correctly drawn it is most extraordinary that it should not be specially mentioned in the text. But it is so opposed to all facts hitherto observed or published that, until Mr. Springer himself compares fig. 9 of pl. vii with the original specimen and assures us

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[1] " Crinoidea of Gotland, I," pl. x, fig. 378: *Svensk. Vetensk. Akad. Handl.*, xxv, 2 (1893).

publicly that the pores have the position there assigned to them, and gives a properly enlarged drawing or photograph in support of his statement, scepticism will be more than justified.

F. A. BATHER.

CORRESPONDENCE.

THE SUBMERGED PLATFORM OF WESTERN EUROPE.

SIR,—The question of whether the border of this platform is an escarpment or not cannot be left where Professor Hull leaves it, for, as it stands, one of us must certainly have a false idea of the meaning and use of the word *escarpment.* I am consequently obliged to refer Professor Hull to textbooks for a definition, and it will probably suffice if I quote the Student's Manual of Geology, by Jukes & Geikie (3rd edition, p. 474) : " An escarpment is a cliff or precipitous bank formed by the outcrop of a bed or series of beds of harder consistency than those on which they rest."

Professor Hull asserts that the question " is really one of form " or shape of the ground, and he implies that the submerged declivity is an escarpment because it "has a terraced upper surface, has a descent sometimes almost precipitous, and falls off in a slope, sometimes gentle, at its base into the abyssal plain." Then he proceeds to put geological structure aside, which is precisely what the definition of an escarpment forbids him to do. It is quite true that the height and length of a declivity are matters of degree, but if he cannot show that a given declivity is formed by the outcrop of one series of beds he has no right to call it an escarpment.

Professor Hull, however, has another argument : he says, " the question of the origin of the escarpment might have remained problematical," but for the existence of the river channels which cross the platform and open out through the " escarpment."　He regards these channels as being " unquestionable proof of subaerial origin, both of themselves and of the physical features with which they are connected." This is a novel argument certainly, but how the existence of river-made valleys can possibly prove the declivity to have been made by subaerial agencies passes my comprehension.

Let us apply the argument to an existing terrestrial surface, and for choice let us take Portugal ; then we have this syllogism :—The surface of Portugal is trenched by river-valleys which open through the cliffs that form the western border of the land ; such valleys prove all the physical features with which they are connected to be of subaerial origin ; therefore the sea-cliffs of Portugal are " escarpments " of subaerial origin !

No one wants to deny that the surface of the platform has once been a land-surface, but I do deny that its border can properly be called an *escarpment* or that there is any proof of its having been fashioned by subaerial agencies.　　　　A. J. JUKES-BROWNE.

ORTHITE.

SIR,—In the interesting and instructive paper on Scottish Rocks containing Orthite, communicated by Dr. Flett to the September number of the GEOLOGICAL MAGAZINE, the author states that the

occurrence of this mineral in Great Britain has not, so far as he is aware, been observed up to the present.

May I point out that Orthite was reported from the granite of Criffel (which is close to Dr. Flett's first locality) as early as 1858. It is mentioned in Greg & Lettsom's book, which is of course the standard work of reference for British localities, and is referred to in all the larger manuals of Mineralogy, e.g. Dana's.

Since the discovery in Kirkcudbrightshire by Dr. Heddle, many additional localities have been recorded by the same energetic investigator. Without attempting to give an exhaustive list of the localities published, I may mention Aboyne, Anguston, Tilquilly, and Badnagauch, in Aberdeenshire; and Lairg and Tongue, in Sutherland. In the last edition of the " Encyclopædia Britannica " will be found figures of Orthite from Boat of Garten and from Urquhart.

It will thus be seen that the occurrence of this mineral in Scotland is already well established, and that Orthite has a considerable geographical range. Many more localities will no doubt be given in Professor Heddle's forthcoming work on the Mineralogy of Scotland, to which mineralogists are now looking forward with much interest.   James Currie.

Larkfield, Goldenacre, Edinburgh.
    October 3, 1898.

OBITUARY.

JOSEPH CHARLES HIPPOLYTE CROSSE.
Born 1826.   Died 7th August, 1898.

Dr. H. Crosse, the celebrated conchologist, was born at Paris in 1826, and from 1861 was co-editor of the *Journal de Conchyliologie* with the late Dr. Paul Fischer, whom he has not long survived. His sole palæontological paper was written in conjunction with Fischer, and treats of some fossil land mollusca from Madagascar; but no man could write, as he did, between 300 and 400 papers on mollusca, mostly descriptive of new exotic forms, without producing work of considerable interest to palæontologists as well. He died at Paris, 7th August, 1898.

FÉLIX BERNARD.
Born 1863.   Died August, 1898.

By the death of M. Félix Bernard, of the Paris Museum, science loses another brilliant malacologist. His " Éléments de Paléontologie," published in 1895, is well known; but his researches into the morphology of the hinge in the Pelecypoda mark a new era, and will help materially towards the foundation of a classification of that group that shall prove acceptable to the palæontologist as well as the conchologist. His work was marked by an amount of exactitude and care that one would fain see more widely imitated, and we are therefore glad to learn that the summary of the results of his observations, which has been left in a fit state for publication, is to appear shortly in the *Annales des Sciences naturelles*.

ORIGINAL ARTICLES.

I.—Note on a Devonian Cœlacanth Fish.

By A. Smith Woodward, F.L.S., F.G.S.

STUDENTS of Palæozoic fishes are indebted to Professor A. von
Koenen, of Göttingen, for two interesting memoirs on the
fragmentary fish-remains of the North German Devonian formations.[1]
Owing to their incomplete character, however, the Professor is only
able to suggest a provisional interpretation of most of the specimens,
and the determination of their true nature must be left for future
discoveries.

When visiting Göttingen last year, Professor von Koenen kindly
permitted me to examine those of his original specimens which are
now in the Geological Museum under his direction. There are many
fragments of great interest, including the much discussed Coccosteans
and a *Macropetalichthys*, which are better preserved than the others;
but there is only one specimen concerning which I am able to make
some observations amplifying the description already published.

The fossil in question is of considerable importance because, if
I am correct, it is the first discovered evidence of the Crossopterygian
family Cœlacanthidæ in the Devonian period. The Cœlacanth fishes
are known to range, with very little modification, from the base of
the Carboniferous to the summit of the Cretaceous. They are
completely developed on their first appearance in the Calciferous
Sandstones of southern Scotland. Their ancestors must thus be
sought in the Devonian rocks, where they have hitherto escaped
notice both in Europe and North America.

The specimen is named *Holoptychius Kayseri* by Von Koenen,[2]
but he observes that the external ornament of its scales differs so
much from that of *Holoptychius* that it may represent a new genus
for the definition of which the material is insufficient. The supposed
scales, however, seem to me to be characteristic Cœlacanth opercular
bones, and several other parts of the Cœlacanth head appear to be
identifiable.

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[1] A. von Koenen, "Beitrag zur Kenntniss der Placodermen des norddeutschen
Oberdevons": Abhandl. k. Ges. Wiss. Göttingen, phys. Cl., vol. xxx (1883),
pp. 1–41, pls. i–iv. Also, "Ueber einige Fischreste des norddeutschen und böhmischen
Devons": ibid., vol. xl (1895), pp. 1–37, pls. i–v.
[2] Loc. cit., 1895, p. 28, pl. ii, fig. 1.

An explanatory outline sketch of this fossil, of the natural size, is given in the accompanying figure. It is based upon Von Koenen's beautiful drawing. In the left upper corner are the two opercula (*op.*), slightly overlapping and exposing their outer ornamented

Cœlacanthus Kayseri (Von Koenen); outline of associated head-bones, etc. Upper Devonian: Müllenborn, Gerolstein. For explanation of lettering see text.

face. They taper rapidly in their lower half, and their maximum width is about three-quarters the measure of their maximum depth. The ornamental ridges are frequently interrupted, almost all directed horizontally, and somewhat coarser behind than in front. Below these plates are the two clavicles (*cl.*), rightly identified by Von Koenen. Their lower end is obscured, but the upper portion has the typical Cœlacanth form and is marked by a few transverse ridges. Another characteristic fragment of bone (*x.*) lies to the right of the expanded lower end of the clavicles. This is the hinder part of the supposed copula of the branchial arches. The two gular plates (*gu.*) are distinct, each slightly more than four times as long as broad, and ornamented with fine concentric ridges, which are not subdivided into tubercles. These plates seem to be gently rounded at either end, not tapering in front more than behind. Remains of the mandible (*d.*) occur on each side of the gular plates, and the characteristic articulo-angular bone (*ar.*) of the left side is displaced so as to show its form and proportions. It is ornamented with fine ridges which are mainly directed longitudinally. Upwards and forwards the two pterygo-quadrate elements (*ptq.*) seem to be crushed together; but these and other fragments are too imperfect for description.

Sufficient characteristic bones are thus preserved to indicate that the fossil in question represents a typical Cœlacanth head. The

only difficulty arises in reference to its generic determination. It will be best to place it provisionally in the genus *Cœlacanthus*, from which the parts described differ in no essential respect; while the minor characters of form and ornamentation just enumerated readily separate it from all known species.[1] It must thus be recorded for the present as *Cœlacanthus Kayseri*. The only well-known Lower Carboniferous species, *C. Huxleyi*,[2] differs very considerably from this form in the feebleness of its ornamentation; but a detached gular plate from the Lower Carboniferous Limestone of Armagh exhibits a nearer approach to it.[3]

The type-specimen of *Cœlacanthus Kayseri* was found by Dr. von Koenen in the lower part of the Upper Devonian at Müllenborn, near Gerolstein; and it is interesting to add that in the same formation and locality he met with a second small fossil, which he provisionally regards as a scale of *Rhizodopsis*,[4] another Carboniferous genus. I am, however, convinced that this supposed scale is much too thick and bony to be referred to the latter fish, and its systematic determination must remain as entirely problematical.

II.—Notes on some Lower Tertiary Shells from Egypt.

By R. Bullen Newton, F.G.S.

(PLATES XIX AND XX.)

THE Tertiary shells referred to in this paper constitute a portion of the Egyptian collection of fossils sent to the British Museum for description by Capt. H. G. Lyons, R.E., F.G.S., Director of the Geological Survey of Egypt.

Among the principal writers on this subject may be mentioned the names of Bellardi, Fraas, and Mayer-Eymar; the contributions of the last-mentioned having mostly appeared in the *Journal de Conchyliologie* (Paris), *Vierteljahrsschrift Naturforschenden Gesellschaft Zürich*, and in Zittel's memoir on Egypt contained in the *Palaeontographica* for 1883. For the latest information on the distribution of the Tertiary rocks of Egypt we must consult Captain Lyons' monograph in the Quarterly Journal of the Geological Society of London, vol. l (1894), "On the Stratigraphy and Physiography of the Libyan Desert of Egypt."

The specimens have been obtained from several localities, chiefly in the neighbourhood of the Nile, such as Minyeh, Esna, Assiout, Wadi Faregh, etc.; and the various horizons represented include—

> (?) Oligocene.
> Middle Eocene (Mokattam Series).
> Lower Eocene (Libyan Series).

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[1] A synopsis is given in A. S. Woodward's " Catalogue of Fossil Fishes in the British Museum," pt. ii (1891), pp. 399–408.

[2] R. H. Traquair, Trans. Roy. Soc. Edin., vol. xxx (1881), p. 20, pl. i, figs. 1–4; A. S. Woodward, op. cit., p. 407, pl. xiv, fig. 1.

[3] J. W. Davis, Trans. Roy. Dublin Soc. [2], vol. i (1883), p. 524, pl. lxiii, fig. 12.

[4] A. von Koenen, loc. cit., 1895, p. 29, pl. ii, fig. 2 (*Rhizodopsis dispersa*).

MOLLUSCA: GASTEROPODA.

Genus MITRA, Chemnitz.

Conchylien-Cabinet, vol. iv (1780), p. 205, pl. cxlvii, fig. 1,360.

TYPE.—*Voluta episcopalis*, Linnæus.

MITRA TURRICULATA, Schafhäutl.   (Pl. XIX, Fig. 1.)

Mitra turriculata, Schafhäutl, "Süd-Bayerns Leth. Geogn. Kressen-
          berg," 1863, p. 209, pl. lii, fig. 5 ; Fraas, "Aus dem
          Orient," 1867, p. 149.

DESCRIPTION.—Species narrow, elongate, fusiform ; whorls deep,
flattened, turriculate, and canaliculated at the suture ; aperture
elongate and narrow ; columella slightly oblique.

DIMENSIONS.

Largest specimen—Length	...	...	...	...	55 mm.
Diameter ...	...	...	...		23 mm.

REMARKS.—The Egyptian specimens referred to this species appear
to be in every way analogous to the type from the Kressenberg
Eocene, examples of which in the British Museum have been
available for comparison.   Like the type they are mere casts,
showing rather long and prominent turriculate spires with depressed
whorls and a sutural canaliculation.   The matrix is a light yellowish
foraminiferal limestone.

HORIZON.—Middle Eocene (Mokattam Series).

DISTRIBUTION.—Kressenberg. Egypt: Mokattam (Fraas) ; Minyeh.
Coll. Geol. Surv. Egypt (No. 848, Box No. 50c).

Genus HIPPOCHRENES, Montfort.

Conch. Syst., vol. ii (1810), pp. 522, 523.

TYPE.—*Strombus amplus*, Brander.

HIPPOCHRENES, sp.   (Pl. XIX, Fig. 2.)

REMARKS. — This genus is represented by four specimens in
a somewhat worn condition, without aliform expansions or complete
anterior canals.   An attachment line is, however, present on the side
of the spire, which denotes the position either of a former decumbent
canal, as in *H. columbarius*, or a large expansion such as characterizes
H. amplus.   The first-named species, already recorded from Egypt
by Bellardi,[1] is a perfectly smooth form without any spiral striations.
A spiral sculpture is observable on the present Egyptian specimens,
the lines being almost horizontal, though becoming more oblique and
closer together at the anterior prolongation.   Such ornamentation
would suggest affinities with *H. amplus*, but in the absence of other
details it is not desirable to attempt a specific determination of
remains so incomplete.   They are of fusiform shape, having a short
conical pointed spire and an inflated body-whorl.

DIMENSIONS.

Chief specimen—Length	...	...	...	...	40 mm.
Diameter	...	...	...	...	22 mm.

[1] "Cat. Foss. Nummulitici d'Egitto": Mem. R. Ac. Sci. Torino, 1854, p. 178.

G.M.Woodward del. et lith.

West, Newman imp.

Egyptian Lower Tertiary Shells.

HORIZON.—Middle Eocene (Mokattam Series).

DISTRIBUTION.—Egypt: Minyeh. Coll. Geol. Surv. Egypt (Nos. 844, 848; Box Nos. 12* c, 50c).

Genus POTAMIDES, Brongniart.

Annales Muséum Paris, vol. xv (1810), p. 367, pl. xxii, fig. 3.

TYPE.—*P. Lamarcki*, Brongniart.

POTAMIDES (allied to) PERDITUS (Bayan). (Pl. XIX, Figs. 3, 4.)

Cerithium perditum, Bayan : "Études Foss. Nouveaux," fasc. i (1870), p. 41 (= *Cerithium Lamarcki,* Deshayes *non* Brongniart, and *C. deperditum,* Deshayes *non* Michelotti).

DESCRIPTION. — Shell with an elongate, turreted, and acuminate spire ; whorls numerous, convex, deeply sutured, spirally striate, and longitudinally ribbed ; terminal whorl large and basally depressed ; aperture round ; labrum sinuated ; canal short.

DIMENSIONS.

Length	...	...	...	...	...	12 mm.
Spiral angle ...	...	...	...	...	17°.

REMARKS.—A number of silicified casts of a small *Cerithium*-like shell are determined as being allied to *Potamides perditus,* a well-known Paris Basin univalve. The specimens, well exposed on the surfaces of a lenticular chert-bed measuring about an inch in thickness, have from ten to twelve whorls separated by a deep suture, and a prominently sinuated labrum. Sculpture has mostly disappeared, but a few examples exhibit two spiral lines in the centre of the whorl, crossed by longitudinal costæ. The main difference between this form and the typical species appears to be its very much smaller size, so that a relationship so close would suggest an Eocene age for this particular chert-deposit, although the Egyptian Survey officers are inclined to regard it as belonging to a somewhat later period.[1]

HORIZON.—Eocene or Oligocene (?).

DISTRIBUTION.—Egypt: Wadi Natrum, lake deposits, north-west of Cairo. Coll. Geol. Surv. Egypt (No. 633, Box No. 37a).

LIMNÆA, MELANOPSIS, etc.

REMARKS. — Numerous casts of *Limnæa, Melanopsis, Potamaclis, Bithynia,* etc., are observable in a highly saliferous, white, chalky limestone[2] of variable hardness. In its fauna and general lithological features this matrix bears a curious resemblance to the Headon Hill limestone of the Isle of Wight, and even the species, judging from the imperfect condition of the specimens, show a similar facies in both. The molluscan remains are, however, so badly preserved that they do not lend themselves to either accurate identification or description, making it difficult to refer them to any special horizon, although they may temporarily be regarded as doubtfully of Oligocene age.

[1] Information supplied to the writer by Dr. Hume in August, 1898.

[2] Mr. G. T. Prior, of the British Museum, informs me that this matrix is not a dolomite, although referred to as such on the manuscript lists accompanying the collection.

Horizon.—Oligocene ?

Distribution.—Egypt : Wadi Natrum. Coll. Geol. Surv. Egypt (No. 635 ; Box Nos. 44*a*, 45*a*, 46*a*).

Conus and Voluta.

Remarks.—The collection contains some worn and fragmentary specimens of *Conus* and *Voluta*, which are unfortunately not specifically determinable ; they occur in a light foraminiferal lime-stone associated with *Mitra turriculata* and *Hippochrenes*, sp.

Horizon.—Middle Eocene (Mokattam Series).

Distribution.—Egypt : Minyeh. Coll. Geol. Surv. Egypt (No. 844, Box No. 12*c*).

[Gasteropod Casts—indeterminable.]

Remarks.—Two fragments of a light-coloured matrix containing casts of a small univalve shell without definition.

Horizon.—Eocene (?).

Distribution.—Egypt : Wadi Natrum. Coll. Geol. Surv. Egypt (No. 638, Box No. 49*a*).

Gasteropods and Lamellibranchs—indeterminable.

Remarks.—A number of diminutive mollusca belonging to the genera *Potamaclis*, *Corbula*, etc., mostly casts and impressions, are contained in a fawn-coloured calcareous sandstone, which is made up of innumerable rounded fragments of quartz, agglutinated by a siliceous cement. Professor Mayer-Eymar[1] has described a some-what similar sandstone from the neighbourhood of Cairo, in which he has recognized eighteen species of shells under the genera *Astarte*, *Cyrena*, *Tellina*, *Corbula*, *Hydrobia*, *Melanopsis*, *Potamaclis*, etc., regarding them as of Tongrian age.

Horizon.—Oligocene ?

Distribution.—Egypt : Wadi Faregh, south-east of Wadi Natrum. Coll. Geol. Surv. Egypt (No. 634, Box Nos. 38*a* to 43*a*).

MOLLUSCA : LAMELLIBRANCHIATA.

Genus OSTREA, Linnæus.

Systema Naturæ, 1758, ed. x, p. 696.

Type.—*O. edulis*, Linnæus.

Ostrea aviola, Mayer-Eymar. (Pl. XIX, Figs. 5–8.)

Ostrea aviola, Mayer-Eymar, " Diagnoses Ostrearum novarum ex agris Ægyptiæ ": Viert. Nat. Ges. Zürich, vol. xxxiv (1889), p. 297 (not figured).

Description.— *O. testa parva, satis variabili, modo ovata, modo ovato-rotundata, modo subquadrata, leviter obliqua, modo tenuiuscula,*

[1] " Zur Geologie Egyptens ": Viert. Nat. Ges. Zürich, vol. xxxi (1886), p. 261. " Ueber das Tongrian von Cairo (Egypten) ": ibid., vol. xxxiv (1889), p. 195 and plate of fossils. " Le Ligurien et le Tongrien en Egypte ": Bull. Soc. Géol. France, ser. iii, vol. xxi (1893), p. 31.
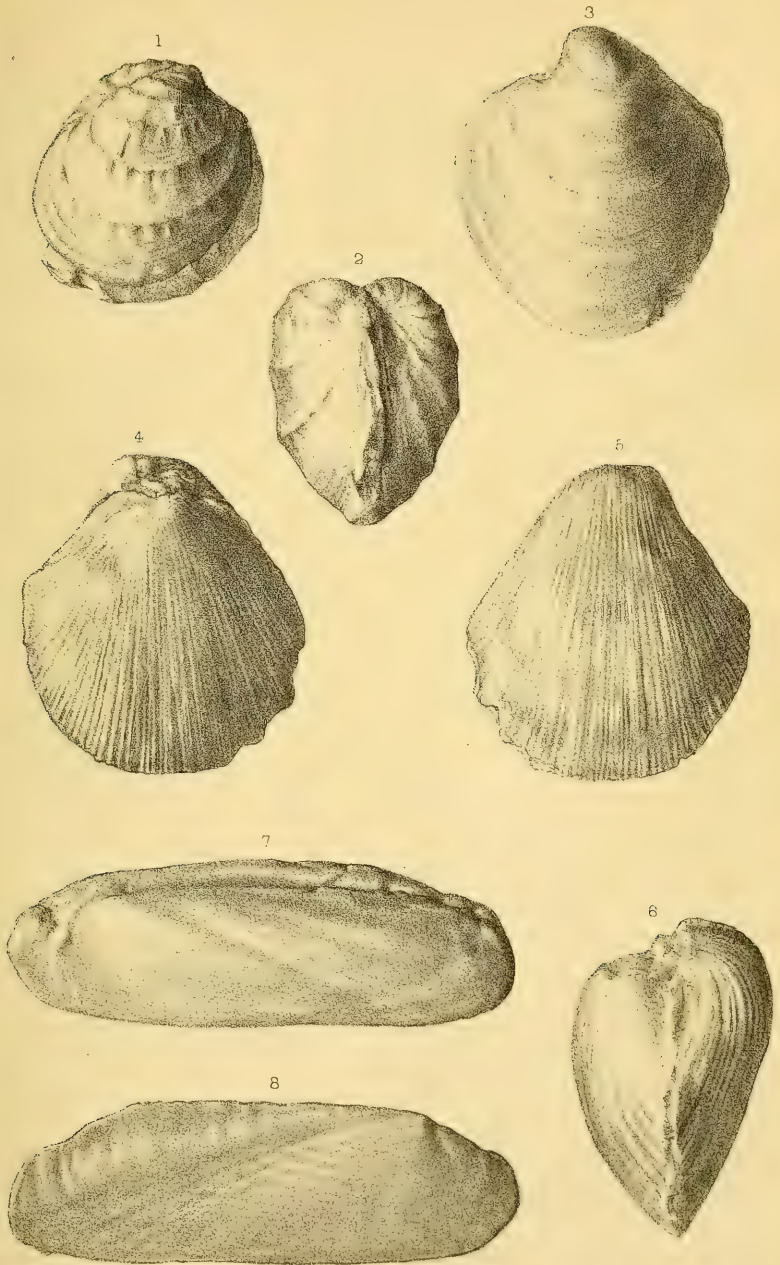
Egyptian Lower Tertiary Shells.

*modo solidula ; valva inferiore plus minusve convexa, plerumque
umbone adnata, costis paucis, crassis, depresso-fornicatis, inæqualibus,
postice minoribus, raro dichotomis, a lamellis concentricis, plus minusve
distantibus, nodoso-spinosis ; umbone parvo, plus minusve obtuso, leviter
incurvo ; cardine brevi, obliquo, canali lato ; marginibus superne
scrobiculato-striatis ; cicatricula musculi subtriangulari, leviter obliqua ;
valva superiore minore, plano-convexa, leviter lamellosa ; cardine lato,
plano ; marginibus superne crenulatis, inferne leviter denticulatis.*
(Mayer-Eymar.)

REMARKS.—The diagnosis here given *in extenso* refers to a small
Egyptian oyster which apparently has never been figured, but which
the author states is related to *O. Flemingi* of D'Archiac and Haime,[1]
from the Nummulitic formation of India. Some specimens in the
Egyptian Collection appear to belong to this species. They are
smaller and narrower than the Indian species (*O. Flemingi*), with
a lower valve bearing fluted or lamellose costæ and an upper valve
marked with fine imbricating concentric laminæ, besides being
crowded with minute vertical striations. The specimens are of one
nearly uniform size, and although no interiors are seen, the valves
being in contact, marginal denticulations are clearly displayed.
From the number of examples sent, this species must be fairly
abundant ; they are slightly encrusted with ' Beekite.'

DIMENSIONS.

Height	...	...	...	...	...	28 mm.
Length	...	...	...	...	...	17 ,,
Diameter of united valves	...	...	...	14 ,,

HORIZONS.—Middle Eocene (Mokattam Series) ; Lower Eocene
(Libyan Series).

DISTRIBUTION.—Egypt : El Guss Abu Said ; Nokba ; Oasis Farafrah ;
Mons Medine Abu, near Thebes ; Mokattam—(Mayer-Eymar) ; left
bank of Nile about ten kilometres north of Esna. Coll. Geol.
Surv. Egypt (No. 1,001, Box No. 41c).

Genus PECTEN, O. F. Müller.

Zool. Danicæ Prod., 1776, p. xxxi.

TYPE.—*Ostrea maxima*, Linnæus.

PECTEN MAYER-EYMARI, sp. nov. (Pl. XIX, Figs. 9–11.)

DESCRIPTION.— Shell lenticular, circular, fan-shaped, costated ;
costæ 20, subrotund or carinated, obsolete laterally ; grooves well
channelled ; surface ornamented with fine concentric lines of growth ;
auricles subequal.

DIMENSIONS.

Height	...	...	...	...	...	27 mm.
Length	...	...	...	...	...	27 mm.

This species bears a true Eocene facies, being related to *P. recon-
ditus*, Solander, and *P. carinatus* of J. de C. Sowerby. It differs
from the former in the absence of any grooval squamulose orna-
mentation and in the possession of almost smooth sides ; from the

[1] Desc. Anim. Foss. Nummulitique l'Inde, vol. ii (1854), p. 275, pl. xxiii,
figs. 14, 15.

latter it is separated by its rounder and more fan-shaped contour, the closer arrangement of its costæ and consequently narrower grooves. In the adult stage the summits of the ribs show a decided angularity, suggesting affinities with *P. carinatus*. On the early stages of the ribs a minute nodulose character is present, somewhat resembling *P. solariolum* of Mayer-Eymar [1] from the Egyptian Eocenes.

REMARKS.—The shell appears to be fairly common, occurring in a soft cream-coloured chalky rock as well as in a reddish-brown matrix of a marly character. The specimens are, however, rarely well preserved, being chiefly impressions; associated with them are some obscure plant remains, a small *Arca* (*A. Esnaensis*, n.sp.), and other mollusca of a fragmentary nature. Professor Mayer-Eymar's name is associated with this shell in acknowledgement of his important researches on the geology and palæontology of Egypt.

HORIZON.—Lower Eocene (Libyan Series).

DISTRIBUTION.—Egypt: Hills west of Jebel Zait, western shore of the Gulf of Suez (28*a* to 30*a*); and right bank of the river Nile opposite Esna (49*c*). Coll. Geol. Surv. Egypt (No. 628, Box Nos. 28*a* to 30*a*; No. 1,003, Box No. 49*c*).

Genus SPONDYLUS, Linnæus.

Systema Naturæ, 1758, ed. x, p. 690.

TYPE.—*S. gæderopus*, Linnæus.

SPONDYLUS ÆGYPTIACUS, sp. nov.   (Pl. XX, Figs. 4–6.)

DESCRIPTION.—Shell subovate, inequivalve, nearly equilateral, inflated at the summit; lower or right valve the largest and most convex, with usually a depressed, adherent surface at the umbo; valves ornamented with numerous fine radial ribs (between fifty and sixty), which are rounded or acute according to preservation, smooth, and separated by simple grooves without striations; sculpture more or less zoned, with from eight to ten more distinctive ribs than the rest; ribs apparently without spines; internal characters not seen.

DIMENSIONS (with valves united).

Height	...	...	...	...	...	43 mm.
Length	...	...	...	...	...	38 ,,
Diameter	...	...	...	...	...	27 ,,

REMARKS.—According to the researches of Bellardi [2] and Zittel [3] two species of *Spondylus* have been recognized from the Egyptian Eocenes, viz., *S. rarispina*, Deshayes, and *S. Rouaulti*, D'Archiac, a form originally described from the Nummulitic of India. Both, however, differ from the present shell, not only in outline, but in their primary ribs being furnished with conspicuous spines; *S. Rouaulti*, in addition, exhibiting transverse striations between the

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[1] Journ. Conchyliologie, 1888, pl. xiv, fig. 5, p. 328.
[2] Bull. Soc. Géol. France, 1851, ser. II, vol. viii, p. 261.
[3] Palaeontographica, 1883, vol. iii, p. cvii.

costal grooves. The absence of spines, also, separates the new form from *S. multistriatus* of Deshayes, and from Schafhäutl's [1] Kressenberg species, *S. astragalus.*

This species is represented by six specimens, the largest (a lower valve) measuring 44 × 41 millimetres, the remainder being of more uniform size and having united valves. They are in a fair state of preservation, without spinous attachments to the ribs, nor is there any indication of striations between the grooves. The matrix is a white chalky foraminiferal (*Operculina*, etc.) limestone and similar to that containing *Chama late-costata.*

HORIZON.—Lower Eocene (Libyan Series).

DISTRIBUTION.—Egypt: near Assiout. Coll. Geol. Surv. Egypt (No. 630, Box No. 33a).

Genus CHAMA, Linnæus.

Systema Naturæ, 1758, ed. x, p. 691.

TYPE.—*C. lazarus,* Linnæus.

CHAMA LATE-COSTATA, Bellardi. (Pl. XX, Figs. 1–3.)

Chama late-costata and *C. latilamellata,* Bellardi, "Cat. Rais. Foss. Nummulitiques Nice": Mém. Soc. Géol. France, ser. II, vol. iv (1851), p. 254, pl. xx, fig. 12.

DESCRIPTION.—*Testa ovato-rotundata, subequivalvis, lævi, concentrice costata; costis lamellosis, postice subimbricatis, distantibus dente cardinali recurvo, crasso, lævi; umbonibus recurvis, subspiratis* (Bellardi). This is the original diagnosis of a shell which is mainly distinguished from other *Chamæ* by the widely distant concentric ribs ornamenting its valves. The upper valve is more sculptured than the other, possessing numerous pillar-like, radial costæ in the concentric spaces, thereby connecting the species very closely with *C. calcarata,* Lamarck, from the Paris Basin Eocenes. Although somewhat worn, the Egyptian specimens show all these details of structure, besides preserving some faint indications of concentric striæ between the primary costæ of the lower valve. No interiors are seen.

DIMENSIONS.

Largest lower valve—				
Height	...	...	42 mm.	
Length	...	...	37 ,,	
Diameter	...	...	15 ,, (about).	

REMARKS.—Found in a white chalky foraminiferal limestone stained with iron peroxide, and accompanied by a *Spondylus.* The smallest and most perfect specimen has both its valves united.

HORIZON.—Lower Eocene (Libyan Series).

DISTRIBUTION.—Environs of Nice (Bellardi); Pyrenees (D'Archiac); Spain (Mallada); Egypt, near Assiout. Coll. Geol. Surv. Egypt (No. 636, Box No. 47a).

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[1] Süd-Bayerns Lethæa Geognostica der Kressenberg, etc., 1863, p. 148, pl. 65b, fig. 13.

Genus ARCA, Linnæus.

Systema Naturæ, 1758, ed. x, p. 693.

Type.—*A. Noæ*, Linnæus.

ARCA ESNAENSIS, sp. nov. (Pl. XIX, Figs. 15, 16.)

DESCRIPTION. — Shell small, inequilateral, moderately convex, transversely oval; surface ornamented with a close cancellation formed by a series of radial, fimbriate costæ, crossed by concentric striæ, which at the junctions assume a noded or beaded appearance; valve slightly depressed in the centre; carination oblique and dorsally acute; margins more or less rounded; slight mesial depression present.

DIMENSIONS.

| Height | ... | ... | ... | ... | ... | 11 mm. |
| Length | ... | ... | ... | ... | ... | 18 mm. (about). |

REMARKS.—This description is drawn up from a single right valve, embedded in the same matrix as contains *Pecten Mayer-Eymari*. The specimen has a highly ornamented test, with rays of equal thickness and a uniform distance from each other. One of the margins is round, the other imperfect. It is most closely related to *Arca appendiculata* of J. Sowerby, especially in its decussated sculpture, and is doubtless a good Eocene form of the genus. From its rarity in Egyptian rocks the specimen is considered of sufficient importance to merit a notice under the present new name.

HORIZON.—Lower Eocene (Libyan Series).

DISTRIBUTION.—Egypt: right bank of river Nile opposite Esna. Coll. Geol. Surv. Egypt (No. 1,003, Box No. 49* *c*).

Genus MACROSOLEN, Mayer-Eymar.

Palaeontographica, vol. xxx (1883), p. 116.

Type.—*Sanguinolaria Hollowaysi*, J. Sowerby.

MACROSOLEN HOLLOWAYSI, J. Sowerby. (Pl. XX, Figs. 7, 8.)

Sanguinolaria Hollowaysi, J. Sowerby : Mineral Conchology, vol. ii
        (1817), p. 133, pl. clix.
Solen uniradiatus, Bellardi, " Cat. Foss. Numm. Egitto " : Mem. R. Ac.
        Sci. Torino, ser. ii, vol. xv (1854), p. 16, pl. ii, fig. 5.
Sanguinolaria (Macrosolen) Hollowaysi, Mayer-Eymar in Zittel :
        Palaeontographica, vol. xxx (1883), p. cxvi.
Gari (?) *Hollowaysi*, R. B. Newton : Syst. List Edwards Coll.
        Brit. Mus., 1891, p. 76.

DESCRIPTION.—This species was originally described as "depressed, transversely elongate, ovate, and striated; anterior [should be posterior] side gradually expanded; posterior [should be anterior] side very small."

It is a well-marked shell, and easily distinguished by its transversely elongate shape, the very anterior position of the umbones, and the oblique furrow extending from the umbonal area to the posterior margin. The hinge consists of two diverging teeth in

each valve; the ligament being supported by a prominent elongate nymph or fulcrum.

Some excellent casts of this species are in the Egyptian Collection, though of course showing no dental characters such as are preserved in the beautiful examples from the Bracklesham Beds of England.

DIMENSIONS.

Height	...	...	...	...	...	20 mm.
Length	...	...	...	...	...	68 ,,
Diameter	...	...	...	...	...	13 ,,

REMARKS.—A very pronounced pallial sinus and some important dental differences separate this genus from *Cultellus*. It appears to be rather closely related to *Gari* (= *Psammobia*) in the deep sinus and character of the teeth, though possessing more inequilateral valves. Such differences as are here indicated make it convenient to adopt *Macrosolen*, proposed by Professor Mayer-Eymar in 1883 for the reception of *S. Hollowaysi*. Professor Mayer-Eymar has kindly furnished the writer with the following note on this subject: " The genus *Macrosolen* was indeed proposed by me for Sowerby's *Sanguinolaria Hollowaysi*, and published for the first time in the work of Mr. Zittel on Egypt, 1883. I have never given a description of this genus, but I think it may be a good one, taking rank in the family of the Solenidæ near *Cultellus* and *Solen*, having the same mode of increasing beaks and the same long ligament. In Egypt the species is very common, both in the Lower and Upper Parisian or Middle Eocene. I know of no other species of *Macrosolen*."

The shell figured and described by Bellardi from Egypt as *Solen uniradiatus* is doubtless the same as Sowerby's species; its name is therefore regarded here as a synonym of the older form.

HORIZON.—Middle Eocene (Mokattam Series).

DISTRIBUTION.—England: Bracklesham Bay; Stubbington; White Cliff Bay. Egypt: between Guiset and Fayoum; Abu Zabel. Coll. Geol. Surv. Egypt (No. 644, Box No. 60*a*).

[CAST OF A LUCINIFORM SHELL.]

REMARKS.—Cast of a small Luciniform shell showing rather prominent concentric sulcations: indeterminable.

HORIZON.—Eocene?

DISTRIBUTION.—Egypt: Wadi Natrum. Coll. Geol. Surv. Egypt (No. 639, Box No. 50*a*).

Genus LITHOPHAGUS, Megerle von Mühlfeld.

"Entwurf Syst. Schalthiergehäuse": Mag. Ges. Nat. Freund. Berlin, vol. v (1811), p. 69.

TYPE.—*Mytilus lithophagus*, Linnæus.

SYNONYM.—*Lithodomus*, Cuvier, 1817.

LITHOPHAGUS CORDATUS, Lamarck. (Pl. XIX, Figs. 12–14.)

Modiola cordata, Lamarck: Annales Mus. Hist. Nat., vol. ix (1807), pl. xviii, fig. 2; Hist. Nat. Anim. sans Vert., vol. vi (1819), pt. 1, p. 117. Deshayes: Desc. Coq. Foss. Paris, vol. i (1830), p. 268, pl. xxxix, figs. 17–19.

Lithodomus cordatus ? Bellardi, "Cat. Foss. Numm. Egitto" : Mem. R.
        Ac. Sci. Torino, ser. II, vol. xv (1854), p. 193.
Mytilus subobtusus, D'Archiac : Desc. Anim. Foss. Numm. Inde, vol. ii
        (1854), p. 268, pl. xxiii, fig. 13.
Mytilus (*Lithodomus*) *cordatus*, Mayer - Eymar : Viert. Nat. Ges.
        Zürich, vol. xxxvi (1891), p. 174.

DESCRIPTION.—*Testa elongata, cylindracea, arcuata, tumida, lævi-
gata ; umbonibus inflatis, antice inflexis, cordatis, subspiratis,
prominentibus.* (Deshayes.)

This diagnosis of Lamarck's shell is reproduced from Deshayes'
work in preference to the original as being rather more
complete. The present examples of the species consist of several
excellent casts, the valves of which are attached; some coral
structure is retained at the anterior end of the largest specimen,
into which the mollusc had burrowed. The species is easily dis-
tinguishable from other fossil forms by the strongly modioliform
and tumid character of the valves, together with the terminal
incurved beaks and its generally striking resemblance to *Litho-
phagus cinnamominus*, Chemnitz, of recent seas. The Indian species,
M. subobtusus, agrees in all essential details with *L. cordatus*, and it
has therefore been united here, this being in accordance with the
views of Professor Mayer-Eymar.

DIMENSIONS.

				Largest.	Smallest.
Height ...	...	...	...	40	10 mm.
Length ...	...	...	...	20	5 ,,
Diameter	...	...	...	22	6 ,,

REMARKS.—Bellardi appears to have made the first record of this
shell from Egypt.

HORIZON.—Lower Eocene (Libyan Series).

DISTRIBUTION.—Paris Basin ; Germany ; Belgium ; Alps ; India ;
Egypt, Abu Zabel (60a) and fifteen kilometres west of Esna
(51c). Coll. Geol. Surv. Egypt (No. 645, Box No. 60a; No. 240,
Box No. 51c).

EXPLANATION OF PLATE XIX.

MITRA TURRICULATA, Schafhäutl.

Middle Eocene (Mokattam Series) : Minyeh.

FIG. 1.   Dorsal view, with typical spire : Foraminifera are seen at the suture.

HIPPOCHRENES, sp.

Middle Eocene (Mokattam Series) : Minyeh.

FIG. 2.   Ventral aspect, showing obscure spiral ornamentation.

POTAMIDES (allied to) PERDITUS, Bayan.

? Oligocene : Wadi Natrum.

FIG. 3.   Portion of a small chert-slab with scattered examples of the shells.
FIG. 4.   Magnified view of a specimen, showing sculpture (× 4).

OSTREA AVIOLA, Mayer-Eymar.

Lower Eocene (Libyan Series) : about ten kilometres north of Esna.

FIG. 5.   External view of lower valve } same specimen.
FIG. 6.   ,,   ,,   upper valve }
FIG. 7.   Surface magnification of upper valve, showing striations.
FIG. 8.   Another lower valve, with adherent surface at the summit.

PECTEN MAYER-EYMARI, sp. nov.

Lower Eocene (Libyan Series) : opposite Esna.

FIG. 9.   External view of one of the valves.
FIG. 10.   Surface magnification of same, showing sculpture.

Lower Eocene (Libyan Series) : Hills west of Jebel Zait.

FIG. 11.   External aspect of specimen, with fairly perfect auricles.

LITHOPHAGUS CORDATUS, Lamarck.

Lower Eocene (Libyan Series) : Abu Zabel.

FIG. 12.   View of adult form, exhibiting the right valve.
FIG. 13.   Anterior aspect of same, showing the beaks.
FIG. 14.   A young specimen.

ARCA ESNAENSIS, sp. nov.

Lower Eocene (Libyan Series) : opposite Esna.

Fig. 15.   External view of right valve, magnified twice.
FIG. 16.   Magnified view of surface, showing sculpture.

EXPLANATION OF PLATE XX.

CHAMA LATE-COSTATA, Bellardi.

Lower Eocene (Libyan Series) : near Assiout.

FIG. 1.   Outer view, showing the upper or more sculptured valve.
FIG. 2.   Posterior aspect of same specimen.
FIG. 3.   External view of the largest lower valve.

SPONDYLUS ÆGYPTIACUS, sp. nov.

Lower Eocene (Libyan Series) : near Assiout.

FIG. 4.   Front aspect of chief specimen.
FIG. 5.   Back   ,,   ,,   ,,
FIG. 6.   Profile   ,,   ,,   ,,

MACROSOLEN HOLLOWAYSI, J. Sowerby.

Middle Eocene (Mokattam Series) : between Guiset and Fayoum.

FIG. 7.   Outer view, exhibiting the left and part of the right valves $\}$ same specimen.
FIG. 8.   ,,   ,,   ,,   right valve

(Except where otherwise mentioned, the figures on both plates are of the natural size.)

III. — ON A DEFORMED EXAMPLE OF *HOPLITES TUBERCULATUS,*
J. SOWERBY, SP., FROM THE GAULT OF FOLKESTONE.

By G. C. CRICK, F.G.S.,
Of the British Museum (Natural History).

THERE has recently been presented[1] to the British Museum collection an Ammonite from the Gault of Folkestone that seems to be worthy of a short note. It is represented in the accompanying figures. At first sight it appears to be a new species. The shell is nearly complete and exceedingly well preserved ; there has evidently been another half whorl to the specimen (see Fig. *a*), but this, which apparently constituted the body-chamber, has been broken away, leaving at the anterior end of the specimen the surface of the last septum. The sculpture of the sides instantly reminds one of the ornaments of the well-known *Hoplites tuberculatus,* J. Sowerby,[2] sp., but in that species the middle of

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[1] By Mr. C. Coles.
[2] J. Sowerby, Min. Conch., vol. iv (1821), p. 4, pl. cccx, figs. 1–3. The originals of figs. 1 and 3 are in the British Museum collection.

the ventral area is occupied by a well-marked and sharply-defined
channel with a row of tubercles on each side, the tubercles on one
side usually alternating with those on the opposite side, whereas
in the present specimen the median part of the periphery (see
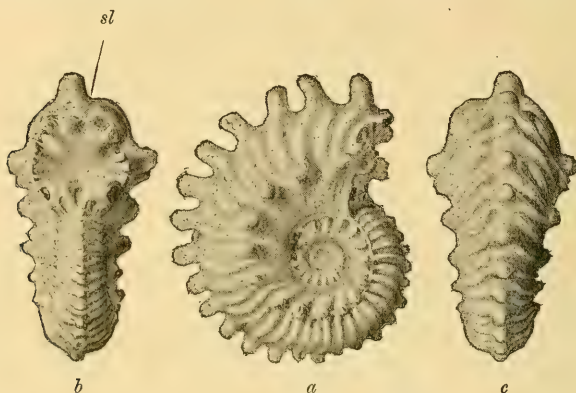
Deformed example of *Hoplites tuberculatus*, J. Sowerby, sp., from the Gault,
     Folkestone. *a*, left lateral view; *b*, front view, showing the single row of
     tubercles on the periphery and the asymmetry of the last septal surface,
     sl indicating the siphonal lobe; *c*, peripheral view, showing the single row of
     tubercles on the periphery and the feeble, imperfectly-defined groove on the
     right (left in the figure) side at the base of the tubercles. Drawn of the
     natural size from a specimen in the British Museum collection.

Figs. *b*, *c*) of the whole of the outer whorl is occupied by a single
row of rounded and nearly equidistant tubercles. A careful
examination of the specimen, however, shows that the whorl is
not quite symmetrical; that the row of tubercles is not quite
central, but placed a little to the left of the median line; and that
on the right[1] at the base of the tubercles (see Figs. *b* and *c*) there
is a very feeble, imperfectly-defined groove. As we have already
remarked, the anterior end of the specimen is formed by the last
septum (see Fig. *b*). This is not quite symmetrical, the siphonal
lobe (*sl*) being clearly on the right of the median line, and the
lobes and saddles on the right side consequently smaller than those
on the left. It is quite clear that the specimen is deformed, and
there can be no doubt that it is a deformed example of *Hoplites
tuberculatus.* It seems, then, that the tubercles occupying the
periphery belong chiefly to the left side, but since the ribs on
the right side pass across the very feeble and imperfectly-defined
groove, and are also joined to the median row of tubercles, this
row may represent also the tubercles belonging to the right side.
This opinion is supported by the *shape* of the tubercles, for in the
present specimen these are nearly circular and sometimes even
transversely elongated in cross-section, whereas in the normal form
of the species they are laterally compressed.

[1] The terms ' right ' and ' left ' are here used in a strictly morphological sense.

IV. — STUDIES IN EDRIOASTEROIDEA. I. *DINOCYSTIS BARROISI,* N. G. ET SP., PSAMMITES DU CONDROZ.

By F. A. BATHER, M.A., F.G.S.

(PLATE XXI.)

HORIZON AND LOCALITY.

ON April 30th, 1897, the Trustees of the British Museum purchased from Dr. F. Krantz, of Bonn, seven specimens labelled "*Agelacrinus*, n.sp., Unter Devon, Condroz, Frankreich." But the Condroz is a district in Belgium, south of Namur and Liège, between the rivers Meuse and Ourthe; the species do not belong to *Agelacrinus* or any known genus; and the matrix clearly is that of the well-known "Psammites du Condroz," which are Upper, not Lower, Devonian. The species, however, is new, and would have been described by me many months ago had it not been necessary to compare it with other species as rare as they were obscure. The kindness of the authorities at the Imperial University and at the Academy of Sciences in St. Petersburg, the Museum of Practical Geology in London, and, most of all, at the Geological Survey in Ottawa, has enabled me to make a fairly satisfactory study of the forms that elucidate the Condroz species. In addition to them, I have to thank my friend Professor Otto Jaekel, who had at Berlin another specimen of this species, which he purposed introducing to science in his forthcoming Phylogeny of the Pelmatozoa under the name *Dinocystis Barroisi*; on learning that we had more and better specimens for study he generously waived any objections he might have had to my prior publication.

The ascription of these specimens to the "Psammites du Condroz" is confirmed both by the Berlin specimen and by a statement in Dr. Michel Mourlon's "Géologie de la Belgique" (tome ii, Bruxelles, 1881). A "Liste des fossiles des psammites du Condroz" (p. 23) notes "*Agelacrinus*" as "très-rare" in "Assises de Montfort et d'Évieux," but refers to no published authority for the statement. The "Assises" in question are numbered III and IV by Mourlon, and are the lower two of his divisions of the "psammites" (op. cit., tome i, pp. 92, 93). There is little doubt but that the present species is the *Agelacrinus* of Mourlon.

The "Psammites du Condroz" consist of a micaceous sandstone varying in coarseness, sometimes bluish but, in consequence of weathering, usually brown or even reddish. The calcareous constituents have been leached out, and the fossils occur as either internal casts or external impressions. Unfortunately, the available specimens of *Dinocystis* all belong to the former category. The sandstone may be regarded either as an independent horizon above the Famennian shales and below the Limestone of Etroeungt, or as a littoral equivalent of the typical Famennian shales. The latter view, that adopted by Renevier, is supported by the fact that in the Condroz area the Etroeungt Limestone is replaced by the shales

of Wattignies with *Phacops granulatus*, *Orthotetes crenistria*, and *Clisiophyllum Omaliusi*, while the shales of Colleret and of Cousobre below the " Psammites " have less thickness than the Famennian shales elsewhere.   In either case the " Psammites du Condroz " must be taken as the uppermost member of the true Upper Devonian, the succeeding limestones or shales being regarded as beds of passage to the Carboniferous.   The known forms most nearly allied to *Dinocystis* have not as yet been found above the Ordovician.

The Material.

The seven specimens preserved in the British Museum are registered E 7,581 to E 7,587, and may here be termed for short **1, 2, 3**, etc., respectively.   Of these **2** is selected as holotype, while **1** and **3–7** constitute the paratypes.

All are internal casts; but **3** and **7** had small portions of matrix adherent to the under side, and these, being broken away, show parts of the impression.

In outline, as seen from above, the fossils are roughly elliptical, but the orientation of the ellipse varies.   A line drawn through anus and actinal pole, and called the antero-posterior axis, almost coincides with the long diameter of the ellipse in **1**, **2**, and **6**; in **3** the long diameter is shifted in the direction of the clock-hand about 25°; in **4** about 35°; in **5** about 20°; while in **7** the shift is contrary to the clock-hand about 75°.   The measurements of the diameters of the ellipse, in millimetres, are :—

1	2	3	4	5	6	7
43	38·5	35	32·5	30	28·5	24
38·5	31	26·5	27·5	22	23·5	21

Distance of actinal pole from posterior margin, in millimetres :—

1	2	3	4	5	6	7
19·5	16	12·5	12	12	16	14

These measurements show that the present shape of the specimens is probably due to contortion after death, whether before or after the consolidation of the matrix.   But they further suggest that the tendency was for elongation to take place in an antero-posterior direction, and that in life as in death the actinal centre lay posterior to the geometric centre.   To confirm these suggestions there is needed a larger series of specimens, and information concerning their relations to the rock-masses in the field.

Description of the Species on the Evidence of the Seven Specimens.

One may compare the fossil in a rough way to a Tam-o'-Shanter cap or a Breton béret.

The periphery was approximately circular, varying in diameter from 41 mm. (**1**) to 22 mm. (**7**).

From the periphery, the test curved gently over to the upper surface, and rolled gently inwards on the under surface towards

DINOCYSTIS BARROISI, 1898.

what would correspond to the opening of the cap. Thus the under surface is hollowed, but since the central region is always filled by matrix one cannot ascertain its structure in full (Pl. XXI, Figs. 1*b*, 2*b*). If the fossil be placed on a flat surface, the actinal pole reaches a height of 14 mm. (**1**), 9 mm. (**2**), 9·5 mm. (**4 and 6**), 6 mm. (**7**). But, owing to the concavity of the under surface, the thickest portion of the actual specimen would be slightly less and would lie about half-way between the actinal pole and the periphery. (Diagram 2.)

1.   2.
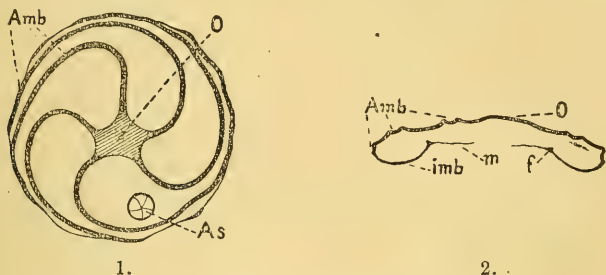
DIAGRAMS OF DINOCYSTIS.

(1) The upper or actinal surface.
(2) Vertical section across the middle of the test (based chiefly on **3** and **7**).

O, the actinal pole; *Amb*, the five grooves radiating therefrom and passing over the periphery; *As*, anus; *f*, frame of abactinal surface; *imb*, imbricated peripheral area of same; *m*, thin membrane of central area of same.

On the U p p e r S u r f a c e, from the actinal pole, five Radial Grooves pass outwards over the test, each curving as it goes in a sinistral or contra-solar direction (Diagram 1). Each reaches the periphery, and passes along it for fully a fifth of the circumference, or may even pass over to the under surface, so that in nearly all the specimens one or more of the grooves is visible from below.

Apart from the contortion of the specimens, the grooves are not wholly dominated by pentamerous symmetry. They show the primitive division into one anterior, and two pairs of lateral grooves, and are besides not quite regular in their course.

The grooves, as seen on the internal casts, are clearly marked channels, deeper and narrower towards the periphery, where they have undergone more compression. They are bordered on each side by a row of equidistant small knobs, which become smaller distalwards; the knobs are either opposite each other or slightly alternating, and each pair is connected by a faint ridge (Figs. 1*c* and 2*d*). A wax squeeze shows that this appearance is due to the former presence of plates flooring the groove (Figs. 2*e* and *f*). It is probable that these plates originally were in two alternating rows, but that they usually came to lie in pairs without alternation. They may even have fused (as was perhaps also the case in *Haplocystis* Roemer); at any rate there is no sign of a median suture. Between successive plates, on each side, was a pore, represented in the

internal cast by a knob. Of these pores from three to six may be counted in 5 mm., according to the distance from the ambulacral centre (**2**). (Figs. 2*e*, *f*.)

A flattened, elevated, roughly pentagonal area over the actinal pole in **1**, **3**, and **5**, may indicate that this was roofed in by covering-plates. Such a structure may also be inferred from the evidence of allied genera. The covering-plates that doubtless once roofed in the rest of the grooves, were probably removed before fossilization.

The Interradial Areas of the upper surface form slightly concave depressions between the radial grooves. They were covered with polygonal plates (about $2 \cdot 5 \times 2$ mm., or less), having their longer diameters parallel to the grooves; there is no evidence that these plates overlapped each other.

In the interradius which (for that reason) has been here termed 'posterior,' lay the anal opening, surrounded apparently by minute plates, the number of which cannot be ascertained. The representation in Diagram 1 is purely diagrammatic. The rounded anal eminence can be recognized on all the casts, at a varying distance from the actinal centre and from the periphery. This interradius is wider than the others near the actinal pole, and in that region probably lay the hydropore. The interradial areas are really continuous with the test of the under surface; but practically they are separated, partly by the almost complete encircling of the periphery by the radial grooves, partly by a rather sudden change in the structure of the test.

The Under, or Abactinal Surface, was divided into two areas, an inner or central, and an outer or peripheral, by a circular Frame, corresponding in position to the rim of a Tam-o'-Shanter, but turned inwards and slightly upwards, not downwards (Diagram 2). Evidence for this frame is presented by specimens **2**, **4**, **3**, and **7**, especially the two latter, which had this region protected by matrix. Removal of the matrix, or cutting across it (Fig. 7*b*), shows a distinct space, triangular in section, encircling the central area. This can only be accounted for by supposing that thicker calcareous plates existed here, and have been dissolved away (cf. Figs. 7*c*, 7*d*).

Peripheral Area.—The frame was depressed to about half the total thickness of the animal, and between it and the periphery there rolled convexly a somewhat flexible integument in which were set minute narrow plates, with their long axes at right angles to the radii of the circle. The edges of these plates appear to have projected outward, towards the periphery of the test, so as to produce an imbrication (**1**, **2**, **3**, **4**, **7**). Flexibility is ascribed to this area chiefly on the evidence of **2**, which shows a radial folding in places.

Central Area.—What was inside the frame cannot be determined satisfactorily. There are in **2**, **3**, and possibly in others, suggestions of a fine and flexible membrane stretched loosely across the opening of the frame. Traces of this are only seen near the edge, and there is no proof that it was continuous. In **2**, however, the visible traces show a fine radial pleating, such as might have been produced, had the membrane been continuous, by some pressure in the central region. (Fig. 2*b*.)

Systematic Position.

Discussion of the meaning of the above-mentioned structures, and of the affinities of the genus, must be postponed until *Edrioaster* has been decently described and figured. I may, however, anticipate by saying that the Condroz form is clearly a close ally of *Edrioaster*, but that it may be distinguished from that genus, as now known, by the tenuity and flexibility of the peripheral area of the abactinal surface, which area in *Edrioaster* is formed of plates no less solid than those in the interradial areas of the actinal surface.

Edrioaster and *Dinocystis* may be separated from the Agelacrinidæ and Cyathocystidæ, as a family Edrioasteridæ, by the absence of a definite border defining the actinal surface, and by the passage of the radial grooves on to the abactinal surface. We may therefore give the following diagnosis of

Dinocystis,[1] gen. nov.

An Edrioasterid with the peripheral region of the abactinal surface composed of a thin flexible integument containing narrow imbricating ossicles.

Genotype : *D. Barroisi*,[2] sp. nov. (= *Agelacrinus*, sp., Mourlon), Upper Devonian, Psammites du Condroz, Belgium.

The characters of the species are of course those of the above description, but one may allude specially to the relatively narrow radial grooves, and to their consistent sinistral curvature. The holotype is in the British Museum, registered E 7,582.

EXPLANATION OF PLATE XXI.

Dinocystis Barroisi.

[All the drawings are from specimens in the British Museum. Figures 1*a*, 1*b*, 2*a*, 2*c*, 3, 4, 5, 6*a*, 6*b* are based on photographs by Mr. J. Green ; the other figures are by Mr. G. C. Chubb. All figures are natural size, except 1*c*, 2*d*, 2*e*, 2*f*, which are × 4 diam., 7*b*, which is × ⅔, and 7*c* and 7*d*, which are × 2 diam. In all the complete views the right and left of the specimen correspond with the right and left of the observer.]

Fig. 1 (E 7,581).   *a*. Actinal surface ; anus distinct in lower interradius.
          b. Abactinal surface ; radial grooves are seen at top and on left ; imbricating plates of peripheral area well shown.
          c. Distal portion of a radial groove drawn from the specimen.
Fig. 2 (E 7,582).   *a*. Actinal surface ; impressions of interradial plates are clear.
          b. Seen from anterior end ; the groove in the middle is anterior.
          c. Abactinal surface ; the trace of the frame is seen between east and south of the drawing ; the coarse radial folding of the peripheral area and the fine folding of the central area are seen between S. and S.S.W. ; portions of radial grooves are visible at both top and bottom.
          d. Portion of anterior radial groove, drawn from specimen just where the groove first curves sharply to the left in Fig. 2*a* ; shows knobs and transverse ridges.

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[1] Δεινός, *terrible, wondrous.* It might astonish anyone not acquainted with the true structure of *Edrioaster*.

[2] In honour of Dr. Charles Barrois, whose valuable work on Devonian rocks and fossils, of other districts, must be held to excuse this dedication to him of a fossil with which he has had no obvious connection. The undesirability of applying the names of persons to species, without cogent reason, has been maintained by me so consistently that it will be understood that these names, suggested by Dr. Jaekel, are here adopted merely so as to avoid any possible confusion.

>   *e.* Wax squeeze of the same; showing pores and flooring-plates of the groove
>   as they would appear on the inside of the test.
>   *f.* Similar squeeze from a part of the groove nearer the periphery, showing
>   the twisting over of the flooring-plates.

Fig. 3 (E 7,583). Actinal surface; the crack running from N.E. to S.W. shows the
  fracture that enabled the transverse section, Diagram 2, to be reconstructed.

Fig. 4 (E 7,584). Abactinal surface; shows imbrication of peripheral area, and
  traces of the frame.

Fig. 5 (E 7,585). Actinal surface; the pentagonal area at the actinal pole is well
  marked, owing to the breaking away of the portion of the cast that
  represented the covering-plates.

Fig. 6 (E 7,586).   *a.* Actinal surface.
        b. Abactinal surface; shows large central hollow and traces of frame.

Fig. 7 (E 7,587).   *a.* Actinal surface; the line *x—y* is that of the section *b*; this
        latter shows the trace of the frame in the left half.
        c. Portion of abactinal surface of specimen, showing marked trace of the frame.
        d. Wax squeeze from impression of same in matrix, therefore representing
        outside of test; shows imbricating plates more distinctly, but trace of
        frame far less distinctly.

V.—The Value of Type-Specimens and Importance of their Preservation.[1]

By Professor O. C. Marsh, M.A., Ph.D., LL.D., F.G.S.;
of Yale College, New Haven, U.S.A.

IN the present state of Natural Science, there are too many
obstacles in the path of the original investigator. That this is
the case in the study of Botany, we may well believe, as authorities
of that science have frequently placed the fact on record. It is
certainly true that everyone who does original work in systematic
Zoology, either among the living or extinct forms, meets many
difficulties at the start in endeavouring to ascertain what others
have done before him. The literature of the subject is often dis-
couraging from its extent, and especially from its uncertainty. If
the work in hand requires the comparison of type-specimens, the
difficulties greatly increase, and often prevent definite conclusions.
The type will frequently be found the most important element in
the problem, far more so than the literature, however extensive.
This is more especially true among the extinct vertebrates, with
which the present communication mainly deals.

1. *The Value of Type-Specimens.*

The value of a type depends first of all upon whether it is
a characteristic specimen, worthy of being the representative of
a new group of individuals. Without this distinctive quality, its
importance is greatly diminished. If, for example, the specimen
first described is immature, its essential features may thus be
obscured, and its value as a type much diminished. On the other
hand, a very old animal may be uncharacteristic. The teeth of
a mammal, for instance, may be worn down or even lost, so as to
make the normal dentition uncertain. This is true of recent forms,
but is more important if the type belongs to an extinct fauna, as
then the chance of duplicating it is much less.

[1] Read before Section B, International Congress of Zoology, Cambridge, England,
August 23, 1898.

The value of a type-specimen, again, may depend largely upon its completeness. Among the invertebrates, especially those now living, types are usually complete enough to show the more important features. This, however, is far from being the case among extinct forms, particularly from the older formations, and the records of Palæontology are burdened with the names of many fragmentary fossils, types of species practically unknown.

Among the vertebrates of the past, the case is much more serious, and here especially reform in methods is a pressing necessity. From the nature of the case, the older extinct forms are usually represented by fragmentary remains, the investigation of which is one of the most difficult problems offered to natural science. A single tooth or a vertebra may be the first specimen brought to light in a new region, and thus become the sole representative of a supposed new form. The next explorer may find more perfect fragments of the same or similar forms, and add new names to the category. A third investigator, with better opportunities and more knowledge, may perhaps secure entire skulls or even skeletons from the same horizon, and thus lay a sure foundation for a knowledge of the fauna.

As the number of described forms increases, the necessity of a direct comparison of types becomes imperative, and the comparative value of each type-specimen is thus brought into notice. It will then frequently be found that not a few are uncharacteristic, while others are too incomplete to disclose their own essential features, and hence of little aid in indicating the affinities of forms found with them.

Type-specimens that do not show characteristic features are, of course, of little value to science, and many such prove a delusion and a snare to the investigator, however faithfully he may endeavour to study them. The imperfect types require still more labour to decipher them. Not a few specimens to-day are types, for the simple reason that they are imperfect. If they had been entire when described, their true nature would have been recognized, and much confusion in nomenclature have been avoided. The chance preservation of some marked features may, indeed, give a hint as to what the whole specimen once was, but too often a suggestion only is thus offered, while the real nature of such types must always remain in doubt.

A type in Palæontology should consist of the remains of a single individual, and this should stand as the original representative of the name given. A second specimen, or even more, may be used later to supplement the first, but not to supplant it. This, however, has been done by some authors, with the natural result of causing endless confusion in the nomenclature.

2. *The Selection of Type-Specimens.*

The descriptions in Palæontology are too often descriptive only, and not comparative. This, if well done, is preferable to long academic discussions in regard to the affinities of a specimen of

which the main characters are not known, or not placed on record. A vertebra of a reptile or the tooth of a mammal, if perfect and characteristic, may form a type that will be distinctive enough for the present requirements of the investigator. What the future may demand, will depend upon the advance of knowledge in that branch of science.

In the choice of specimens worthy of being types, I can only suggest a course that seems to me the proper one. I believe experience has already shown that to make types of incomplete or uncharacteristic specimens is seldom of permanent advantage to an author, and almost always a lasting injury to the branch of science he represents. There are more good specimens waiting to be found than any naturalist can possibly describe, and one such specimen is worth many of inferior grade.

I may perhaps be permitted to mention in this connection my own experience in the matter of type-specimens. As a student in Germany, years ago, I had my attention called particularly to this subject, and was then strongly impressed with the importance of using only good specimens for first descriptions. This rule I have endeavoured to follow. My researches, especially in western North America, have resulted in the discovery of more than one thousand new species of extinct vertebrates, and of these I have described about five hundred. Had I been satisfied to use inferior specimens as types, I might have increased the number by one-half at least.

No small part of the present literature of the palæontology of vertebrates is based on names applied to fragments, and a long period of more accurate work will be required before these can be rejected or incorporated into the digested knowledge of the subject. I recall one collection of types of extinct vertebrates, published in a single volume, and near a hundred in number, the greater part of which are uncharacteristic fragments, well fitted to burden science for all time with a legacy of uncertainty and doubt. Such work is a positive discouragement to all future investigators in the same field, and its value to science may well be questioned.

The necessity of greater care in selecting type-specimens, in Palæontology at least, needs no argument to any student of the science who has done sufficient original work to appreciate the increasing difficulties of accurate investigation. To those who have had less experience, a word of warning, I trust, will not be in vain.

3. *The Preservation of Type-Specimens.*

The careful preservation of their own type-specimens is a sacred duty on the part of all original investigators, and hardly less so of those who are the custodians of such invaluable evidence of the progress of natural science.

Local museums, as a rule, are less desirable repositories of type-specimens than private collections, since the former usually can have little hope of permanent care, while the latter, if important, have a fair chance, by gift or purchase, of becoming part of a large endowed museum, where those in control are more likely to appreciate the importance of types, and carefully preserve them.

For the preservation of type-specimens, fire-proof buildings are indispensable. I recall no less than five Museums of Natural History, in America, that have either been destroyed, or their contents consumed, or seriously damaged by fire, since I became actively interested in natural science. Several others, in the meantime, have had narrow escapes from the same danger, so that I regard all type-specimens as insecure that are not preserved in buildings practically safe from fire.

Another danger to which type-specimens are subject, is loss or injury during transit, when loaned or otherwise sent away from their regular place of deposit. This evil has become so serious, that some museum authorities do not permit type-specimens to leave the building. This I regard as a wise regulation, and it is now in force at New Haven and various other scientific centres.

If a type-specimen be important, the investigator will come to the type. I once made a long pilgrimage to a famous university town, mainly to see a single bone, the 'tibia' of an extinct reptile, according to the description, and the type of a new genus. I found the bone in good custody, and well preserved. It was not a tibia, however, but a radius, and this fact changed the classification based upon it. Had that bone been lost or destroyed, a new animal of strange proportions might have existed on the records of Palæontology, if not in Nature. That bone fortunately is still preserved, a witness whose testimony is conclusive.

When fossil skeletons are discovered in position, the best methods of preservation, especially of types, requires the retention as nearly as possible of the bones as found. One fore and one hind foot, at least, should always be kept in the rock, and all impressions in the matrix carefully preserved.

The importance of indelibly marking type-specimens, and the separate parts of each, so that they may be studied essentially as found, is also evident. If a type is restored with plaster or other substance, the limits of each should not be so obscured that investigators cannot distinguish them. These are not imaginary precautions. Cases of the kind mentioned are not uncommon in vertebrate palæontology, as every worker knows. One well-known skull, with portions now preserved in two museums, is restored in one of them, as an original, and is thus misleading.

Type-specimens preserved from other dangers may be injured unintentionally. Among the rare specimens damaged by zealous but unskilful hands in the house of their friends, three of the most important to palæontology, a reptile, a bird, and a mammal, are well-known examples, and not a few others both in this country and America might be mentioned if it were proper to do so on this occasion. Such lack of intelligent custody of types will make the work of future investigators much more difficult.

An indirect way of preserving type-specimens is by means of casts. These, if accurately made, may be of much service, and, in fact, an insurance on the original specimen. They may often save an investigator a long journey, and in case the type itself is

lost or destroyed, the copy may prove of great value in indicating what the name was intended to cover.

Another indirect means of protecting type-specimens would be to publish catalogues of them, giving the places where they are preserved. Such a list of a single group would be of great service to anyone investigating it, and could be renewed from time to time whenever necessary. It would be well if everyone who described a species also stated where the type was deposited. In time this would become the established usage, and thus greatly facilitate the preparation of catalogues of types and their places of preservation.

Palæontology has been called an exact science, but its records up to the present time do not bear out this statement. If, as I believe, it will yet be worthy of such a distinction, one means of its advancement will be for those who represent it to select better type-specimens, and preserve them more carefully.

In all branches of Natural Science, type-specimens are the lights that mark the present boundaries of knowledge. They should be, therefore, not will-o'-the-wisps, leading unwary votaries of science astray, but fixed beacon lights to guide and encourage investigators in their search for new truth.

VI.—Blind Trilobites.

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

THE majority of fossiliferous beds in the Cambrian are of an argillaceous nature, and limestones are comparatively rare, but we need not here enter into a discussion as to the causes of their rarity. When, however, we come to the Ordovician, we find calcareous beds much developed, and since we find in them, as well as in the slates and shales, these blind genera, and as far as we know not less abundantly, it appears as if the physical conditions of sedimentation had but little to do with the existence and perpetuation of these forms. We cannot, therefore, argue that their survival was a direct result of a similar physical environment; but probably biological influences which we cannot now gauge played an important part, and to some extent determined their survival. Barrande, on the other hand, held strongly to the opinion that the pellucidity of the water in which limestones were formed led to or was associated with the absence of blind trilobites, and believed that it was owing to the muddy waters in which argillaceous sediment was deposited that the eyeless and large-eyed trilobites were especially abundant. The evidence which induced him to hold this view was obtained in Bohemia, where he noticed that in the Second Fauna (which corresponds in a general way to our Ordovician) the majority of the blind trilobites were found in the fine argillaceous slates of $Dd1$ and $Dd5$, while the fewest occurred in those rocks (quartzites and

limestones) which accumulated in comparatively clear and pure water. On the other hand, in the British Isles, Sweden, and Russia, when once we get above the Cambrian, there are just as many blind genera in our Group 1 occurring in calcareous beds (e.g. the Keisley and Kildare Limestones, the *Leptæna* Limestone, and the Russian homotaxial limestones) as in shales and slates ; and, in fact, some of the blind genera seem restricted to these limestones (*Tiresias, Isocolus*). The character of the sediment seems also to have but little to do with the presence or absence of the 'adaptive' species in our Group 2, for while in Bohemia Barrande notices that the blind species of *Illænus* occur in the fine argillaceous slates, the northern species of the same genus occur principally in the above-mentioned limestones.

Barrande (loc. cit.) also lays stress on the fact that the large-eyed genera *Æglina* and *Remopleurides* only are found in the two bands of fine argillaceous shale, Dd1, Dd5, in which occur the majority of the blind forms of the Second Fauna ; and that in the Primordial fauna of Étage C an analogous state of things exists in the association of the large-eyed *Paradoxides* and *Hydrocephalus* with the eyeless forms. In both cases he imagines the same cause to have been operative, i.e. the turbid muddy state of the water, which made eyes of a normal size useless and led either to the development of enormous visual organs or to the degeneration and loss of those of an ordinary character. Whatever connection, however, these cases may indicate between the association of blind with large-eyed forms, it cannot apparently have been one universally induced by such a cause as Barrande supposes, for we find the large-eyed and blind forms of our Group 1 occurring together in calcareous beds, such as the Keisley and homotaxial Limestones, in which the conditions of deposition must have been of an utterly opposite character. The difference in the facies of the faunas associated shows that the bionomic conditions must also have been dissimilar.

In connection with the question of the action of the environment on the structure or sense-organs of animals, we may refer to Neumayr's [1] arguments in favour of regarding the Cambrian fauna as indicating conditions analogous to those now existing in the deep sea, especially as he makes so strong a point of the occurrence of blind trilobites. After the foregoing careful consideration of the subject, it will only be necessary to sketch briefly the kind of answers which may be made to his arguments, and the different explanations possible of the phenomena which he adduces. He mentions four peculiarities of the Cambrian fauna which make him believe that it represents deep-sea conditions : —

(1) Its wide distribution ; but we have remarked above that this merely indicates uniform conditions of life, and that such most probably existed in early geological times.

(2) Its impoverished character as a fauna, shown by its pover' in variety of types, since it consists chiefly of trilobites

[1] Erdgeschichte, vol. ii, p. 51.

brachiopods with only rare representatives of other groups. In so far as this argument affects our subject of consideration we may remark that (*a*) a variety of types is not necessarily demanded in such an early geological period ; (*b*) an impoverished fauna is capable of several other explanations than deep-sea conditions, as for instance the Permian. The superabundance of two such groups of organisms as trilobites and brachiopods is not of much value as evidence, since one group is extinct and the other is by no means characteristic of the deep sea (*Lingula*, the oldest surviving type, being in fact an inhabitant of shallow water).

(3) The almost complete want of organisms with skeletons of carbonate of lime. To this the reply may be made that modern deep-sea deposits consist largely of carbonate of lime, and are mostly composed of the remains of animals that secreted carbonate of lime, with the exception of the Radiolarian Ooze and Red Clay, to which few, if any, Cambrian trilobite-bearing deposits can be compared except by neglecting many characteristic features or making unwarrantable assumptions.

(4) The occurrence of blind and large-eyed animals. If we leave out of the question the disputed *Paradoxides* and allies, all the blind genera which Neumayr here refers to are devoid of eyes because of their phylogenetic position, as we have shown. Neumayr regards all these forms as having lost their eyes by a secondary modification, and quotes *Trinucleus Bucklandi*, which as we have remarked possesses visual organs when in a larval stage, but loses them at maturity. But these are eye-spots and not compound eyes, and are not characteristic of any phylogenetic stage. Their significance has been discussed above. An example which has been supposed[1] to be similar (but is probably not so, as the eyes are of the normal crustacean type) is that of the deep-sea decapod *Willemœsia*, the embryo of which is said to possess well-developed eyes. The eyes of the larval *Trinucleus*, on the other hand, are not normal trilobite eyes. Neumayr also lays stress on the association of blind and large-eyed forms. But we have just dismissed the majority of blind ones from the question, and have seen that they are to be explained in a totally different manner, resting on the ascertained facts of phylogeny and ontogeny, and not on theoretical considerations. So the occurrence of the large-eyed forms such as *Æglina* and *Remopleurides* must be dealt with alone. The great development of visual organs, though a striking character in many deep-sea Crustacea (e.g. *Cystisoma neptunus*) and other deep-sea organisms, is not confined to them ; nocturnal and cave-frequenting animals have extraordinarily developed powers of sight, and, as we have mentioned, Barrande indeed suggested the muddiness and therefore comparative shallowness of the water in which these trilobites lived as a sufficient cause. But the large-eyed *Remopleurides* frequently occur in limestones which accumulated in clear water. Perhaps the large eyes served simply for the better blind

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[1] W. Marshall, " Die Tiefsee und ihr Tierleben " (Leipzig, 1888), p. 265.

detection of enemies, or the capture of prey, and were correlated with a lack of agility; at any rate the evidence is antagonistic to supposing that they signify deep-water conditions. It should be observed also that the character of the fauna associated with these large-eyed genera varies much, as we may at once see in examining the lists of organisms from the beds in which they occur.

It is a remarkable fact that in the case of such deep-sea deposits as the Culm beds which are associated with the Radiolarian cherts of Devonshire,[1] none of the trilobites show degeneration or abnormal development of their eyes.

The highly-developed trilobites such as *Encrinurus, Cybele, Acidaspis,* many species of *Phacops,* etc., which possess eyes smaller than the average, are not found in deposits or with associated faunas suggestive of deep-sea conditions. We have also no reason to suppose that those species of *Phacops* and *Proetus* with unusually large eyes lived in the abysses of the ocean, for the lithological character of the deposits and the features of their contemporaneous faunas point usually to the existence of shallow water.

Conditions of Life of Blind Trilobites and Comparison with Modern Blind Crustacea.

The most popular and widely accepted view of the conditions under which the blind forms lived is that put forward prominently by Suess, Neumayr, and others. They suppose that these forms existed under deep-sea conditions, and that the partial or complete absence of light in the abysses of the ocean led either to the reduction or loss of the visual organs or to their enlargement to an extraordinary degree. In the first place, before we test this theory and see how far it satisfies the facts of the case, we must remember that it is a theory of adaptation and therefore cannot be applied to those genera which, as we have seen, could never have possessed compound eyes because of their low phylogenetic rank. Accordingly we have to exclude all the genera of our Group 1, for we have shown that we cannot even consider the post-Cambrian primitive blind forms as surviving on account of a maintenance or repetition of an identical biological or physical environment, but rather because they occupied a place in the economy of nature which higher forms could not fill. The survival of all primitive and lowly forms of life at the present day appears to be due to this cause.[2]

We must therefore consider that all theories of adaptation are only applicable to our Group 2, which consists of what we have called, *a priori,* the adaptive blind forms, because their blindness is an

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[1] G. J. Hinde: Q.J.G.S., vol. li (1895), p. 609; Trans Dev. Assoc., vol. xxvii (1896), p. 747; ibid., vol. xxix (1897), p. 518.

[2] Suess ("Antlitz der Erde," vol. ii, p. 274), however, regards the oldest known fauna of the Bohemian Silurian beds (i.e. E'tage C) to be an 'adapted' fauna, therefore the successor of a still older and unknown fauna. But he seems to shales at this opinion by neglecting the testimony of phylogeny and ontogeny, amined, regarding the absence of eyes in every case necessarily as an adaptive feature. .R.S.

exception in the genus to which they belong, and their phylogenetic rank (with the exception of *Harpes*) demands that compound eyes should be present. We must seek therefore for the special conditions which lead to the loss of eyesight.

In the case of modern marine animals it is found that a large number of those inhabiting the abysses of the ocean, to which few or no rays of sunlight can penetrate, are either devoid of eyes or have these organs enormously developed, while closely allied species or genera living in well-illuminated zones of the sea have normal eyes. From the analogy of blind cave-animals it is generally believed that this state of things is due directly to the absence or feebleness of the light at the bottom of the deep sea. Packard[1] discusses the question and says that "it is most probable that the causes of atrophy or blindness under one set of conditions [i.e. in caves] are the same or nearly the same as in the other." But this is questionable, and, apart from the action of other factors, such as pressure and equable temperature, which operate in the deep sea, the facts gathered by Professor S. J. Smith[2] from the dredgings of the "Albatross" indicate "some difference in the conditions as to light in caverns and in the abysses of the ocean, and make it appear probable that in spite of the objections of the physicists some kind of luminous vibrations do penetrate to depths exceeding even 2,000 fathoms." If we exclude shallow-water species, no definite relation has been traced between the amount of modification of the eyes and the depth which the species inhabit. The experiments of Forel, Asper, Fol, and Sarasin, on the depth to which the rays of sunlight penetrate which affect photographic plates, were not made in mid-ocean, where the purity and transparency of the water is said to be much greater than near shore or in lakes; and, moreover, we are not bound to assume that the limits of luminous perception are the same for the retina and visual nerves of all the lower animals. It is, however, proved that "although some abyssal species do have well-developed eyes, there can be no question that there is a tendency towards very radical modification or obliteration of the normal visual organs in species inhabiting deep water" (Packard). The amount of modification appears to depend to some extent on the length of the period during which the organism has inhabited the deep water. Thus *Pentacheles*, which belongs to a group believed to have frequented deep water for considerable geological periods, has highly modified eyes, while the species more closely allied to shallow-water forms have less modified or only partially reduced eyes, suggesting a more recent immigration into the abyssal regions. In the case of those deep-sea fishes, as Lendenfeld has said, in which the eye was originally strong and well constructed, and the migration into deep water was gradual and spread over many generations, the eye became gradually enlarged; but in those forms in which the eye was originally weak

blind [1] "Cave Fauna of North America": Nat. Acad. Sci., vol. iv (1886), Mem. 1, -137.
an[1] Ann. Mag. Nat. Hist., 1886, pp. 194–7.

and the change of habitat too rapid for adaptation of the organ to
the new conditions, it degenerated and atrophied. There may be
little truth in Verrill's view that more or less sunlight penetrates
to the greatest depths, giving an illumination at 2,000 to 3,000
fathoms perhaps equal to our partially moonlight nights, and possibly
at greater depths equal to starlight; but McCulloch and Coldstream's
clever suggestion that the light of phosphorescent organisms supplies
the place of sunlight in the deep sea has much probability in it when
we consider the great development of phosphorescent organs in
animals at abyssal depths. Hickson[1] remarks that phosphorescence
is only locally distributed, and that in some regions the darkness is
so absolute that it can only be compared with the darkness of the
great caves. The fact that the fauna of the deep sea does not entirely
consist of blind or large-eyed forms is partly explicable on this view,
but is probably to a larger extent due to the immigration of species
with normally developed eyes which has always been taking place
from the shallow-water regions. It is to be remembered that the
majority of modern deep-sea animals are merely modified types of
shallow-water forms, and that there are few which can be considered
ancestral in character. Thus, even if other considerations already
discussed allowed us to consider the blind trilobites belonging to our
'Primitive' group as members of a deep-sea adapted fauna, the
abundance and large proportion of such ancestral types would be
contrary to modern analogy. Many characteristic modern deep-sea
forms also may occasionally wander into shallower regions where
faint rays of sunlight penetrate, and the young stages of others may
be passed at or near the surface of the sea.[2]

It is not, therefore, very surprising that very few animals
belonging to families usually provided with eyes are completely
blind. Hickson remarks that the large-eyed forms preponderate
from 300–600 fathoms, which includes the region which rays of
sunlight faintly penetrate. But in water of over 1,000 fathoms
small-eyed and blind forms are in a majority, for it is below the
sunlight limit, and eyes are therefore for the most part useless.

Agassiz[3] has said that it is difficult to draw any conclusions from
the great diversity presented by the organs of sight in the Crustacea,
and that one cannot help being struck by the small number of
deep-sea Crustacea which have lost their eyes. It is well to bear in
mind his caution[4] as to "drawing conclusions with reference to
physical conditions derived from organs of sense which may serve
other purposes than that of vision alone."

It must also be remembered that there are many blind Crustacea
and other marine invertebrates either without eyes or with only
rudimentary organs of sight which have been dredged from
comparatively shallow water. From the habits of these forms it

[1] "Fauna of the Deep Sea" (Mod. Sci. Series), pp. 22–28.
[2] Hickson, loc. cit.
[3] Three Cruises of the "Blake," vol. ii, p. 44. See also W. Marshall.
Tiefsee und ihr Tierleben" (Leipzig, 1888), p. 260, etc.
[4] Ibid., vol. i, p. 308.

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seems that their mode of life here leads to just the same modifications as the deep-water conditions. It is not, indeed, improbable that the similar mode of life in many deep-sea forms has more to do directly with their blindness than the fact that light is practically or nearly absent in the abysses of the ocean. Thus Agassiz (loc. cit.) says that the deep-sea blind fishes belong to families with burrowing habits, and the same may be said of the blind Crustacea and Gastropoda. Semper[1] has pointed out that many blind animals live in well-illuminated situations.

Many Isopods are blind in shallow water as well as in the deep sea (e.g. *Munnopsis* and *Eurycope*). *Pleurogonium* is quite blind in 20 fathoms of water, and the much quoted blind species *Petalophthalmus armiger* ranges from 140 to 2.285 fathoms, and *Pseudomma Sarsi* from 110 to 1,500 fathoms.[2] The forms which grub in the mud have frequently no eyes,[3] while free-swimming allied species have well-developed eyes. Marshall[4] remarks that it is very strange that the blind Schizopod *Pseudomma australe* lives in only 33 fathoms of water, but he does not give any account of its habits.

Indeed, benthonic conditions of life seem to lead to reduction or loss of eyes, whether the organisms live in deep water or shallow. Packard (loc. cit.) suggests that it may be found that the deep-sea forms without eyes burrow in the ooze or live under loose objects at the bottom, thus being subjected to conditions which may be completely paralleled in shallow water, and which the above examples seem to show produce the same results.

Semper (loc. cit.) also mentions a fact showing that other causes as well as the absence of light lead to the loss of the eyes. Thus, in the cave-beetle *Machærites* the females are blind, but the males have well-developed eyes. It is also a well-known fact that the free-swimming larvæ of parasitic Crustacea and the Holothurians possess organs of vision, whereas the adults have no eyes, though frequently living in well-illuminated portions of the sea. The mode of life has made eyes superfluous, and therefore they have been lost.

Turning now to the blind trilobites to see how the above facts derived from living Crustacea apply to them, we notice that the members of our Group 2—i.e. the 'adaptive forms'—have not a wide distribution; they are mostly local forms found only in a small and restricted area. The wide distribution of modern deep-sea species finds therefore no analogy in them; and the statement that it does is due to the inclusion of those phylogenetically blind forms which belong to our Group 1. Incidentally it may be remarked that the wide distribution of these phylogenetically blind genera may be due to the same cause as that which causes the wide distribution of modern deep-sea organisms, and this cause is the uniformity of physical conditions, particularly of temperature, which

[1] "Animal Life" (Internat. Sci. Ser.), pp. 76–87 and 419–421.
[2] Walther, Einleitung in die Geol., etc. (Jena, 1893–4), pp. 43, 44.
[3] Sars, Chall. Rep., vol. xxxvii.
[4] Die Tiefsee und ihr Tierleben, 1888, p. 265.

we know prevails at great depths, and which with considerable probability is held to have existed in early geological times over wide areas owing to the non-differentiation of climatic zones.

It is also deserving of mention that the very character of the beds which accumulated in the Lower Cambrian Period in Wales, where so many of the blind genera of our Group 1 are found, points to rapidity of deposition and fairly shallow water.[1]

Some members of our 'adaptive' group of blind trilobites probably lost their eyes as a result of their burrowing habits in the soft ooze on the sea-floor, or from frequenting muddy turbid waters in which organs of vision would be of little or no service, as Barrande suggested for the Bohemian forms in the Ordovician shales. Others may have inhabited submarine caves into which few rays of light could penetrate, and natural selection may have developed other organs of sense of greater use to them than eyes. A few may have generally lived in the deep-sea abysses, and occasionally have visited the shallower regions, in which their remains were entombed in the deposits there accumulating. Others may have lived in shallow water, but possessed delicate tactile organs and more highly-developed other sensory powers as a compensation for the absence of eyes. Others may have possessed nocturnal habits. If it be difficult to account for the blindness of many living shallow-water Crustacea we ought not to be surprised if we find greater difficulty in discovering any satisfactory explanation of some fossil forms. But, as above suggested, there are several ways of reasonably accounting for the absence of eyes, and we need not despair of ultimately solving each difficult case.

Conclusion.

From the above examination into the nature and distribution of blind trilobites we have seen that the great majority of them are primitive forms, possessing no compound eyes because of their low phylogenetic rank and great geological age. No question of adaptation to environment therefore concerns these blind forms. But there is a small number of blind trilobites which we are led to believe owe their blindness to degeneration of the visual organs as a result of certain conditions of life. From the physical and biological evidence of their occurrence we must suppose that different factors have produced the same result. We have seen that amongst modern Crustacea blindness is a condition brought about by a variety of causes, and is by no means always dependent on their bathymetrical distribution or aphotic habitat. Such appears also to have been the case in the geological past, and each instance must be considered on its own merits and with due attention to circumstantial evidence.

[1] Hicks, Pres. Add., Proc. Geol. Soc., 1897, vol. liii, p. 68.

VII.—On the Occurrence of Arenig Shales beneath the Carboniferous Rocks at the Menai Bridge.[1]

By Edward Greenly, F.G.S.

THE shore of the Menai Straits on the Carnarvonshire side, near the Suspension Bridge, is composed, as is well known, of sandstones and shales belonging to the Carboniferous Series. About a quarter of a mile west of the bridge, however, some fissile, reddish and greenish shales appear on the foreshore, dipping at higher angles than usual. This might easily be ascribed to local disturbance, as a large fault is not far off, though the shale differs somewhat from that which is common in the Carboniferous rocks of the district, a fact which was noticed by Mr. G. H. Morton,[2] who went with me along this part of the section. The difference, however, might easily escape the eye, especially as the exposures are small. The dip is about 25°–30° S.E. or S.S.E., but sometimes as high as 50°. The shales soon rise into a low cliff, overhung by woods which mask their relation to the Carboniferous rocks to the east, and extend along the shore for about 80 yards as far as a little glade in the woods, beyond which drift comes down to high-water mark for about another 80 yards. The shales here rise again, and form a little rocky point some 20 to 30 feet high, where the red and green varieties can be seen to be merely the upper and stained portion of a mass of black shales, which form the lower part of the rocky point and the foreshore. These are dark, evenly bedded, platy shales, very fissile, and quite unlike anything in the Carboniferous system in this district, but strongly resembling the usual Ordovician type of S.E. Anglesey and the Straits. They are quite uncleaved, and dip E.S.E. at about 25°. Drift then again conceals the rock for about another 80 yards, beyond which the annexed section is seen.
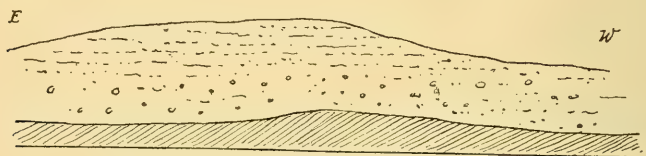
Fig. 1.—Sketch of section on shore below Treborth.

At the top are four or five feet of red and green, soft, flaggy sandstones, very micaceous, and of a type common in the Carboniferous rocks; passing down into about two feet of pebbly sandstone or conglomerate, which rests upon the same reddish fissile shales as those above described. The junction is only a foot or two above high-water mark, to which the sandy beds descend in a few yards, which they form the whole cliff and foreshore, the shales not appearing so far as I have been able to see. In this section the beds are practically horizontal, while the shales dip E.S.E. at

about 25° to 30°, and the line of junction is exposed, obscured only in places by a little stalagmite. The base of the pebbly sandstone, which is a little uneven, overhangs in a little shelf, underneath which the upturned edges of the reddened shales upon which it rests can be clearly seen.

Further, the shales, in their black, unstained portions, have yielded the following fossils :[1] *Didymograptus patulus*, Hall ; *Did. nitidus*, Hall ; *Did. extensus* ?, Hall ; *Climacograptus* ?; and *Caryocaris* —an unmistakable Arenig assemblage. One stipe of *Did. nitidus* measured $1\frac{3}{4}$ inch and is incomplete, and another of probably *Did. extensus* is two inches in length.

It is clear, therefore, that the base of the Carboniferous rocks is exposed in this shore section, and that they rest unconformably upon a series of black shales of Arenig age.

I had for some time hoped to find an exposure of such rocks in the vicinity of the Bridge, for the following reason :—At Tyn y Caeau on the Holyhead Road, about a quarter of a mile west of the Bridge Village, there is a large section in glacial gravels, which are composed chiefly of well-rounded pebbles of a soft black shale. The shale is of Ordovician type, and the pebbles have yielded *Didymograptus Murchisoni* ; *Did. bifidus*, Hall ; *Did. extensus* ?, Hall ; *Did. patulus*, Hall ; *Caryocaris Wrightii*, Salter ; *Caryocaris* ; and *Lingula* or *Lingulella*. I know of no such shale in the neighbourhood on the Anglesey side. The gravels appear to rest upon and to be completely surrounded by crystalline schists, and, as the general direction of transport of the blocks in the drift is from the north-east, the beds from which the fossiliferous pebbles have been derived are probably concealed beneath the waters of the Straits a little to the north-east of the Suspension Bridge.

There is some reason to suppose, indeed, that the floor of the Straits east of the Tubular Bridge is in great part composed of these Ordovician shales. For, as the Carboniferous rocks, though lying at low angles, dip on the whole to the south-east, and as we have seen that their base rises above high-water mark for about 250 yards of the shore on the Carnarvonshire side, it is improbable that they cover much of the floor of the Straits, which descends to

Fig. 2.—Hypothetical section through the Menai Straits between the bridges.
a, Crystalline Schists. *b*, Arenig Shales. *c*, Carboniferous Sandstone.

some 40 feet below that level. The evidence yielded by the gravels above mentioned points to an extension of the Ordovician shales

[1] The graptolites and other fossils mentioned in this paper have been examined, with his usual kindness, by my friend and former colleague, Mr. B. N. Peach, F.R.S.

along the hollow to the N.E. of the exposure described in this paper; and dark shales of the same lithological character are known to occur below high-water mark on the Anglesey shore at Garth Ferry. The existence of such a band of shale must have been an important element in determining the excavation of the Straits, by whatever agency we suppose them to have been eroded. For, as soon as the retreat of the Carboniferous escarpment began to expose the shales, erosion would be facilitated, and their direction of strike would tend to accentuate, if it did not initiate, the N.E.-S.W. trend of the hollow.

VIII.—Note on the Martley Quartzite.

By Theodore Groom, M.A., D.Sc., Professor of Natural History at the Royal Agricultural College, Cirencester.

MY attention has been drawn to a recent notice[1] by Mr. Coles of a quartzite at Martley. Since this area is included within the district of the Malvern and Abberley Hills, which I have been engaged in studying for more than two years, a brief description of the relations of the rocks, as determined by myself in January of the present year, may not be out of place. The small patch of interesting rocks here is likely to become covered up as cultivation progresses; indeed, the exposure is evidently much less extensive than it was when Phillips described it in his memoir on the Malvern and Abberley Hills. Mr. Coles has, moreover, I think, hardly done justice to the remarkable section exposed here.

On certain points I am quite in agreement with Mr. Coles. The lowest rock seen is certainly a quartzite of the type found in the Lickey Hills, Wrekin, and, as I hope to show soon, in the Malverns and in Cowleigh Park.

I could detect no traces of fossils in the Martley rock, though the corresponding quartzite of the Malvern Hills is richly fossiliferous in places.

The quartzite, somewhat shattered, is arranged in the form of a plicated anticline, or anticlinal dome, dipping towards the west and east, and showing a tendency to a *quâ-quaversal* arrangement. The visible thickness of the quartzite is about 42 inches, although, the base not being seen, a much greater thickness may be present.

The uppermost rock seen, termed by Mr. Coles a "quartziferous mica-syenite, or possibly a diorite," is indistinguishable from the crushed coarse diorite prevalent in many parts of the Malvern range.

The diorite is separated from the quartzite by two feet or more of greenish schists, the "powdery rotten rock" of Mr. Coles. The foliation of the schists is parallel to the surface of the quartzite, and to what is apparently bedding in the latter. These schists essentially resemble certain of those formed by dynamo-metamorphism in the Malvern Chain, as shown by Dr. Callaway.

The most remarkable feature in the section is the superposition of the diorite and schists on the quartzite; the readiest explanation

[1] "An exposure of Quartzite and Syenitic Rock near Martley, Worcestershire": Geological Magazine, 1898, p. 304.

of this fact would be that we have here a quartzite interstratified with rocks of the Malvernian Series.

Mr. Coles suggests that the apparent relation seen here is "not the real one." If by this be meant not the original one, I am quite in accordance with him. Quartzites certainly occur on a limited scale interfoliated with gneissic and schistose rocks in the Malvern Hills, but they are of quite a different type to that seen at Martley, being, in fact, quartz-schists representing, according to Dr. Callaway, the extreme metamorphism of felsites and gneissoid quartzites produced from diorites.

The Martley quartzite, on the other hand, as Mr. Coles shows, and as my own investigations prove, is a typical sedimentary rock, with a microscopic structure essentially similar to that of the Cambrian quartzite of the Malvern Hills.

I have already maintained[1] that in the Malvern area the Malvernian Series is sometimes thrust on to the Cambrian beds.

FIG. 1.—Section in the Gravel Pit near Martley.
D. Diorite.
S. Schists.
Q. Quartzite.
d. Detritus.
Length *ab* = 9 ft. 6 in.
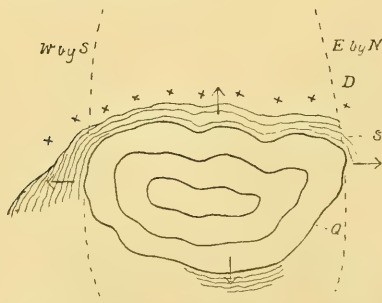
FIG. 2.—Ground-plan of same (diagrammatic). The dotted lines indicate roughly the probable limits of the outcrop of the quartzite on a surface at the level of the floor of the pit.

[1] Ann. Rep. Brit. Assoc., 1898.

This is the explanation I would also apply here. The Archæan mass thrust over the quartzite during a period of intense folding, has been sheared at its base, so as to give rise to the underlying green schists with their foliation parallel to the thrust-plane.

The anticlinal arrangement of the rocks is perhaps due to a subsequent movement, analogous to that which appears to have affected the thrust-plane in Raggedstone Hill, as I hope to show very shortly.

This hypothesis clears the way for the acceptance of the Cambrian age of the Martley quartzite.

IX.—Glacier Motion and Erosion.

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

ALTHOUGH the ice of many glaciers, more especially those which move over massive impervious rocks, is clean and almost free from rock fragments, in many cases towards the bottom of the glacier, boulders, pebbles, and even masses of clay, mud, or sand abound. The rock-masses have evidently been derived from the floor over which the glaciers move, for the fragments become more numerous as we descend in the ice, the upper portion of the glacier being often quite free from foreign matter.

The process by which the boulders rise and become imbedded in the glacier would seem to be somewhat in conflict with our notions of viscous flow, for the stream lines in viscous fluids are always regarded as being direct. It has, however, been pointed out that when a glacier encounters an obstacle a portion of it may pass over the top, and flow over the streams of ice working round the sides. In this way boulders from near the summit of the crag may be trailed over the side streams and thus become imbedded in the mass of the glacier. This explanation may account for some of the intrusions met with, but scarcely seems sufficient to explain the presence of the great quantities of material sometimes found in the lower portions of some large glaciers or ice lobes.

I have pointed out in a previous paper[1] that a viscous substance may be either adherent to its bed or slide slowly over it. Pitch, for instance, adheres firmly to the sides of its channel, and the flow results wholly from the shear of layers of pitch over layers of pitch, the molecules actually in contact with the sides being for all practical purposes stationary. The ice of a glacier, on the other hand, is frequently separated from the rock upon which it rests by a film of water, and moves bodily as well as by the differential motion of its particles. But in both cases the flow is direct and could not cause boulders to work their way from the sides or bottom into the mass. Such a result, however, could be produced if the viscous body were *sliding* over its bed in some places and *adhering* in others. The possibility of this will be seen from the Figure. Here the ice, which is moving from left to right, is sliding over the rocky floor between A and B, and adhering to it from B to C. Between

[1] Geol. Mag., Dec. IV, Vol. IV, pp. 388–397.

A and B the velocity of sliding is v_3, whereas between B and C
it is *nil*. The stream lines v_1 to v_6 show roughly the velocities
along various planes in the glacier. It is clear that the ice before
reaching B must be greatly compressed in the line of motion, and
must eventually spread over the adherent portions, carrying the
boulders, etc., up into the mass of ice as shown in the Figure.
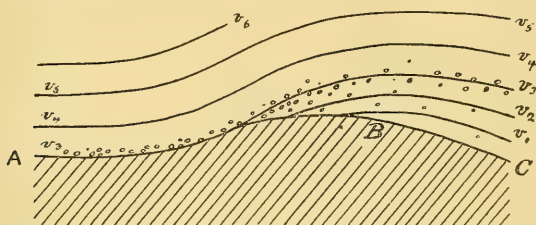
That the ice may freeze firmly to the floor upon which it rests and
drag up and carry along with it the rocky masses thus displaced,
I have shown is a reasonable deduction on theoretical grounds, and
it is interesting to find that the adhesion of the glacier to its floor in
places will also account for the incorporation, in its lower portions, of
boulders, etc.

NOTICES OF MEMOIRS.

I.—THE COMPARATIVE VALUE OF DIFFERENT KINDS OF FOSSILS IN
DETERMINING GEOLOGICAL AGE.[1] By Professor O. C. MARSH,
Ph.D., LL.D.

MORE than twenty years ago, my attention was called to the
subject of the difference between the value of fossil Plants,
Invertebrates, and Vertebrates, as evidence of the geological age of
the strata in which they were preserved. On the comparative value
of these different groups of fossils then depended the solution of
some grave problems in the geology of the Rocky Mountains.
I therefore began a systematic investigation of the subject, and gave
the results in an address before the American Association for the
Advancement of Science in 1877.[2] I stated the case as follows :—

"The boundary-line between the Cretaceous and Tertiary in the
region of the Rocky Mountains has been much in dispute during the
last few years, mainly in consequence of the uncertain geological
bearings of the fossil plants found near this horizon. The
accompanying invertebrate fossils have thrown little light on the
question, which is essentially whether the great Lignite series of the
West is uppermost Cretaceous or lowest Eocene. The evidence of
the numerous vertebrate remains is, in my judgment, decisive, and
in favour of the former view.

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[1] Abstract of communication made to Section C, British Association for the
Advancement of Science, Bristol Meeting, September 9, 1898.

[2] American Journal of Science, vol. xiv (November, 1877), pp. 338–378.

"This brings up an important point in Palæontology, one to which my attention was drawn several years since ; namely, the comparative value of different groups of fossils in marking geological time. In examining the subject with some care, I found that, for this purpose, plants, as their nature indicates, are unsatisfactory witnesses ; that invertebrate animals are much better ; and that vertebrates afford the most reliable evidence of climatic and other geological changes. The subdivisions of the latter group, moreover, and in fact all forms of animal life, are of value in this respect, mainly according to the perfection of their organization or zoological rank. Fishes, for example, are but slightly affected by changes that would destroy reptiles or birds, and the higher mammals succumb under influences that the lower forms pass through in safety. The more special applications of this general law, and its value in geology, will readily suggest themselves."

In the statement I have quoted, I had no intention of reflecting in the slightest degree on the work of the conscientious palæobotanists who had endeavoured to solve the problem with the best means at their command. I merely meant to suggest that the means then at their command were not adequate to the solution.

It so happened that one of the most renowned of European botanists, Sir Joseph Hooker, was then in America, and to him I personally submitted the question as to the value of fossil plants as witnesses in determining the geological age of formations. The answer he made fully confirmed the conclusions I had stated in my address. Quoting from that, in his next annual address as President of the Royal Society, he added his own views on the same question.[1] His words of caution should be borne in mind by all who use fossil plants in determining questions of geological age.

The scientific investigation of fossil plants is an important branch of botany, however fragmentary the specimens may be. To attempt to make out the age of formations by the use of such material alone is too often labour lost, and must necessarily be so. As a faithful pupil of Goeppert, one of the fathers of fossil botany, I may perhaps be allowed to say this, especially as it was from his instruction that I first learned to doubt the value of fossil plants as indices of the past history of the world. Such specimens may indeed aid in marking the continuity of a particular stratum or horizon, but without the reinforcement of higher forms of life can do little to determine the age.

The evidence of detached fossil leaves and other fragments of foliage that may have been carried hundreds of miles by wind or stream, or swept down to the sea-level from the lofty mountains where they grew, should have but little weight in determining the age of the special strata in which they are imbedded, and failure to recognize this fact has led to many erroneous opinions in regard to geological time. There are, however, fossil plants that are more reliable witnesses as to the period in which they lived. Those found

[1] Proceedings of the Royal Society of London, vol. xxvi (1887), pp. 441–3.

on the spot where they grew, with their most characteristic parts preserved, may furnish important evidence as to their own nature and geological age. Characteristic examples are found among the plants of the Coal-measures, in the Cycads of Mesozoic strata, and in the fossil forests of Tertiary and more recent deposits.

The value of all fossils as evidence of geological age depends mainly upon their degree of *specialization.* In the Invertebrates, for instance, a Linguloid shell from the Cambrian has reached a definite point of development from some earlier ancestor. One from the Silurian or the Devonian, or even later formations, however, shows little advance. Even the recent forms of the same group have no distinctive characters sufficiently important to mark geological horizons.

If we take the Ammonites as another example from the invertebrates, the case is totally different. From the earliest appearance of this family, the members have been constantly changing, developing new genera and species, each admirably adapted to mark definite zones or horizons, and already used extensively for that purpose.

The Trilobites offer another example of a group of invertebrates ever subject to modification, from the earliest known forms in the Cambrian to the last survivors in the Permian. They, too, are thus especially fitted to aid the geologist, as each has distinctive features, and an abiding place of its own in geological time.

The above examples are all marine forms, and from their abundance, wide distribution both in time and space, are among the best of all witnesses in marking the succession and duration of changes in geological history.

If we turn now to the fresh-water Mollusca, we find among them little evidence of change from the Palæozoic forms to those still living, and can therefore expect little assistance from them in noting the succeeding periods during their life-history.

Among the fossil Vertebrates the same law as to specialization holds good. The value of particular groups as witnesses of geological changes depends largely on their own susceptibility to change, and this is equally true of single genera and species. There are, indeed, some primitive vertebrates, especially among the Fishes, that appear to have changed little during their geological life. The genus *Lepidosteus* is a good illustration, and hence it is of limited value as evidence of what has taken place during its known geological history. Other fishes, however, are much better witnesses of the past.

The Reptiles as a class offer still better evidence of geological changes, and in many instances may be used to advantage in marking horizons. The great subclass of Dinosaurs, from their beginning in the Triassic, show marked changes of development throughout the whole of Mesozoic time. During the Cretaceous, highly specialized forms made their appearance, and at the close of this period, when all became extinct, the last survivors were the strangest of all, reminding one, in their bizarre forms, of the last

stages of the Ammonites, their cotemporaries. The Crocodiles, too, show great changes during Mesozoic time, and are thus of much value in determining geological horizons. So, also, are the Ptero-dactyles and many other extinct reptiles, each according to the degree of specialization attained.

The Mammals, however, are by far the most important class for marking geological time, as their changes and the high degree of their specialization furnish the particular characters that are most useful to the geologist in distinguishing definite zones, and the more limited divisions of the strata containing their remains. The few mammals known from the Trias are so peculiar that they can only give us hints of what mammalian life then was, but in the Jurassic the many forms now known offer important testimony as to the different horizons in which their remains are found. This is true also of the known mammals from the Cretaceous; all are of special value as witnesses of the past.

During Tertiary time, however, the enormous development of the class of mammals, their rapid variations, and, most important of all, the highly specialized characters they develop, offer by far the best evidence of even the smaller changes of climate and environment that mark their life-history throughout. The ungulates alone will answer the present purpose as an illustration, and even one group, the horses, will make clear the point I wish to bring before you.

Near the base of the Eocene the genus *Eohippus* is found, representing the oldest known member of the horse tribe. Higher up in the Eocene *Orohippus* occurs, and still higher comes *Epihippus*, near the top of the Eocene. Again, through the Miocene more genera of horses, *Mesohippus*, *Miohippus*, and others, follow in succession; and the line still continues in the Pliocene, when the modern genus *Equus* makes it appearance. Throughout this entire series definite horizons may be marked by the genera, and even by the species of these equine mammals, as there is a change from one stage to the other, both in the teeth and feet, so that every experienced palæontologist can distinguish even fragments of these remains, and thus identify the zones in which they occur.

This is true of every group of mammals, although not to an equal extent, so that in this class we have beyond question the best means of identifying the age of Tertiary strata by their fossil remains.

I have thus briefly pointed out some of the evidence on which a decision may be reached as to the value of the different kinds of fossils, Plants, Invertebrates, and Vertebrates, in determining the relative age of strata. All evidence of this kind is of value, but it is the comparative value of each group that is the important point I wish to emphasize, and I have brought the matter before this Section of the Association in the hope that a better understanding on this question may be reached among geologists in the interest of the science to which we are all devoted.

II.—Further Exploration of the Ty Newydd Cave, Tremeir-chion, North Wales. By Rev. G. C. H. Pollen, S.J., F.G.S.

IN a paper read before the Geological Society on December 15, 1897,[1] the author gave the results of an exploration of 60 feet from the old quarry. The work has now been extended to 150 feet in this direction. In the upper portion a stalagmite floor has been found *in situ*, completely sealing up the local gravels. Over this were found five feet of clay with broken limestone, which is all that is left to represent the strata in which the former roof of the cave was situated. The whole is now overlain with boulder-clay, containing many specimens of northern and western drift, with striated stones of more local origin. No trace of erratics or of glaciated stones have been found in the lower cave materials.

The cave has also been traced for 55 feet across the floor of the quarry where it re-enters the rock, running in the direction of the gully which separates it from the Ffynnon Beuno and Cae Gwyn caves. In the lowest gravel of this part a water-worn fragment of the molar of *Equus* was found. The following succession seems to be established for the contents of the cave:—

(*a*) Cave nearly filled by torrents with local gravel containing water-worn fragments of mammalian teeth.

(*b*) Formation of stalagmite floor.

(*c*) Last few yards of floor broken up and redeposited further down the cave by floods, which completely filled lower portion with sand and clay.

(*d*) Denudation of rock above, destroying roof of upper portion and depositing limestone débris on floor.

(*e*) Introduction of striated stones and northern and western erratics, which are deposited as one bed over the hillside.

III.—On the Exploration of Two Caves at Uphill, Weston-super-Mare, containing Remains of Pleistocene Mammalia. By the late Edward Wilson, F.G.S.[2]

(Communicated by Herbert Bolton, F.R.S.E.)

QUARRYING operations now proceeding in the Carboniferous Limestone near the old parish church of Uphill have led to the discovery of two caves.

The caves are about half-way up the face of the quarry, which is 100 feet in height. The floor of each cave is covered with a deposit which varies from one to two feet in thickness.

A typical section of the upper cave deposits is as follows:—

	ft.	in.
1. Deep purplish-red, soft, sandy Marl, containing blocks of Limestone	4	0
2. Greenish-yellow, soft, sandy Marl	1	2
3. Greenish-drab argillaceous Sandstone ...	5	6
4. Limestone floor.		

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[1] Quart. Journ. Geol. Soc., February, 1898, pp. 119–134, pl. viii.
[2] Read before Section C (Geology), British Association, Bristol Meeting, September, 1898.

The Green Marl (No. 3) for a varying thickness in different parts of the cave becomes brecciated and occasionally tufaceous.

The animal remains are contained in this bed, and consist chiefly of the teeth and jaws of hyæna, with gnawed and ungnawed bones of horse, mammoth, cave bear, fox, etc.

The lower of the two caves is partly filled with a deposit of coarse rubble, and has yielded remains of hyæna, rhinoceros, and the teeth and jaws of small carnivora and rodents, together with worked flints, and a number of rounded stones supposed to have been used as pot-boilers. The rubble deposit has evidently undergone a certain amount of displacement, so that it is by no means certain if the remains contained in it are contemporaneous.

IV. — Further Exploration of the Fermanagh Caves.[1] By Thomas Plunkett, Enniskillen.

THE original report was read by me at Dublin in 1878, and I then stated that after the exploration of F cave the work would be suspended, as it seemed probable that none of the caves in this district would yield bones of extinct mammalia.

I spent three summers exploring the caverns which penetrate the Carboniferous Limestone hills in Fermanagh, in which I found flint implements, bone, bronze, and iron pins, a large cinerary urn inverted over burnt human bones, human skulls, ancient hearths, etc., also quantities of the bones of the wild horse, red deer, long-snouted pig, ox, and remains of other animals not extinct. Having explored a number of caves in this county previous to my reading the report referred to above, I came to the conclusion that remains of extinct mammalia were not likely to be found in this locality. Now, on the contrary, I am glad to be in a position to report that I have been fortunate in finding an entire cranium of what I believe to be the great cave bear (*Ursus spelæus*) in one of the Knockmore caverns, which penetrates a cliff not far from the caverns I formerly explored, and is a narrow cleft with vertical sides. The height of the cave is about 40 feet and length 90 feet. When standing at the extreme end of this cleft-cavern one may observe near the top of one of the sides an opening which is evidently the end of a horizontal cave which runs at right angles into the cave in question; a good deal of débris has been during heavy rains washed out of the higher cave down into the lower one; in this débris, the cave bear's head was found, and I have no doubt that, when explored, the higher cave will yield more remains of the skeleton of the bear and possibly other extinct animals.

I have commenced excavations on the top of the rock, and hope to find the upper or horizontal cavern (which cannot be reached from the narrow cave below), which formerly must have had an opening out to the surface of the ground, and probably has been filled up level with the surface for the protection of cattle.

[1] Read before Section C (Geology), British Association, Bristol Meeting, September, 1898. See also earlier Report, 1878, pp. 183–185.

I thought it well to place this find in Fermanagh upon record in the proceedings of the British Association, and I shall be happy to report to the Association next year the results of the cave-digging which I am carrying on here at present.

REVIEWS.

I.—A Text-Book of Mineralogy, with an Extended Treatise on Crystallography and Physical Mineralogy. By Edward Salisbury Dana. New Edition, entirely rewritten and enlarged. 8vo; pp. 593, with nearly 1,000 Figures and a Coloured Plate. (New York: John Wiley & Sons, 1898.)

BY the irony of Fate the author of this treatise, Mr. E. S. Dana, though an experienced mineralogist, is a University Professor, not of Mineralogy, but of Physics; those who have been his pupils report him to be an ideal teacher of that branch of knowledge: further, Mr. Dana prepared for press the last edition (1892) of his father's well-known "System of Mineralogy," a book which is in constant use by mineralogists throughout the world. An excellent teacher and closely associated with Mineralogy as a living science, Mr. Dana was thus particularly qualified to furnish the Students of Minerals with a good text-book of their subject, and he has done so.

The work was first issued twenty-one years ago: the author has now rewritten it with the results of recent researches in mind. Part I (144 pages) deals with Crystallography in a practical way, demanding from the student only the elements of mathematical science. The subject is treated from the point of view of Symmetry, and the thirty-two classes of symmetry are briefly but clearly explained; the name assigned to each of the prominent classes being taken from some mineral species, of which the crystals present good illustrations of the class of symmetry. The facial symbols are those of Miller, and stereographic projection is made extensive use of. Part II (94 pages) treats of Physical Mineralogy in a similarly elementary way, and necessarily deals for the most part with the characters which depend upon Light, and with the modes of their determination. "Axes of optical elasticity" are dropped, and the "Indicatrix" is explained and made use of in the discussion of doubly-refracting crystals. Part III, Chemical Mineralogy, is compressed into 30 pages, and is limited to the explanation of the general principles of Chemistry and of the modes of chemical determination of minerals. The last Part, Descriptive Mineralogy, extending to 225 pages, is not susceptible of much variation of treatment, but is accurate and brought up well to date. The book is plentifully illustrated throughout.

We may assume that so completely changed an Edition is evidence of the recovery of the author from the shattered health to which he had been brought by the years of toil required by the preparation of the last edition of the "System of Mineralogy";

we take this opportunity of congratulating both Professor Dana and the Science to which he so largely devotes his energy on this improved position.

II.—FIRST LESSONS IN MODERN GEOLOGY. By the late Professor A. H. GREEN, M.A., F.R.S. Edited by J. F. BLAKE, M.A. pp. vi and 212, with 42 woodcuts. (Oxford : Clarendon Press, 1898. Price 3*s.* 6*d.*)

GEOLOGICAL handbooks intended for the use of beginners take various lines of teaching. Some seem to aim at presenting an abstract of the contents of the more or less complete treatises on the principles, elements, and conclusions of the science. Others, taking a separate line of thought, try to lead the tyro through strata and rock-masses, cliffs and escarpments, valleys and mountains, to the heights or levels hoped for. Of others we may say that a book-knowledge of some branches of the science, laboriously fashioned into a more or less readable category of statements, with borrowed tables and oft-used woodcuts, is offered to the public. There are, however, better guidebooks than such as these for beginners, and an example of this sort is noticed in the GEOLOGICAL MAGAZINE for November.

Still, there is another kind of first-geology book, which adopts a familiar style with the popular and almost homely language of a well-informed and well-qualified teacher. Such a primer was foreshadowed long ago by dialogues with children, in parlour, field, and study. These formal, old-fashioned, didactic, and sometimes pedantic, catechismal or conversational books, intended for the young, are extinct. Nowadays the subject-matters of both questions and answers, taken in their simplest form, run on in paragraphs or chapters, successively as one suggests another, or as they are systematically planned to occur.

In the " First Lessons in Modern Geology," we have evidence that the teacher is decidedly conversant with the latest descriptions and explanations of geological facts, and that he possesses the power of illustrating his statements by references to analogous affairs and things of current life and common observation. He moreover freely offers explanations of the nature and conditions of the earth's surface and materials as far as the as yet unschooled mind of the tyro can comprehend them.

Those to whom a simple primer and some first lessons in geology are useful may be — either (1) young folk and school-children with an aptitude to observe and a wish to inquire about stones and other natural objects in roads and quarries, or in public museums and collections at home ; or (2) more advanced scholars who have to be prepared for professions in which geology is more or less important. Led on by homely remarks on common materials, the student is taught in clear every-day language how to examine them with precision, and step by step to know their aspects, characters, and composition. Thus prepared he is taken to observe

quarries, hill-sides, and other places where sections of various rock-masses are, by the well-educated teacher, made to indicate the how and the why of their origin, changes, and present condition. Lesson VII supplies a good example of the line of thoughtful inquiry into the succession of events which go to make up the long geological history of the changes which have taken place during the building-up of the Earth's surface. We are reminded here and there that for some of the great problems in the Earth's history explanations cannot be given in the *first* lessons in geology, but they must be reserved by the student till a later stage in his progress.

That these are lessons in *modern* geology Professor Green's teaching gives full evidence throughout; especially on the subject of thrust-faults, schistose rocks due to crush, transverse valleys, origin of flints in chalk, cautious reference to the origin of Boulder-clay, etc.

The printer's type in this book is good and clean. Of the forty-two illustrations nineteen are new, very useful, and well printed; of the others several are from Professor Green's larger work. We heartily recommend this excellent and well-written primer or handbook of "First Lessons" for home use in intelligent families, and to educational establishments as a trustworthy early guide in the study of geology.

III.—SUPPLEMENT TO THE GEOLOGY OF THE NEIGHBOURHOODS OF FLINT, MOLD, AND RUTHIN. By A. STRAHAN. Memoirs of the Geological Survey. 8vo; pp. vii. (London, 1898. Price 2*d*.)

THE object of this Supplement is to record a series of borings which have been put down in the reclaimed portion of the estuary of the Dee. They prove the existence of Upper Coal-measures, which nowhere appear at the surface, and which were not previously known to be present in Flintshire or West Cheshire. The discovery of these strata is of importance, as they may underlie much or all of the Cheshire Trias; they are not productive, and consequently they would have to be penetrated before the productive Middle Coal-measures could be reached.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—November 9, 1898. — W. Whitaker, B.A., F.R.S., President, in the Chair.

The President drew the attention of the Fellows to the new Geological Survey Index Map of England and Wales, which had been hung upon the walls of the meeting-room during the recess.

Mr. Bauerman, in exhibiting a map of the Gellivara iron-ore deposits, pointed out that these constitute a chain some five miles

in length, and are made up essentially of magnetite interlaminated with apatite. In addition to these mines, which are far north of the Arctic Circle (70 miles N. and 120 miles W. of the Gulf of Bothnia), he had had an opportunity of visiting the deposits of Kirunavara, 100 miles still farther north; here the rocks are of a slaty character, and the magnetite is included in felsite-porphyry. The Gellivara ores are contemporaneous with the surrounding rock, while the Kirunavara ores appear to have been introduced at a later period. Mr. Bauerman exhibited specimens from both districts, and drew attention to the phenomena of polishing by wind-action, etc.

The following communications were read :—

1. "On the Palæozoic Radiolarian Rocks of New South Wales." By Professor T. W. Edgeworth David, B.A., F.G.S., and E. F. Pittman, Esq., Assoc. R.S.M., Government Geologist, New South Wales.

The first evidence of the presence of radiolaria in the rocks of New South Wales was obtained by Professor David in 1895, as the result of a microscopic examination of some red jaspers from different areas. Further research by the same author was stimulated and guided by seeing the radiolarian rocks recently discovered in Mullion Island, Cornwall, and in the Culm districts of Devonshire, during a visit to England in 1896; and on his return to Sydney he recognized the existence of a series of cherts, lydites, and siliceous limestones containing radiolaria in four distinct areas. A brief preliminary account of these rocks was communicated to the Linnean Society of New South Wales, and specimens were forwarded to Dr. G. J. Hinde for determination of the radiolaria. Subsequently, in conjunction with Mr. Pittman, a detailed examination of the rocks in the field was carried out, and the results are given in the present paper. In this final investigation it was ascertained that not only in the cherts and siliceous limestones, but also in the jointed claystones which form the prevalent sedimentary rocks of the Tamworth district, radiolaria were distributed in vast numbers.

The three chief areas of radiolarian rocks in New South Wales are Bingara, Barraba, and Tamworth, situated in the New England District, between 180 and 270 miles north of Sydney. Bingara, the farthest locality, is 30 miles north of Barraba; and this latter is 60 miles north of Tamworth. The character of the rocks in these localities tends to show that they belong to the same series; and in this case its extension from south to north is about 85 miles.

The fourth area of radiolarian rocks is at the well-known Jenolan Caves, about 67 miles due west of Sydney and about 200 miles south-by-west of Tamworth. It is probable that the Jenolan rocks may be on a somewhat different, perhaps lower, horizon than those of the northern district.

At Bingara and Barraba the radiolarian rocks consist of red jaspers and fine-grained jointed claystones, accompanied by thick coral-limestones and numerous beds of interstratified tufaceous materials.

The radiolaria occur as casts in chalcedony in the jaspers and clay-stones. The rocks dip at a high angle. No macroscopic fossils are known with certainty from these districts.

In the Jenolan Cave district the radiolarian rocks consist of black cherts and clay-shales overlying the Cave Coral Limestone, and of greenish-grey shales underlying this rock. The series is traversed by felsitic dykes, and the hardness of the cherts is attributed to silica derived from the acidic dykes, rather than to that derived from the tests of the siliceous organisms.

It is at Tamworth that the radiolarian rocks are developed on a grand scale; their measured thickness amounts to 9,267 feet, after allowing for an immense fault, and neither upward nor downward limit is shown. The rocks consist of jointed claystones, black cherts, lenticular siliceous radiolarian limestones, and coral-limestones. Numerous beds of submarine tuff also occur. The claystones are largely formed of radiolaria. In certain beds of the claystones, and in some of the tuffs as well, impressions of *Lepidodendron australe* are not uncommon; and beds of radiolarian limestone occur in close proximity to the beds with these plant-remains, and radiolaria moreover abound even in the same rock with the *Lepidodendron* impressions.

At the eastern end of the Tamworth section, and also near the westerly portion, there are limestones containing corals, which have been determined by Mr. R. Etheridge, jun. They are similar to those of the Burdekin Limestones of Queensland which belong to the Middle Devonian, and the radiolarian rocks are thus shown to belong to this period.

Analyses of the radiolarian chert, cherty shale, shale, and siliceous limestone prepared by Mr. J. C. H. Mingaye, F.C.S., are given; and from these it appears that, while the amount of silica in the chert and shale ranges between 68 and 91 per cent., there is only 18 per cent. in the siliceous limestone.

Descriptions of numerous micro-sections, both of the sedimentary and of the tufaceous rocks, are appended, and in their conclusions the authors point to the remarkably fine-grained character of the materials forming the base of the radiolarian cherts, jaspers, and shales, the constituent particles not being more than 0.05–0.025 mm. ($\frac{1}{500}$ to $\frac{1}{1000}$ inch) in diameter. They are of opinion that the radiolaria were deposited in clear sea-water, which, though sufficiently far from land to be beyond the reach of any but the finest sediment, was nevertheless probably not of very considerable depth.

2. "On the Radiolaria in the Devonian Rocks of New South Wales." By G. J. Hinde, Ph.D., F.R.S., F.G.S.

Hand-specimens of the various radiolarian rocks discovered by Messrs. David and Pittman in New South Wales were forwarded to the author, and from them numerous microscopic sections were prepared. In the chert and jasper rocks of the Jenolan, Bingara, and Tamworth districts, the radiolaria were for the most part in the condition of casts filled with chalcedonic silica and without structure,

so that their generic characters could not be determined. Also in the claystones, the radiolaria were but poorly shown in sections, though the structure could be seen in specimens weathered out naturally on the surface of the rock. But in the siliceous limestones and in the volcanic tuffs the radiolaria were embedded in, and infiltrated with calcite, and by careful etching of thin sections of the rock, the lime was eliminated and the organisms were shown very distinctly. The rock then appeared as a confused mass of entire and fragmentary radiolaria and minute débris of their spines and latticed tests. The silica of these forms is for the most part still in its colloid condition ; in some, however, it has been replaced by a dark mineral.

Fifty-four species belonging to 29 genera have been determined and figured ; all the species and four genera are regarded as new ; excepting a few primitive types of *Nassellaria*, the forms belong to the *Spumellaria*. The large majority may be included in the *Sphæroidea* and *Prunoidea* with medullary tests and radial spines. They do not show any near relationship to the radiolaria described from Devonian rocks in Europe, but in some features they resemble the radiolarian faunas of Ordovician age in the South of Scotland, Cornwall, and Cabrières, Languedoc.

No other fossils beyond a few simple sponge-spicules and, on two or three horizons, some fragmentary impressions of *Lepidodendron australe*, have been found in association with the radiolaria.

These New South Wales radiolarian deposits are by far the most extensive of any hitherto known, and they are remarkable, not only for their great thickness, but also for the manner in which the radiolaria are preserved in the limestones, tuffs, and claystones.

MISCELLANEOUS.

COAL IN WESTERN AUSTRALIA.—The Agent-General for Western Australia has received the following cablegram, dated Perth, W.A., October 20 : " Sir Frederick M'Coy reports, regarding further coal specimens and fossils from Collie Coalfield, he is now able to state deposit is exact geological age as great coalfields Newcastle, New South Wales. Coal specimens from bore cores quite equal to best coals Newcastle district. He considers it magnificent and valuable discovery, and says fossils are *Glossopteris Browniana.*"—*Morning Post*, October 22, 1898.

WEST AUSTRALIAN GOLD. — The output of gold in Western Australia for October amounted to 115,376 oz., valued at £438,428. This is by far the greatest monthly output in the history of the colony. During the ten months of the year ending October 31 the gold exported from the colony has amounted to 841,625 oz., valued at £3,198,176, as compared with 526,736 oz., valued at £2,001,600, in the corresponding period of last year.—*Morning Post*, November 2, 1898.

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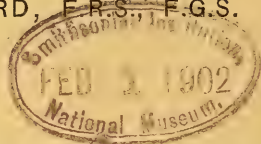
"THE GEOLOGIST."

EDITED BY

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JANUARY, 1898.

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Ælurosaurus felinus, Owen. (Imperfect skull and mandible.) Described and figured in Quart. Journ. Geol. Soc., vol. xxxvii (1881), pp. 261–265, pl. ix, figs. 1–3. Karoo Formation : Gouph District, Beaufort West, Cape Colony. 10s.

Cynognathus crateronotus, Seeley. (Skull and skeleton.) Described and figured in Phil. Trans., vol. 186B (1895), p. 59, figs. 1–5, 13–18. Karoo Formation : Lady Frère, Cape Colony. £10 (the skull separately, £3 10s.).

Cynognathus leptorhinus, Seeley. (Anterior portion of skull.) Described and figured, ibid., pp. 141–144, figs. 31, 32. Karoo Formation : Cape Colony. [Albany Museum.] 12s.

Cynognathus platyceps, Seeley. (Skull.) Described and figured, ibid., p. 139, fig. 30. Karoo Formation : Wonderboom, Cape Colony. [Albany Museum.] 20s.

Delphinognathus conocephalus, Seeley. (Skull and mandible.) Described and figured in Quart. Journ. Geol. Soc., vol. xlviii (1892), pp. 469–475, figs. 1, 2. Karoo Formation : Cape Colony. [S. African Museum.] 15s.

Eurypterus lanceolatus, Salter. Figured and described by Dr. Henry Woodward, F.R.S., etc, in Pal. Soc. Monograph " Merostomata," part iv, pl. xxviii, fig. 1. Upper Silurian : Lesmahagos, N.B. 5s.

Gomphognathus polyphagus, Seeley. (Cranium showing palate, etc.) Figured and described in Phil. Trans. Roy. Soc., London, vol. 186 (1895), pp. 11–19, figs. 6–8. Karoo Formation : Lady Frère, Cape Colony. 30s.

Gomphognathus, sp. (Skull.) Figured in Phil. Trans., vol. 186B (1895), pp. 20, 21, 24, figs. 9–11. Karoo Formation : Lady Frère, Cape Colony. 20s.

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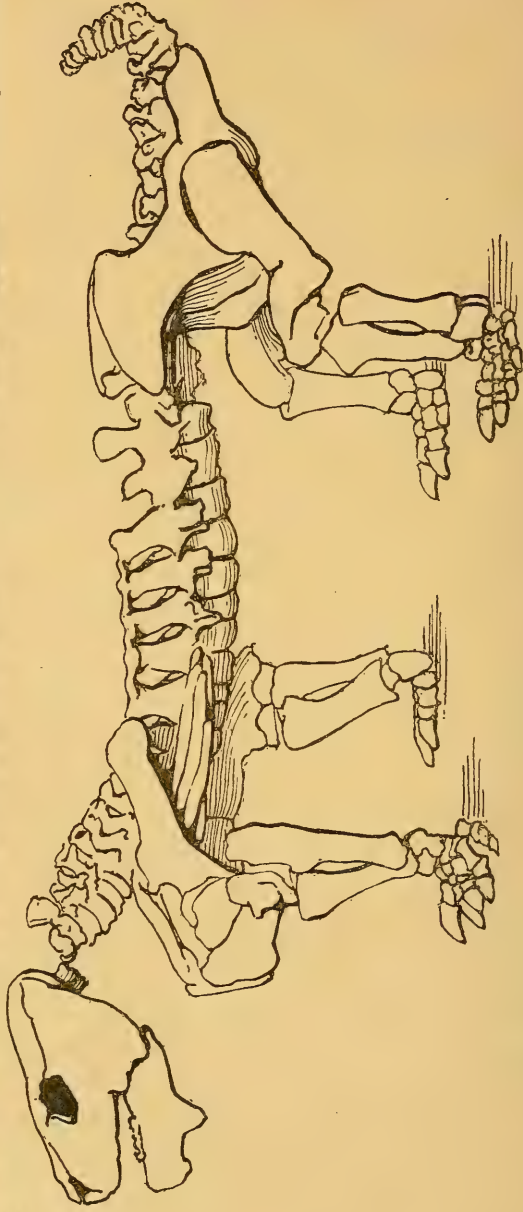
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